Knowledge

Founded by Richard A. Proctor, 1881.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

CONDUCTED BY

Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

"Let Knowledge grow from more to more."
—*Tennyson.*

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JANUARY, 1913.

THE SHINGLE BEACH.

By E. S. GREW, M.A.

ALIKE in Europe on its north-western and western shores, and in the United States along the eastern coast of North America, as well as along the coast of Peru, the wandering sand-dune has been an object of systematic and continuous study. The shingle beach, as Professor F. W. Oliver, F.R.S. has recently pointed out in *The New Phytologist*, has received, on the other hand, comparatively little attention, probably because in the countries where attention to the sand-dune has been an economic necessity, the shingle beach is of comparatively small importance. But in Great Britain the shingle beach is not unimportant. It is part of the drift of our coasts, and as such plays a very important rôle as a defence against the wastage of the shore-line—a point which has been emphasised in the recent Report on Coast Erosion. The extent of the British shingle beaches is hardly realised, though few holiday-makers at the seaside will have found themselves at any distance from some shingle drift, and there are actually some three hundred miles of the coast of England and Wales lined by shingle. Even the most casual observation of these deposits reveals that they are not entirely stationary, and that their presence must influence the hinterland where they occur, if only to the extent of protecting golf links from the surrounding sea, as at Felixstowe, or of threatening them with curtailment as at Westward Ho! To the geologist and botanist they offer many interesting problems, both in respect of their own increase of material, and in the vegetation for which they afford either protection or a difficult foothold.

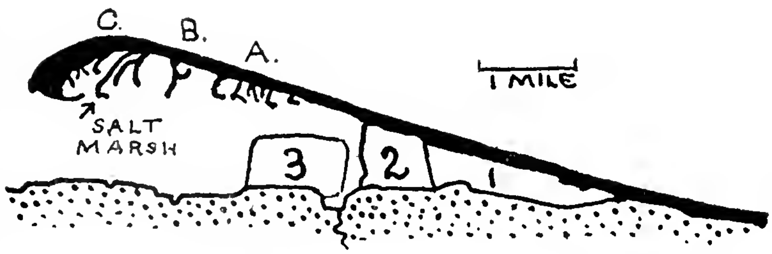


FIGURE 1. Sketch Map of the Blakeney Bank, showing systems of hooks at A, B and C. 1, 2 and 3 denote areas of marshes in the order in which they were reclaimed. The arrow above the letter S in "salt," indicates the position of the bank whose tip was turned at a right angle in 1911.

Professor Oliver's interest in shingle beaches is chiefly botanical, and in its direction is analogous to the inquiries which have been pursued by him and by the students of University College, for a number of years past in Western France. At Erquy, in Brittany, an area of salt-marsh was selected some seven years ago, and on this area has been noted the distribution of zones of vegetation; the physical characters of the soil, its salinity, and the plants appropriate to such conditions; the migration of the plants, and so on. A large number of problems have arisen out of this field of study: and some of them are repeated in different aspects in the neighbourhood of the shingle beach. But in order to define them, it is necessary to comprehend first the methods of formation of the beach; and to this question Professor Oliver, to whose article we are indebted for the information which is to follow, gives preliminary attention.

Shingle banks arise when suitable materials from the waste of the shore find their way into the currents which run along the coast. In these shallow waters the shingle is always on the move owing to the action of the waves, and is kept steadily moving in the direction of the current. Heavy seas, and on-shore gales pile the shingle up above high-water mark and thus form the banks or beaches. These are of three types:—

(1) The Fringing Type.—This is the simplest case, the shingle being directed by the shore current and forming a strip in contact with the land on top of the sand beach. There are many examples of this kind of shingle beach in Sussex.

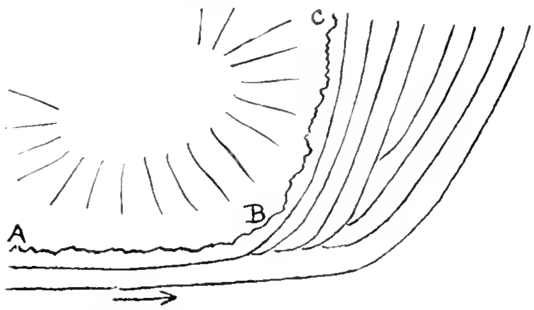


Figure 2. Apposition type of Shingle Bank. A, B, C, indicate a point of land; the arrow marks the direction of coastal drift; the successive shingle banks lie to the right of the figure; modified from F. Drew.

(2) The Shingle Spit.—Suppose now that the coast line suddenly changes its direction, and turns inwards, while the current running along it still goes shooting past the point of deflection. The drifted shingle accumulates along the line of the current to form a bank or causeway, often reaching a length of several miles. This type is attached to the shore at the point where the current leaves it, and then runs straight on or with a gentle curvature towards its growing distant end. It generally turns inward. Examples are Hurst Castle Bank and Blakeney Bank.

(3) The Bar.—When a shingle spit of this kind continually stretching and growing touches land again it forms a bar. Professor Oliver notes that the Chesil Beach which is so conspicuous a feature at the Isle of Portland (its eastern extremity) seems at first sight to belong to this category; but its exact status is still a matter of discussion.

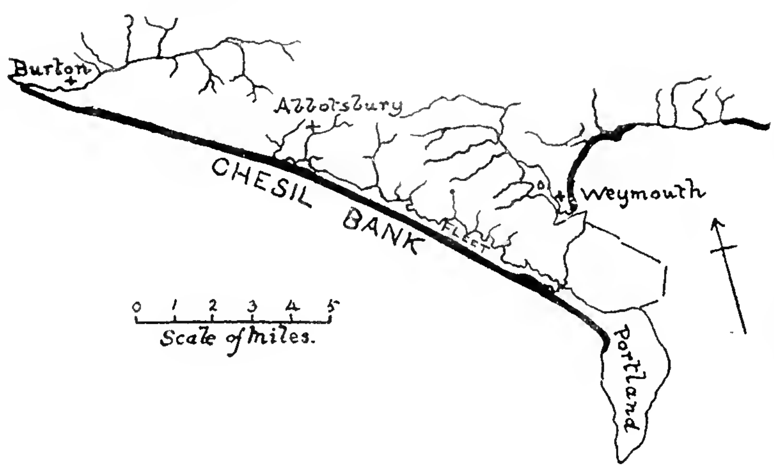


Figure 3. Sketch Map of the Chesil Bank (after Bristow and Whitaker) to show the relations of Bank, Mainland and Fleet. Shingle is drawn thick black.

(4) The Apposition Type.—Sometimes the pushing current by changing its direction or force has not enough strength to carry the shingle to the end of the bank; or else the end of the bank has been hooked inwards so far that the current cannot reach it. In these cases the spit cannot lengthen and the additions of shingle are merely dropped by the current on the flank of the forming bank. These additions may be lifted above the top of the bank by a high tide or gale. In this way a succession of more or less parallel banks may be thrown up one behind another, with the result that very extensive areas of shingle are produced.

The outstanding example of this type is Dungeness (see Figure 2).

To return to the Shingle Spit. As already explained, the point at which the spit leaves the shore is a salient angle of the mainland. The axis of the bank runs along the line of the current and generally presents a gentle convex curve to the sea. As a rule this type runs at some distance from the shore line, the protected area between bank and shore being occupied by salt marshes subject to the tides. These salt marshes are practically a kind of littoral shelf on the edge of which the shingle rests: and they often offer facilities for reclamation. The spits which protect them most often pursue their course from the point where they are attracted to the mainland, without any alteration in character beyond an occasional narrowing or widening. The Aldeburgh bank in Suffolk goes right on to its apex without alteration.

But usually, towards the apex, there appears a marked landward deflection in the form of a hook: and frequently several hooks are present in close proximity (Hurst Castle, Hamstead, Dover): while, as at Blakeney, there are occasionally extremely complex systems of hooks (see Figure 1). "One of the hooks at Blakeney has in recent years become exposed to gales from the north-west in consequence of the wasting of the top of the main bank which formerly masked it. At Easter, 1911, a succession of heavy gales from this quarter removed the terminal portion of this hook and deposited the eroded material as a new bank one hundred and forty feet long, fifty feet wide, and over six feet high, at right angles to the old hook, on its lee side" (see Figure 5). Professor Oliver concludes that a shingle spit has quite definite, successive phases. There is the phase of youth in which growth is mainly in length; and this is followed by a more or less prolonged phase of hook formation, when the action of the current begins to yield its domination to the activity of the gale. Blakeney Bank illustrates in its finger-like stretch of two miles the formation of multiple hooks on the grand scale (see Figure 6); and here there seems to be evidence of the oscillation of conditions in which the current and the wave have alternately triumphed.

FIGURE 4. Chesil Bank looking S.E. from a point opposite Burton Mere, near Burton Bradstock.

The Chesil Bank, which furnishes the most considerable and imposing accumulation of shingle in the British Isles, forms a problem by itself. It stretches fifteen miles as a continuous strip from Burton Bradstock to Portland (see Figure 3). The height of its crest above high water mark ranges from twenty to thirty feet, while its width averages five hundred feet. The roar of a south-western gale on its pebbles at the Isle of Portland is a sound which lingers in the ears of anyone who has ever slept, or lain awake, during a night there. From Burton Bradstock to Abbotsbury (six miles) the Chesil Bank fringes the mainland (see Figure 4); from this point to Portland the bank is separated from the land by a shallow estuary, the Fleet, or Backwater, about eight miles long, and sometimes half a mile in width. As already observed the Chesil Beach might be regarded possibly as a Spit or a Bar. Quite recently it has been thought to have developed not as a spit but as a fringing beach behind which the land has retreated in consequence of sub-aërial denudation. The Fleet or Backwater would thus have been excavated behind the bank. Professor Oliver remarks on a peculiarity of the Chesil Bank, confirmatory of this theory, which is that the bank presents not a convex but a concave front to the sea. There are many other problems of the shingle bank, especially the movements of its hooks, and the percolation of water through it—for which further reference may be sought in Professor Oliver's original work; and there, too, will be found an outline of the development of the flora of the beach. One of the outstanding mysteries of the shingle spit is its water supply and the plants which are nourished by it. The lower parts of the spit are tenanted by plants which do not need salt. Above them there is a residuum of plants intolerant of salt. Where do they obtain the water to nourish them? Such water exists, and is indeed astonishingly copious, in the interstices of the shingle. In last year's burning summer the upper vegetation of shingle spits prospered, and the sheep fed on it—especially on the Chesil Bank. The source of this water is possibly to be attributed to the formation of internal dew in the shingle.

From a Photograph by *E. J. Salisbury, July. 1911.*

FIGURE 5. A new hook at Blakeney Point, formed in March-April, 1911, on the bank marked with an arrow in Figure 1.

FIGURE 6. Inner edge of Blakeney Main Shingle Bank encroaching on the "Marains," looking west. The bushes are *Suaeda fruticosa*.

THE PSYCHOLOGY OF TELESCOPIC VISION.

By W. ALFRED PARR.

LITTLE BUTTERCUP, of "H.M.S. 'Pinafore'" fame, gave vent to a profound piece of general philosophy when she assured Captain Corcoran, of that vessel, that "Things are seldom what they seem." Now, although this is a fundamental verity familiar enough to us all, we are occasionally reminded of the peculiar virtue underlying this Gilbertian dictum in quite an unexpected manner when looking through a telescope. If we regard a far-off landscape through a powerful telescope, fitted with an erecting day eyepiece, we soon become aware of the fact that any distant cottages or houses which our landscape may contain appear to us strangely out of drawing. More especially is this the case with such houses as happen to have their longest sides parallel to our line of sight, so that we look along them, as it were, instead of squarely at them. We shall find, on examining these closely, that, instead of presenting the ordinary aspect we are accustomed to associate with the rules of foreshortening, they boldly bid defiance to all our ideas of perspective and stand out at us in a manner which is truly astonishing. And, if we recall the statement we so often hear, that the function of a telescope is to make a far-off object appear as if it were only at a short distance from us, our astonishment will be the greater, since no houses within our previous experience wear such a curiously distorted guise as these.

It was claimed by the promoters of the giant telescope, which was intended to form the *clou* of the Paris Exhibition in 1900, that the moon was to be brought by this instrument literally within our grasp!—if we could reach a metre—and popular accounts of the great Yerkes telescope affirmed that it would make our satellite appear just as it would be seen with the naked eye if it were suspended but sixty miles over our heads. Such irresponsible statements as these are not only in the highest degree misleading in themselves, as I ventured to point out some years ago in a letter to the British Astronomical Association,* but, even supposing the exaggerated claims, just quoted, as to the "approximating" power of a great telescope to be possible of realization, it can still be shown that the telescopic image of an object is vastly different from the actual aspect that object would present if viewed by the naked eye at the same apparent distance. This somewhat ignored fact is a distinct and important feature of telescopic vision; for it has an interesting bearing on our interpretation of telescopic pictures in general, be they astronomical or terrestrial.

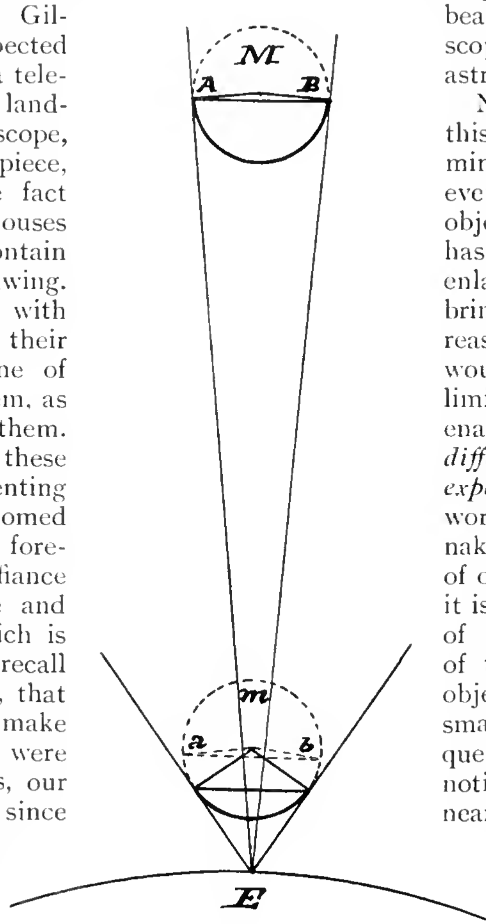


FIGURE 7.

Now, our surest way of keeping this peculiar action of the telescope in mind is to remember that, far from even apparently bringing distant objects nearer, as the popular claim has it, the telescope in reality merely enlarges the naked-eye view. It brings to our notice objects which, by reason of their great distance from us, would otherwise remain beyond the limits of critical vision, and thus enables us to see them ***under conditions different from those under which our experience is usually gained.*** In other words, the telescopic image and the naked-eye image are essentially copies of one another on varying scales, and it is only in our different interpretation of these scales that the peculiarity of telescopic vision resides. Distant objects are habitually seen under a small visual angle, and they consequently fail to excite our critical notice in the same degree as do near objects which are seen under a larger visual angle. But when the telescope comes to our aid and enlarges our naked-eye view for us, we are apt to fall into error, and, if we do not in reality consider ourselves suddenly confronted with an actually nearer object, we, at any rate, regard that object with all the inferences which the enlarged image conjures up in our minds. We mentally endow the magnified retinal image with all the attributes which an object of its apparent size would possess, and fancy our larger picture also nearer, in conformity with our past association of largeness and nearness. We must remember, however, that in looking through a telescope we become aware of conditions which are foreign to our usual experience, and of which, but for the instrument's power, we should have remained in ignorance.

Thus, to consider for a moment the simple

* See *Journal Brit. Astro. Assoc.*, Vol. IX, p. 271.

geometrical aspect of the question in its relation to astronomy, as illustrated in Figure 7, where the circle M may be allowed to represent the moon, it is clear that the portions of the lunar surface at A and B are seen under what we can only describe as unnatural conditions when viewed telescopically from E, since they would remain wholly invisible to an observer capable of inspecting the moon at close quarters. Now, when we apply a powerful telescope and bring the moon apparently nearer, as at *m*, the portions of the lunar limb at A and B remain visible, instead of lying beyond our sight at *a* and *b*, as the figure shows they would do, if we were in reality as near the moon as the telescope apparently brings us. It follows that the lunar features near the limb are always seen under a certain amount of distortion, which decreases as we approach the centre of the disc; but so familiar has this telescopic deformation become, that the eye practically ignores it, and accepts the illusion of an actually approximated moon.

FIGURE 8.
The Villa Fabbricotti, Florence, taken with a telephoto lens, magnifying 15 diameters, at a distance of ¼ mile.

Though a telescope magnifying one thousand times is said to theoretically bring the moon within a distance of only two hundred and forty miles, we must bear in mind that an observer, who might be supposed to regard our satellite at this distance with the naked eye, would have a very different scene presented to his view from that with which telescopic astronomy has made him familiar. Not only would there be the geometrical reduction of the visible area noticed above, but that area itself, being viewed under altered visual conditions, would wear a different aspect. The astronomer's eyes, in fact, have become vitiated, so to speak, by this peculiar action of the telescope; much as the musician complains that his ears have become corrupted by accepting the artificial intervals brought into universal musical practice by the adoption of the system of tuning by equal temperament.

FIGURE 9.
View of Florence, taken from the Palazzo Vecchio, and showing the hills of Fiesole in the background.

But if the eye, in accepting the illusion of an approximated moon, has learned to tolerate selenographical distortion, since it is solely under telescopic conditions that lunar detail has been brought to our notice, the case is quite another one when we contemplate distant terrestrial scenery through the telescope. Here all is familiar, and the same, or at least similar, objects have been originally studied by us at close quarters, so that when we expect to witness the anticipated approximating effect of our telescope we stand amazed at the curious spectacle offered to our view. In Figure 8, for instance, we notice to some extent the singular out-of-drawing effect of the ordinary telephotograph. The building illustrated has an interest of its own, being the Villa Fabbricotti, just outside the gates of Florence, where Queen Victoria resided in the spring of 1894; while the photograph, which was taken with a telephoto lens magnifying fifteen diameters at a distance of a little over a quarter of a mile, shows, especially on the right hand side, in the seeming divergence of the lines along the top of the machicolated tower and the roof of the villa, that peculiar effect of telescopic

FIGURE 10. The Villa degli Angeli at Fiesole, as photographed from Florence through a telescope magnifying 40 diameters.

vision which is brought out more vividly in a powerful instrument.

In order to exhibit this peculiarity to its fullest extent, I instituted some experiments in the photography of distant buildings by means of an ordinary Kodak camera, from which the lens had been previously removed, attached to a three-inch refracting telescope, fitted with an eyepiece magnifying some forty diameters; and although, as might be expected from the non-photographic character of the usual telescopic objective, the resulting pictures leave a good deal to be desired as regards strength and clearness, they are sufficiently distinct to show the characteristic feature of telescopic vision in a very striking manner. Taking advantage, therefore, of the extensive view commanded from the terrace of the Palazzo Vecchio near the centre of Florence, I first took an ordinary photograph of the group of hills, some three miles distant, upon which is situated the ancient town of Fiesole, and then, combining camera and telescope in the manner described, photographed separately some of the more conspicuous villas embraced in the general view. Thus Figure 9 may be regarded as representing the naked-eye view of Fiesole as seen from Florence*, while Figures 10, 11 and 12 represent the telescopic images of the villas just discernible, and marked respectively with one, two, and three dots, in Figure 9. Of these, Figure 12, which shows the corner and foreshortened side of the villa marked with three dots in the middle-distance of Figure 9, offers undoubtedly the most violent shock to our ideas of rational perspective, and may for this reason be taken as a fitting object lesson in connection with our present topic. The distance from the observer—about one and a half miles—and the position of the house with regard to his line of sight, as well as the magnification employed, all conspire in this case to produce a most interesting result; and so odd, in fact, was the aspect which this particular building presented in the telescope that it was known as the *Villa Storta*, or crooked villa, by those who thus beheld it for the first time. But the crookedness is, after all, merely psychological, for the photograph serves as a singularly apposite illustration of what Professor James Sully calls interpretative illusion.†

Now, as the perception of magnitude is closely connected with that of distance, and the building depicted is sufficiently removed from the observer for its near and far ends to be seen under practically the same visual angle, our ordinary ideas of perspective are disturbed. We are, in fact, by virtue of the magnifying power of the telescope, able to contemplate this building under conditions foreign to those under which our experience has been hitherto gained, so that the lines of roof and first story, instead of converging as they recede from us, as would certainly be the case if the building were actually as near

FIGURE 11. The Villa Torrosa, Fiesole, as photographed from Florence through a telescope.

FIGURE 12. The Villa Ventaglio, as photographed through a telescope.

* The two towers in the picture, which, as here reproduced, is necessarily seen on a reduced scale, are (from left to right) those of the Badia and the Bargello.

† *Illusions, A Psychological Study*, by James Sully, 1895 (Vol. XXXIV of the International Scientific Series).

the spectator as the telescope apparently brings it, are here found to be practically parallel, since their *vanishing point*, as the draughtsman expresses it, is in this case extremely remote. We are thus confronted with a condition of things which in the ordinary way of life would be beyond the critical limit of vision. But now comes an interesting psychological moment; for the mind insists upon continuing its usual operation even under the present unusual circumstances. Knowing the two ends of a house to be of equal size, we make a habit of mentally enlarging the reduced image of the distant end to fit the near end: and here, where there is practically no dissimilarity between the retinal pictures of the two ends, we persist in mentally enlarging the distant end, with the curious result that the lines of the house appear actually to *diverge* as they recede from us. But that this astonishing effect is nothing but a psychological illusion, anyone can easily prove for himself by simply holding the picture in such a position that the eye can glance obliquely down the seemingly divergent lines, when he will at once become aware that they are practically parallel; the actually existing, but extremely slight, *convergence* towards the distant end being quite inappreciable.

To a lesser degree the same effect may be traced in the appropriate portions of the other telescopic pictures, notably in the right sides of the Villa degli Angeli (see Figure 10) and the Villa Torrosa (see Figure 11), while it is instructive to note how persistently the illusion of divergent receding lines reasserts itself in each of the photographs, although we may convince ourselves with compasses and ruler that geometrical orthodoxy in reality reigns supreme.

This is a striking confirmation of the truth that the same personality enters into the examination of a photograph which is known to exist in the actual observation of nature, and the interesting fact is once more brought home to us in the study of such unusual phenomena as the present, that things are apt to change their seemings to suit our preconceived opinions concerning them; for our judgment is to a great extent a process of semi-conscious inference based upon a variety of circumstances drawn from our past experience and sense of association. We may, indeed, reverse the old saying in such a case as this and claim that, here at least, Believing is Seeing.

A HEN OSTRICH WITH PLUMAGE OF A COCK.

By F. W. FITZSIMONS, F.Z.S., F.R.M.S.

(Director of the Port Elizabeth Museum.)

IN April, three years ago, at a caponizing demonstration at Graaff Reinet, Cape Province, at which there were over forty farmers and townsmen present, Veterinary Surgeon Elley removed the ovaries from three hen ostriches. The hens were each four years of age at the time. Shortly after the operation the three hens began to assume the black body plumage of the adult cock bird, and from the characteristic drab colour of the feathers of a female, these feathers turned jet black and became glossy as in the male. Another remarkable thing happened. The wing and tail feathers also changed, and became so like those of the cock bird that feather experts, to whom they were shewn, declared them to be the typical feathers of a cock ostrich.

FIGURE 13. A Hen Ostrich with the plumage of a Cock.

These hen ostriches belong to Mr. W. Rubige, a well-known Graaff Reinet farmer, and he kindly consented to have one of them chloroformed and presented to the Port Elizabeth museum for exhibition. The bird was sent to us in the flesh and I had the satisfaction of making a personal examination to make quite sure it was a female. There are many, no doubt, who will be sceptical, but I can assure them there is absolutely no doubt about the bird being a female. In the accompanying photograph, the hen bird is shewn after it was mounted by my taxidermist.

It will thus be seen that the removal of the ovaries in these three instances caused remarkable constitutional changes. Hitherto we have supposed that the ovaries, as their name implies, were concerned only in the production of ova or eggs.

MODERN CONCEPTIONS OF CELL-STRUCTURE AND FUNCTION.

By HAROLD A. HAIG, M.B., LOND.; M.R.C.S., ENG.

(Lecturer in Histology and Embryology, University College, Cardiff.)

NOWADAYS, the study of the complex problems dealing with cell-organisation and function is becoming more and more important and in certain branches of biology, notably pathology and bacteriology, is one which becomes intimately connected with abnormal processes in the cell; these processes are only to be correctly interpreted when the inner workings of the *normal* cell are understood, and in but few instances can it be said that the normal phenomena are fully explained. In the present article it will be my object to place before the reader a few of the more modern ideas with regard to the structure and function of the cell, and to try and explain the reasons why a normal cell-unit when subjected to morbid influences should have its life-cycle so profoundly altered as to produce, either in the individual cell or cell-aggregate, signs of obvious functional derangement.

At the outset, it should be remembered that a typical *cell*, whether animal or vegetable, is made up structurally of at least four parts (see Figure 14) *viz.*:—

a. The cytoplasm.

b. The nucleus, an oval or spheroidal body situated somewhere in the cytoplasm.

c. The plastids, small living structures concerned with the manufacture of various foods in the cell.

d. The vacuoles; these are spaces filled with fluid, usually a watery solution of salts, certain proteins, organic acids, sugars, and so on (cell-sap).

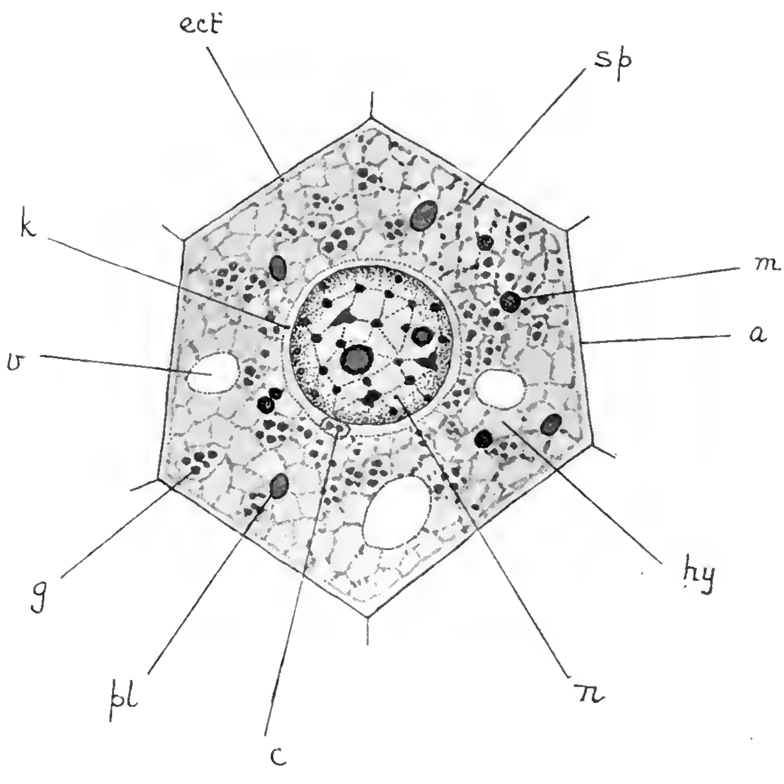


FIGURE 14.

Diagram of a typical cell (stained with nuclear and plasmic stains).

a. Cell wall: not always present; *ect*. Ectoplasmic layer of cytoplasm: this is often present in plant cells; *sp*. Spongioplasmic network of cyptoplasm, upon which minute granules or "microsomata" are to be seen; *hy*. Hyaloplasm; *g*. Granules, either of the nature of zymogen-granules or Altmann's (see text); *b*. Vacuoles; *pl*. Plastids; *m*. Metaplasm granules (starch, protein, etc.); *k*. Kinoplasm; *n*. Nucleus showing (*i*) clear nuclear plasm (*ii*) Linin network (*iii*) Chromatin-granules and Karyosomes (*iv*) Plasmosomes or nucleoli, the whole surrounded by the nuclear membrane. *c*. The centrosome (doubled).

The cytoplasm, nucleus, and plastids constitute the protoplasmic portions of the living cell or *protoplast*: the cytoplasm is often, especially in vegetable cells, surrounded by a firm *cell-membrane* composed either of carbohydrate material (cellulose) or of a rather firmer protoplasmic substance derived from the outer part of the cytoplasm (ectoplasm). The animal cell is, however, rarely enclosed by a complete cell-membrane, and this membrane, when present, is never composed of cellulose.

In its elementary structural details, as put forward above, there is very little difference between the plant and the animal cell; but in ultimate function there are often very marked differences, the most well known of these being perhaps those connected with the presence in the plant cell of the *chloroplastids*, the small oval protoplasmic structures which contain the green pigment *chlorophyll*. The chloroplastids are thus able, by virtue of their possession of this pigment, to utilise a portion of the radiant energy of white light, and to turn this energy to account in furthering the decomposition of carbon dioxide and water by the plastid, the ultimate result being the formation, by means of *chemosynthetic* reactions, of some form of *sugar* (probably dextrose). The animal cell rarely, if ever, possesses chlorophyll; and in those instances where chlorophyll-containing bodies are found in an animal cell (Hydra, Euglena and other Flagellata), these almost always turn out to be members of the Volvocaceae which appear to be living in symbiotic connection with the animal cell. This being so, the animal cell is not able by its own efforts to make use of the carbon dioxide existing in the surrounding medium (atmosphere or water), and in the majority of instances receives its raw food materials in the form of complex carbohydrate and protein compounds, the former of which have already been built up for it by the vegetable cell; the latter, perhaps by the vegetable cell, but in many cases by other animal organisms. The above elementary physiological processes in a cell serve to partially distinguish between the character of the functions of vegetable and animal protoplasm, although, as was pointed out, there may be no structural distinction; moreover, the explanation of such variation in function must be looked for, not in structural distinctions, but in the gradual changes taking place during *evolution* from the plant to the animal type,* changes, which, although undoubtedly existent, still remain more or less unexplained.

With regard to the structure of the several parts of the cell noted above, it will perhaps be best to take these in order, and consider some of the hypotheses which have been advanced with respect to their ultimate physical constitution. I do not propose to go into the consideration of the chemical composition of protoplasm, as this somewhat undecided question is one which is likely to lead the reader too far afield, and, moreover, might have the effect of confusing his mind as to the object of this article, *viz.*, the conception from a purely biological point of view of cell-structure and function.

(*a*) Structure of Cytoplasm.

Early conjectures as to the internal structure of cell-protoplasm were not of such a nature as to enable much criticism, seeing that the methods then in use for "fixing" cells and for staining their constituent parts were hardly adequate to bring out many structural details; moreover, the microscope, at the period when Hugo von Mohl made his interesting discovery of the "primordial utricle" in vegetable cells, was not the high-class instrument it is nowadays. Nevertheless, many interesting and accurate observations were made at that time, more especially in connection with the composition and structure of the cell-wall.†

Protoplasm was at that period looked upon as being quite homogeneous in physical constitution, and it is only fair to state that there are many nowadays who have come back to this view; it was, however, soon found that such a conception must be modified, in that, in many living cells, notably *Amoeba*, *Aethalium*, and numerous plant-cells, the main cytoplasm was found to be made up of a clear outer part, the *ectoplasm*, and an inner portion which was granular and in some cases reticular, the *endoplasm*, the latter enclosing as a rule one or more vacuoles filled with fluid contents. This distinction into outer and inner portions is not to be made in every cell, since very young cells of embryonic tissues appear during life to be almost entirely, if not quite, filled with a mass of homogeneous living substance, in which the nucleus and some granular structures are suspended.

Later observers, notably Nägeli, Schwann, Flemming, Cohnheim, Bütschli, Heidenhain, and many others have attempted to explain the structure brought out by "fixing" living cells rapidly by means of such substances as osmic acid, chromosmium acetic acid, alcohol-formalin-acetic acid, and others, upon the lines that the appearances produced by these reägents represent the true living structure of the cell-protoplasm; some of these appearances are, no doubt, correct representations—as, for instance, the fixation of the vacuoles in the cytoplasm, and the chromatin-network in the nucleus; but others are at least of doubtful significance, and the present-day cytologist has to guard very carefully against mistaking an "artefact" in the cell for the true structure. One conception as to cytoplasmic structure which, although open to considerable criticism, is, nevertheless, provisionally accepted by many workers at the subject, is that which gives to it a reticular basis or ground-substance of fibrils, the so-called *spongioplasm*, in the meshes of which a more fluid portion, homogeneous in appearance, the *hyaloplasm*, exists; it cannot be denied that even in the living cell, in some instances, a fibrillated appearance is to be seen in the cytoplasm, and this persists and becomes more pronounced after fixation.‡

Another hypothesis which at one time appeared likely to gain ground was that put forward by Bütschli, who considered that cytoplasm might possess an alveolar or froth-like structure, the spaces in this being filled with liquid; certainly the egg-cells of certain animals, notably *Ascaris* and *Asterias*, possess a cytoplasm which suggests strongly the alveolar structure, and cells of the nephridia of *Lumbricus* and the Leech show a typical froth-like appearance. But on the other hand there are many cells the cytoplasm of which conforms more closely to the reticular type; and in the case of certain large nerve-cells in the spinal cord and brain it has been shown by Cajal and Bielchowski that a very fine system of fibrils, the so-called *neurofibrils*, can be brought into evidence by a process of treatment with nitrate of silver and subsequent development. These *neurofibrils* were also shown to extend into the axis-cylinder process (axon) of the nerve-cell, as well as into the processes known as dendrons.

The *granules* seen in protoplasm are nowadays considered to be very important structural elements,

* It has been shewn that the Flagellata probably represent a sort of connecting link between the vegetable and the animal kingdoms.

† See "The Vegetable Cell," by Hugo von Mohl, translated by Professor Henfrey. 1854.

‡ Mention must be made, in this connection, of the experiments carried out by Hardy with colloids (such as various mixtures of gelatine and water) which pointed to the similarity of cytoplasm in physical constitution, to the "solid within a liquid" type of gelatine hydrosol.

and many of them are undoubtedly of cytoplasmic origin (microsomata); a few of them are capable of taking on certain stains, such as "neutral red" in the living cell prior to any fixation, and after fixation at least four types of granule may be distinguished according to the manner in which these structures stain. Thus there are to be found the so-called *neutrophilic* granules (see Figure 15) staining with neutral dyes (neutral red), the *oxyphilic* type (see Figure 16) staining with acid dyes such as eosin and acid fuchsin, the *basiphilic* granules (see Figure 17), which stain deeply with alkaline stains such as methylene blue; and there are at times to be found *amphophilic* granules staining with either an acid or a basic dye. Many of the larger granules seen in the cytoplasm are, of course, to be placed amongst the category of "metaplasm," these being the various granules of reserve food (starch, protein, and so on), and the plastids are naturally quite distinct from the small elementary structures noted above.

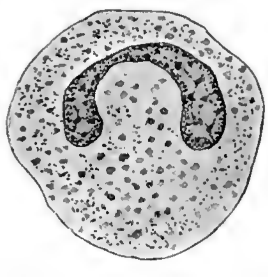


FIGURE 15.

A polymorphonuclear neutrophile leucocyte from human blood, showing minute neutrophilic granules (represented too large in figure).

The *Microsomata** mentioned above usually exist upon the reticulum of spongioplasm (where this can be definitely stated to be present) and stain as a rule with the acid dyes; the other granules described are usually small rounded bodies, varying in size from a quite distinct particle to a fine granular appearance in the cell, the ultimate granules being very indistinct (neutrophile type in certain leucocytes). Such granules are, as a rule, found scattered throughout the cell without any definite relation to the spongioplasm network.

Another type of granule remains to be mentioned, and that is the one first described by Altmann (Altmann's granules); these, which stain with acid stains (acid fuchsin) after special treatment with other reägents, are found in all animal and plant cells with the exception of the ovum, the male germ-cell, and cells forming cancerous growths. They are assumed to possess an important rôle in the cell economy; but the precise nature of their function is, I believe, still *sub judice*.

Some of the granules mentioned above are looked upon as possessing the capacity of manufacturing *enzymes* in the cell, or may be the actual precursors of the enzyme themselves; the granules seen in the secreting cells of many glands, both in animals and plants, are known to be *zymogens* and these granules may be seen readily in the living cell. But the function of many of the types noted is by no means settled, and the study of them is perhaps one of the most important branches of cytological work which is being carried out at the present time in biological laboratories.

(*b*) STRUCTURE OF THE NUCLEUS.

I have had occasion before in this magazine to describe the structure of the nucleus in connection with the mechanism of nuclear division,† and since writing the article in which this occurred have made further observations upon nuclear structure. The results have gone to confirm the generally-accepted description of the constitution of the nucleus, *viz.*, that this body is to be looked upon as a spheroidal space limited externally by a firm membrane formed, in all probability, of altered hyaloplasm (kinoplasm), this space being filled with clear nucleohyaloplasm, suspended in which latter is a network of *linin*, and in the resting nucleus the granules of chromatin are arranged upon this network at somewhat irregular intervals (see Figure 18). With regard to the presence of a nuclear membrane, a somewhat controversial point, the fact that the nucleus moves bodily along in the endoplasm during the phenomenon of "rotation" in the living assimilating cells of plants (*Vallisneria*, *Elodea*, and so on) without any alteration of shape, seems to point to the possession of an external firmer delimiting pellicle, quite distinct from the cytoplasm of the cell. The nucleoli (plasmosomes) appear also to have an external skin, within which the fluid parts of these bodies is contained.

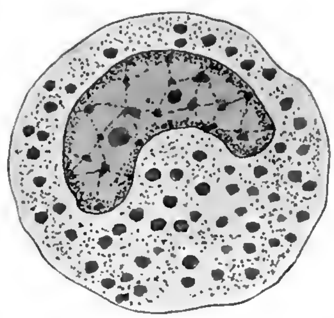


FIGURE 16.

A coarsely granular oxyphile leucocyte from human blood.

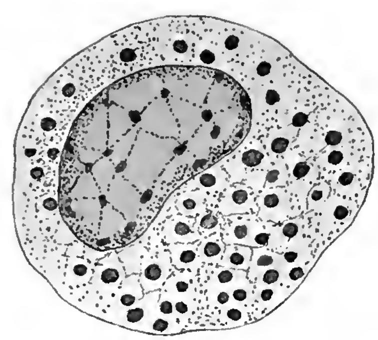


FIGURE 17.

A coarsely granular basiphile leucocyte from human blood (very rarely found.)

[NOTE.—This and the previous two figures are from coloured diagrammatic drawings from a blood film made by the author.]

Further research by cytologists has pointed to the presence of fine fibrils passing from nucleus to nucleus in adjacent protoplasts; it will be remembered that distinct intercytoplasmic connecting bridles have long been demonstrated passing between adjacent cells (Gardiner and others: see Figure 19)

*The Microsomata are, it appears, chiefly concerned in the production of the cell-wall in plant-cells, a process akin secretion going on, which results in the deposition of cellulose.

†See "KNOWLEDGE AND SCIENTIFIC NEWS," August–September, 1909.

and the demonstration of an internuclear connection is certainly an interesting point.

It is noteworthy that in a few instances the chromatin constituent of the nucleus takes, in place of separate granules, the form of a so-called "permanent spireme" suspended in the nuclear plasm; the chromatin in these cases takes the shape of small discs placed end to end quite close together. The permanent spireme is best seen in the cells of the salivary gland of the larva of *Chironomus*. At times, also, the chromatin granules become split into two and even in the resting nucleus a spireme may be seen made up of two parallel bands of granules, an arrangement which is obviously of value when karyokinesis takes place, since the earlier stages of the prophase are eliminated.

With regard to the changes taking place in the structure of the nucleus during mitosis, reference may be made to the article mentioned above (see footnote on page 10); these changes indicate, in the main, an increase in the chromatin, a relative decrease in the para-chromatin (nucleolar material) and loss of the nuclear membrane. The latter change is important since, if the membrane persisted, the movements of the chromosomes to opposite poles of the cell would be prevented; this, then, is further evidence of the presence of a membrane in the resting condition of the nucleus. [The question of the centrosome is one more directly connected with nuclear division, and will not be gone into here.]

(c) STRUCTURE OF THE PLASTIDS; OUTLINE OF THEIR FUNCTION.

These small bodies, many of which contain pigment (chromoplasts) and others being colourless (leucoplasts) have a structure which appears to repeat in some respects that of the nucleus; but there is no nuclein constituent in them comparable to the chromatin of the nucleus. In the main, each plastid appears to possess an outer membrane, and internally, either a clear fluid part, or, as some observers state, a groundwork of fibrils (spongioplasm) in the meshes of which is a clear, more fluid portion; it is the latter which has dissolved or suspended in it the pigment, when this is present (chlorophyll, xanthophyll, carotin, and so on).

In many cases the plastids contain starch or oil in their substance, this being evidence of the secretory function of these bodies, and it appears probable that these stored substances are formed by an actual breaking down of the protoplasm of the plastid with a subsequent re-construction of the starch or oil. The function of the pigment chlorophyll has already been touched upon (see page 8), but it should be borne in mind that in the colourless plastids (leucoplasts) found in the cortical cells of subterranean stem-structures and roots, the starch is formed from the circulating sugar brought to the cell without the intervention of the photosynthetic process, the necessary energy for the secretory reactions being derived from other sources than white light.

Fats and oils occurring in the so-called *elaioplasts* are formed in much the same manner; but, of course, oxidation is at times incomplete and a hydro-carbon is sometimes formed in place of a carbohydrate.

(d) THE VACUOLES.

The modern conception of the *vacuole* has been elaborated considerably of late years; in fact, ever since the importance of the biophysical phenomenon of *osmosis* in the cell was recognised. The fluid contents of the vacuole in the plant cell always possess one or more of the *organic acids* in an amount sufficient to set up osmotic currents between the fluid in the vacuole and the medium surrounding the cell, with the result that in many instances water and salts are drawn into the vacuole according to the needs of the protoplast.

Observations upon the origin and growth of the vacuole have determined the interesting fact that directly a vacuole becomes visible, the fluid contents become surrounded by an extremely delicate pellicle of ectoplasm (hyaloplasm), and many investigators have looked upon the formation of the vacuole as being akin to that of a plastid—vacuoles being sometimes known as *tonoplasts* (De Vries) in that they govern the relative turgidity of a cell. The pellicle of ectoplasm of the vacuole, the endoplasm, and the layer of outer ectoplasm of the protoplast together form a membrane, which, in the opinion of most biologists nowadays, is of great importance in the process of absorption by the cell of water and salts in solution; the so-called "selective capacity" of a root-hair, for instance, being largely due to the presence of the three living layers surrounding the vacuoles. The physical laws governing osmosis naturally come into play during the process of absorption, and the amount of saline constituents entering the cell depends largely upon the relative "osmotic pressures" exerted, on the one hand, by the osmotically active substances (organic acids, chiefly) in the vacuoles, and on the other by those outside the cell. It will be seen, then, that the vacuole governs the process of absorption of raw food-materials; but it must be borne in mind that osmotic processes also govern in a cell-aggregate the distribution of circulating "food" (elaborated food) such as sugar, soluble proteids, and the amido-acids; all these substances are attracted to those living cells in need of them for purposes of construction, and here again the organic acids which possess a relatively high osmotic power are probably the determining factors in this attraction. The two processes, then, both absorption of raw food-materials and circulation of elaborated food, are dependent partly upon purely physical influences and partly upon the regulating action of the cytoplasmic membranes in the cell.

THE "BIOPLAST" OR "PANGEN" HYPOTHESIS, AS A BIOLOGICAL CONCEPTION.

The hypothesis that the various structures met with in the cell are all ultimately derived from a common elementary body, the so-called "bioplast" or "pangen" is one which for some time now has occupied the attention of biologists. It argues that any part of the protoplast may be, according to the needs of the cell, transformed by chemical processes into any other, and the most striking instances in support of this hypothesis are, perhaps, to be seen in the origin of the plastids from the cytoplasm, and in the formation of zymogen granules from the living substance of the cell. Although this conception is open to considerable criticism, it is one which has to be taken into account; for it is well known that the protoplast, both animal and vegetable, is capable of a certain degree of adaptation to changed conditions of existence, and that structural variations in the cell are by no means uncommon under these changed conditions. The hypothesis, then, seems to be provisionally a sound one, but requires more discussion before it can be placed in the category of the more definite biological conceptions of the cell; more than this cannot be said at present, owing to lack of evidence.

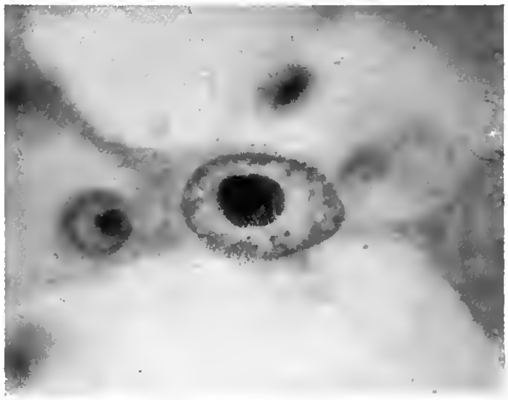


Figure 18.

A Photo-micrograph of the definitive nucleus in the embryo-sac of an Angiosperm (*Helleborus niger*) to show the nuclear membrane, chromatin, reticulum and one large nucleolus (to the left is the nucleus of the egg-cell).

Certain Problems Connected with Cell-Metabolism: The Probable Causes of Perverted Metabolism: Reaction of the Protoplast to Poisonous Substances and the Various Types of Irritant.

Some of the most interesting cell-problems are those relating to the unorganised ferments or *enzymes* manufactured by the cytoplasm, and the question of certain substances which are produced in the cell consequent upon irritation by the presence of bacteria or morbid influences in the immediate vicinity of the cell. The *enzymes* appear to be protein-like bodies which have a remarkable action upon (*a*) Carbohydrates, (*b*) Proteids, (*c*) Fats and (*d*) Glucosides, existing in the cell; the main factors in their action upon these bodies seem to consist in a process whereby *water* is first of all synthesised with them to form a somewhat unstable compound, and subsequently this compound is broken up again, with the result that several simple substances are formed, some of which are capable of being directly utilised during cell-metabolism for constructive purposes. The manner in which the enzymes are produced from the zymogen-granules is not as yet fully understood; it appears that the zymogen may be converted into the enzyme in certain cases by the action upon the former of a dilute acid or alkali, and that the production of zymogen in the cytoplasm is of a constructive (anabolic) nature, whereas the conversion of zymogen into ferment belongs to the destructive (katabolic) type of reaction.

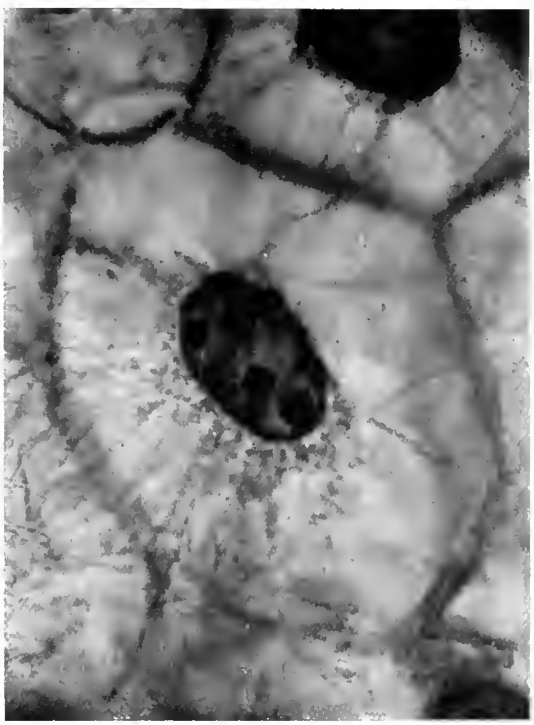


Figure 19.

A Photo-micrograph of a single cell of the Endosperm in the embryo-sac of an Angiosperm to show (on the left side) bridles of cytoplasm passing through the cell-wall to an adjacent protoplast. Note the oval nucleus with several nucleoli.

Again, it is now well-established that in the case of the so-called organised ferments (*Saccharomyces*, *B. butyricus*, *B. lactis* and so on) the actual enzyme is a product manufactured in the actual yeast cells and bacilli, and then passed out of the cells into the surrounding medium; many of the toxins and toxic proteids (including also the so-called toxalbumoses are of this nature, otherwise known as *intracellular toxins*; but in certain cases, as, for instance, when bacteria gain entry into the tissues of the animal body, the actual cells of the tissue may react in a special manner and produce *anti-toxins* which tend to limit the production of toxins by the bacteria, or else neutralise such toxins.

Of late years two other types of enzyme have been shown to exist in the cell in some cases; these are the oxidising and reducing enzymes (oxidases and reductases) and they have been found to be present in many plant cells. The oxidases are capable of furthering the oxidation of the cytoplasm in the absence of free oxygen, and it appears that the instances of so-called *anaerobic respiration* (certain bacteria) are due to the presence of some form of oxidase.

The question of proteid-metabolism in the cell is a problem which still remains largely unsolved; it seems, however, to be established that one of the intermediate stages consists in the combination of three classes of bodies, *viz.*, the *amido-acids*, some form of *carbohydrate*, and a *sulphur-compound*; but the formation of the amido-acids themselves is a complex process. In the plant-cell in some cases, as was shewn by Pfeffer, it appears that calcium nitrate is decomposed by oxalic acid, nitric acid being set free and utilised in the formation of more complex nitrogenous compounds, and it seems that at times hydrocyanic acid may be used in the same manner.

Living protoplasm is constantly undergoing a series of oxidative and reconstructive reactions, and it is quite impossible to make a sharp line of distinction between the so-called anabolic and katabolic processes going on in the living substance; these two types of reaction are always going on hand in hand, and we must look upon the protoplasm as being the seat of a large number of oxidative and constructive processes, some of which are always going on; others, such as those concerned with the storage of food-substances (proteid, carbohydrate or fat), taking place only at certain periods, depending to a large extent upon the needs of the organism at the time.

It will be seen, then, that *normal* metabolism is a highly complicated series of interactions between various compounds in the cell; when the nutrition of a cell is modified in any way, either in quantity, quality, or both, the protoplasm is certain to react in some special manner to the changed conditions. Nutrition may be so profoundly modified that the cell may not be able to carry on any kind of metabolism, whether proteid, fat or carbohydrate, and in such a case function will be stopped or at least suspended. In many instances, when the medium surrounding a cell contains substances which act adversely upon metabolism (toxins, alkaloidal poisons, and so on), the protoplasm will not react in a manner adequate to cope with surrounding conditions, and subsequently the noxious substances gain the upper hand, the living substance passing into a condition known as "fatty degeneration"; this must be distinguished from true "fat metabolism" in the cell, since in the degenerative process no reconstruction takes place as in the normal cell.

Less virulent irritants acting upon the cell over long periods of time (chronic irritation) may, in the long run, produce marked changes in metabolism, and cells in which such perversion of normal metabolic processes has taken place may, if carried from one part of an organism to a remote part, set up similar perversions in the cells amongst which they settle. It seems, in fact, that once the cycle of metabolic changes in a cell has undergone a *complete* alteration, a cell is able to influence others in its immediate vicinity; it is possible that a substance or substances of the nature of toxins (cytotoxins) or enzymes may be produced which have a profound effect upon normal metabolism.

As evidence of the power which small quantities of certain substances have when distributed throughout a cell-aggregate, the various *internal secretions* manufactured in the animal body may be taken: there is no doubt nowadays that the thyroid gland, the suprarenal capsules, the islets of Langerhans in the pancreas, and the ovary manufacture internal secretions which are of immense value to the cells of the body in aiding the furtherance of normal metabolism, since, when any of these internal secretions is absent or produced in excess, it is found that metabolism is profoundly altered. The internal secretions formed in these bodies are in most cases protein substances, some of which are possibly akin to enzymes in their action; but their constitution is in many cases obscure, although their physiological action is definite enough in a few instances.

The above brief considerations will enable the reader to grasp the fact that the cell possesses a highly complex organisation, and that the processes going on in the protoplasm are of such a nature as to call upon our keenest powers of observation and experiment for the purpose of their elucidation: and it will have been gathered that not one of the least remarkable features in connection with cytological phenomena is the infinite capacity of the living cell to react to stimuli of varying nature, and to adapt its metabolism to altered external conditions.

GLOW WORMS AND LIGHTNING.

By ROBERT W. PETHEN.

THE common glow worm (*Lampyris noctiluca*) is a most interesting member of that large order of insects, the Coleoptera, and before proceeding to describe how I found this insect to be susceptible to the influence of lightning, I would like to make a few observations on its light-giving capabilities as shewn by the perfect female and also by the same insect when in the larval stage.

It may not be out of place to mention here that the glow worm gives forth a greater or lesser amount of light in every stage of its existence, including the egg, which "glows" more or less brightly when moistened with water and held in a dark place.

The beautiful phosphorescent light displayed by this little beetle is far more familiar than the insect itself, and although the female is popularly credited with being the cause of the twinkling lights to be seen amongst the grass and hedge-banks in certain favoured localities during the summer months, this is not always the case.

I have proved by actual experiment that the larvae have the power of emitting light from the moment that they leave the egg.

As the young larva increases in size, so the light-giving area of the anal segments becomes larger and also brighter, so that it is at times almost impossible to tell whether the light in the grass proceeds from a larva or a perfect female.

If the light of a full-grown female larva be closely compared with that of a perfect female, the former will be found to be smaller and also of a more greenish colour.

With regard to the duration of the light there is also a decided difference; for the light of the perfect female may continue to shine steadily for several hours when undisturbed, *i.e.*, from dusk until 1 a.m. or even an hour or so later; whereas in the larval form it is seldom that one finds the light shining continuously for more than a few minutes.

Glow worms, like ants, are very sensitive to vibration, and when approaching them in the grass one must not tread heavily, or they will extinguish their light and thus be lost to view.

This applies to the larvae as well as the perfect females.

If you pick up a female glow worm and turn it about in your hand, it feigns death and its light remains extinguished until all apparent signs of danger are past. Whilst it is still in the larval form, this insect behaves in quite a different manner under similar circumstances: for when turned about in the hand, it generally lights up at once, the light gradually dying away, but reappearing again and again as often as the insect is disturbed. It will light up in the same manner if the glass or box, or other vessel in which it has been placed, is smartly tapped with the fingers.

The glow worm larva will also give forth its light if it is sprinkled with cold water, or suddenly immersed in the same, while it is also apparently influenced by the effects of lightning, as I venture to think the following particulars will prove.

For several years I have been working at the life-history of the glow worm, and with this object in view I had, at the end of July, 1911, about a hundred and fifty larvae of *L. noctiluca*, all of them having been hatched between June 23rd and July 27th of that year.

These larvae were fairly evenly distributed in four glass tumblers. Each glass had a closely-fitting lid made of cardboard and fine wire gauze, and also contained a small moistened root of grass.

The four glasses containing these larvae were kept on the shelf of a hanging book-case in our sitting-room, in a rather dark corner about seven feet above the floor, and near a window facing east.

These tiny larvae would give forth a very small spark of light, if they were disturbed by tapping on the glasses, or even by tapping the shelf on which the glasses were kept.

On the evening of July 29th, 1911, we had a storm with thunder and much lightning, and as I happened to be at home, I thought I would see if the lightning had any effect on the larvae; having previously read a brief account* stating that glow worms were affected by it.

For an hour, from 8.15 p.m., when the lightning flashes were very frequent, I kept the larvae under observation. The unusual amount of electricity in the air certainly appeared to effect these larvae, for tiny bright greenish lights kept appearing and disappearing from first one glass and then another, right throughout the time that I was watching them. Occasionally there would be lights showing in all four glasses at one and the same time, when from six to twelve distinct points of light could be seen; at other times there would be only three or four lights visible.

No doubt many more of the larvae were affected in a similar manner; but their light would be hidden by the intervening roots and blades of the grass, amongst which they were generally to be found.

None of the flashes of light lasted more than a second or two, and they were all produced without any mechanical disturbance of the larvae.

The window was partly open, and although the hour was not very late, the corner of the room where the larvae were kept was dark enough for their lights to be clearly seen. The lightning had not ceased at 9.15 p.m.; but as we lighted the lamp at that time, the display of miniature fire-works could no longer be seen.

I watched and waited on many evenings afterwards, to see if the display would be repeated under normal weather conditions, but without result.

On the 19th of the following month (August, 1911), however, there was another storm in the evening with lightning, and the glow worm larvae acted in exactly the same manner as they did on the 29th July.

Unfortunately, I was prevented from making any further experiments in this direction, owing to my glow worm larvae all gradually dying off during last autumn and winter.

At the present time I have several hundred fresh larvae, hatched during July and August, 1912; but the warm thundery weather suitable for carrying out further experiments in this direction is still lacking; and here I will leave the matter for the present.

* See *Nature*, October 1st, 1903.

AN "IDEAL" MUSEUM AND ITS GUIDE.

By A PROVINCIAL CURATOR.

On the principle that there are those who step in where angels fear to tread, I am venturing to refer to the very latest in the way of museums, namely the new London Museum, and its Guide.

Probably no museum ever came into being with such a flourish of trumpets as the new museum at Kensington Palace. The illustrated papers have given picture after picture of the museum's contents, or its curator, and have thus shown to an admiring world photographs of this, that, and the other object, scores of better examples of which are to be found in the many other London Museums, and even in provincial collections.

But I do not wish to deprecate the sweet uses of advertisement as adopted by the new museum. In fact, all admire its methods. And no doubt even our national collections would benefit if their recent additions were duly reported, described, and figured in the papers. But from illustrated interviews, special articles, pictures of people holding pots, and other items that have appeared in the daily and weekly press, it is clear that the museum is on extremely new and up-to-date lines. We are told that there are no headaches in the new museum! No confusing labels. Everything is simply and properly arranged, so that he who wishes may read the story of the city's growth and greatness from the time when the pool of London was wallowed in by men with oakum-covered arms and legs (such as shown in the museum "Annexe") to the time when a similar individual, bereft of his oakum, but in a boiled shirt, sits in a "Handsome" cab. And we learn that as the visitor flits from case to case a panoramic view of London's history is presented to him. And thus for the first time, so 'tis said, a visit to a museum is to be both pleasant and profitable. The curator and his assistants (we learn from the official "Guide"), are "luckily unhampered by the entangling meshes of red tape" and have consequently "achieved results which would have taken *ordinary officials*, less fortunately circumstanced, years to carry through." It is, perhaps, as well that there is no red tape, or the "author" would certainly not have been permitted to advertise his private literary ventures on the cover.

Being among the "ordinary" officials, and at all times anxious that the long-suffering ratepayers, who pay for my golf clubs and send me to conferences, should get the greatest possible benefit from the collections under my charge, I paid two visits to the new Museum, in order to derive inspiration from the work of its, presumably, "extraordinary" officials, and I paid a shilling for its "Guide"; but I only did that once! I was anxious to see this ideal museum, with its perfect classification, and its lack of red tape. I wanted to see (quoting from the guide book) "the palpable and material object lessons, more likely to impress the mind with the realities of the life of London in the olden times, than reams of dry sociological theories, learned historical disquisitions, and pompous moralising tracts." (To grasp the full import of the last sentence, it should be read three times!)

There is another paragraph in the guide which appeals to the provincial curator:—"Many private individuals, *moreover*, have generously come forward and presented their laboriously garnered stores ("laboriously garnered stores"!) illustrative of London's manufactures and arts, in order that these *cherished treasures* of theirs may become the heritage of their *fellow* Londoners—in being and *yet to be*! Others have munificently provided the funds requisite to enable the Trustees to acquire collections, *unequalled in their completeness*, of ancient costume, armour, weapons, pottery, glass, porcelain, enamels and silver! This "unequalled in their completeness" is pure piffle. The "author" (as he styles himself) of the Guide can never have been in the British Museum, The Victoria and Albert Museum, The Tower, The Wallace Collection, The Guildhall Museum, and many others not very far away: or if he has, he must have been "blind," in some way or other.

On my first visit it was raining, and I had an umbrella. This had to be left at the cloak-room, which was in another building some distance away, and the ticket I got in exchange was not large enough to keep the rain off while I walked back to the museum, and back again for the umbrella when I had seen it. I felt relieved that there were no "entangling meshes of departmental red tape" here, or I should probably have had to run round the park in my shirt.

On my second visit the weather was fair, so I was not requested to walk across the garden to leave my umbrella, but could carry it with me where I would!

As I entered the building I found two ways to the stairs; a wide one, open and free, and a narrow one, barred by a piece of wood—I believe polished oak—possibly to illustrate the kind of trees that once grew in London. I naturally went through the wide opening, and was going up the stairs when a policeman seemed to drop from an aeroplane or somewhere, hauled me back again, and made me push my frail form against the bar of oak, which proved to be a species of turnstile. I don't know what it registered me as, but doubtless, judging from the published numbers of visitors, a "large party."

I obtained my first object lesson before I had reached the top of the stairs. In order to inform visitors to "keep to the right," the best way is to hammer a nail into the middle of a large old oak panel, and hang a placard up on it. But upstairs, all my fondest hopes and anticipations fled. I found a number of rooms, of varying sizes, each crammed with as many mid-Victorian funereal exhibition cases as it could hold, and each case similarly crammed with as many specimens as possible. But each absolutely without any attempt at classification or arrangement. Even the rooms were not set apart for definite purposes, but similar objects were to be seen in almost every room, and in many instances, in several different cases.

By the press reports I was foolishly led to believe that I should first see specimens illustrating London in prehistoric times, then, step by step, through Roman, Saxon, Danish, and other periods, down to the present day. Nothing of the sort. Any object of almost any date could be seen in almost any room—nay—in almost any case! It is quite possible that the new London Museum is not unique in this respect; there may still be seen some musty collection formed by a "Literary and Philosophical" Society a century ago, in some old-world town, which is similarly "arranged." But in such instances the news is kept quiet. Anyway, it is not trumpeted forth, east and west, south and north, that perfection and classification *lies* here. And only of the new London Museum can it be said that the specimens are displayed (I am quoting now!) "Moreover, as much with a view to scientific precision as with a keen appreciation of the artistic effects of suitable surroundings and grouping; all, moreover (whenever "moreover" appears, I am quoting!) with the ever-present aim, not so much of instructing and educating the public, as of arresting their attention and stimulating their imagination—in a word—interesting and amusing them."

I am not quite sure whether the curator, or director, or keeper and secretary (who, by the way, did not write the Guide) has tried to act up to this ideal of *amusing* the public: but in some respects he has certainly succeeded.

To an ordinary mortal (if a provincial museum curator can be thus described) "classification" implies that objects of a similar kind, or similar period, are arranged together. Just as we should expect to find cabbages in a greengrocer's shop, trousers in a tailor's, and blouses at the draper's; so in the new model museum one might expect to find the pre-historic objects together, Roman objects together, mediaeval, and so on, all sorted and arranged, and china in one case, enamels in another, iron objects in another, coins in another, and so on. Such a method is the very alphabet of classification.

But, instead, case after case is filled with objects dating from pre-historic or Roman times to the nineteenth century, and case after case with iron objects, coins, pottery, embroidery, and so on, hopelessly and unaccountably jumbled. There is a good collection of bellarmines, all similar in shape and design, and of the same period, and all presumably found in London. Yet one must examine about fourteen different cases, and a mantelpiece or two, in various parts of the building, if he wishes to see all the bellarmines. Iron objects, such as knives and daggers, are well represented; but they are scattered in different sections of different cases, in different rooms. The china, enamels, embroideries, coins and medals might be considered to be representative, had one the patience or time to search for them all, and endeavour to carry them in one's mind. It can only be assumed that it is possibly the intention to illustrate the various historical periods in each individual case so that the visitor need not examine them all, but simply stand in front of any one case and then walk away with the history of London at his finger tips.

In addition to the Palace proper there is an "annexe," with prison cells, a Roman boat, a wooden Ancient Briton, Adam's fireplaces, and models of old London. This is arranged after the plan of the maze in Hampton Court, and there is quite an army of officials to push visitors the right way each time they go wrong. An extraordinary exhibition, and quite of a Madame Tussaud flavour, is that of a model of Jack Sheppard, the thief and robber, in his cell, apparently at dead of night, with a lantern dimly burning. And dare I interject, for the benefit of "the author," that even the name of this great hero is spelt incorrectly in the guide?

Still another building, a magnificent one that might be used so well, contains half-a-dozen palm trees and a "Handsome" cab. The number of people who stop and read the brass plate, and examine the cab, is astonishing, especially as probably many of them found their way to the museum by taking a seat in one.

I have already explained that I bought a guide. I thought perhaps it would act as a key to the collections. It cost a shilling. One shilling. I presume the price is arranged so that the Guildhall and South Kensington Collections may soon be purchased from the profits, and thus make the London Museum, *the* London Museum indeed. Anyway, I am not the first Northerner who has "Banged awa twa saxpences" in London!

The cover is a brilliant danger-signal red, and in the centre are the Royal arms, and "G.R." in large letters, which the policeman told me stood for King George, though he did not quite know how. On the inside cover we are informed of the hours of opening, the hours of closing, and that visitors are invited to communicate with the author if they have any suggestions to make! As I was not spending my holidays in the museum, I declined the modest request, but hope to forward a copy of this paper to him. There is no date on the cover of the guide. There is a portrait of Queen Mary as frontispiece, and the next page is dated 1912, so that one page at any rate is up-to-date. There is an introductory note (from which we have already quoted), then a view of Kensington Palace and Gardens in the reign of Queen Anne, and a portrait of the late Queen Victoria at the age of eight. This is dated May 24th, 1819. Then follows a "preface" which is dated May 24th, 1899, so that there seems to be the same glorious uncertainty with regard to the date of the publication of the guide that there is with regard to the chronological arrangement of the specimens in the museum.

It is also apparent that the writer of the guide has some relatives who are oculists and opticians, who will certainly have to be consulted by anyone trying to read the pamphlet carefully.

On the title page we are told to "*Notice*"—"This catalogue and guide are copyright, and *immediate proceedings in Chancery* will be taken against any infringers thereof." As our old friend Pooh-Bah, F.L.A., would say, the punishment would certainly fit the crime.

The guide is a fair model of what a guide should not be. It is badly printed, with ancient type, on poor paper. The details of the cases are mixed up with the history of the Palace, and with a catalogue of the pictures, and there is no index: so that it is really a difficult matter to find anything in it. Many of the cases are not numbered at all, and we read of Case No. (long), Case No. (side), Case No. (centre), Case No. (side long), and so on. By the words side, centre, side long, and so on, I presume reference is made to the position of the various cases in their respective rooms, but as I was unsuccessful in identifying them, I cannot confirm this supposition.

An idea of the "scheme of classification" can be obtained from the following particulars of the first few cases, in which, if anywhere, an attempt at order has been made:—Case 1, Stone Ages, Bronze Age, late Celtic Period; Case 2, Ceramic Art. Case 3 (no heading at all! but apparently contains objects of the first to fifth century A.D.) Case 3, "continued"! Saxon Period; then follow "Relapse to Barbarism" (*sic*); Case 4, Early Mediaeval Pottery; Case 5, Battle Axes, Swords, etc.; Case 6, Wine Bottles; Case 7, Lighting Appliances; Case 8, Prehistoric Mammalia, etc. (the "etc." includes all sorts of things that ought to be miles away). Next is a "Green Coloured Bust' (*sic*), which sounds rather like a bilious attack! and a "Bell in case." Then Case 9, Mediaeval London, and so on to Case 12. A description follows of the "Queen's Closet" and "Pictures of Old London," followed by "Nos. 20 to 34," which are apparently pictures. After all this, oddly enough, is a heading in large type, "London Museum Exhibits," and it calmly proceeds to a list of the contents of Case 13. And the guide ends up with "A condemned Cell, Old Roman Galley, Mantelpieces, etc.; Panoramic Models of Old London, Lobby for various exhibits, Old Jacobean Room." It was with some such expression as "A condemned Cell" that I closed the "Guide," and thought of what might have been done with the shilling. However, I will not say it is useless; when folded round, and fitted with a pill-box lid on the top, it makes an excellent toy letter-box or money-box, coloured red, and with G.R. on it already complete!

NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

OBITUARY.—The deaths of two well-known English astronomers have occurred recently. Sir George Darwin, the Plumian Professor, had been in failing health for some time, though he was able to read in person his last paper (on a new form of periodic orbit) to the Astronomical Society last summer. His principal work was on the theory of the tides, and their secular effects on the development of our system. He was the originator of the view (still, I think, held by most astronomers, though there are some important dissentients) that the moon was formed by tidal disruption of the earth by solar tides at a time when the rotation was very rapid, and that the moon has acted as a brake on the earth ever since, bringing the rotation to its present value, while the reaction on the moon has caused its recession. He was the author of a very useful popular treatise on the tides, which explains the method of Harmonic Analysis, and shows how the tides may be predicted for any port after a sufficiently long series of records is available. His work on periodic orbits was an investigation of the different paths a small planet might follow under the action of the Sun and an imaginary large planet, Jove, whose mass was one-tenth of the Sun's. This list of his works only includes those portions which are of most interest to non-specialists.

The death of Mr. S. A. Saunder, the Gresham lecturer, was far more unexpected. He was taken ill during his course of lectures on the Tides last October, but managed with difficulty to finish them. Many of our readers must have heard his lucid explanations of some rather difficult branches of astronomy. He was a Vice-President of the Royal Astronomical Society, and it was expected that he would before long fill the Presidential chair. The astronomical work for which he will be chiefly remembered was the accurate determination of the positions of a large number of points on the moon, using the beautiful large-scale photographs taken at Paris and in America. He found that the previously assumed positions were much in error; they had been made by measures at the telescope from the limb; he showed that it was far better to get them from measures on the photographs, provisional coördinates being first assumed for some leading points, which could be afterwards checked and corrected by the results. Accurate places of several thousands of points were thus found, and by comparing their positions in different librations it was possible to say which regions of the moon were above the general level and which below it. He showed that this was as difficult as finding the parallaxes of the nearer stars. He was superintending the preparation of a large map, on which the points measured by him were accurately laid down, and the filling in of detail done from the photographs. Mr. J. A. Hardcastle was associated with him in some of his work, and gave much help in the measures.

THE ALBEDOES AND BRIGHTNESS OF THE PLANETS.—Some photometric observations of the stellar magnitude and albedo of the planets have been made with the Draper Telescope at Harvard College Observatory. The result for Venus at mean superior conjunction was $-2^{m}\cdot 56$ (thirty-four exposures on twenty-eight plates). The following magnitudes are for mean opposition:—Mars, $-0^{m}\cdot 57$ (thirty-seven exposures on thirty-six plates); Jupiter, $-1^{m}\cdot 78$ (twenty exposures, nineteen plates); Saturn, $+1^{m}\cdot 52$ (twelve plates). The differences, photographic magnitude *minus* Müller's photometric magnitude, are:—Venus, $+1^{m}\cdot 08$; Mars, $+1^{m}\cdot 33$;

Jupiter, $+0^m \cdot 57$; Saturn, $+1^m \cdot 23$. The Sun being of Spectral Class G, a difference of magnitude of $0^m \cdot 98$ would be expected, and this would be greater for the planets, as reflexion would tend to make the light redder. The deduced photographic albedoes are:—Venus, 0·66; Mars, 0·15; Jupiter, 0·80; Saturn, 0·53.

The very high value for Jupiter is noteworthy, and suggests that a little of his light may be inherent, especially as some portions of his disc are obviously dusky.

SATURN.—This planet has been in opposition in November, and now that it is getting into considerable North Declination it is attracting more attention from English observers, especially as Mars and Jupiter are invisible. It is most desirable that the disc should be searched for features sufficiently distinct to determine the rotation period. This differs very widely in different latitudes, from ten and a quarter hours at the equator to $10^h\ 38^m$ in the temperate zones; but it is most desirable that these values should be checked by other spots, and that it should be found whether the transition is sudden, or whether intermediate values exist. Spots sufficiently well marked to be easily identified on their return are not very common, and whenever one is seen it should be utilised to the full, and notice telegraphed to the possessors of large instruments.

Mr. P. Hepburn, the Director of the Saturn Section of the B.A.A., gave some interesting notes in November, on recent observations. A curious feature, confirmed by several observers, was a dark shading on the ring along the planet's limb, on the side opposite to the true shadow. This is a very perplexing observation, and I have not yet seen any plausible explanation. Mr. Hepburn also points out that careful observations should be made as to where the southern portion of the planet's limb lies on the ring, relatively to its southern edge and the Cassini Division. In this regard it should be remembered that the dimensions of the ring used in *The Nautical Almanac* do not include the latest measures, and that their value of the polar semi-diameter of the planet is faulty; what they give is the value of the actual polar radius as it would look if seen unforeshortened; but what we observe is a radius of the planet which is now twenty-four and a half degrees distant from the pole, and therefore decidedly longer.

LIMITING DISTANCE FOR HYPOTHETICAL SATELLITES OF NEPTUNE.—Mr. C. T. Whitmell recently gave me an interesting problem, *viz.*, to find the greatest distance at which a satellite of Neptune need be searched for. Dr. G. W. Hill in his researches on the Lunar theory, gave the elements of a satellite which had 1·7 lunations in the planet's year. The shape of the orbit is curious; its distance from the planet at Syzygies is only one-third of that at quadrature, and when the motion is referred to the line joining sun and planet (considered as fixed), there are cusps at the quadrature points. In the case of Neptune I find that such a satellite would be distant 0·30 astronomical units from Neptune in syzygies and 0·87 in quadrature. If the latter took place in opposition the satellite would appear 1·7 degrees distant from Neptune. As there is little chance of an actual satellite being so distant we may take one degree from the planet as the limit of useful search. A good deal of search has already been carried on by photography, but there is plenty of room for further efforts. In the case of very close satellites visual search would be more promising. All the probabilities point to Neptune having other satellites, but at such a distance only very large ones can be seen. Such tiny bodies as Phoebe, the outer satellites of Jupiter, or even (probably) the four satellites of Uranus would be beyond our reach.

PROFESSOR FOWLER'S DISCOVERY OF A NEW SERIES OF LINES IN THE SPECTRUM OF HYDROGEN.—Four sets of lines arranged so as to form regular rhythmical series were already known in the spectrum of hydrogen. A few stellar spectra showed evidence of a fifth series related to the fourth in a simple manner that suggested that it belonged to the same element. The lines were, however, much fainter than the others, and had not been detected in the spectrum of terrestrial hydrogen. This Professor Fowler has now succeeded in doing, taking the spectrum of the gas in a low-pressure tube, mixed with a little helium. He has not yet succeeded in getting the lines in the absence of the helium, but their exact accord with the formula for the fourth series, when one of the constants is halved, leaves practically no doubt that they belong to hydrogen. His paper was read at the December meeting of the Royal Astronomical Society.

BOTANY.

By PROFESSOR F. CAVERS, D.SC., F.L.S.

THE GENUS *LEITNERIA*.—In Engler's system of classification the genus *Leitneria*, constituting the order Leitneriaceae, is placed in a separate cohort (Leitneriales) near the base of the Lower Dicotyledons (Archichlamydeae) on account of its catkin-like inflorescence and simple flower structure. The two species of *Leitneria*, confined to North America, are shrubs with spikes of dioecious flowers; the male flower has from three to twelve stamens and no perianth, while the female has a scaly perianth and one carpel with a long style, the unilocular ovary containing a single ovule. Pfeiffer (*Bot. Gaz.*, LIII., 3) has made a thorough examination of the development of the flowers of this isolated genus, and finds that the ovule contains a single archesporial cell, differing from most of the Amentiferae or catkin-bearing trees in this respect, though the same condition occurs in *Betula alba*, *Alnus*, and some species of *Salix*—hence a multicellular archesporium can hardly be considered a group character. The young embryo is pear-shaped, and has a massive suspensor; there is no fixed sequence of cell-divisions in its development. The most striking features of *Leitneria*, however, are the resemblances which it shows to Gymnosperms; but such resemblances are also found commonly among the Amentiferae. The author's conclusion is that while the morphology of *Leitneria* is not such as would make it possible to place it definitely in any of the families of Archichlamydeae, it agrees with the Amentiferae in suggesting the possibility of the derivation of the lower Dicotyledons from Gymnospermic forms with compound inflorescences.

DEVELOPMENT OF *SALVINIA*.—Few groups of plants have been so much worked at as that containing the four "water-ferns" or Hydropterideae, though it is now generally recognised that the two families formerly classed together under this name ought to be separated somewhat widely, the Salviniaceae (*Salvinia* and *Azolla*) having probably arisen from a homosporous family like the filmy ferns (Hymenophyllaceae), while the Marsiliaceae (*Marsilia* and *Pilularia*) are probably connected with the Schizaeaceae. The most striking character of these two families is, of course, their heterospory—they are the only ferns with two kinds of spores—but they present many other interesting features. In a recent paper, Zawidski (*Beihefte zum Bot. Centralbl.*, Band 28, Abt. 1, 1912) gives an elaborate account of the development of the vegetative organs and sporangial receptacles (sori) of *Salvinia natans*, clearing up various points and giving a very complete picture of the morphology of this type. The growth of the shoot takes place with great regularity; the stem grows by a two-sided apical cell, and soon shows differentiation into nodes and internodes, each node showing four peripheral cells which form the initials for the two floating leaves, the submerged leaf, and the branch. All these organs grow by a two-sided apical cell, and this is also the case with the sori, each sorus being a metamorphosed segment of a submerged leaf. The oldest sorus produces the large spores (megaspores), the others produce the small spores (microspores).

MASSULAE OF *AZOLLA*.—In connection with the preceding note, mention may be made of a recent paper by Hannig (*Flora*, Band 102) on the development of the massulae of *Azolla*. This plant is, like *Salvinia*, a free-floating aquatic fern, but it has roots, not modified root-like leaves, and its leaves are divided into two lobes, the upper lobe having a small cavity inhabited by the blue-green alga *Nostoc.* The spore-case groups (sori) are usually in pairs, the microsporangial sori being much larger than the mega-sporangial sori and the latter containing a single megasporangium with a single spore. The mega-sorus of *Azolla* has often been compared with the ovule of a seed-plant, the indusium being likened to the integument of the ovule. One of the most striking characters of *Azolla* is the presence of several masses of frothy substance (massulae) in each microsporangium, the massula having the microspores embedded in it while its surface is covered with curious barbed hairs (glochidia). The spongy massulae float about on the surface of the water; the mega-sorus sinks at first, but eventually decay of the indusium sets the spore free and it germinates, producing a female prothallus which rises and floats about on the water, becoming anchored to a floating massula by the barbed glochidia.

Hannig has investigated especially the structure of the massulae, and of the three curious floating-masses on the top of the megasporangium which are formed in the same way as the massulae. He finds that the substance (periplasmodium), from which the massula material is formed, is derived from the well-developed tapetum layer, the nuclei of which show repeated division. These periplasmodium nuclei lie originally just within the wall of the microsporangium, but later become scattered through the protoplasm; the periplasmodium increases in volume, stores up starch, and produces a number of vacuoles in which the microspores become enclosed. Within these vacuoles there appears a fine foam-like network, and from the surface of this foam there arise finger-like processes which become glochidia, developing recurved hooks at their tips. The periplasmodium is originally composed of living protoplasm, but eventually the walls of the foam-like structure become changed into cellulose, while the glochidia walls are cutinised. Hannig also examined the floating-apparatus of the megasporangium, and found that it is developed in exactly the same way as the massulae in the microsporangium; he detected the thirty-one abortive megaspores as irregular yellowish inclusions in the meshes of the floating-mass. He confirms the view of former investigators that the unisexual sori of *Azolla* have arisen from an originally monoecious condition.

MENDELISM AND PIGMENTATION.—The greater part of the President's address to the Botanical Section of the British Asssociation was devoted to a consideration of the methods of Mendelian research, with special reference to the chemical phenomena concerned in the production of colour in flowers. The Mendelian method is analogous to that of the chemist, who, given a complex mixture, sorts out the ingredients and submits them severally to analysis. The Mendelian analyst, given that complex mixture which is called a plant or animal individual, sorts out the ingredients and analyses them. The Mendelian analysis is made not by direct but by indirect methods; so long as the physical nature of living substance remains unknown we can hardly hope to resolve an individual into its physical components—all that can be done is to make comparative analyses of individuals, and discover how their several components differ from each other. For this purpose one may represent the individual by the equation, Individual $= X + C$, where C represents the sum of the Mendelian characters, and X the imaginary or real individual groundwork left after all the Mendelian characters have been removed by analysis. The Mendelian method is concerned directly with the resolution of C into its components. Indirectly, it is also concerned with X; for if the full value of C be determined, that of X may be inferred. This concession made, it is permissible to concentrate our attention on the term C, and the business of the Mendelian is to resolve this complex of characters into its constituent unit characters.

As the result of experimental analysis, Mendelism is enabled to state the problem of the behaviour in inheritance of two individuals in the following terms. The complex of characteristics which distinguishes an individual is the expression of the sum of a long series of characters. As the individual arises from germ-cells, so each character arises from a germ within the germ-cells—such germs of characters are called factors. When two germ-cells unite to form an incipient individual, or zygote, they bring together the similar factors of a given character—one factor from the one germ-cell and the other from the other. As the zygote forms the individual, so the paired factors give rise to a character of the individual. The body characters may be termed the flowers of the factorial seeds implanted in the germ-cells.

Some characters are simple and derive from one pair of factors only; others are of an ascending order of complexity and may be traced to the coöperative agency of two or more pairs of factors. In the case of a complex character the determining factors may be either like or unlike each other. Thus two pairs of different factors are required to produce the character of colour in certain flowers; but it is probable that certain characters are the outcome of repeated doses of the same factorial stimulant.

The individual is a dual thing, comparable to a double-barrelled gun, each barrel loaded with the factorial charge supplied by one of the two gametes or germ cells by whose union its duality is constituted. Conversely, a gamete or germ-cell is of single and not of dual nature; it has only one barrel and therefore can give effect to only one of the two factorial charges with which the individual was supplied at the time of its formation. The image of the double-barrelled gun serves to illustrate the several states in which an individual may exist with respect to its charge of factors of any given simple body character. Both barrels may be loaded—an individual in like state has two factorial charges and produces gametes all of which are alike in the possession of one of these factors; such an individual when self-fertilised, or mated with its like, produces gametes which are all alike in this respect, and these gametes, fusing in pairs, give rise to individuals which all possess the character in question; such individuals are homozygous, they breed true to the character. Neither barrel may be loaded—an individual in like state is also homozygous, it breeds true to the absence of the character. If a gamete of the former individual meet with one from the latter individual, the resulting zygote is like a double-barrelled gun with only one chamber loaded; the zygote is heterozygous for the character, and unlike the homozygotes, which breed true, the heterozygous individual does not breed true to the character in question.

From these propositions it may be predicted that the offspring of the heterozygote fall into three groups—one homozygous for the character, another heterozygous, and a third homozygous for the absence of the factor; and that these types of individual occur in the proportion of 1 : 2 : 1. This prediction is verified by experimental breeding from the heterozygote.

The Chinese Primrose, *Primula sinensis*, has given rise to many distinct varieties, white and coloured. It would appear self-evident that the white races differ from the coloured races merely in lack of pigment, but Mendelian analysis shows that there are more subtle differences between the different races. These differences become apparent when true-breeding white and coloured plants are crossed with one another; for it is then discovered that two types of white-coloured plants exist, and it is only by their fruits—their offspring—that we may know them. Thus, if certain white-coloured races are chosen for the experiment, the result of crossing white and colour is that all the offspring of the cross bear coloured flowers. If certain other white races are used and mated with the coloured form, however, the offspring all bear white flowers. In the former case, where the first generation (F_1) consists of coloured offspring, the second generation (F_2) raised by self-fertilising F individuals by crossing with one another, consists of coloured and white in the proportion of three to one; hence we conclude that the white used in this case owes its character of whiteness to lack of the pigment-producing factor which is present in the coloured parent race. This conclusion is confirmed by the genetical behaviour of the whites of the F_2 generation; such extracted whites breed true to flower-character, and give rise to white-flowered offspring only. White-flowered races which behave in this way are termed recessive whites. In the second case, where the F_1 generation consists of white-flowered offspring, the F_2 generation, from selfed or intercrossed F_1 plants, consists of three white to one coloured. The coloured offspring breeds true; of the three whites, one breeds true to whiteness and the other two give rise, like the white F_1 generation, to three white: one coloured. White races which thus impose their whiteness on the offspring of their union with a coloured race are known as dominant whites. Mendelians account for the genetical behaviour of dominant whites by assuming that they carry the character for colour, and also a character for colour-inhibition. This hypothesis, though novel to Biology, is amply justified by genetical results, and it propounds a series of questions to the physiologist and biochemist.

Until recently, knowledge of the processes of pigmentation has advanced along two main and independent lines:—(1) that followed by students of genetics, which has led to a wealth of exact knowledge concerning the factors and characters which determine coloration; (2) that pursued by biochemists, which has resulted in a great increase of our understanding of the biochemistry of pigmentation. The first to combine the genetical with the biochemical method was Miss Wheldale, to whom we owe a good working theory of the nature of the processes involved in pigment-formation.

Palladin has shown that respiration consists of a sequence of enzyme-like actions, the later of which result in oxidation and are ascribed to the enzymes (ferments) called oxydases; that chromogens play a part in the oxidations set up by oxydases, and that these colourless chromogens may undergo either alternate oxidation and reduction and so take a continuous part in oxydase action, or undergo permanent oxidation and so constitute the pigments of the plant. Chodat and Bach have suggested that oxydases are of dual nature, the complete oxydase consisting of two parts—a peroxydase and an organic peroxide. An oxydase reacts with oxidisable reägents, such as guiacum, to produce a characteristically coloured product; hence these reägents may be termed oxydase-reägents. Peroxydases react with oxydase reägents only if there be added, as a substitute for the organic peroxide of the complete oxydase, a source of active oxygen in the form of hydrogen peroxide. Both oxydases and peroxydases occur in the cells of plants, and may be identified in extracts therefrom. Gortner's work on the pigments of insects confirms the view that pigments are the product of the action of oxydase on chromogens; he has shown that the black or brown melanin of the integuments of insects is produced by the action of an oxydase called tyrosinase upon some such product of protein-hydrolysis as tyrosin.

Miss Wheldale's theory is that the anthocyan pigments of plants are the outcome of a series of chemical changes of the following order:—Glucosides on being hydrolysed by the ferment emulsin yield chromogens which, acted upon by oxydases, give rise to anthocyan pigments. The difficulty in the way of further advance lay in the unsatisfactory nature of the methods for identifying oxydases derived from plant tissues. When Professor Keeble and Dr. E. F. Armstrong began their work on this subject they found, after trials of various known reägents, that α naphthol and benzidine are each suited admirably for the purpose of locating oxydases, and by means of these reägents they have been able to map out the distribution of oxydase and peroxydase in the flowers and other parts of various plants. Their results confirm Miss Wheldale's hypothesis of the mode of formation of anthocyan pigments; but this confirmation was made possible only by reason of the fact that they worked with races of plants bred on Mendelian lines and therefore of known genetic constitutions.

On treating coloured flowers of *Primula sinensis* with each of the two reägents, it is found that the actions of α naphthol and benzidine are in considerable measure supplementary one of the other. Thus, the lilac-blue α naphthol reaction is confined to the veins of the corolla; the brown benzidine reaction is shown by the superficial (epidermal) cells and also by the veins. The peroxydases are therefore termed epidermal peroxydase and bundle oxydase, the former occurring in the epidermis and hairs, the latter in the bundle-sheath which accompanies the veins. Similarly, the stem of *P. sinensis* contains a superficial peroxydase and a deep-seated peroxydase. The distribution of peroxydase coincides broadly with the distribution of pigment; that is, the peroxydase framework for pigmentation occurs throughout the species, and the building of the several colour varieties is determined by the activity of the factor for chromogen production, and if we conceive of this factor as administered in a series of doses we have a picture of the mode of evolution of the series of varieties characterised by increasing or decreasing amount of pigmentation of their parts.

The application of these reägents to *recessive* white races shows that these white-flowered races, though lacking the factor for colour, contain in the flower both epidermal and bundle peroxydase, as might be expected from analogy with the peroxydases of the stem. Hence we conclude that the absence of colour from recessive white flowers is due not to the absence of peroxydase, but to absence of chromogen, and this conclusion conforms with that arrived at previously by Mendelian methods, which show that anthocyan pigmentation of the flower of *P. sinensis* depends on the presence of one factor only, and that the absence of pigmentation characteristic of recessive whites is due to the absence of that single colour-factor.

The investigation of the peroxydases of *dominant* white flowers gives a very different result; for these show no sign of peroxydase either in epidermis or in bundles. Hence such flowers either lack peroxydase or else they contain a substance which inhibits peroxydase from exercising its oxidising action on the oxydase reägents. It is known that the addition of certain phenolic compounds (orcin, resorcin, and so on) prevents tyrosinase from exercising its characteristic action upon tyrosin. Assuming that an inhibitor of peroxydase exists in dominant white flowers, it may act either by destroying the peroxydase or by setting up conditions under which the activity of peroxydase is arrested; and if the latter is the mode of action, it follows that if by some means the inhibitor can be removed, the peroxydase will be free to effect the oxidation of the reägents used. This train of reasoning led Keeble and Armstrong to the discovery that hydrogen cyanide forms a means of removing peroxydase inhibition; if dominant white flowers are immersed in a dilute solution of hydrogen cyanide and then treated with either of the two oxydase reägents together with hydrogen peroxide, pronounced peroxydase reactions are obtained both in the epidermal and bundle tissues of the corolla.

To test this hypothesis further, a race of Primulas was used in which the flowers are blue with white patches on each petal, the known ancestry of this race indicating the probability that the white patches are produced by a localised inhibitor. On treating corollas of these flowers with the two oxydase reägents and then with hydrogen peroxide, the parts originally blue are stained lilac-blue or brown according to the reägent used, and the inhibitory patches stand out as in the intact flower as white areas on the coloured ground. If, however, these parti-coloured flowers are treated first with hydrogen cyanide, then with the reägent and subsequently with hydrogen peroxide, the peroxydase reaction is produced over blue and white areas alike—the inhibition located in the white areas has been removed. Hence the Mendelian hypothesis of the inhibitory nature of dominant whites is confirmed by biochemical methods; these methods, moreover, prove that the inhibitor acts not by destroying but by preventing the action of oxydase upon the chromogen.

This fruitful line of investigation has given various other results and has raised many questions for further research. For instance, the close proximity in the flower of the superficial and deep-seated oxydases suggests that the latter may coöperate with the former in producing flower-pigments. This possibility entails the hypothesis of a translocation of oxydase from the region in which it is secreted to that in which it acts; and there are various facts in favour of this view—the lines of deep colour that occur along the veins of many flowers, the frequency with which the walls of cells appear to contain oxydase, the occurrence of oxydase in the mesophyll cells adjoining the bundle sheath, and the evidence provided by the mutual influence of stock and scion in grafted plants and in graft-hybrids.

Again, it has been found that the nature and amount of oxydase contained in a plant tissue varies in an orderly manner according to external conditions. Among the conditions which determine this fluctuation are light and darkness. Plants subjected to normal illumination possess less oxydase than those kept in darkness; after one or two days of exposure to darkness, plants of *P. sinensis* contain more peroxydase than sister plants kept under normal conditions of illumination.

Should the results of similar investigations with other plants show that this diurnal variation of the oxydase content of plant tissues is general, we may perhaps discover therein the means whereby many of the phenomena of periodicity shown by plants are maintained and regulated. The light and darkness of day and night set up rhythms in the plant; the leaves of various plants assume nocturnal and diurnal positions, and the rhythm thus established may be maintained for a certain time under uniform conditions of illumination, as in the Sensitive Plant and many others. Animals also show a similar periodicity; the shrimp-like *Hippolyte varians* rolls up its brilliant pigment-bodies (chromatophores) at night and becomes sky-blue in colour; but when daylight comes the pigment of the chromatophores is spread out in superficial networks. Kept in darkness these animals retain for many days this periodic habit, and when the hour of night arrives, though they have no light to tell it by, they lay aside their daily garb and put on the uniform of night. So also the "plant-animal" *Convoluta roscoffensis*, which lives on the seashore, orders its behaviour by the sun and moon, lying on the sand till the waves of the rising tide are upon it and then descending to security and darkness; when the tide recedes it rises to the light. Even the uncongenial surroundings of a tea-cup and a laboratory fail to break this habit; for in these surroundings its uprisings and down-lyings keep time with the tides. It is possible that light and darkness may work these wonders of periodicity and rhythm through the control of chemical agents such as oxydases.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON.), F.I.C.

THE HARDENING OF FATS.—For many years one of the chief problems of the oil industry has been to obtain a harder material from soft fats, and numerous ingenious methods have been tried, though only with limited success. The chemical problem involved in the ideal process is the addition of hydrogen to unsaturated fatty acids or their glycerides as represented, for example, in the case of oleic acid by the equation:—

$$\underset{\text{oleic acid}}{C_{18}H_{34}O_2} + H_2 = \underset{\text{stearic acid}}{C_{18}H_{36}O_2}$$

Oleic acid is the chief constituent in most oils, while stearic acid is a main constituent of solid fats such as lard and tallow.

All attempts to make the hydrogen combine with the unsaturated compounds in this way proved failures until a few years ago it was discovered by MM. Sabatier and Senderens that the combination could be effected by bringing the hydrogen and the liquid fat together at a high temperature in the presence of finely-divided nickel, which acted as a catalytic agent.

This discovery was followed by other processes in which other metals or metallic oxides such as cobalt, palladium and platinum were used as the catalytic substances, and numerous patents on these lines have been taken out for the manufacture of solid fats suitable for food and candle-making from liquid and semi-solid fats.

In the current issue of the *Chem. Rev. Fett Ind.* (1912, XIX, 247) there is a description by Dr. A. Bömer, of the chemical and physical properties of a number of these hardened fats prepared from earthnut oil, whale oil and cotton seed oil. In each case solid products resembling lard or tallow, according to the duration of the process, were obtained. From whale oil, for example, a hard white tallow-like fat melting at 45·1° C. was prepared, while earthnut oil gave a product which closely resembled lard both in its appearance, chemical properties, taste and smell.

As these hardened fats are now being sold as food products physiological tests were made to discover whether any injurious substances were formed in the process, but they were found to be quite innocuous, provided that care had been taken to eliminate all traces of the nickel used in the manufacturing process. Stress is laid upon the point, however, that only liquid fats that are already fit for human food should be used as the raw material, while such fats as horse-fat, bone fat, whale oil and the like should be kept for technical purposes such as the making of soaps and candles.

METROPOLITAN WATER BOARD'S REPORT.—The sixth annual report of the results of the chemical and bacteriological examination of the London waters, which has just been published, contains many details of great interest, to which here it is only possible to allude briefly. The *raw* waters, from which the supply is drawn, consist principally of rivers that have previously been polluted with sewage, and in the future it will be an increasingly difficult matter to obtain sufficiently satisfactory water to meet the greater demands upon the waterworks. Obviously, the greater the quantity of the water drawn from a river the more impure will be that which remains. Chemical purification of sewage effluents has rendered them much less objectionable; but apart from sterilisation there is no practical method of removing bacteria from these effluents.

Fortunately, the effect of mere storage of the water is automatically to reduce the number of bacteria to the extent of over ninety-nine per cent., so that on subsequent filtration of the water a reasonably safe filtrate is obtained. For example, the average number of microbes in raw Thames water during the twelve months ending March, 1912, was 9155 per cubic centimetre, while after subsidence and filtration of the water there were only 17·2 per cubic centimetre. In Dr. Houston's opinion it is hardly conceivable that any pathogenic micro-organism would succeed in reaching the filter beds after a sufficient period of storage. At the same time he lays stress upon the importance of obtaining water in as pure a condition as is practically possible, notwithstanding the proved safeguard afforded by efficient storage. Theoretically it should be possible to bring all river water to the same degree of purity before its intake into the waterworks and its delivery to the filter beds; but in practice during periods of flood it is necessary either to draw upon such water, which is unsuitable for the purpose, or to deplete the reservoirs by closing the intakes and thus reduce the period of storage for water subsequently taken into store.

For these reasons Dr. Houston advocates the desirability of taking greater supplies of water at favourable periods than is at present permitted. Apart from this, it is suggested that supplementary processes of purification might with advantage be employed occasionally, in addition to the present processes of devitalisation of bacteria by sedimentation and removal of the bulk of the remainder by filtration.

CHEMISTRY AT THE BRITISH ASSOCIATION.—The address of Professor Senier, President of the Chemical Section at the Meeting of the British Association in Dundee, is an interesting outline, full of suggestion, of what chemistry is and by what methods it works. It is clearly demonstrated that imagination is necessary for the advance of the science, and that our educational resources should be devoted to assisting promising students in the direction of research rather than to giving an elementary smattering of indigestible facts to everyone.

Of the papers of more general, apart from purely chemical interest, mention may be made of *The Report of the Committee on the Study of Plant Enzymes particularly with*

Relation to Oxidation; and the very important *Report on Diffusion in Solids* by Dr. C. H. Desch, in which the conclusion is drawn that "the occurrence of diffusion in metals is established beyond any doubt; but that experiments are still lacking to prove its occurrence in transparent crystals of minerals, salts, or organic substances, even under favourable conditions, although, even here, indirect evidence points to its possibility."

Other notable papers are *On the Dissociation of Phosphorus Vapour*, by Professor Stock and Dr. Gibson, and *The Chemical Nature of Uranium X, Radio-Actinium and Thorium B* by Mr. Fleck, who was unable by means of fractional precipitation to effect any concentration of the short-lived radio-element in thorium, or to separate thorium from radio-actinium or thorium B from lead.

GEOLOGY.

By G. W. Tyrrell, A.R.C.Sc., F.G.S.

GEOLOGY OF THE LIZARD AND MENEAGE.—A memoir with the above title has just been published by the Geological Survey, and written by Dr. J. S. Flett and Mr. J. B. Hill. The Lizard has long been a happy hunting ground for geologists, largely on account of its fascinating petrological problems, especially those connected with the great mass of serpentine which is the central feature of its geology.

The Lizard area can be divided into a northern and a southern portion. The dominant feature of the northern portion is the occurrence of four bands of sedimentary rocks (killas or clay slate, with subordinate grits, limestones, and conglomerates), named the Mylor, Falmouth, Portscatho, and Veryan series respectively, of which the last-named is the youngest, and has been determined by fossil evidence to be approximately of Llandeilo or Arenig age. Volcanic activity in Veryan times gave rise to the well-known spilitic lavas of Mullion Island, which are interbedded with limestones and radiolarian cherts.

The southern area is composed of a great metamorphic series, consisting of sedimentary and igneous rocks, of which the latter are overwhelmingly predominant. The metamorphosed sedimentary rocks are the oldest, and consist of mica-schists, granulites, and green schists, containing also hornblende schists of undoubted igneous origin. Subsequent to the formation of these rocks, an intrusion of granite took place. This rock has been greatly metamorphosed, and is now a highly foliated hornblende gneiss, which occupies the Man of War Islands off the Lizard shore.

Before the intrusion of the great serpentine another sedimentary formation was deposited, the Treleague quartzite, a quartzose rock in which the original pebbly structure is well preserved. In many places also, on the margin of the serpentine, there are coarse, gnarled, hornblende schists—the Traboe schists—representing the coarse dolerites or gabbros which immediately preceded the great plutonic intrusions.

The serpentine covers an area of twenty-one square miles, and is probably the largest serpentine mass in the British Islands. It has a more or less circular outline and is clearly a large laccolite or boss similar to the granite bosses that stud Cornwall and Devon. Three main varieties have been distinguished, the cherzolite or bastite-serpentine, the tremolite-serpentine, and the dunite serpentine. The first named of these is the rock which affords the beautiful ornamental stone for which the Lizard serpentine area is famous.

Later the serpentine was invaded by some bosses and an enormous number of dykes of gabbro. In many localities these have been crushed and rolled out with the formation of "flaser"-gabbros. After the cooling of the gabbro, a further injection of basic material took place, giving rise to abundant black dykes of olivine-dolerite, many of which have been crushed into epidiorites and hornblende-schists. Before this episode had finished, a final uprush, this time of acid material, occurred; and in some places, a mixed or hybrid rock, consisting of imperfectly mingled acid and basic material was produced, forming a heterogeneous banded gneiss called the Kennack Gneiss.

It is interesting to remark how this long and intricate igneous period of the Lizard is paralleled in the Ordovician of Ayrshire. Here also is a large mass of serpentine, intruded by gabbro and dolerite dykes with later masses of acid material. These intrude Ordovician sediments, the basal portions of which contain numerous flows of spilitic lavas associated with limestone and radiolarian cherts just as in the Mullion Island district of Cornwall.

THE PETROLOGY OF SANDSTONES.—The petrological study of the sedimentary rocks is now an important adjunct to their stratigraphical study. The investigation of the constituent grains of a sandstone is often especially helpful in obtaining an idea of the mode of origin and the derivation of the rock. Important results are being obtained from the study of the Scottish Carboniferous sandstones. An investigation by Mr. T. O. Bosworth, brought forward at the British Association, shows that these sandstones belong to two entirely different kinds, those in which the heavier mineral grains consist mainly or largely of garnet, and those in which garnet is absent or scarce. As far as Mr. Bosworth has yet examined the Carboniferous succession, the Coal Measure sandstones have been found to be highly garnetiferous, whilst those of the underlying Millstone grit were almost entirely non-garnetiferous. In the sandstones of the Carboniferous Limestone Series, out of fifteen samples examined, nine were garnetiferous, and six devoid of garnet. The Calciferous Sandstones were found to be entirely non-garnetiferous.

The garnets, and indeed all the heavy grains, were found by Mr. Bosworth to be characteristically angular. The garnets were broken along the dodecahedral cleavages, giving elaborate zig-zag shapes with numerous corners and edges. These grains were in marked contrast to those found in desert sands.

An independent investigation by Mr. W. R. Smellie (*Transactions of the Glasgow Geological Society*, 1912) of the Upper Red Barren Measure sandstones, which overlie the Coal Measures to the east of Glasgow, shows that the sandstones suffer a progressive change upwards in regard to mineral content and the degree of rounding. The lower beds are still characterised by angular garnets, but these do not occur to nearly the same extent as in the Coal Measure sandstones. The higher beds, however, are devoid of garnet, and contain abundant zircon, rutile, and tourmaline, the grains of which are frequently well-rounded and polished, especially the zircons.

MICROSCOPY.

By F.R.M.S.

LOW POWER PHOTO-MICROGRAPHY.—BACKGROUNDS.—It is a practical maxim in picture making of all kinds, scientific, technical, and pictorial, that nothing is seen without a background.

Thus a uniformly lighted quite white object is unnoticeable against a uniformly lighted equally white background.

The next point is that the useful effect of a background is to show contrast. This is so obvious that that it is very frequently entirely ignored. In Figure 20 we have a precisely similar pair of tiny cowrie shells side by side, similarly lighted. That on the right is backed by black paper, that on the left by a bit of white postcard; the two backgrounds being pasted side by side on an ordinary micro slip so that both parts had the same lighting, exposure and development.

First we notice that the shell on the right seems to be decidedly lighter than that on the left. But this is an optical delusion due to contrast effects with the backgrounds. Next we notice that with the light background (left) we get a decided cast shadow as well as a shaded side, and that where this side of the shell is close to the light card background we get a little reflected light on the shadow side, while with the black background (right) the cast shadow is apparently absent though really present.

It may be here noted that general experience among photographers shows that with a dark background we require a little longer exposure than with a light background, all other things remaining the same. With certain types of subjects it is desirable to employ a light background in conjunction with a side lighting, but without any cast shadow such as shown in my last note.

This can be easily accomplished in those cases where the object can be affixed to an ordinary clean, clear glass micro-slip. This is now held by the spring clips in front of the cut out part of the holder, and then a suitable white ground (*e.g.*, postcard) put in a position and angle where it is well and evenly lighted, and a few inches away from the object.

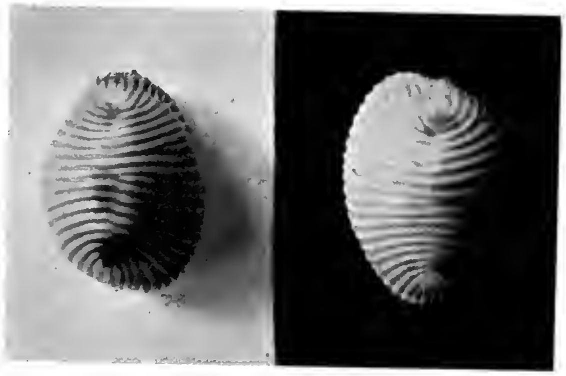


Figure 20.

In Figure 22 we see this arrangement showing a postcard background and glass-supported tiny shell and in Figure 21 we have the result showing the object enlarged about four diameters with a side lighting, light ground and no cast shadows.

In Figure 23 we have a (practically) white shell supported on a glass slip in a side lighting, against a black ground. In this case the ground was a bit of black velvet pasted to a piece of cardboard. It is far enough away to be quite out of focus and shows no texture.

Next comes the question of a reflector, which in some cases is of special value. In Figure 24 we see an object stuck to a glass slip, and a bit of white card close behind it. To our right we see a postcard used as a diffusing and reflecting screen throwing light on to the shadow side of the object. (The postcard is affixed to the base board with a couple of drawing pins.)

Figure 21.

In Figures 25 and 26 we see the effect of the non-use and use of such a card reflector in the case of a light shell showing some curious black markings. In the one case we get a dark shaded side and a cast shadow on the background. In the other case we nearly get rid of the cast shadow and also see a great deal more detail on the shadow side of the object as well as seeing more of the inside of the shell mouth.

These two examples, Figures 25 and 26, are precisely similar as regards lighting, exposure, and so on, and in all other respects, except the matter of the reflector.

One word of warning: do not use a glass mirror, or even a glossy card, or cross lighting and other ugly effects are likely to arise.

For all work of this kind it is preferable to employ bright sky light rather than direct sunlight. If direct sunlight falls on the window this should be covered with a piece of thin fine white muslin.

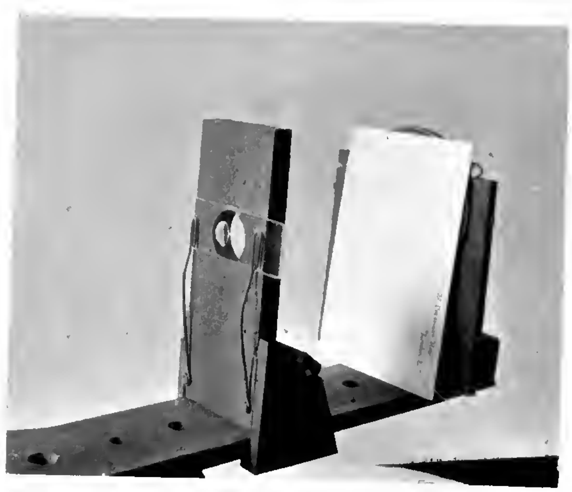


Figure 22.

F. C. Lambert, M.A., F.R.P.S.

QUEKETT MICROSCOPICAL CLUB.—November 26th, 1912.—The President, Professor A. Dendy, D.Sc., F.R.S., in the chair.

The President made some remarks on new species of Holothurians, with special reference to a form of *Chiridota* found in Port Phillip Bay, Victoria, and described by E. C. Joshua as *Taeniogyrus allani*. It was not, as was at first thought, identical with *Chiridota dunedinensis* Parker.

Mr. E. M. Nelson, F.R.M.S., read a paper "On microscope construction and the side-screw fine-adjustment." He pointed out that the modern method of placing the coarse-adjustment slide and the body upon the fine-adjustment, and the side-pinion fine-adjustment (now so much in vogue), were both invented by Powell, in 1841. The disadvantages of modern horizontal fine-adjustments were mentioned, and an improvement suggested by the author, preventing injury to the delicate moving parts, was described. The same author also made some remarks on "a new low-power condenser," and referred to the impossibility of obtaining an evenly lighted field, under critical illumination with any power lower than a two-thirds. Substage condensers suitable for low powers are all of too short a focus. A sufficiently long-focus condenser cannot be used because there is not room to focus it, even on a Powell and Leland No. 1 stand. The author had surmounted the difficulty by designing a condenser on the telephoto principle. This was exhibited at the meeting by Mr. Baker. It had an equivalent focal length of four inches, but required only one inch of working distance.

ROYAL MICROSCOPICAL SOCIETY.—November 20th, 1912. H. G. Plimmer, Esq., F.R.S., President, in the chair. Messrs. E. Heron-Allen and A. Earland read a paper on the Distribution of *Saccammina sphaerica* M. Sars and *Psammosphoera fusca* Schulze in the North Sea; particularly with reference to the suggested identity of the two species. These Foraminifera, belonging to the family Astrorhizidae, and originally described as from the North Sea, but occurring also in all the great oceans, have been the subject of considerable controversy. Dr. Ludwig Rhümbler asserts that *Psammosphoera* is only an immature stage of *Saccammina*. As a result of the examination of about one hundred and fifty dredgings made in the North Sea, the authors have no hesitation in affirming that the life-history of *Saccammina*, as recorded by Rhümbler, is a composite sketch involving three separate and generally recognised specific organisms:—

Stages I–III represent the life history of *Crithionina mamilla* A. Goes.

Stage IV is *Psammosphoera fusca* Schulze, an extremely variable species, which occurs both free and sessile, but is in all its stages normally recognisable by the absence of a general aperture.

Stages V–VII represent the complete life-cycle of *Saccammina sphaerica* Sars, so far as it is a shell-bearing organism.

An abstract of a paper by the Rev. Hilderic Friend on British Henleas was read. The Henleas are microscopic annelids belonging to the family of Euchytraeids. The genus was created in 1889 by Michaelsen, and contained four authentic species and four which were doubtful. Another species was added in 1899 by Bretscher. In 1900, when "Das Tierreich" was published, the number recorded was five, with four doubtful forms. During the next decade some progress was made, eight new species being added. and four definitely recorded as British. In 1911 Friend described *H. perpusilla*, and added one or two others to the British list. The present paper gives an enumeration of no fewer than nineteen species, eighteen of which are found in England and one in Ireland. Of these, seven new to science were found at Hastings in December last, and three have been found in Nottingham during the present year. Descriptions, with figures, are given of *H. marina*, *H. curiosa*, *H. arenicola*, *H. heterotropa*, *H. attenuata*, *H. fridericoides*, *H. variata*, *H. triloba* and *H. fragilis*, all new to science. The paper closes with a carefully prepared table, by means of which the various species can most readily be distinguished.

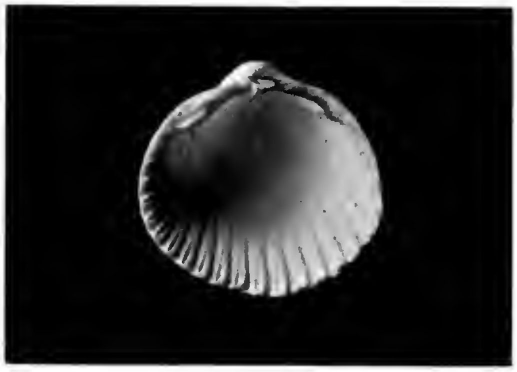


FIGURE 23.

An abstract of a paper by Mr. James Murray, F.R.S.E., on African Tardigrada was read. This paper adds thirteen species to the list of African Tardigrada, twelve were described in the author's previous paper, and Daday added a new species, *M. tetronyx*. There are now twenty-six species recorded for Africa, eighteen for tropical Africa, and seventeen for South Africa. Nine of these were first discovered in Africa, and only one of them (*E. perarmatus*) has been found outside that continent. Our knowledge is still too incomplete to allow of any useful study of the origin and distribution of the African Tardipode fauna. Amended and fuller descriptions are given of *E. africanus* and *M. crassidius*. Only one new species is described, *M. allani*, but there are figured varieties of *E. crassispinosus*, *E. duboisi*, and *hupelandioides* which are probably of specific value, to which I give no names. In the present state of the group it is well to be cautious in making new species, till our knowledge is consolidated in some monographic work.

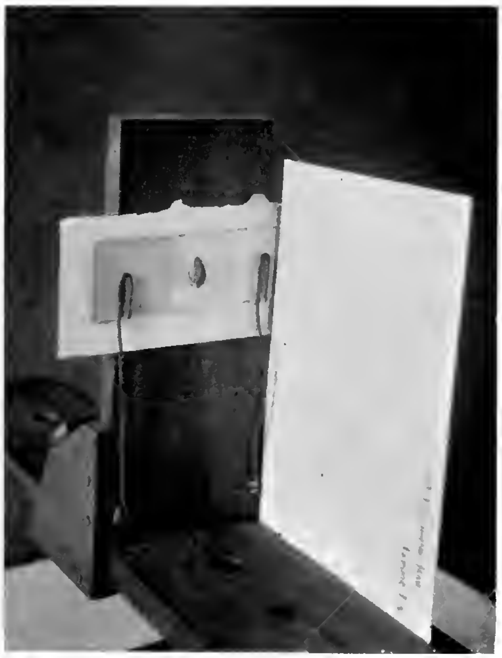


FIGURE 24.

INSECT INTELLIGENCE. — At a meeting of the Royal Microscopical Society on December 18th Mr. Frederick Enock, under this title, described how a wood-boring wasp brought no less than twenty-seven examples of the rarest British "Daddy-long legs" (*imperialis*—of which Mr. Enock had only taken one in forty years) and in order to get them into its burrow, cut off the six legs and the two wings close to the body.

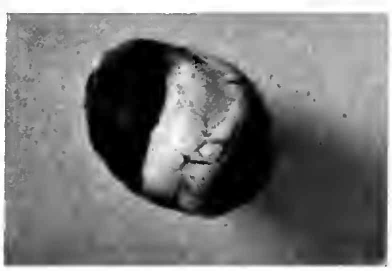


FIGURE 25.

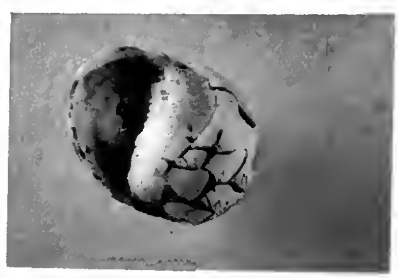


FIGURE 26.

ORNITHOLOGY.

By WILFRED MARK WEBB, F.L.S.

THE CUCKOO.—As an instance of the interesting information which one can sometimes glean from a catalogue one may mention that of Major Proctor's collection of birds' eggs recently sold by Mr. Stevens. That the cuckoo chooses a nest of the same species of bird in which to deposit its eggs is shown by two eggs evidently laid by the same individual, one taken from a Reed Warbler's nest on May 31st, 1907, and the other from that of the same species in the same place (Twyford, Berks) six days later. That the Cuckoo deposits two eggs in the same nest was shown by that of a Hedge Sparrow found at Dean, in Hampshire, on May 31st, 1893. Another Cuckoo's egg in the collection was found by Major Proctor in a Blackbird's nest at Torquay in 1889.

THE RECOVERY OF MARKED BIRDS.—In *British Birds* for December a report on marked birds that have been recovered, is given. In many cases the specimens were recaptured in the same place. One or two of the instances of birds that have travelled a considerable distance we may give. A Linnet marked by Mr. Masefield at Cheadle, Staffordshire, as a nestling, was caught at Wellington, Salop, on September 25th in the same year. A Pied Wagtail, marked by Mr. Ford-Lindsay at Pett, Sussex, on June 20th, 1912, was recovered at Blaye, Gironde, France, on October 6th. A Whinchat and some Cormorants, Common Terns and Little Terns also went to France. A Lapwing, marked by Lord Lucas in Yorkshire on June 19th, 1912, was recovered in Portugal in November of the same year.

THE DARTFORD WARBLER IN IRELAND. — Mr. R. M. Barrington, in *The Irish Naturalist* for December, records the occurrence of the Dartford Warbler in Ireland, a female having been caught at the Tuskar Lighthouse, County Wexford, by Mr. A. O'Leary, the light-keeper, on October 27th. The Dartford Warbler is looked upon as a resident in England, and was said in 1880 not to be uncommon on furzy ground in the Land's End district. Mr. Barrington thinks that if a pair had arrived in County Wexford, where furze is more prevalent than any Irish, or probably English, county, a colony might have been established; that is to say, were the birds lucky enough to escape being killed by a collector or some other misguided person.

NESTING-BOXES IN RUSSIA.—In many parts of Russia, especially in the towns along the Baltic, the traveller cannot help being struck by the numbers of nesting-boxes in the gardens and courtyards. This is particularly noticeable in the quaint old town of Libau, where in almost every garden, however small, a nesting-box may be seen. These boxes are invariably stuck on the top of a pole—never against the trunk of a tree or the side of a house as with us in England. In many cases a small branch is fixed to the box to render the site more natural and attractive.

This pleasing custom is due to a pious desire to shelter the Dove, a bird entirely sacred to the Virgin in Russia, and which is never molested in any way, much less killed and used for food—indeed, anyone found guilty of such an act would run the risk of serious reprisals from the neighbours.

The name Dove embraces any kind of pigeon, wild or tame, and fancy kinds are often kept as in England.

The owners of those boxes which happen to attract a Dove are greatly envied, as the privilege of harbouring and sheltering the "Virgin's Bird" is considered to entail good luck. Of course, only a small proportion of these boxes are selected by Doves; Starlings and other birds make frequent use of them, and are always welcome.

Figure 27 is from a sketch which I made of a typical box in the garden of a small house in Libau. Notice the two small perches below the entrance hole. LIONEL E. ADAMS.

FIGURE 27.

A Typical Russian Nesting-box.

PHOTOGRAPHY.

By EDGAR SENIOR.

PHOTOGRAPHING ROCK SECTIONS.—One of the most interesting, and at the same time valuable, applications of photography to the microscope, especially when considered from an educational standpoint, is its use in obtaining permanent records of geological specimens. In work of this nature, except in very few cases, low powers are all that are necessary. Although quartz, felspar, and mica form the chief constituents in rocks, the other substances which occur being of secondary importance, the sections themselves vary so much in character that the method of illumination employed in one case, may be totally unsuitable in another, so that no absolute rule can be laid down, the operator having to use his own discretion in the matter. With a little experience, however, there will be no difficulty in judging the most suitable means to employ in order to obtain the desired results. With a large number of rock sections it is necessary to make use of polarised light in order to differentiate their structure, and in some cases selenite and mica films, used either separately or in combination are an advantage also. In many cases the best results photographically are got by means of the crossed nicols only; many forms of granite are of this nature, as they give so much colour themselves that only crossed nicols are required. Others again require the selenite to show them properly. In the accompanying illustration Figure 28, which is from a section of Aberdeen granite, a red and green selenite plate was used, in order to show the structure at its best for the purpose of photography. In taking the negative, a twenty-four millimetre objective was used, with the analyser screwed into the nosepiece above it, and a two-projection ocular as eyepiece. An achromatic sub-stage condenser with its top lens removed, and the polariser fitted in below completed the whole optical arrangement, the source of illumination being a paraffin oil lamp. In order to make a correction for the so-called chemical focus of the objective, the light was filtered through an orange glass screen. It may not perhaps be apparent why this is necessary, considering the conditions under which the photographs are taken, but it has been found better in practice to do so, especially if lantern slides are going to be made from the negatives. One very essential condition above all others in order to ensure success in work of this class, is that the sections must be thin, otherwise the definition will be very seriously impaired. There should not be much difficulty in this, however, with the improved methods in use now for making sections. In taking the photographs it is advisable to bear in mind the photographic values of the colours, remembering that they have to be translated into monochrome, and that however fine the effect may be when seen in colours, the result may be totally disappointing in black and white. It therefore becomes necessary to employ plates which by falsifying the luminosities of the colours themselves produce the necessary contrast in the finished photograph. This very power becomes at times of immense value, as in objects which exhibit colours under polarized light such as plant-hairs, cotton-fibres, silk, flax, hemp, and so on, it affords a means of rendering details in structure which would otherwise be lost. In preparing slides for use, the objects should whenever possible be mounted in balsam, as the effect is much more striking than when mounted dry or in water. Then, again, the Lumière Autochrome process affords a means of producing very fine lantern slides showing the colours themselves, and when photographing in this way the compensating screen for subduing the too great action of the blue, is not required when the oil lamp is used, as the colour of the light is sufficient in itself for the purpose. It will also be found that with moderate powers the exposure is not long.

FIGURE 28.

Section of Aberdeen Granite photographed with polarized light × 70 diameters; objective employed 24 mm., together with a two projection ocular.

PHYSICS.

By ALFRED C. G. EGERTON, B.Sc.

DENSITY OF LIQUIDS.—While investigating the behaviour of various liquids of different densities which were sufficiently insoluble to maintain a meniscus of separation, Professor A. L. Clark finds that chloroform and water have equal density at a certain temperature. The two liquids are placed in a thick-walled capillary tube which is placed in a paraffin bath. The chloroform is denser than water at the ordinary temperature, but at a few degrees below the critical temperature (260°) the chloroform rises to the top; as the system cools down, so the chloroform again sinks to the bottom. This experiment is similar to those devised by Mr. C. R. Darling: as, for example, with aniline and water. The solubility of the liquids in each other causes the equilibrium to become unstable and the position of the liquids to reverse, at a temperature slightly different from the temperature corresponding to equal density. Chloroform and water have different indices of refraction, but as the temperature rises the index of chloroform decreases more rapidly than that of water, and when the two indices become equal the separating surface disappears from view and gives the appearance of complete homogeneity.

THE PHOTOELECTRIC EFFECT.—When metal surfaces are exposed to ultra-violet radiations, negative electrons are expelled from these surfaces. Each metal has a definite photoelectric effect of its own. It is interesting to gain knowledge of the emission velocities of the electrons from the salts of metals and various compounds, and the work of Dr. A. Ll. Hughes supplies that information. It was necessary to experiment with surfaces of which the state of the surface is similar to the mass of the substance, because the photoelectrons come from a layer only a few molecules in thickness. This has been ingeniously effected by vaporising the substance *in vacuo* from a small quartz bulb furnace, electrically heated, on to a nickel disc lowered near the mouth of the furnace. Most halogen salts show marked photoelectric effect after exposure to light, but such substances as zinc chloride or phosphorus pentoxide show no such effect. It appears that only those substances which are decomposed by light show the photoelectric effect, and that the light first decomposes the surface and then acts on the metallic element in the ordinary way.

SILENT DISCHARGES.—In Chili, observations have been made on the "Andes glow," which appears to start from an altitude of ten thousand feet along a ridge or conical peak. Luminous arcs up to 25° in width, surrounding a dark core, or radial groups of rays shooting up as far as the zenith, were observed, and lasted for several seconds. The phenomenon is frequent on warm, clear nights.

FLICKER.—When a disc with black and white sectors is spun round at a moderate speed, a flicker may be seen; on increasing the speed the flicker disappears, but if the illumination increases the flicker may reappear if the speed is not too great. The disappearance of the flicker is connected with the speed, the intensity and hue of the illuminating light, and with certain physiological effects on the eye. Dr. T. C. Porter has investigated the connection between illumination and critical speed at which flicker vanishes, and an abrupt alteration in the relation occurs when a certain low illumination is reached, and this must in some way be connected with the behaviour of the eye. Mr. H. E. Ives has published a detailed investigation on the application of the "flicker" method to the photometric comparison of lights of different hue, a problem of considerable complexity. The relative brightness of differently coloured lights is not constant under all conditions, owing to two main physiological effects—the Purkinje effect and the "yellow spot" effect. The former is the greater sensitiveness of the eye to blue light at low illumination, and the latter is the change of relative brightness of different colours when the size of the field of view is changed and different areas of the retina of the eye are illuminated. Mr. Ives has found the reverse of these effects when experimenting with the flicker method of comparing lights of different colours. There are four methods open to the comparison of lights of different hue, viz.:—

(I) The estimation of the sensation of equal brightness.

(II) The visual acuity or the estimation of the fineness of detail detectable as the luminosity decreases.

(III) The critical frequency or the comparison of the intensity of the light illuminating discs of black and the colour at the same speed of alternation.

(IV) The "Flicker" method, when the two colours alternate and the slightest change of either at a particular speed produces "flicker."

The work of Mr. Ives will certainly lead to a method of comparing the intensity of light of different hue, but the accuracy will always be dependent on the eye of the observer to some extent.

ZOÖLOGY.

By Professor J. Arthur Thomson, M.A.

HOW DOES EXPERIENCE COUNT FOR THE RACE? It is certain that many animals have an inborn capacity of reacting in a definite and adaptive way to particular stimuli. We call their behaviour instinctive. In many cases it seems possible to think quite clearly about the possible origin of these inborn capacities. We can think of them *beginning* as germinal variations; we can think of them *progressing* as germinal variations; we can think of them being most subtly *perfected* in the course of Natural Selection. And all without supposing that the tutelage of experience counted for anything except in the individual lifetime. This is the ordinary Darwinian view, in contrast, for instance, to the view of Professor Richard Semon, who holds very strongly that we must suppose that the offspring directly benefit by the premiums which their parents and ancestors have paid to experience. And some of the cases of very specific instinctive reaction are so striking that one is inclined, at first sight at least, to conclude that the lessons of experience must be in some way entailed. Let us cite one case taken by Semon from Lenz's "Schlangen und Schlangenfeinde" (Gotha, 1870). Lenz took two young buzzards from the nest and reared them. They killed slow-worms and ringed snakes carelessly, but they were in a most striking way excited when they first had to deal with an adder. They had previously devoured pieces of adder's flesh quite greedily, so it could not be smell that pulled the trigger. Moreover, buzzards work by sight. Now, what was it made the buzzards treat the adder in a way entirely different from that in which they dealt with grass snakes?

VINDICATION OF THE CABBAGE FLEA.—When we turn up the well-known leaflets of the Board of Agriculture under the heading Cabbage Flea or *Haltica oleracea*, we find it stated that this little bluish-green beetle is often far more harmful than the Turnip Flea, that "in some districts it is the chief root crop and general pest," and that it "attacks old and young plants, especially cabbages, but also turnip and other crops." Now we do not wish to take up the cudgels on behalf of flea-beetles, but it is of interest to call attention to a vigorous protest by Franz Heikertinger in Vienna, who has been engaged for seven years in a study of the Palaearctic Halticinae. The cabbage flea has been grossly libelled. It frequents Polygonaceae like buckwheat and Onagraceae like willow herb. It does not frequent Crucifers, nor eat them, nor develop on them. The fact seems to be that *Haltica oleracea* has been carelessly mixed up with species of *Phyllotreta* such as *Ph. nemorum*, the turnip-flea-beetle, and with species of *Psylliodes*, such as *Ps. chrysocephala*. It is strange that the mistake should have remained so long undetected, and it is satisfactory to have it corrected. For not only should justice be done even to a flea-beetle, but it is of practical importance in agriculture, that the true culprit should be persecuted.

CTENOPHORES.—In his finely-illustrated memoir on the Ctenophores of the Atlantic coasts of North America, Mr. A. G. Mayer calls attention to the fascinating beauty of these animals. "In the extreme tenuity of their bodily substance and their diaphanous delicacy of coloration, the ctenophores stand apart from other marine animals. Their presence in the water is commonly denoted only by the brilliant flash of rainbow colours, which play along the lines of their ciliary combs as they move languidly beneath the unrippled surface of the sea. Yet these creatures are no more wonderful in their complex organization than in their remarkable adjustment to their habitat; for so delicate are most of them that a current such as that of an oar suffices to tear them into misshapen shreds—a fate which they escape in time of storm by sinking far into the depths. This fact accounts for the extreme rarity of many of these forms, for the ocean's surface must have remained flat as a mirror for many hours before they can be lured upward from the calm of their deep retreat. Yet tender as they are to the touch, passing jelly-like between the fingers of the hand that attempts to seize them, their food consists largely of young fishes which they engulf in great numbers, seizing their prey by means of their peculiar adhesive cells. Thus, in the cold northern waters where ctenophores occur in vast swarms, they constitute a serious menace to the cod fisheries by devouring pelagic eggs and young fish."

FIVE-YEAR PEDIGREED RACE OF PARAMOECIUM.—Many facts seem to point to the conclusion that conjugation or fertilisation in Protozoa renews the vigour of the cell-lineage. Another view is that fertilisation is in some way concerned with the phenomenon of variation, or that it may enable the units to withstand changed environmental conditions. Professor Lorande Loss Woodruff has devoted many years to the experimental study of the slipper animalcule (*Paramoecium*), and one of his last papers is very interesting.

On May 1st, 1907, he started with a "wild" *Paramoecium aurelia*, isolated from an aquarium. When it had produced four individuals by division, these were isolated to four lines. The pedigreed culture has been maintained by a specimen isolated from each of these lines practically every day up to May 1st, 1912, thus precluding the possibility of conjugation taking place and facilitating an accurate record of the number of generations attained.

In the five years there were three thousand and twenty-nine generations, four hundred and fifty two in the first, six hundred and ninety in the second, six hundred and thirteen in the third, six hundred and twelve in the fourth, and six hundred and sixty-two in the fifth. The mean rate of division was over three divisions in forty-eight hours. The organisms were as healthy in 1912 as in 1907. They had given evidence of the potentiality of producing a volume of protoplasm approximately equal to 10^{1000} times the volume of the earth! This seems to show that in favourable environment there is no need of conjugation and no reason for senescence.

FILOPLUMES.—It is usual to distinguish on a bird four kinds of feathers,—the ordinary contours, the down-feathers, the half-down, and the filoplumes. The last are most familar on a plucked bird, standing up in scores on the bare body, each like a hair with a tuft at the top. Very little is known in regard to their development or their replacement, but Otto Fehringer has recently described their arrangement in a number of representative birds. They occur regularly along with contour-feathers and occasionally with down feathers. Their pits or follicles are separate from those of their companion feathers, but closely juxtaposed. If contour-feathers grow strong at one part of a feather-tract, so do the filoplumes. On the main feather-tracts, the filoplumes occur in definite relations to the contour-feathers. Thus, if the contour-feather is median and directed backwards, it has a filoplume on each side of its base; if the contour-feather is lateral and directed outwards and backwards, the filoplumes are on the median side; if the contour-feather is lateral, but directed inwards and backwards, the filoplumes are on the lateral side.

SOLAR DISTURBANCES DURING NOVEMBER, 1912.

By FRANK C. DENNETT.

NOVEMBER has proved very unfavourable to the solar observer. Six days were too cloudy to admit of observation, and some others were too dull to yield very satisfactory results. The disc was apparently clear of disturbances, bright or dark, on thirteen days, and on eight only faculae were visible. At noon on November the 1st, the longitude of the central meridian was 90° 3′.

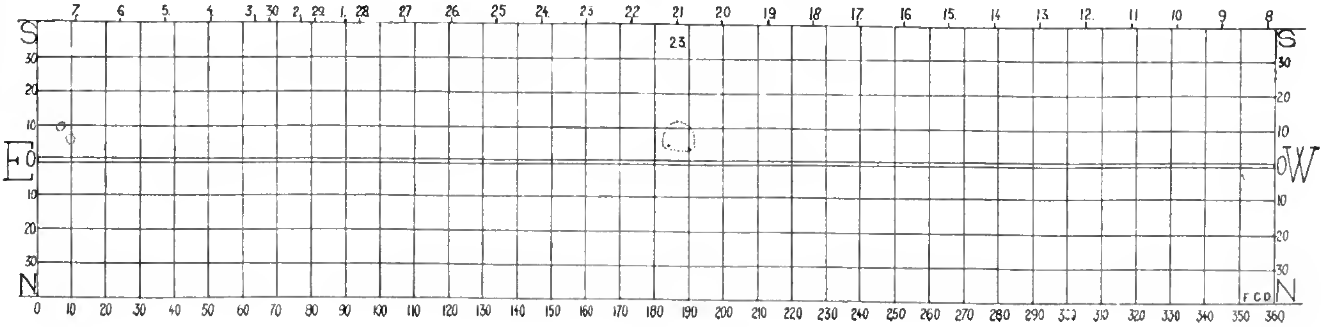
No. 23.—The only spot disturbance seen was first recorded on the 17th, the Sun not having been visible on the two previous days. At 10.45 a.m. it was described as a small very black spot having little penumbra, but followed by an elliptical faculic disturbance containing at least eight pores. A little after noon the edge of the umbra was observed to be frayed, and at the other side of the faculae were indications of a trailer or end spot. Directly eastward of the leader a dark hydrogen flocculus was visible with the spectroscope, pointing towards the S.S.E., deflecting the C.-line towards red. On the 18th the group seemed little altered and when last seen, on the 19th, there appeared to be two spots, one at each end, but clouds intervened before measures could be completed.

On November the 30th there was apparently a badly-formed spot in the equatorial region near longitude 95°, with traces of pores in a rough-looking area by which it was surrounded. No measures were obtained. It was doubtless the remains of the disturbance which produced the groups of Nos. 18 and 20.

Faculic disturbances near longitude 10°, S. latitude 6° to 10°, were observed within the eastern limb, on November 1, 2, 3, and 29, and approaching the western edge on the 11th. The faculic area connected with the spot group 23, was seen as it approached the western limb on the 25th and 26th.

In the preparation of this little note the importance of combined study by observers at distant stations cannot be over-estimated. Six observers at five stations so far separated as Lisburn, Manchester, Bath, Margate and Hackney, the greatest number of observations at any one station being eighteen. The observers were Messrs. J. McHarg, A. A. Buss, C. Frooms, E. E. Peacock, W. H. Izzard, and the writer.

DAY OF NOVEMBER, 1912.



THE FACE OF THE SKY FOR FEBRUARY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Feb. 5	21 14·3	S. 16·0	20 47·4	S. 22·3	20 54·8	S. 19·6	0 8·8	N. 1·6	18 31·8	S. 23·1	3 41·6	N. 17·7	7 43·4	N. 20·8
,, 10	21 34·3	14·4	0 26·8	N. 3·3	21 20·6	17·0	0 27·1	4·2	18 36·1	23·0	3 42·0	17·7	7 42·8	20·8
,, 15	21 53·9	12·8	4 31·0	N. 26·7	22 4·4	13·9	0 44·9	6·6	18 40·4	23·0	3 42·5	17·8	7 42·3	20·9
,, 20	22 13·2	11·0	9 45·6	N. 17·1	22 39·2	10·1	1 2·0	9·0	18 44·4	22·9	3 43·3	17·8	7 41·9	20·9
,, 25	22 32·3	S. 9·2	14 14·2	S. 16·6	23 13·2	S. 6·0	1 18·3	N. 11·3	18 48·3	S. 22·8	3 44·2	N. 17·9	7 41·4	N. 20·9

TABLE 1.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2	Saturn. P	Saturn. B
Greenwich Noon.	°	°	°	°	°	°	°	°	h. m.	h. m.	°	°
Feb. 5	−13·9	−6·4	265·3	−14·6	−4·3	−2·0	312·2	192·9	11 8 *e*	4 36 *e*	−2·3	−24·2
,, 10	15·8	6·6	199·5	−21·8	4·7	2·0	21·3	223·5	1 34 *m*	5 50 *m*		
,, 15	17·5	6·9	133·7	− 8·0	5·1	2·0	90·3	254·2	7 22 *e*	2 55 *e*	2·3	24·3
,, 20	19·1	7·1	67·8	+18·2	5·6	1·9	159·1	284·9	7 39 *m*	2 4 *e*		
,, 25	−20·6	−7·2	2·0	+18·1	−6·0	−1·9	227·9	315·7	3 36 *e*	3 17 *m*	−2·4	−24·4

TABLE 2.

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Jupiter L_1 refers to the equatorial zone, L_2 to the temperate zone, T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

THE SUN continues his Northward march. Sunrise during February changes from 7–44 to 6–51; sunset from 4–43 to 5–35. Its semi-diameter diminishes from 16′ 15″ to 16′ 10″.

MERCURY is a morning star till February 11th, then an evening star. Illumination, full at beginning of month, four-fifths at end.

VENUS is an evening Star, approaching its greatest elongation, which it reaches on February 12th. Illumination one-half, semi-diameter $12\frac{1}{2}''$. The planet is very favourably placed for observation by Northern observers.

THE MOON.—New $6^d\ 5^h\ 22^m m$; First Quarter $14^d\ 8^h\ 34^m m$; Full $21^d\ 2^h\ 3^m m$; Last Quarter $27^d\ 9^h\ 15^m e$. Apogee $7^d\ 8^h m$, semi-diameter 14′ 43″; Perigee $20^d\ 12^h e$, semi-diameter 16′ 47″. Maximum Librations, 2^d 7° N., 14^d 8° E., 17^d 7° S., 27^d 7° W. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

Date.	Star's Name.	Magnitudes.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.		h. m.	
Feb. 1 ...	BAC 5737	6·7	—	—°	5 30 *m*	285°
,, 2 ...	γ^1 Sagittarii	var.	6 46 *m*	144	7 40 *m*	227
,, 14 ...	BD+24°599	6·6	7 44 *e*	95	—	—
,, 17 ...	47 Geminorum	5·6	11 11 *e*	155	11 55 *e*	235
,, 17 ..	BD+27°1337	6·8	11 41 *e*	44	—	—
,, 18 ...	BAC 2383	6·5	1 28 *m*	110	2 25 *m*	283
,, 18 ...	ω^2 Cancri	6·2	4 12 *e*	45	4 47 *e*	329
,, 19 ...	BD+21°1969	7·7	5 0 *e*	67	—	—
,, 21 ...	χ Leonis	4·7	6 13 *e*	122	7 6 *e*	289
,, 22 ...	80 Leonis	6·4	5 45 *m*	146	6 36 *m*	277
,, 25 ...	BAC 4682	6.5	5 59 *m*	74	6 49 *m*	339
,, 26 ...	BAC 4923	5·7	4 46 *m*	69	5 38 *m*	343
,, 27 ...	*b* Scorpii	4·7	4 21 *m*	188	4 41 *m*	219

TABLE 3. Occultations of stars by the Moon visible at Greenwich.

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

MARS is a morning Star, but practically invisible.

JUPITER is still badly placed, having been in conjunction with the Sun on December 18th. It is, however, just coming into view as a morning star. Polar semi-diameter, $15\frac{1}{2}''$.

Day.	West.		East.		Day.	West.		East.	
Feb. 1	3	○	214		Feb. 15	3	○	$^{1}_{2}$ 4	
,, 2	$^{3}_{2}$ 1	○	4		,, 16	321	○	4	
,, 3		⊙	234		,, 17	2	○	14	3●
,, 4		○	1423		,, 18	1	○	234	
,, 5	2^{1}_{4}	○	3		,, 19	2	⊙	34	
,, 6	42	○	31		,, 20	2	○	134	
,, 7	431	○	2		,, 21	$^{1}_{3}$	○	$^{2}_{4}$	
,, 8	43	○	21		,, 22	34	○	12	
,, 9	4321	○			,, 23	4321	○		
,, 10	4	○	$^{3}_{1}$	2●	,, 24	42	○	1	3●
,, 11	4	○	23	1●	,, 25	41	○	$^{3}_{2}$	
,, 12	4^{1}_{2}	○	3		,, 26	4	⊙	13	
,, 13	24	○	13		,, 27	42	○	13	
,, 14	31	○	24		,, 28	4^{1}_{3}	○	2	

TABLE 4.

Configurations of Jupiter's satellites at 6^h *m* for an inverting telescope.

Satellite phenomena visible at Greenwich, 1^d 6^h 24^m II. Sh. I.; 3^d 5^h 48^m I. Tr. I.; 7^h 19^m I. Sh. E.; 10^d 6^h 56^m I. Sh. I; 11^d 7^h 17^m I. Oc. R.; 17^d 5^h 43^m III. Oc. D.; 6^h 31^m 3^s II. Ec. D.; 18^d 6^h 3^m 34^s I. Ec. D.; 19^d 5^h 34^m I. Sh. E.; 5^h 43^m II. Tr. E.; 6^h 33^m I. Tr. E.; 24^d 5^h 58^m 27^s III. Ec. D.; 26^d 5^h 11^m I. Sh. I.; 5^h 42^m II. Tr. I.; 6^h 14^m I. Tr. I.; 6^h 19^m II. Sh. E.; 27^d 5^h 45^m I. Oc. R.

All the above are in the morning hours.

Attention is called to the simultaneous transits of I. and II. on the 19th and again on the 26th.

SATURN is an evening Star, 6° South of the Pleiades. Polar semi-diameter $8\frac{1}{2}''$. The major axis of the ring is 43″, the minor axis $17\frac{1}{2}''$. The ring is now approaching its maximum opening and projects beyond the poles of the planet.

East elongations of Tethys (every fourth given). February 2^d $6^h \cdot 4$ *m*, 9^d $7^h \cdot 7$ *e*, 17^d $9^h \cdot 0$ *m*, 24^d $10^h \cdot 2$ *e*. Dione (every third given). February 5^d $7^h \cdot 8$ *m*, 13^d $0^h \cdot 9$ *e*, 21^d $6^h \cdot 0$ *e*. March 1^d $11^h \cdot$ 2*e*.

Rhea (every second given). February 1^d $2^h \cdot 8$ *e*, 10^d $3^h \cdot 7$ *e*, 19^d $4^h \cdot 7$ *e*, 28^d $5^h \cdot 7$ *e*.

For Titan and Iapetus, E. W. mean East and West elongations, I. S. Inferior and Superior Conjunction, Inferior being to the North, Superior to the South. Titan, 3^d $4^h \cdot 8$ *e* I., 7^d $0^h \cdot 9$ *e* W., 11^d $0^h \cdot 0$ *e* S., 15^d $3^h \cdot 4$ *e* E., 19^d $4^h \cdot 0$ *e* I., 23^d $0^h \cdot 4$ *e* W., 26^d $11^h \cdot 6$ *m* S. Iapetus 19^d $8^h \cdot 9$ *e* I.

URANUS is invisible, having been in conjunction with the Sun on January 24th.

NEPTUNE was in opposition on January 14th. Its motion may be traced on the map of small stars which was given in "KNOWLEDGE" for December, 1911, page 476.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant.		Remarks.
	R.A.	Dec.	
Feb. 5—10	75°	+ 41° N	Slow, bright.
,, 15 ...	236	+ 11 N	Swift, streaks.
,, 15 ...	261	+ 4 N	Swift, streaks.
,, 20 ..	181	+ 34 N	Swift, bright.
,, 20 ...	263	+ 36 N	Swift, streaks.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 6^h to 10^h, next month 8^h to 12^h, and so on. In the case of Algol variables, the time of one minimum is given where possible, and the period. Algol, owing to its brightness, will be given for wider limits.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Minimum.
	h. m.			d. h m.	d. h. m.
Algol	3 2	+40°·6	2·3 to 3·4	2 20 49	Feb. 2 6 27 *e*
RW Monocerotis	6 30	+ 8 ·9	9 to 10·5	1 21 45	
RX Geminorum	6 44	+33 ·3	8·5 to 9·5	12 5 0	
RU Monocerotis	6 50	− 7 ·5	9·5 to 10·5	0 21 30	
R Canis Maj.	7 15	−16 ·2	6 to 6·5	1 3 16	Feb. 6 8 38 *e*
RY Geminorum	7 22	+15 ·8	8·5 to 10·5	9 7 13	
Y Camelop	7 29	+76 ·3	9·5 to 12	3 7 20	
RR Puppis	7 44	−41 ·2	9·5 to 10·5	6 10 19	
V Puppis	7 56	−49 ·0	4 to 5	1 10 54	Feb. 7 10 24 *e*
X Carinae	8 29	−58 ·9	7 8 to 8·6	0 12 59·6	Feb. 2 0 36 *e*
S Cancri	8 39	+19 ·4	8·2 to 9·8	9 11 38	
S Velorum	9 30	−44 ·8	7·8 to 9·3	5 22 24·4	
Y Leonis	9 32	+26 ·7	9·0 to 10·6	1 16 28	
W Urs. Maj.	9 38	+56 ·4	7·9 to 8·7	0 4 0·2	

TABLE 5.

Of long period variables *o* Ceti (Mira) will reach a maximum at the end of April, when it will be invisible in the sunshine, but it may be seen brightening early in the year.

REVIEWS.

ASTRONOMY.

The Sun.—By CHARLES G. ABBOT, of the Smithsonian Institution. 448 pages. Numerous illustrations. 8-in. × 5-in.

(D. Appleton & Co. Price 7/6 net.)

The publication of this treatise is indicative of a most healthy change that is coming over astronomy. All through it exhibits an able attempt to explain phenomena, to correlate and to classify observations. A dynamical deduction that furnishes a clear explanation even if not the final word on the subject is of value. It is said that truth more easily arises from error than from confusion. Attempting to observe without a working hypothesis is like building without a scaffold, yet it is not many years ago since an eminent astronomer said that we do not want theory, we want facts. The promise of the preface is well sustained. In it the author says that the time seems ripe for collecting the splendid array of new solar knowledge which such unprecedented activity has produced, and for discussing the probable nature of the Sun in the light gained. All this he has done most admirably.

There are other explanations and generalizations that he has evidently not read, hence he has not given us the whole truth. He has, however, examined many obsolete explanations, in the light of modern chemistry and physics and has shown them to be wrong, such as the Laplace ring theory, and the carbon cloud theory of the photosphere. This is especially good work: we do not want false explanations to fossilize into supposed firm fact, no matter how beautiful the errors may be. The author argues conclusively that the photosphere is a gaseous surface, but he does not seem to be aware that it is almost certainly the limit of static equilibrium, all above it being supported by kinetic energy; the supporting power of the reversing layer being the energy of volcanic projection, and that of the chromosphere being molecular kinetic energy. Nor does he seem to realize that if meteors have anything to do with sunspots their function is probably similar to the detonator of a dynamitic explosion. Meteors are, as it were, the triggers, the dynamical rigidity of the Sun supplying the effective energy. Altogether this is a great book, fearless in the expression of new ideas, and intensely sane in their advocacy. It will do much to render solar information available, instead of remaining a lumber of uncorrelated facts.

A. W. B.

The Star Calendar for 1913. With Revolving Chart.—By MRS. H. PERIAM HAWKINS. 10-in.×10-in.

(Simpkin, Marshall & Co. Price 1/- net.)

Users of this chart will find it one of the very best forms of planisphere yet designed. The area of the heavens visible at any time is shown by an oval cut in a covering card. Hence the zenith can be recognised at once. This card is hinged at the top, so that it can be lifted to see the whole of the stars ever visible in England.

The chart has proved itself of great value to troops who are studying marching by the stars. The explanations of how to use it are very clearly described.

It would be an improvement were the North Polar Circle drawn to show precession, and also were the Milky Way indicated by a faint whiteness.

This is a most useful chart, and can be highly recommended.

A. W. B.

The Star Almanac, for 1913.—By MRS. PERIAM HAWKINS. 6 illustrations. 30-in.×24-in.

(Simpkin, Marshall & Co. Price 6d. net.)

Again Mrs. Periam Hawkins has introduced improvements into this excellent Almanac. In addition to the star charts for the four seasons, there is a diagram showing the North Polar clock. She has also brought in a table of hints in connection with marching and telling the time by the stars, the sun, and the moon. There is all the usual information contained in a star almanac.

The Almanac would be most valuable on the walls of any astronomer's study or observatory.

A. W. B.

The A.B.C. Guide to Astronomy. Second Edition. By MRS. H. PERIAM HAWKINS. 120 pages. 7½-in.×5-in.

(Simpkin, Marshall & Co. Price 1/6 net.)

This little book is of the kind one is glad to see in its second edition, for it is a very valuable contribution to Astronomy. The first edition had a few misprints and slight errors from which this edition seems quite free, as one would expect after it had passed the keen eye of so able and accurate an astronomer as Dr. A. C. D. Crommelin. Mrs. H. Periam Hawkins must have read very widely in preparing this book, for there is scarcely an astronomical idea of importance the meaning of which is not described with the utmost clearness.

The information is brought quite up to date. Good abstracts of the latest correlations are given, some of which are seldom seen in any astronomical work. This attention to broad generalizations is of the utmost importance in these days, when the mass of detail accumulated by astronomers threatens to bury the essential facts out of sight. The A.B.C. arrangement is also very useful in the case of points needing reference. The book is strongly to be recommended to the amateur astronomer.

A. W. B.

A Primer of Astronomy.—By SIR ROBERT BALL. 222 pages. Numerous maps and illustrations. 7-in.×4½-in.

(The Cambridge University Press. Price 1/- net.)

This excellent little book has its value much increased in its re-issue, by the addition of maps of the northern and southern hemispheres, and by a new chapter of forty-two pages on celestial objects. This chapter is written in Sir Robert Ball's usual perspicuous style. It is exactly suited to the amateur observer, every interesting object in both northern and southern hemispheres being very fully described. The book is thus rendered suitable to Africa and Australia. The descriptions are brightened by interesting folklore. In the older parts of the book one could have desired a few alterations to bring it up to date. For instance, in the nebula of Andromeda, which is described as showing rings elongated by projection into ellipses, while the latest photographs leave no room to doubt its spiral character. Some of the explanations are also a little antiquated, and not quite in accord with modern chemical physics.

A. W. B.

A Beginner's Star-Book.—By K. MCKREADY. 148 pages. 70 maps and illustrations. 10½-in.×8-in.

(G. P. Putnam's Sons. Price 9/- net.).

The author says in his Preface that this book is "in a sense but one effort more to help those who are without technical equipment, to claim through the unaided eyes or through simple optical instruments their heritage in things of the sky"; "It is intended for the general reader," and not as a text book, but "as a simple observational manual," and, further, "The volume is also intended for those who wish to add to their knowledge of the skies without aid of any kind" . . . . "much of it is, necessarily, a recapitulation of elementary facts; it is frankly a book for the beginner." These extracts adequately explain the nature of this work and we heartily congratulate the author in having so successfully accomplished what he set himself to do. We are acquainted with most books of this nature or aim published during the last forty years, but we cannot recall the title of one that so well fills the need of an elementary and ***progressive*** book on observational astronomy for the beginner, young or old. Most err in being either too easy or simple without the redeeming feature—given in this book—of opportunities for promoting or satisfying advancing knowledge; too technical, too profuse or laborious for the convenient and daily use of a beginner in out-door astronomy; or too much out of date to meet the recent advances even in observational astronomy. To us this book appears to be the bridge.

Beyond the data or details in the book being brought up-to-date there can be little that is new, nor does the author claim that it is so. The principles of the book are to encourage the beginner to learn from the ***objects***, not from mere book reading; to proceed slowly, get a good grasp of one thing at a time, and not to attempt too much at once.

The book of one hundred and forty-eight pages is divided into ten chapters or divisions: I, Introduction, brief but very useful; II, Objects to be seen. The Stellar World; III, Learning to observe; IV, Star maps; V, Objects to be seen. The Solar System; VI, Some Instruments of Observation; VII, An Observer's Catalogue of Telescopic Objects; VIII, Statistical

Tables of Star Distances, and so on; IX, Index, quite good; X, Additional maps.

The whole-page illustrations of Stellar objects are numerous and are scattered through the chapters. The selection of those relating to nebulae has been judicious, representing many of the most striking and well-known types; as the photographs have been excellently reproduced from the unsurpassed photographs made at the Yerkes Observatory, it is almost needless to say that they are of the best. The night star-maps from pages 38 to 61 are given both in black and white stars on opposite pages, and below each map is added much information for use without and with small instrumental aid. The chief features of the Sun, Moon, Planets and Comets are given, also with plates from photographs taken at the Mount Wilson, Lowell and Lick Observatories. Chapter VII consists of an alphabetical description of the Constellations, proper names and their pronunciation; much useful and accurate information has been provided in a small space of twenty-one pages: Webb, Smyth, Ambronn and Harvard Observatory books have been utilized in forming the catalogue. This chapter is followed by another containing lists of distances of double and of variable stars, also the photometric magnitudes of the seventy brightest stars; and at the end is a summary or list of books useful to an astronomical observer. We do not think this portion is so replete with information as the other portions of the book; we notice that a number of most useful elementary and general books on Astronomy of recent publication are omitted.

For such a book of information and excellent illustrations the price is quite moderate. There is one objection to the book, and that is the highly-surfaced coated paper upon which the text is printed.

F. A. B.

Their Winged Destiny: being a Tale of Two Planets.—By D. W. Horner. 240 pages, with a frontispiece, 7¼-in. × 5-in.

(Simpkin, Marshall & Co. Price 2/- net).

This is a book of convenient size for the pocket, being nicely printed with good-sized type and on rough laid paper. The author need hardly have remarked in his preliminary note that the narrative was purely imaginary. The tale reminds us of our Jules Verne days. Certain definite scientific facts—this time the airship—are carefully worked in with the author's imagination "run-riot." Sudden difficulties arise and they are just as quickly and easily overcome. A journey is made in the airship to an unknown planet and the return to the Devonshire moors is accomplished in the thirty-third chapter,—some of the more useless members of the party having been left behind on the planet,—when the happy end is achieved in the marriage of the airman and the once little girl.

F. A. B.

Notes on the use of the Portable Reversible Transit Instrument.—By C. E. Monro. 60 pages, 2 Plates, 8 Figures. 8-in. × 5-in.

(J. D. Potter. Price 3/-.)

The author made good use of his time by recording notes when he was at the Royal Observatory, Greenwich, learning the practical use of a transit instrument for the purpose of longitude determinations. These notes, supplemented by later experience when at Ascension, form the basis and body of this useful little hand-book. The author states that the book is "intended purely for the use of beginners."

Chapters I–IV. form nearly half the book and deal with the description and principle of the instrument in considerable detail, also with its level and mounting. Chapter V. is concerned with the method of observation. Chapter VI. relates to the reduction of the observations; this chapter with appendices II to V. constitutes the most important part of the book; the forms and methods of reduction are those in use at Greenwich. A theoretical explanation of the reduction of transit observations is given in Appendix I. There are two plates and eight diagrams to aid the explanations. Pages three and four contain a good index. The author expresses his great indebtedness and gratitude to Mr. H. P. Hollis for his valuable help in instruction, in suggestions, and in the revision of the manuscript. This is a book that all who are interested in transit and time observations should possess.

F. A. B.

CHEMISTRY.

Modern Research in Organic Chemistry.—By F. G. Pope, B.Sc. (Lond.) 324 pages. 261 illustrations. 7½-in. × 4¾-in.

(Methuen & Co. Price 7/6.)

In no branch of chemistry has greater advance been made through the application of pregnant hypotheses, than in the study of the compounds of carbon. Until about half a century ago all was confusion, and it was not until the theory of organic radicles had been proved workable that order began to develop out of an accumulated mass of apparently unrelated details, and that organic chemistry was shown to be as capable of systematic treatment as was the inorganic branch of the science. The series of brilliant researches which laid the foundations of the structural formulae of carbon compounds formed another stage in the advance, and now we have reached the stage of establishing the relationship between physical properties and the structure of different bodies.

All these successive steps in the development of organic chemistry are sketched in an interesting preface to the book, by Dr. J. T. Hewitt, and this forms a fitting introduction to the subjects of which the text treats.

The book is conveniently divided into chapters dealing with the work that has been done in connection with different classes of compounds, such as the polymethylenes, terpenes and camphors, the uric acid group, and the alkaloids. There is also an interesting chapter upon the relationship between colour and the constitution of chemical compounds. Although much work has been done in this direction, there are still numerous instances where no such relationship has been discovered. In the author's opinion, however, it is not improbable that even in such cases as these further investigation may show that certain molecular groupings are associated with the particular vibrations giving the impressions of certain colours.

Research will also probably prove fruitful in establishing a relationship between physiological properties and chemical constitution, and in a future edition of the book a chapter upon this aspect of the subject might with advantage be added.

The work is well illustrated with diagrams, and, as is essential in a book of the kind, gives full references to the original papers. It is not intended to be an elementary text book, but to the research student it should prove an invaluable companion.

C. A. M.

Industrial and Manufacturing Chemistry (Organic).—By Geoffrey Martin, Ph. D., M. Sc. Assisted by Specialists. 726 pages. 249 illustrations. 10-in. × 6½-in.

(Crosby Lockwood & Son. Price 21/- net.)

The name of Dr. Martin will be familiar to the readers of "Knowledge," and its occurrence on the title-page of a book is of itself presumptive evidence that the work will be interesting and well written.

The aim of this book is quite different from that of Allen's "Organic Analysis," for its object is to give a clear outline of the numerous manufacturing processes based upon organic chemistry, together with some details of the methods used in the examination of the different products—sufficient to follow the meaning of an analytical report, though not for the making of an analysis.

The extent of ground covered may be gathered from the fact that it deals with industries as far apart as the making of soap and the brewing of beer, or the manufacture of artificial perfumes and the preservation of timber. Chemistry is now so much a matter of specialisation that no man can hope to have a thorough knowledge of more than one or two branches, and the chief author and editor has therefore very wisely availed himself of the assistance of specialists in the different subjects, while at the same time keeping the general style and arrangement the same throughout the book.

In the case of each industry there is not only a clear description of the manufacturing processes with illustrations of modern apparatus, but outlines are also given of methods suggested by recent patents. Full references to the scientific literature are also placed under each section, so that the book must prove of great assistance to the manufacturers, patent agents, and students engaged in industrial research, as well as being of interest to the general reader. We notice that in the section upon vinegar, the editor acknowledges his indebtedness to an article that appeared in "KNOWLEDGE" as the source of his most recent information.

It is perhaps invidious to single out any particular sections, but the chapter on Synthetic Rubber, by Dr. Martin, and that on the manufacture of Synthetic and other Drugs, by Dr. Challenger, deserve mention as being particularly good. In some of the sections however, there are indications that the writer has a general rather than a special knowledge of his subject, although for the reason mentioned above this was probably inevitable.

It is surprising how few organic industries have escaped notice, as the present reviewer has found by test references to the excellent index. The manufacture and valuation of artificial organic manures, however, ought certainly to find a place in a treatise of this kind, and the modern processes of treating roads for the prevention of dust, with their advantages and drawbacks would form another useful section. Considering the enormous amount of matter in the book the misprints are very few, and are mainly slips of a single letter. "Zoological" for "zoogloeal" however, on page 316, is an amusing example of a printer's interpretation of a word that was new to him.

C. A. M.

A Second Year Course of Organic Chemistry for Technical Institutes.—By F. B. THOLE, B.Sc. (Lond.). 186 pages. $7\frac{1}{4}$-in. $\times 4\frac{3}{4}$-in.

(Methuen & Co. Price 2/6.)

This little manual, which is in continuation of one that has already appeared in the same series, deals mainly with the chemistry of the carbocyclic, or (as they are more generally termed), the aromatic compounds. As in the case of Part I., the book is simply and clearly written, and although primarily intended for students in technical colleges it should be found useful by all who are not far advanced in the study of organic chemistry. The latter part of the book contains sections dealing with practical work, including an excellent scheme of qualitative analysis, but we venture to think that some experimental work should have been incorporated with the theoretical part. A very good feature is the description of special reactions, which in many text books are merely alluded to under the names of their discoverers, it being assumed that the reactions themselves are common knowledge. French text books are the worst offenders in this respect, but the fault is not uncommon in elementary English books.

C. A. M.

GEOLOGY.

Dana's Manual of Mineralogy. — By W. E. FORD. Thirteenth Edition. 460 pages. 357 figures. 10 plates. ($7\frac{1}{2}$-in. $\times$ 5-in.)

(J. Wiley & Sons. Price 8/6 net.).

This is a revised and rewritten edition of Dana's famous manual, first published in 1848. It is now, however, twenty-five years since the text was last revised. Whilst the figures and text are new, the original scope and character of Dana's book remain, and it appeals to the same constituency as heretofore. The chapter on petrography has been omitted and for it is substituted a brief and general description of the principal rock-types. The opening section on crystallography is up-to-date, and is illustrated by much better figures than are usual in these text-books. This is followed by an account of the other physical characters and the chemical characters of minerals. The treatment of determinative mineralogy is rather full and renders the book of particular value to miners and prospectors. In the descriptive section, occupying the greater part of the book, the minerals are taken according to the usual chemical classification and are treated with regard to their chemical composition, crystallisation, general physical properties, occurrence, and use. This section is illustrated by many fine photographic plates of mineral groups, and is concluded by a long and elaborate set of determinative tables. A notable misprint is "Crypiocrystalline" for "Cryptocrystalline" in a heading on page 176, otherwise the book is very free from typographical errors.

The section on Rocks in connection with rock-making minerals would have been better for revision by a competent petrologist. Such a mistake as the inclusion of anorthosite as a variety of syenite might then have been avoided. Possibly this is due to the megascopic mode of treatment under which an anorthosite might be regarded as a "syenite" since it is built mainly of light-coloured felspars.

G. W. T.

On the Origin of the Himalaya Mountains. Professional Paper—No. 12. Survey of India.—By COLONEL S. G. BURRARD, R.E., F.R.S. 26 pages. $11\frac{1}{2}$-in. $\times$ 8-in.

(The Survey of India, Calcutta.)

This is a concise and valuable presentation of the geodetic evidence bearing on the origin of the Himalayas, whether the accompanying geological theory of the author be accepted or not. The plumb-line observations in the vicinity of the Himalayas shew an extraordinary deficiency of mass under the Gangetic alluvial belt immediately south of the mountains. The deflection of the plumb-line is much greater than if the Himalayas were exercising the whole of their attraction uncompensated. This line of low density is supposed to be due to a deep invisible trench or channel buried beneath the alluvium of the Ganges.

Colonel Burrard believes that in this region the sub-crustal shell has cracked, and its northern portion has then shrunk and moved away from the southern, giving rise to the folding of the Himalayas. He explains the observed fact that the folds are clearly overthrust to the south by saying that there is only an apparent movement of the upper part of the folds to the south. The real movement has been that of the underpart of the folds to the north. This, of course, contradicts the views of such distinguished geologists as Hayden, Griesbach, and Suess, who believe that the Himalayan mountain folds are due to horizontal thrust from the north against the immobile buttress of Peninsular India.

Whether Colonel Burrard's ingenious theory will be accepted by geologists depends largely on further geological evidence. It seems difficult to account for the enormous quantity of alluvium that would be necessary to fill the postulated rift, and further evidence of the depth of the Gangetic alluvium is needed. Also, should we not expect similar rifts in front of the other great folded mountain ranges of the earth?

G. W. T.

The Structure of the Earth.—By Professor T. G. BONNEY, D.Sc., F.R.S. 94 pages. $6\frac{1}{2}$-in. $\times 4\frac{1}{2}$-in. (The People's Books).

(T. C. & E. C. Jack. Price 6d.)

It is a difficult feat to compress the story of the earth into the small scope of a volume of this size, but Professor Bonney has achieved the apparently impossible with remarkable success. Considering the limitations of space under which the book labours the resumé of geological science is fairly complete. The work of rain, rivers, snow, ice, and the sea, and their part in shaping the surface of the earth as we now know it, is treated in broad outline, with a necessary avoidance of detail. Volcanoes, earthquakes, land movements, and finally the history of life upon the earth, are treated in the later chapters. As a simple, concise account of geology up to date this small book may be recommended to beginners in the science.

G. W. T.

The Building of the Alps.—By Professor T. G. BONNEY, D.Sc., F.R.S. 384 pages. 32 plates. 16 figures. 9-in. × 6-in.
(T. Fisher Unwin. Price 12/6 net.)

From an early period, the many problems of Alpine rocks, snowfalls and ice-streams, have attracted men of science, especially geologists; and Professor Bonney in this book, which is the fruit of almost yearly Alpine wanderings over a period of forty-five years, shews that he is a worthy successor of the great line of de Saussure, Perrandin, de Charpentier, Agassiz, Forbes, and Tyndall. A list of his thirty-five journeys in the Alps is given in an appendix, along with the titles of no less than forty-six original papers dealing with Alpine physiographical and petrological questions.

A large part of the book, however, is really a non-technical account of Alpine geography, although purely geological matter occupies the first few chapters. In addition to descriptions of Alpine rocks and broad tectonic features, there are interesting sections on Alpine meteorology, avalanches, floods, fauna and flora, and the Alps in relation to man. The last chapter, entitled "Fifty Years of Change" gives racy reminiscences of the discomforts of travel in the Alps in the early days.

Professor Bonney's name is identified with strongly-marked views on certain controversial questions, especially in regard to the origin and age of Alpine schists, and the efficiency of ice as an eroding agent. In regard to the latter he holds and has defended in vigorous controversy the conservative and minority view that the work of ice is not more than abrasive, and is only erosive in peculiarly favourable situations. A clear account of the dispute is given in the present volume.

This entertaining book would be the better for a topographical and geological map of the Alps, without which it is hard to follow the descriptions of the first part.

G. W. T.

Rough Stone Monuments and their Builders.—By T. ERIC PEET. (Harper's Library of Living Thought). 172 pages. 3 plates. 22 figures. 7-in. × $4\frac{1}{2}$-in.
(Harper & Brothers. Price 2/6 net.)

This is a description in clear and simple language of the great megalithic monuments which strew the seaward parts of Europe, Asia, and North Africa. These are of perennial interest, and in times past have given rise to curious conjectures as to their origin, the agency of fairies, virgins, witches, dwarfs, devils, saints, druids, and even historical personages, being frequently invoked. These monuments range from the great structures like Stonehenge, and the even more elaborate *nuraghi* of Sardinia, and the temples of Malta, to simple standing stones (menhirs), rock-tombs, and the barrows that stud the English downs. The author has woven his description of these structures, and their mode of erection, into a most fascinating narrative, along with fact and conjecture as to the remote civilization by which they were erected. He adopts the theory that the monuments are due to a single race, whose style of building was brought to different countries in the course of a great migration or series of migrations, and finds confirmation in the remarkable fact that in geographical distribution these monuments occupy a vast seaboard, including the Mediterranean coast of Africa and the Atlantic coast of Europe. That is, they lie entirely on a natural sea route, which would be followed by a migrating race in preference to the more difficult land routes.

The book will be useful alike to the scientific archaeologist and to the interested "popular" reader. It is written in an attractive literary style, and is well illustrated. The only slips noticed are that on page 10 megalithic monuments in Italy are said to be confined to the south-east corner of the peninsula, and on page 76 to the south-west corner; and a "to" is substituted for "of" on page 59.

G. W. T.

METEOROLOGY.

Weather Science.—By R. G. K. LEMPFERT, M.A. The People's Books No. 17. 94 pages. 15 illustrations. $6\frac{1}{2}$-in. × $4\frac{1}{2}$-in.
(T. C. & E. C. Jack. Price 6d. net.)

The seeker of knowledge on the processes involved in our varied weather will find in the above work, a review of the salient features of the Science and the principles underlying the frequent changes to which our Islands are subject. The author is the Superintendent of the Forecast Division of the Meteorological Office.

W. C. J.

PHOTOGRAPHY.

Nature Photography.—By STANLEY C. JOHNSON, M.A. 115 pages. 11 illustrations. 7-in. × $4\frac{3}{4}$-in.
(Hazell, Watson and Viney. Price 1/- net.)

Mr. Stanley C. Johnson takes excellent natural history photographs himself, and it is to be expected that from his experience he could give help to others. We are not disappointed, for in his little book in *The Amateur Photographer* Library, he gives a great many valuable hints with regard to apparatus, and to photographing river and pond life, as well as small creatures to be found in the garden; while he touches on the subject of birds, which, perhaps, is the one which has attracted the attention of photographers to the greatest extent. Mr. Johnson alludes to the interest which may be obtained from photographing birds in gardens, and speaks of the usefulness, in attracting them, of the Selborne Society's nesting boxes which he has put up. If we may suggest one correction, it is that in a second edition, the words "protective coloration" be used instead of "protective mimicry" for cases in which creatures are like their surroundings. Mimicry, in its technical sense, means the special resemblance of one creature to another. There are some useful miscellaneous notes and a calendar with suggestions as to what work may suitably be done in the various months.

W. M. W.

PHYSICS.

Junior Sound and Light.—By R. W. STEWART, D.Sc., and JOHN SATTERLY, D.Sc. 227 pages. 129 illustrations. 7-in. × 5-in.
(The University Tutorial Press. Price 2/6.)

This book contains a condensed account of the rudiments of "Sound" and "Light," together with numerous examples and experiments. The descriptions are clear, and the book is handy and admirably adapted for use in schools.

A. C. E.

Elementary Chemical Theory and Calculations.—By JOSEPH KNOX, D.Sc. 103 pages. $7\frac{1}{2}$-in. × 5-in.
(Gurney & Jackson. Price 2/- net.)

This work is only intended to be used with a textbook of systematic chemistry. The theoretical matter usually included in an elementary course, is fairly well covered; the theory is presented with the problems, which will therefore make the book a valuable aid to the teacher, who often finds some difficulty in making the somewhat long arguments, which establish the formula or the atomic weight of a substance, quite clear to the student.

A. C. E.

ZOÖLOGY.

Wild Life in the West Highlands.—By CHARLES HENRY ALSTON. 271 pages. 9 illustrations. $8\frac{1}{2}$-in. × $5\frac{1}{2}$-in.
(James Maclehose & Sons. Price 6/- net.)

This book consists of a number of articles, some of which have been reprinted from *The Scotsman* and deal principally with mammals and birds. They are very interesting reading but do not contain very much new material.

W. M. W.

The Marine Mammals in the Anatomical Museum of the University of Edinburgh.—By SIR WILLIAM TURNER, K.C.B. 207 pages. 17 plates. Over 100 figures. 9-in. × $5\frac{3}{4}$-in.
(Macmillan & Co. Price 6/- net.)

It is a very great advantage to students to know where specimens are to be seen which illustrate any particular work in which they may be engaged. The title of this book speaks for itself and its value is obvious. The introduction is interesting because it tells of the history of the study of Marine Mammals in Scotland and gives hints as to differentiating the various forms. There is a large number of illustrations, the great majority of which are embodied in the text at the exact place where reference is made to them, and hence they are not provided with underlines.

W. M. W.

SYNTHETIC RUBBER.*

By GEOFFREY MARTIN, Ph.D., M.Sc., B.Sc.

Lecturer on Chemistry at Birkbeck College, London.

Author of "Practical Chemistry," "Triumphs and Wonders of Modern Chemistry," "Industrial and Manufacturing Chemistry," "Researches on the Affinities of the Elements," etc., etc.

The commercial production of artificial or synthetic rubber is undoubtedly the most important problem, from a financial standpoint, ever faced by the chemical industry. Compared with it such triumphs as the successful manufacture of artificial indigo, alizarin or camphor become quite small affairs.

Figure 29.
Sir William Tilden's historic samples of Isoprene and Synthetic Rubber.

For example, the total value of synthetic indigo annually produced at the present time does not exceed two million pounds; and the value of all the coal-tar dyes annually exported by Germany only amounts to ten million pounds.

The world's production of such an important chemical as sulphuric acid amounts to about ten million pounds yearly, while the enormous soda industry probably has a value of somewhat similar dimensions.

Yet, at the present time, crude rubber is annually produced of a value reaching the enormous total of thirty-four million pounds, and were we to add up the value of all manufactured rubber goods we would arrive at figures far exceeding those given for crude rubber, and running into some hundreds of millions of pounds. Huge as these figures are, there is no doubt that the demand for rubber far exceeds the supply, and for this reason the price paid for it considerably exceeds its cost of production. The rubber industry is a modern one. From small beginnings it has grown into a vast industry in which more than a hundred millions of capital are invested and in which hundreds of thousands of workmen all over the world find lucrative employment.

Figure 30.
Dr. Matthews' first tube of Synthetic Rubber.

How recent is the growth of this industry may be gauged by the fact that in 1830 only twenty-five tons of rubber were exported from America, a quantity which had increased to seven hundred and fifty tons by 1850, and one thousand five hundred tons by 1870, against eighty-eight thousand tons now produced from all sources, and representing an annual value of thirty-four million pounds: this great change having occurred well within the lifetime of a single man. Within the last ten years no less than seventy million pounds have been invested in rubber plantations, and over twelve thousand tons of plantation rubber are now produced annually.

The selling price of rubber has fluctuated enormously. In 1908 it once sank to two shillings and ninepence per pound, while in 1910 speculators actually ran it up to the fabulous price of twelve shillings and sixpence per pound, and many were the fortunes made and lost over rubber in that year, which recalls to mind the times of Priestly, who in 1770 could only purchase it at the rate of £16 per pound. At the present time good Para rubber sells

* See also an interesting article in "Knowledge" March, 1912, by Mr. Stanley Redgrove. The reader who wishes for a full account of the technical literature, and the chief patents relating to synthetic rubber, will find them fully discussed in my recent book "Industrial and Manufacturing Chemistry, Organic," published by Crosby, Lockwood & Son, London. 21/- net.

at from four shillings to five shillings a pound. Natural rubber could probably be produced profitably at as low a price as one shilling.

Naturally, a product of such value did not escape

Figure 31.

Dr. Otto Hehner testing Messrs. Strange & Graham's process for the production of fusel oils from starch.

the attention of the chemist, and numerous attempts have been made to produce rubber artificially, although until quite recently with no commercial success. The synthetic production of rubber, in fact, is a problem of extreme difficulty. Indeed, so complex that no one individual could hope to get over the difficulties: and it was only when chemists banded themselves together and began to work coöperatively with this object in view that any success was obtained.

To mention some of the difficulties, isoprene—the volatile hydrocarbon from which synthetic rubber was first obtained—is a liquid so volatile that it has only to be poured from one glass to another a few times before it all disappears in invisible vapour; it could at first only be produced by imperfect methods, and the yield was so bad that Kondakow could only obtain ten grammes, while Ipatjew only managed to make five grammes and Euler not two grammes! Before much progress could be made, methods had to be laboriously worked out for obtaining it in quantity. The chemists employed by the great German firm, Fr. Bayer & Co., of Elberfeld, endeavoured to obtain isoprene from coal-tar products in no less than fifty distinct ways, and all these ways failed except one! Indeed, until the chemical constitution of rubber had been worked out with a tolerable degree of certainty, its synthetic production commercially was scarcely realisable; the recently discovered methods of producing synthetic rubber by a chain of processes from maize, other cereals, potatoes or petroleum has been an immensely laborious task, requiring years of work and a large group of investigators. For any single man to have attempted it would have been hopeless.

An Englishman, Greville Williams, seems to have been the first to produce anything resembling rubber from isoprene nearly fifty-two years ago (in 1860); next, in 1875, Bouchardat, in France, definitely found that isoprene could be converted into rubber. In 1882, 1884 and 1892, Sir William A. Tilden (Figure 33) worked out the problem much further, and finally showed that synthetic rubber could be vulcanised like ordinary rubber. A large number of investigators have since worked at the problem, amongst whom should be mentioned Kondakow, Wallach, Mariutza, Weber, Thiele and many others. Kondakow especially, a Russian by birth, made many valuable observations.

About 1903, Professor Carl Harries (Figure 34), of Kiel University, began his epoch-making work on rubber, and in 1904 it was in full swing. The present writer was at that time studying at Kiel University and well remembers how Professor Harries installed electrical apparatus for producing ozone in quantity in some of the rooms, while everywhere danger notices were posted up "Dangerous to Life—Do not Touch," evidently to prevent inquisitive students from electrocuting themselves with the powerful high tension currents or blowing themselves up with the explosive ozonides which at that time he was producing in quantity.

Professor Harries is in many ways an interesting personality. He is reputed to be a man of enormous wealth, and only a few years ago he bought the Kaiser's famous racing yacht, the "Meteor"; he is

Figure 32.

Tubes containing Isoprene polymerising to rubber in Messrs. Strange & Graham's laboratory.

a well-known figure in German aristocratic circles. At the present time he, it is believed, is working in conjunction with some of the world-famous German chemical firms with the object of producing synthetic rubber commercially.

Harries' work was really epoch-making in every way. He indicated the probable constitution of rubber, reducing it to a simple formula; he showed how to prove chemically whether a substance was a true rubber or not, and indirectly his researches drew the attention of the chemical world to the enormous prizes to be won by the successful synthetic production of rubber. The stimulus produced by Harries' work, coupled with the high price of natural rubber, soon reflected itself in industrial chemical circles, and from 1907 onwards the patent literature bears witness to the extraordinary activity reigning in this department of chemistry.

Among the large continental firms which took part in the race were Fr. Bayer & Co., of Elberfeld, Germany, the Badische Aniline und Soda Fabrik, of Ludwigshafen, and Messrs. Schering, of Berlin. A photograph of Dr. Fritz Hofmann, who directed the work of the chemists of Fr. Bayer & Co., is shown in Figure 35.

Meanwhile in England the firm of Messrs. Strange and Graham united with a number of chemists of note with a view to produce synthetic rubber, and so the "Synthetic Products Co." of London came into existence. No less than fifteen chemists and bacteriologists were thus united at work on the problem. Foremost among these chemists must be mentioned Dr. F. E. Matthews (Figure 36), of the firm of Strange & Graham, who suggested the fusel oil route for the manufacture of isoprene and who was the first to discover and patent the sodium process of polymerising isoprene quantitatively into rubber, thereby making possible the commercial manufacture of synthetic rubber.

Mr. E. Halford Strange (Figure 37), head of the firm of Strange & Graham, organised the work of the group and brought into existence the company; Professor W. H. Perkin, junr., F.R.S. (Figure 38), Professor of Chemistry at Manchester University, with his two assistants Mr. Harold Davies and Dr. Weizmann, perfected the chemical processes employed in producing isoprene. Professor Perkin is the son of the famous Sir William Perkin, who brought into existence the aniline dye industry, and made a fortune out of it, although subsequently the colour industry went over into German hands.

Professor Perkin, who has produced an enormous quantity of research work of the highest quality in pure chemistry, has evidently inherited the practical abilities of his father; for he, a few years ago, invented the "non-flam" process for permanently fireproofing cotton goods.

Professor A. Fernbach (Figure 39), of the Pasteur Institute, succeeded in producing acetone and fusel oils cheaply by a process of fermentation from cereals, thereby producing the raw material for the manufacture of synthetic rubber.

Later, the group was joined by Sir William Ramsay (Figure 41), the famous discover of Argon, Helium and other inert atmospheric gases; it will be recollected that Sir William Ramsay quite recently resigned his professorship of chemistry at University College, London, about the same time that the company was formed.

Sir W. A. Tilden (Figure 33) also joined the company as a consulting chemist. It will be recollected that Sir William Tilden nearly thirty years ago had performed some epoch-making work on isoprene, and the formation of synthetic rubber from it.

Before we can give an account of the chemical processes for producing synthetic rubber commercially, we must explain its chemical constitution.

The net result of a vast amount of research work performed by various investigators, has been to show that when certain unsaturated hydrocarbons containing the grouping :C:C.C:C: are allowed to polymerise (*i.e.*, condense into more complicated bodies) they form a series of caoutchoucs or rubbers which possess many of the properties of the best sorts of natural rubber, including the power of vulcanising. Natural rubber is the rubber produced by the polymerisation of one particular hydrocarbon called *isoprene*; but the chemical sisters and brothers, so to speak, of isoprene all produce rubbers of different sorts, some of them with new and valuable properties for special purposes.

The hydrocarbons from which technical synthetic rubber have been formed are:—

Butadiene (Erythrene, Divinyl), $CH_2=CH-CH=CH_2$.

β-Methyl butadiene (*isoprene*, methyl divinyl), $CH_2=C(CH_3)-CH=CH_2$.

β-γ-Dimethyl butadiene (di-isopropylene, dipropylene), $CH_2=C(CH_3)-C(CH_3)=CH_2$.

The first substance is at ordinary temperatures a gas, but readily condenses on cooling to a volatile liquid. The other two substances are volatile

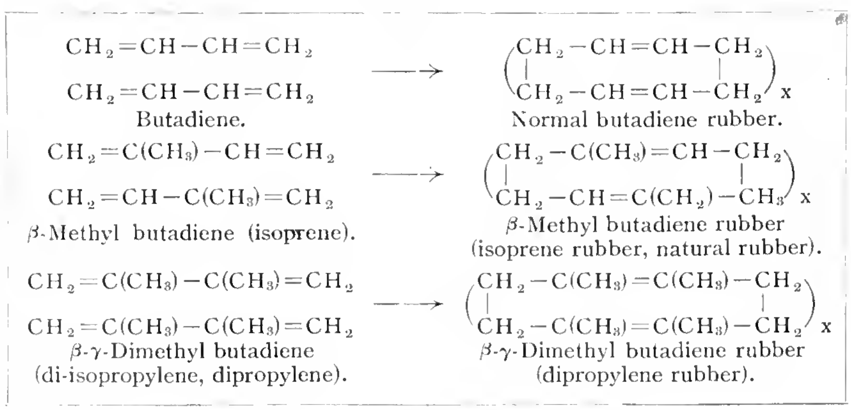
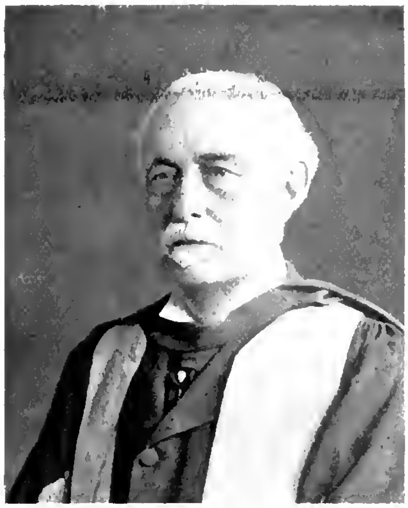


Table 6.



From a photograph by *Lafayette, Ltd.*

FIGURE 33.
Sir William A. Tilden.

From a photograph by *F. Urbahns.*

FIGURE 34.
Professor Carl Harries.

From a photograph by *Herrmann & Klein.*

FIGURE 35.
Dr. Fritz Hofmann.

From a photograph by *Speaight, Ltd.*

FIGURE 36.
Dr. F. E. Matthews.

From a photograph by *Hazel.*

FIGURE 37.
Mr. E. Halford Strange.

FIGURE 38.
Professor W. H. Perkin, Junr.

FIGURE 39.
Professor A. Fernbach.

From a photograph by *Lafayette, Ltd.*

FIGURE 40.
Mr. Charles A. Pim.

FIGURE 41.
Sir William Ramsay.

colourless liquids, boiling at 36°C and 71°C respectively. Higher members of the series are also known.

The polymerisation* may be regarded as taking place as shown in Table 6.

And, in general, a rubber derived from a homologue of butadiene, such as $CH_2{=}CX{-}CY{=}CH_2$, would produce rubbers of the formulae :—

$$\left(\begin{array}{l} CH_2{-}CX{=}CY{-}CH_2 \\ | \qquad\qquad\qquad\quad | \\ CH_2{-}CX{=}CY{-}CH_2 \end{array}\right)_x \quad \text{and} \quad \left(\begin{array}{l} CH_2{-}CX{=}CY{-}CH_2 \\ | \qquad\qquad\qquad\quad | \\ CH_2{-}CY{=}CX{-}CH_2 \end{array}\right)_x$$

Once the hydrocarbons butadiene or isoprene are obtained, it is the simplest thing in the world to turn them into rubber.

All that has to be done is to introduce into the mobile liquids a small amount (five per cent. or less) of thin sodium wire and warm gently for some hours or days, when the products will change from liquids into solid masses of rubber. Figure 32 shows the process being carried out on the small scale. The sodium acts "catalytically" *i.e.*, it is not changed by the process and may be recovered afterwards and again utilised. It induces change without itself changing. Simple as this process seems, it took years of research to discover it, and then it seems to have been discovered almost simultaneously and independently by Dr. Matthews and Professor Carl Harries. The English investigator, however, owing to a priority of discovery of only about three months, succeeded in securing the patent world-rights. The discovery was alighted on almost as an accident. It occurred to Dr. Matthews that it would be of interest to study the action of sodium upon isoprene.

He, therefore, sealed up some isoprene with sodium in the tube shown in Figure 30 and set it aside in July, 1910. In the month of August, during a holiday, he was compelled suddenly to return to London, and on looking at his tube found that the liquid isoprene had now become viscid and contained a proportion of a remarkably good variety of rubber. The tube was again set aside, and in September was found to contain a solid mass of amber-coloured rubber. The patent was applied for on October 25th, 1910, only three months before the German application.

Before this time other methods were known of polymerising isoprene, notably the simple process of heating alone, but none of these methods can compare either in rapidity or certainty with the sodium method. Fr. Bayer & Co., of Elberfeld, simply heat under pressure, which certainly polymerises the isoprene. To show what an important advance this represents I will quote the words of Dr. Fritz Hofmann (who directed the research work on rubber for the German firm of Fr. Bayer & Co.), as published in his Freiburg address a few weeks before the publication of the sodium process. He says :—

"The obtaining of isoprene in quantity did not end our troubles, on the contrary, they now began in earnest, for now arose the problem of converting this benzine-like liquid into the tough, elastic, and resistant colloid known as rubber.

"At first sight nothing seemed simpler; for do we not read in Beilstein's Chemistry that 'isoprene is converted into rubber by treating with hydrochloric acid'? All we had to do then, was to add some hydrochloric acid to our isoprene; this we did, but alas! not a trace of rubber did we obtain, merely an oily chloride.

"Next we tried the action of light, which Wallach has shown to turn isoprene into a rubber-like substance. But such experiments require much patience when one is waiting for synthetic rubber, and at last got on our nerves: for after standing one and a half years in the light our isoprene had only turned into a fluid of the consistency of a thin syrup—evidently a perfectly useless technical process. So that now after months of experimenting we had obtained no useful result. In desperation we next tried acting on our poor isoprene with every possible and impossible chemical and physical influence in order to induce it to polymerise—but to our sorrow it obstinately refused to thicken !"

In fact, such great difficulties were experienced by German experimentalists in causing isoprene to thicken into rubber, that we actually find Professor Carl Harries in 1907, and even in 1910, doubting whether Tilden ever really obtained rubber from isoprene. But like many eminent scientific men Professor Harries is nothing if not a critical doubter.

So that the mere fact that he doubted whether

* As a matter of fact the polymerisation is a much more complex matter than this. Thus sticky or liquid lower polymerides are first formed, and the final polymerisation product is formed gradually by further condensation. Also Harries has shown (*Annalen*, **383**, 157-229) that different rubbers are obtained by using different polymerisation agents, *e.g.*, when butadiene is polymerised by heating alone or with acetic anhydride, it yields a "normal butadiene rubber," $(C_8H_{12})_n$, while when polymerisation is effected by sodium wire it yields quite a different rubber, called "sodium butadiene rubber." In a similar manner several isomeric rubbers are obtained by polymerising isoprene and dimethyl butadiene respectively. Thus, for isoprene rubber (natural rubber) Harries suggests (*Annalen*, **383**, page 187) the presence of three isomerides, which have the double linkage in a different position, as shown in Table 7.

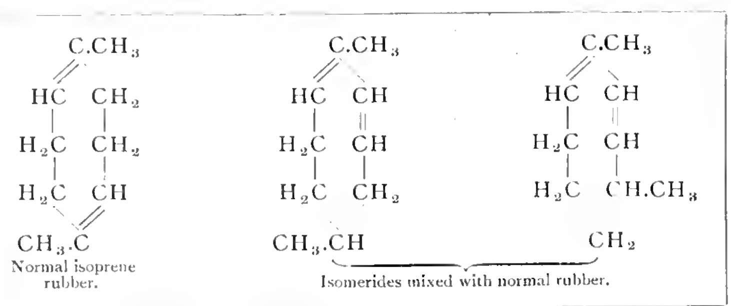


TABLE 7.

Moreover, each of these isomerides may have several stereoisomerides. It will be seen that according to Harries' views the basis of rubber is the hydrocarbon cyclopentadiene (1 : 5) which contains a ring of eight carbon atoms:—

$$\begin{array}{l} CH_2{-}CH{=}CH{-}CH_2 \\ | \qquad\qquad\qquad\quad | \\ CH_2{-}CH{=}CH{-}CH_2 \end{array}$$

Pickles (*Jour. Chem. Soc.*, 1910) and Ostromisslensky (*Jour. Russ. Phys. Chem. Soc.*, 1912, 44, 204–244), suggest rings containing more than eight carbon atoms.

synthetic rubber had ever been obtained by Tilden, years before he had himself begun to experiment with this object, need not cause much surprise; more especially as all organic chemists look with grave suspicion on the labours of their fellow-workers.

However, Figure 29 will set the matter at rest; for therein is shown a photograph of Sir William Tilden's actual sample of synthetic rubber, which was obtained by the complete polymerisation of isoprene obtained by him no less than thirty years ago. The liquid isoprene had taken about twenty years to spontaneously solidify into rubber of good quality! This fact settles all argument about the matter, and there are still a great many people who distinctly remember him showing a sample of synthetic rubber, at a meeting of the Birmingham Philosophical Society on May 18th, 1892, the paper being published in the *Chemical News*, Vol. LXV., page 265 (1892).

After the foregoing remarks it will be seen that the commercially successful production of synthetic rubber depends entirely upon the possibility of producing cheaply the hydrocarbons, butadiene and isoprene — for both yield excellent rubbers.

It must be obvious that the raw materials we start with must not only be very cheap but must also be obtainable in practically unlimited quantity, if we are to produce a synthetic rubber capable of competing in any way with natural rubber.

Among the raw materials which have been suggested as a starting point may be mentioned:—

(1) Coal Tar. (2) Carbohydrates such as starch, sugar or wood. (3) Petroleum. (4) Turpentine oils.

We will deal with methods of obtaining isoprene or butadiene from these sources, taking each in turn. Dr. Fritz Hofmann, of the firm of Fr. Bayer, of Elberfeld, chose coal-tar as his starting point, and worked out a method of producing both isoprene and butadiene in quantity from this substance.

To produce butadiene, first of all *phenol* is isolated from coal-tar and then is converted by the following series of operations into butadiene. (See Table 8.)

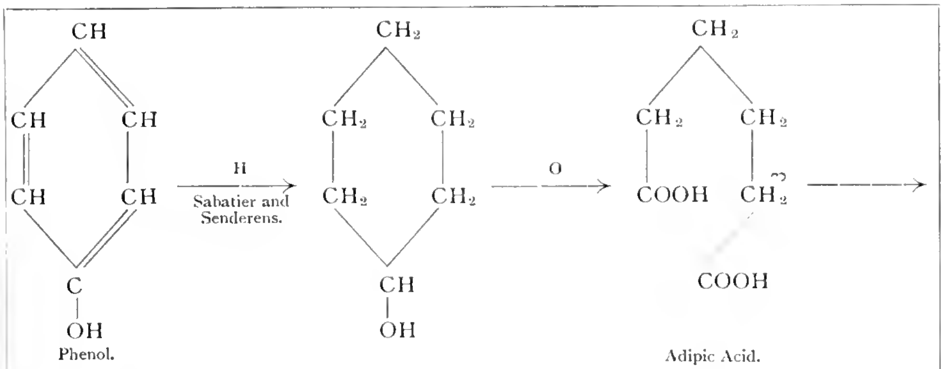
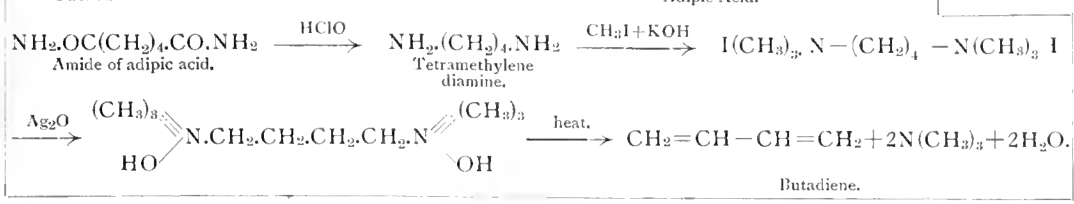



Table 8.

If, however, isoprene is required, it also is obtained from coal tar by isolating paracresol from it and then treating it to the series of reactions shewn in Table 9.

The β-Methyltetramethylene diamine thus produced is converted into isoprene by heating it with caustic potash, water, methyl alcohol, and methyl chloride, CH_3Cl, in an autoclave for twelve hours at 100° C., whereby the compound $Cl(CH_3)_3N.CH_2.CH(CH_3).CH_2CH_2.N(CH_3)_3Cl$ is produced. This

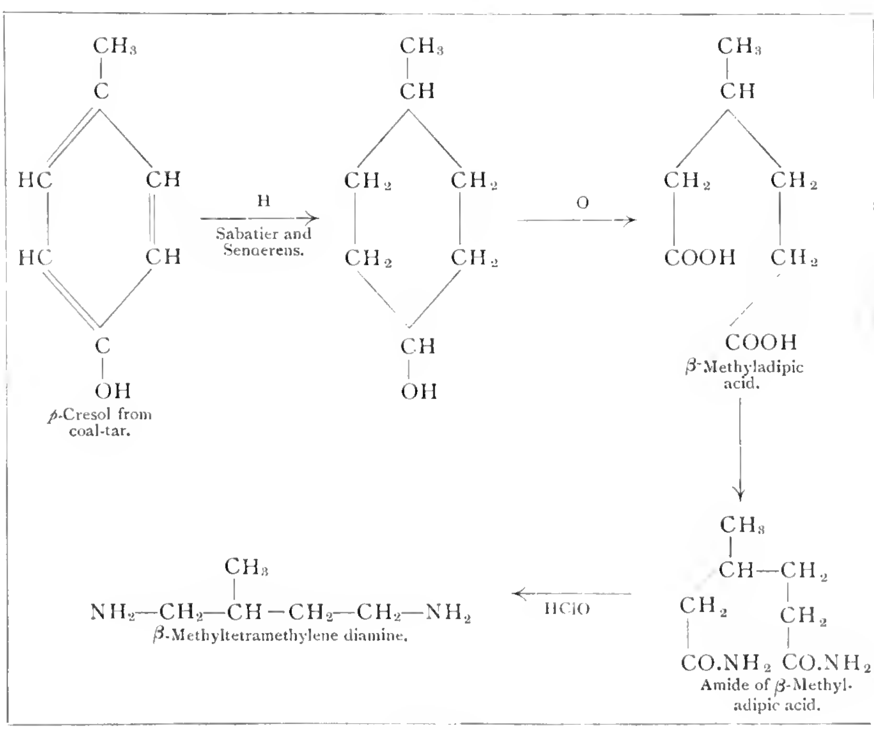


Table 9.

is converted into the base by replacing the Cl with OH by treating with silver oxide in the usual manner. The base, when distilled, breaks up into isoprene, thus

$$\begin{matrix}(CH_3)_3 \\ HO\end{matrix}\!\!>N.CH_2.CH(CH_3).CH_2.CH_2.N\!\!<\!\!\begin{matrix}(CH_3)_3 \\ OH\end{matrix} \longrightarrow$$

$$\underset{\text{Isoprene.}}{CH_2{=}C(CH_3){-}CH{=}CH_2} + 2N(CH_3)_3 + 2H_2O.$$

Homologues of isoprene may be produced in a similar manner.

By this paracresol method Hofmann produced *gallons* of isoprene, which was converted into rubber by polymerising by heating, and the rubber thus obtained was made into a motor-car tyre. One driving wheel of a motor-car was fitted with a tyre made of the best natural Para rubber (the best natural rubber known), and the other with this synthetic rubber; after six months' hard wear the Para tyre was badly worn, while the synthetic tyre was practically untouched—a conclusive proof of what can be done with synthetic rubber.

Quite recently (see *The Daily Mail*, September 11th, 1912,) in New York, two excellent specimens of synthetic rubber tyres, one a heavy five-and-a-half-inch and the other a four-inch tyre, were exhibited before a gathering of the world's chemists, by Fr. Bayer & Co.

(To be continued.)

NOTICES.

SECOND-HAND APPARATUS.—A very useful catalogue of second-hand apparatus and accessories has been issued by Messrs. H. F. Angus & Company, of 83, Wigmore Street, London. It specially deals with microscope stands, objectives, and eye-pieces by all the well-known makers. There are also lists of accessories, and of other instruments, such as telescopes, field-glasses, spectroscopes, and photographic lenses. It is practically certain that if there were not facilities for the obtaining of apparatus at a cheap rate many useful experiments would remain unmade, and it is a great advantage to workers that Messrs. Angus will give a written guarantee that any second-hand instrument which they sell has been tested and adjusted so that it will work as well as ever it did.

MESSRS. W. WATSON & SONS. LTD.—We have pleasure in announcing that Messrs. W. Watson & Sons have moved their electro-medical department from their establishment in High Holborn (which they have occupied for more than fifty years) to their new premises at 184, Great Portland Street, W., where, owing to the greater scope, this section of their business can now be carried on more advantageously than hitherto. For not only are there show-rooms for the display of electro-medical apparatus in every branch, but a testing laboratory has been provided where all the appliances will be carefully examined and checked on their receipt from the works at High Barnet before they are despatched to customers.

LANTERN SLIDE GALLERY.—Mr. J. H. Steward has opened at 406, Strand, a new lantern slide gallery, wherein can be seen at any moment two thousand slides, illuminated by electric light. Here will be found a good selection of slides of scientific interest, in addition to full series of photographic views of excellent quality, both plain and coloured, from all parts of the world. We noted specially a fine series of astronomical slides, produced by the Woodburygravure process. We welcome this addition to the very small number of lantern slide galleries in London.

NOTES ON NEW BOOKS.—From Messrs. Macmillan and Company comes an illustrated list with descriptive notes of their new and forthcoming books. The short paragraphs have advantages in some ways over reviews, because the publisher can say in them exactly what he wants his prospective readers to know about the book.

THE ROYAL INSTITUTION.—The following are the Lecture arrangements at the Royal Institution before Easter:—Professor Sir James Dewar, a Christmas Course of Six Experimentally Illustrated Lectures, adapted to a Juvenile Auditory: 1, Alchemy; 2, Atoms; 3, Light; 4, Clouds; 5, Meteorites; 6, Frozen Worlds. Professor William Bateson, Six Lectures on "The Heredity of Sex and some Cognate Problems." Professor H. H. Turner, Three Lectures on the Movements of the Stars: 1, "The Nebular Hypothesis"; 2, "The Stars and their Movements"; 3, "Our Greater System." Mr. Seton Gordon, Two Lectures on "Birds of the Hill Country." Professor B. Hopkinson, Two Lectures on "Recent Research on the Gas Engine." Sir Sidney Lee, Three Lectures on "The Dawn of Empire in Shakespeare's Era." Mr. W. B. Hardy, Two Lectures on "Surface Energy." Dr. H. Walford Davies, Three Lectures on Aspects of Harmony: 1, "Chord Progression"; 2, "Added Dissonance"; 3, "The New Whole Tone Chord and its Predecessors." Professor Sir J. J. Thomson, Six Lectures on "The Properties and Constitution of the Atom." The Friday Evening Meetings will commence on January 17th, when Professor Sir J. J. Thomson will deliver a Discourse on "Further Applications of the Method of Positive Rays." Succeeding Discourses will be given by Professor J. O. Arnold, Mr. George M. Trevelyan, Sir John Murray, Professor Andrew Gray, Mr. Spencer V. Pickering, Mr. C. T. R. Wilson, Professor the Hon. R. J. Strutt, and Mr. A. E. H. Tutton.

CLASSES IN PHOTOGRAPHY.—Mr. Edgar Senior's work at the following various educational centres begins on the dates set forth below.

Battersea Polytechnic.—Tuesday, January 14th.

South Western Polytechnic, Manresa Road, Chelsea.—Monday, January 13th.

The London Central Y.M.C.A., Tottenham Court Road.—Friday, January 10th.

LANTERN SLIDES.—The new catalogue of lantern slides issued by Messrs. Flatters & Garnett, Ltd., of Dover Street, Manchester, consists of one hundred and thirty-six pages, and many of the subjects in the list are from negatives illustrating natural history and cannot be obtained elsewhere; such, for instance, as the series of British birds, nests and eggs by Mr. Stanley Crook, and the British Plant Associations photographed by Mr. W. B. Crump. We can give the highest praise to the specimen slides which Messrs. Flatters and Garnett have submitted to us for review. The bird-photographs are excellent, as are the plant studies, and all of them should prove extremely useful to lecturers who have not the opportunity of making their own slides, or who wish to fill up gaps in their series. Teachers, who as a rule are not blessed with large means, should be able to take advantage of the slides, as they are by no means expensive. The examples sent to us are contained in one of Messrs Flatters & Garnett's special mahogany dispatch boxes, which we commend to our readers, and which are described on the cover of the catalogue.

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

FEBRUARY, 1913.

SYNTHETIC RUBBER.

By GEOFFREY MARTIN, Ph.D., M.Sc., B.Sc.

Lecturer on Chemistry at Birkbeck College, London.

Author of "Practical Chemistry," "Triumphs and Wonders of Modern Chemistry," "Industrial and Manufacturing Chemistry," "Researches on the Affinities of the Elements."

(*Continued from page 40.*)

We now come to discuss methods for obtaining butadiene and isoprene from starch, which, next to cellulose or wood, is the most abundant of all vegetable material, occurring in cereal grains and potatoes.

There are several methods of transforming starch into isoprene. One of the processes now actually being worked is known as the "fusel oil" route, and was first suggested by Dr. F. E. Matthews, of the Synthetic Products Company.

Maize or potatoes are made into a mash with water, which is then inoculated with new varieties of bacteria discovered by Professor A. Fernbach, of the Pasteur Institute of Paris, and the whole is allowed to ferment for about a week in a special vat (see Figure 31), when about forty-two per cent. of the starch contents were found by Dr. Otto Hehner, the well-known analyst, to have been converted into fusel oils, the main constituent being butyl alcohol. Figure 45 shows the vats now being erected by the Synthetic Products Co., for the manufacture of fusel oil on a commercial scale. By varying the conditions of fermentation *acetone* can be obtained at the same time in large quantities.

Figure 42.
Messrs. Strange & Graham's Apparatus for the production of butadiene from butylene dichloride.

Next, the fluid is removed from the vat and is distilled, whereby the fusel oils and acetone are separated from the watery residues. Next, into the heated fusel oil a stream of dry hydrochloric acid gas is passed (which, as every schoolboy knows, is made by the action of sulphuric acid on common salt), when monochlorides are formed thus:—

$$CH_3CH_2CH_2CH_2OH + HCl = CH_3CH_2CH_2CH_2Cl + H_2O$$

Butyl Alcohol. Hydrochloric Acid Gas. Butyl Chloride. Water.

The butyl chloride thus obtained is then treated with chlorine gas to convert it into dichlorides, thus:—

$$\underset{\text{Butyl Chloride.}}{CH_3CH_2CH_2CH_2Cl} + \underset{\text{Chlorine Gas.}}{Cl_2} = \underset{\text{Butylene Dichloride.}}{CH_3CHClCH_2CH_2Cl} + \underset{\text{Hydrochloric Acid.}}{HCl}$$

Dichlorides of the formulae $CH_3CH_2CHCl.CH_2Cl$ and $CH_2Cl.CH_2CH_2CH_2Cl.$ are simultaneously formed.

If chlorine acts unrestrainedly upon the butyl chloride other products in addition to dichlorides are produced. A special apparatus had to be invented so as to remove the dichloride as rapidly as it is formed. The apparatus of Mr. Charles A. Pim (see Figure 40) is shown in Figure 43. The butyl chloride is boiled in the flask until the chlorinating chamber is full of vapour and liquid drops from the end of the reflux condenser, while a stream of dry chlorine is passed in rapidly, care being taken, however, that the butyl chloride remains in excess. During the whole operation the apparatus must stand in a good light, and on dull days ultra-violet light from a mercury lamp is used to facilitate chlorination. As fast as the higher-boiling dichloride is produced it drops back into the boiling flask, and as this is provided with an efficient fractionating column, only the lower-boiling butyl chloride can pass into the chlorinating column; the dichlorides are thus removed by gravity from the sphere of the action of the chlorine and thus escape further chlorination. The liquid in the flask is finally fractionated and the dichlorides isolated in a pure condition.

These dichlorides are next passed over hot soda lime contained in a tube heated to 470°C as shown in Figure 42; the soda lime abstracts hydrochloric acid from the dichlorides and produces butadiene thus:—

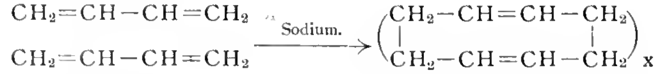
$$\underset{\text{Butylene Dichloride.}}{CH_3CHClCH_2CH_2Cl} \xrightarrow[-2HCl]{\text{Hot Soda-lime.}} \underset{\text{Butadiene.}}{CH_2{=}CH-CH{=}CH_2}$$

The issuing butadiene is a gas, but on cooling it condenses to a colourless liquid, and so is easily separated by passing the vapour coming from the hot soda-lime through a vessel immersed in a freezing mixture. A similar method is used for making isoprene from amyl alcohol—as we will see presently.

Professor Perkin also proposes to produce butadiene from aldehyde, CH_3CHO, which is produced from alcohol merely by oxidising it—the alcohol being obtained from the starch of cereals or potatoes by ordinary fermentation with yeast. The aldehyde is treated with a dilute solution of potassium carbonate (washing soda, soda ash) whereby *aldol*, $CH_3CH(OH)CH_2CHO$, is formed. This is then reduced with nascent hydrogen and yields butylene glycol, $CH_3CH(OH)CH_2CH_2Cl.$, which is then converted into 1:3 dichlorobutane, $CH_3CHCl.CH_2CH_2Cl.$, which yields butadiene when passed over hot soda lime as above described. Alcohol at present costs about threepence per pound.

The butadiene, no matter by which of these processes it is produced, is then converted into butadiene rubber by warming with sodium in the manner previously described.

The formation of butadiene rubber is thus represented by Prof. Harries, of Kiel:—



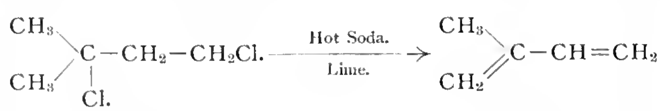
Butadiene. Butadiene Rubber.

A yellowish mass is thus obtained, which is washed with alcohol or heated with steam to drive off any unchanged hydrocarbon. It can be vulcanised to produce an excellent rubber.

It will be noticed that in the two processes above described the raw materials are: *maize or potatoes*—the starch of which at present costs less than one penny a pound; *common salt* (to produce the chlorine and sodium); and *lime*. The total cost of the raw materials does not exceed twopence per pound. In fact, Mr. Strange calculates that synthetic rubber could be produced at fourpence to sixpence per pound. I understand that quite recently Professor Fernbach has further developed the bacteria, so that they will ferment wood in the form of cellulose—instead of maize or potatoes—and produce a fair yield of acetone and fusel oil. This advance, however, has still to be utilised commercially—so that it remains an interesting laboratory experiment.

Instead of starting with butyl alcohol, which is the main constituent of *wine fusel oils*, but which can now be obtained in almost unlimited quantities by the fermentative processes introduced by Professor Fernbach, we can start with *iso*amyl alcohol, which is the main constituent of the fusel oils obtained in spirit manufacture from cereals or potatoes.

*Iso*amyl alcohol has the constitution $(CH_3)_2CH CH_2CH_2OH$. It is first converted into the chloride $(CH_3)_2CHCH_2CH_2Cl.$ by dry hydrochloric acid gas, and the monochloride thus produced is then converted into a dichloride by treating with chlorine gas in a Pim's apparatus as previously described under butyl alcohol. Three dichlorides are thus produced, namely: isopropylethyltrimethylenedichloride, $(CH_3)_2CHCHCl.CH_2Cl.$ (B.P. 142); gem-dimethyltrimethylene dichloride, $(CH_3)CCl.CH_2CH_2Cl.$ (B.P. 152–155) and β-methyltetramethylene dichloride, $CH_2Cl.CH\ (CH_3)\ CH_2CH_2Cl.$ (B.P. 170–172). These dichlorides when passed over hot soda-lime produce isoprene, the soda-lime extracting the elements of hydrochloric acid, thus:—



Butylene Dichloride. Isoprene.

The isoprene is then converted quantitatively into rubber by metallic sodium.

However, as amyl alcohol fusel oils are to-day quoted at one hundred and forty pounds a ton, and have a host of other useful applications, it is doubtful whether such a process would survive competition with the butyl fusel oil process which can be produced at thirty pounds a ton, by Fernbach's new process.

It should also be noted that *isoprene* may be obtained from *acetone* in several ways. For example, Fr. Bayer & Co., of Elberfeld, propose to manufacture isoprene by condensing formaldehyde with acetone in the presence of weak alkali, to form 2-ketobutanol and other products :—$CH_3COCH_3 + CH_2O = CH_3COCH_2CH_2CH_2OH$. From this water is split off and methylene acetone is produced :—$CH_3COCH{=}CH_2$, and from this isoprene is produced. Dr. F. E. Matthews has also worked out methods for changing acetone into isoprene. However, these methods do not appear to be commercially remunerative.

To sum up, then, three practical methods have been devised for obtaining rubber from starch :—

(1) From Fernbach's fusel oil—consisting principally of butyl alcohol and costing about thirty pounds to forty pounds per ton; (2) from industrial alcohol through aldehyde, alcohol costing threepence per pound; (3) from fusel oils obtained from spirits—which at present cost about one hundred and forty pounds per ton.

The raw material is in every case obtained by agricultural processes. Table 10 represents the new industries and their relation to the old. (See page 44.)

Since the whole chain of industries mentioned in this Table ultimately rests upon agriculture as a basis, it would seem that a good time is coming for farmers.

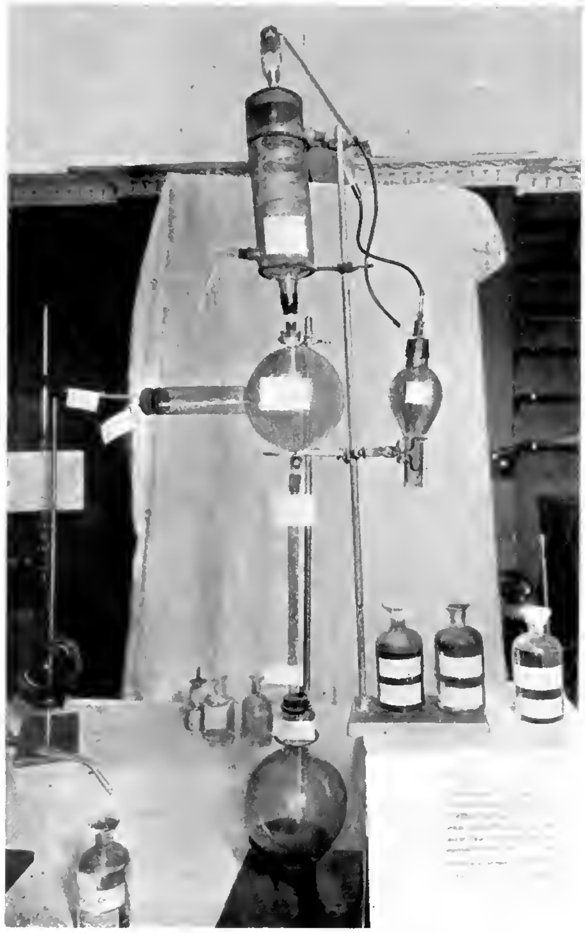


FIGURE 43.
Mr. C. A. Pim's Apparatus for the fractional distillation of butylene dichloride.

So far we have discussed the methods of producing rubber from starch, in the form of cereals or potatoes. It must not be forgotten, however, that wood could be used as a starting point for producing mashes capable of fermentation. For example, several processes are known, and are even worked on a limited scale, of converting wood into sugars, which can then be fermented much in the same way as the starch mashes referred to above. Although possible, however, it is improbable for many reasons that such processes will be able to compete with those which use starch as their starting point.

The next promising method for producing synthetic rubber starts from raw petroleum. From petroleum both butadiene and isoprene have been obtained by special "cracking" processes—for example, passing it over red hot surfaces impregnated with special "contact" substances, and, indeed, at the present time the writer is aware of a vast amount of secret research going on with this object in view.

Somewhat more promising are chemical processes; to give an example, according to one suggested process the petroleum is fractionated, and a product containing isopentane, $(CH_3)_2CH.CH_2CH_3$, is isolated. This is then treated with chlorine and a mixture of dichlorides, $C_5H_{10}Cl_2$, are obtained. These are then sent over hot soda lime, when isoprene is produced thus :—

$$\begin{matrix} CH_3 \\ CH_3 \end{matrix} \!\!> C\,Cl.CH_2CH_2Cl.$$

A dichloride from isopentane.

$$\downarrow \text{ Soda Lime hot.}$$

$$\begin{matrix} & CH_3 & \\ & | & \\ CH_2{=} & C & {-}CH{=}CH_2 \end{matrix}$$

Isoprene.

By treating other fractions of petroleum in a similar manner not only isoprene but also butadiene and dipropylene can be obtained and converted into rubbers in the usual way by treating with sodium.

There still remains to be considered the production of rubber from turpentine oils. When these are passed under certain conditions over hot contact surfaces isoprene may be produced in quite considerable quantities, and a great many patents have been taken out for improving the yield.

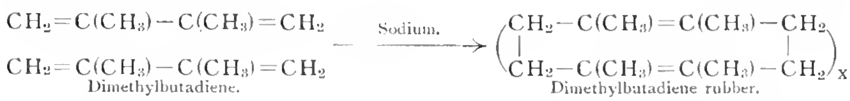
The general consensus of opinion among technical chemists, however, is that the raw materials are too expensive to allow a commercially remunerative synthetic rubber to be produced from turpentine oil.

Before leaving the subject of synthetic rubber manufacture, however, I must say a few words about rubber obtained from still higher homologues of butadiene than isoprene.

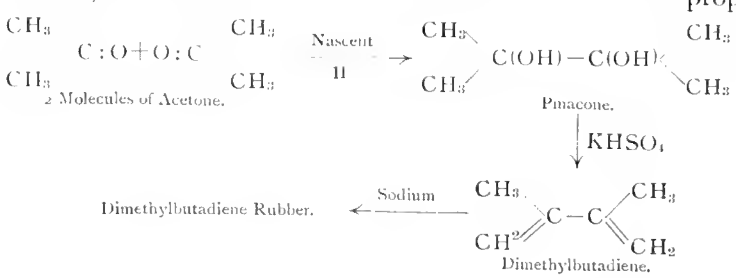
First of all there is the hydrocarbon *β-γ-dimethylbutadiene* also known as dipropylene and isopropylene. This substance is simply butadiene in which two hydrogen atoms are replaced by two methyl groups, thus:—

$CH_2{=}CH{-}CH{=}CH_2$ Butadiene. $CH_2{=}C\,(CH_3){-}C\,(CH_3){=}CH_2$ β-γ-Dimethyl butadiene, dipropylene, isopropylene.

Dimethylbutadiene is also a volatile liquid, boiling at 71°C, and can be turned into a rubber by treating with sodium, thus:—



The rubber thus produced—a white tough leathery mass—can by vulcanisation be made to yield a beautifully elastic substance; unfortunately, however, on allowing the vulcanised product to stand in the air it turns into a sticky mass. Perhaps in the near future experiment may overcome this difficulty and the substance may yet, for special purposes, attain technical importance. Dimethylbutadiene or dipropylene is obtained from *acetone* by reducing it to pinacone by means of magnesium amalgam, and then passing the pinacone over heated potassium bisulphate, which withdraws the elements of water from it, thus:—



Dr. Fritz Hofmann, of Fr. Bayer, Elberfeld, has produced a whole series of similar rubbers, in which ethyl and even phenyl and naphthalene radicles replace the hydrogen of butadiene. So long ago as 1904, Klages and Lauk showed that phenyl isoprene, $CH_2{=}C\,(CH_3){-}C\,(C_6H_5){=}CH_2$ could be made to produce ebonite-like bodies on vulcanisation.

There is thus opened up a rich field of research in the production of these "super-rubbers" from which a veritable mine of ebonite substitutes, bone substitutes, insulators, enamels, or even hornlike artificial glasses, may in the future be manufactured, and an industry be created in these products rivalling that of the coal tar dyes—an industry which also had its origin in investigations connected with the apparently useless products of coal tar. Indeed, no man can foresee the consequences of the research work now being pushed forward with such vigour in every direction in this new field of synthetic chemistry.

Let us hope, however, that these new industries will remain in Great Britain and not pass, like the coal tar dye industry, out of our hands into those of the highly-trained scientific Germans, merely because British manufacturers were too ignorant to employ proper research chemists in a chemical industry, and utterly despised the value of science applied to industry. We have had a shock in this direction, and let us hope that British manufacturers have now had this home truth driven home—that Science and Industry go hand in hand, and that pre-eminence in the one spells pre-eminence in the other.

And now a word about the attitude of the "Practical man" towards these new industries.

I cannot do better than quote a few opinions which these "practical men" have published in trade or technical journals.

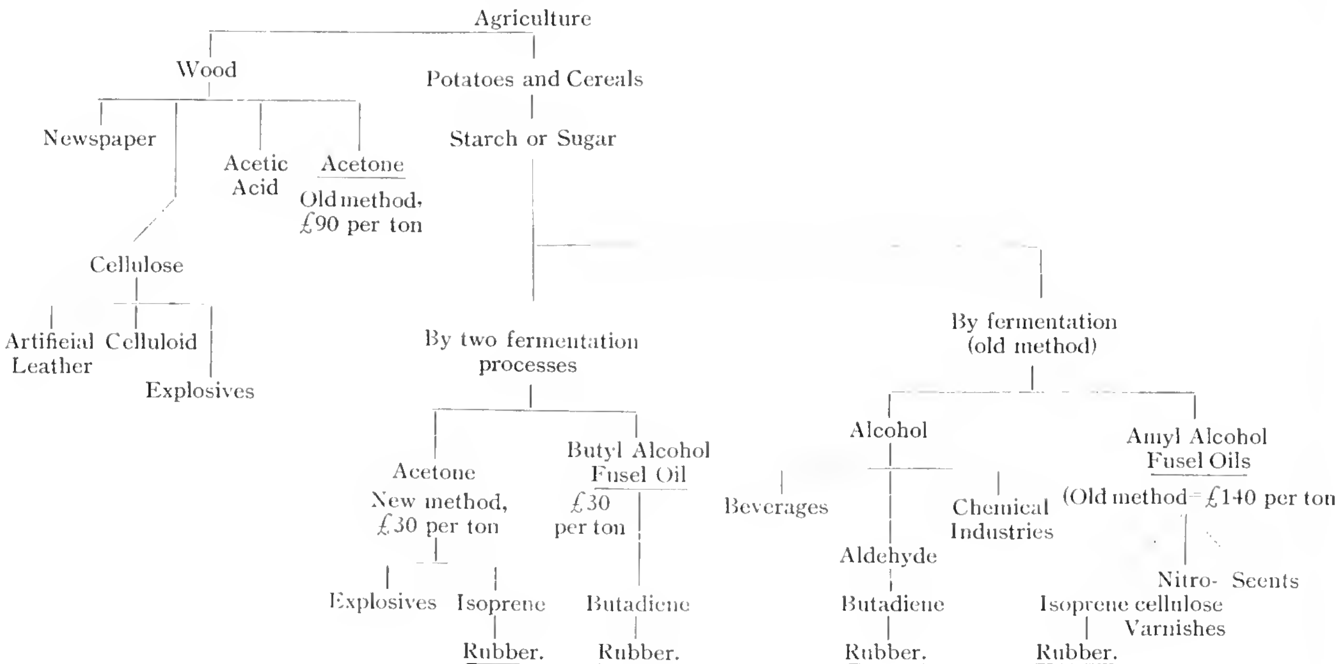


TABLE 10.

In one important technical paper we read to our surprise: "Naturally produced rubber, containing as it does the greatest elasticity with the greatest strength, will ever hold the market"—a statement which may be characterised as simply untrue. Another "practical man" writes: "I observe that twenty-five thousand pounds of the subscribed money is to be devoted to experimenting with the object of producing a rubber substitute. How does that appeal to your readers as a business project?"

"It is not explained how or at what rate the proposed money is to be expended, unless it was thought wise to leave to the public's imagination the rapidity with which laboratories can dissolve gold." The gentleman is, apparently, supremely unconscious that on the basis of research work alone vast chemical firms have in Germany come into existence which pay dividends of between twenty and thirty per cent., and that research work in industrial chemistry is probably the most paying investment that it is possible to make. On research alone some of the large German firms spend thousands upon thousands of pounds annually—one dye factory alone maintaining a huge scientific library and no less than three hundred university-trained chemists—and as a result they dominate the world's markets!

Figure 45.
Fermentation Vats now being erected at Rainham, Essex, by the Synthetic Products Company for the production of fusel oil on the commercial scale.

However, the following luminous extract, gravely printed in a financial journal, fairly reaches the limit:—

"Is it not entirely a question of trying to make bricks without straw, to try and make rubber out of rubbish?

"People have tried to make gold and diamonds, and in these cases the reward of anyone successful would be enormous. Are they more likely to be able to make rubber, the real thing I mean, with all the live properties in it? As well try to make an egg which will hatch out."

However absurd this letter appears to the trained scientific man, it fairly accurately voices the opinions of a great many people connected with the rubber trade—as many personal conversations have convinced me.

It is quite a common opinion that rubber is "alive" in a way, with a special "nerve," and, therefore, like other living matter, cannot be synthesised.

As a matter of fact, however, rubber is simply a colloidal chemical compound or mixture of chemical compounds, and all its properties, both chemical and physical, are all explicable by ordinary chemical or physical explanations without having resort to "vital forces" or anything of a like nature. It is only bare justice to these practical men to say that I have not yet heard any one of them assert that rubber has a "soul" as well as "vital" properties.

Figure 44.
Mr. Harold Davies, Assistant to Professor W. H. Perkin, distilling isoprene for making synthetic rubber.

Many other "practical" men consider that synthetic rubber must necessarily prove inferior to "natural" rubber because "natural" things are always better than "artificial" and that "Nature" is "perfect." These individuals have evidently some characteristics in common with the "back-to-nature" cranks, who wish us to live in trees and do without baths merely because our simian ancestors had the misfortune to be compelled to undergo these hardships.

At the back of the minds of this variety of "practical" men lies, no doubt, the thought that "Nature" has in some mysterious way a special interest, possibly of a financial kind, in enabling plants to produce a material good for making motor-car tyres, and that, therefore, the chemical compound caoutchouc, prepared from the juices of certain tropical trees, must necessarily be superior to the same chemical compound prepared from petroleum or starch or any other material of like nature. As a matter of fact scientific botanists have unanimously come to the conclusion that "Nature" did not have motor-car tyres in view when she evolved these rubber-producing juices. She was probably trying to perfect a means of protecting such trees against boring insects. When a puncture was made by an insect in the bark of a tree the sap was exuded and the insect was overwhelmed, and so by natural selection the highly developed rubber trees of to-day were gradually evolved in the forests of Brazil and of Africa. Other views of latex formation are that the rubber is a reserve food material for the plant, or is an excretory material of the plant's metabolism.

Figure 46.

A corner in Messrs. Strange & Graham's Laboratory showing tubes of isoprene polymerising to rubber.

The fact that the coagulated parts of the juice can also serve to make motor-car tyres is a perfectly accidental circumstance, which so far from being beneficial to rubber trees may probably lead to their extinction—of the wild varieties at any rate—if the destruction of the rubber forests continues at its present rate.

In fact, the synthetic chemist, who is solely directing his energies to producing a substance suitable for making good motor-car tyres or waterproofing material has obviously a great advantage over Dame Nature, who has entirely different objects in view, and there can be little doubt who will in the long run produce the superior product for the uses of industry.

Indeed, the prejudice against "artificial" rubber, as such, is about as reasonable as a prejudice against "artificial iron" or "artificial copper." The production of iron or copper from the earthy matters known as their ores by chemical processes is perfectly analogous to the production of rubber from substances like starch or petroleum by chemical processes; and in the same way that the "artificial" iron or copper of to-day is far superior to the "natural" iron and copper, still to be found in various parts of the world, for the purpose of making engines or tools, so also will the "artificial" rubber of fifty years hence be superior to the "natural" rubber of that day for industrial purposes. Special artificial rubbers will no doubt made be for special purposes, just as special kinds of steel are made to-day for special kinds of work.

That "artificial" rubber will at a blow displace natural rubber is highly unlikely—even if the process of manufacture is perfected. The substitution of the one for the other will probably be a slow process, and may never reach completion—so vast is the demand for raw rubber and so limited are the supplies of raw material. All that can be said at present is that chemists have succeeded in producing synthetic rubber, and that no scientific reason stands in the way of them putting it on the market.

A DETAIL IN THE PROTECTIVE COLOURATION OF BUTTERFLIES.

(Read before the Ashmolean Society of Oxford.)

By The Rev. F. BENNETT, M.A., Oxon.

I do not know whether the particular detail of protective colouration to which I wish to draw attention has been already described in any of the multitudinous works dealing with that fascinating subject; but, if it has, I will refrain from exclaiming with the ancient author: "May they perish who have made our *observations* before us!"

In the case of many of our English butterflies, when one of them alights, and intends, not merely to sun himself or display his beauties to an admiring sweetheart, but to rest for some time, he first folds his wings together closely back to back, and then draws his fore wings downwards in such a manner that they are, as completely as possible, covered by the hind wings; and it is obvious to any observer that in very many cases the underside of the hind wings is the part so coloured in various ways as to resemble the surroundings and thus conceal the creature from its enemies.

I say "as completely as possible"; for the difference in the shapes of the fore wings and hind wings prevents this covering from being quite complete. In almost all cases the hind wing is rounded, while the fore wing is more or less triangular in shape and ends in a point, and thus the tip of the fore wing remains uncovered and visible.

Figure 47.
Orange Tip Butterflies on Wild Chervil.

Figure 48.
Bath White Butterflies.

Now the beautiful detail which I propose to illustrate is this:—that the uncovered portion of the underside of the fore wing repeats in a great number of instances the pattern and colouring of the under surface of the hind wing and thus carries out to perfection the concealment; while the remainder of the under-surface of the fore wing covered when at rest by the hind wing, has often quite different colouring and is in many cases of most brilliant and conspicuous hues.

As I first observed this detail in the "Orange Tip" (I prefer the ordinary English names to the scientific ones, as each butterfly has such a number of systematic synonyms), I will give that charming little herald of spring the first place in the illustrations (see Figure 47), though it is not perhaps the best of them.

No one will, after looking at the picture, doubt for a moment the use of the peculiar pattern on the underside of the hind wing. The butterfly is settled on an umbel of wild chervil and any one who wants a specimen of an Orange Tip has only to wait in a lane full of that plant and he will soon find one coming along, if it be May or June, though he may look in vain for one in the adjoining fields.

The resemblance is so complete that the butterfly in the midst of the umbel can hardly be discovered at all, and if the photograph could have been done in colours, the concealment would only have been more completely shown; the white parts of the wing representing the flowers, and the green parts representing the stalks, involucres and other green parts of the plant as well as the background of grass or hedge in the distance. The conspicuousness of the specimen whose wings are not drawn together proves the point to perfection.

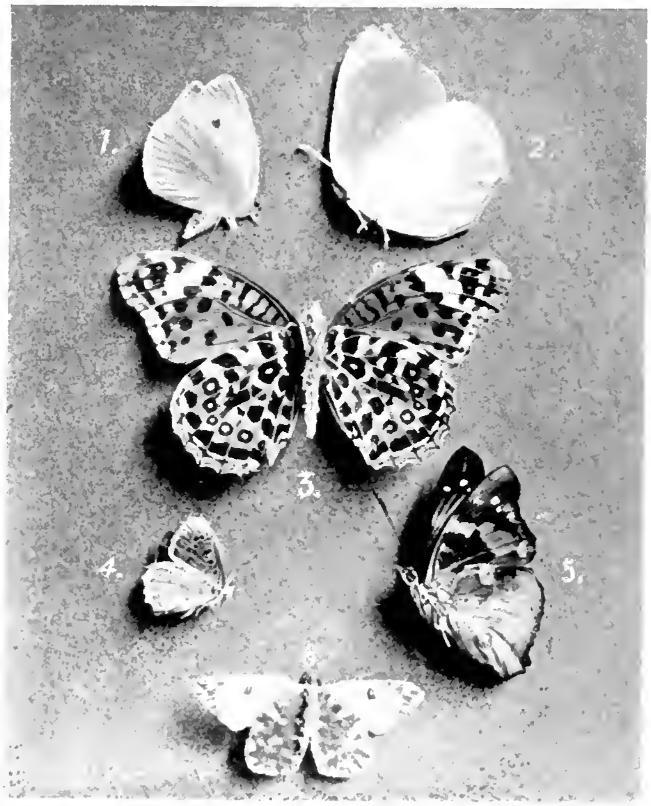


Figure 49.

1. Large Cabbage White.
2. South European Brimstone.
3. Foreign Species.
4. Small Copper.
5. Foreign Species.
6. Foreign Orange Tip.

Now the pattern (we might call it *the design*) on the hind wing which so completely conceals the resting Orange Tip is, it will be seen, continued at the tip of the fore wing and this continuation of the pattern is precisely outlined by the very curve which the end of the hind wing makes. They fit exactly! But the orange spot is completely concealed.

But there is more than this, for it will be observed that the front margin and even the thin, sharp edge of the fore wings (this edge being often somewhat rounded) have markings of the same type, so that, looked at *in front*, the protective resemblance to the flower is continued, in place of a white line which would otherwise appear and be dangerous—so minute are Nature's details in this matter.

But there is yet even more. It will be seen on examination that the pattern on the tip of the fore wing is somewhat run into lines (as may be seen in Figure 50, number 5). This repeats a tendency to the same thing at the margin of the hind wing: and it thus imitates in connection with the background of green, and just at the right place, the appearance which the *edges* of the umbel present.

The completeness and exactness of the continuation of the pattern are even more clearly shown in the butterfly Figure 49, number 6, a foreign relative, I think, of our Orange Tip. In this the imitation of the pattern on the hind wings is much more exact, as will be easily seen.

The *economy* of Nature is wonderfully illustrated in these cases, since there is precisely as much of the needed pattern on the fore wings and no more—the curves fitting so truly—of the hind wing and of the fore wing design.

Just the same sort of pattern and its repetition are seen in the "Bath White," Figure 48.

A brief review of the illustrations will sufficiently demonstrate the use of this arrangement of colour and markings.

Figure 49, number 1, and Figure 50, number 2, show the large and small Cabbage Whites. In both the greenish-yellow of the hind wing is repeated at the tip of the fore wing. The colour is close to that of the cabbage flower, but it more closely still resembles that of a dead piece of cabbage leaf, which, when faded, takes exactly this colour.

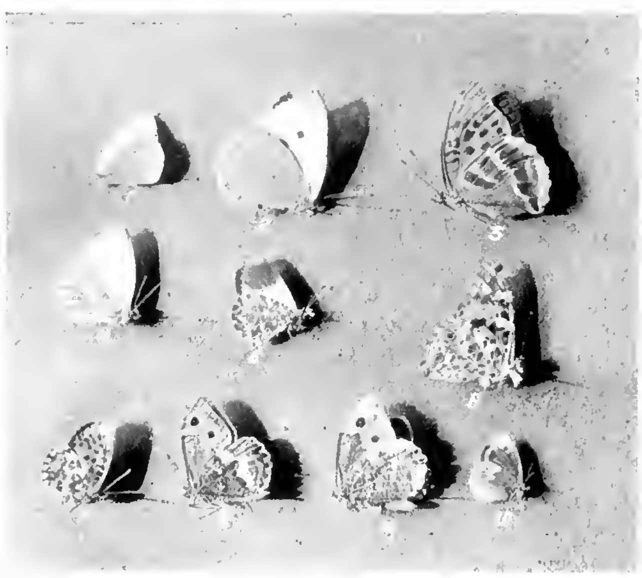


Figure 50.

1 & 4. Green-veined White.
2. Small Cabbage White.
3. Silver-washed Fritillary.
5. Orange Tip.
6. Painted Lady.
7. Pearl-bordered Fritillary.
8 & 9. Grayling.
10. Small Heath.

It may be noticed that a "small white" will sometimes place itself *sideways*, so that its wings lie flat on the leaf. The same is true of "Meadow Browns," which sometimes thus place themselves on the ground. Such a position would aid in the concealment and (in the absence of any other explanation of this curious custom) would seem to be adopted for that reason.

Figure 49, number 2, is a South European form of the "Brimstone" and the greenish-yellow of the hind wing is repeated at the tip and along the front margin of the fore wing, while the folding conceals a brilliant patch of orange. This repetition along the front margin would be useful while the folding of the fore wing behind the hind wing was in progress, or was incomplete.

Figure 51. Leaf Butterfly.

Figure 49, number 3, is a foreign butterfly in which the silver spots and olive green of the underside of the hind wings are repeated at the tip of the fore wing, whilst the rest of the fore wing, concealed when at rest, is of a bright red-brick colour with black spots, and a conspicuous white bar.

Figure 49, number 4, is the "Small Copper," in which the grey of the hind wing is continued at the tip of the fore wing, and the brilliant colour and spots hidden by the folding over.

Figure 49, number 5: Underside of a foreign butterfly. The coloration of the hind wing, a dusky brown, is repeated

Figure 52.
Marbled White Butterflies on dead panicles of grass.

Figure 53.
Leaf Butterfly, *Kallima*.

at the tip, and a brilliant yellow bar concealed.

Figure 50, numbers 1 and 4, are "Green-veined whites." It is well known that these vary very much, so that they have been divided by some authors into several species, and the curious thing is that, as the colours and the markings of the hind wing vary, so precisely do the colours and marking vary at the tip of the fore wing.

Figure 50, number 3, is the "Silver-washed Fritillary," in which the green of the hind wings is repeated at the tip with sometimes a little of the silver. In other fritillaries, more or less of the same arrangement will be found and in the "Pearl-bordered Fritillary" (see Figure 50, number 7), the brick red patches which are on the hind wing, are more or less repeated, with part of the paler yellow at the tip of the fore wing and only there. I do not know what this red brick may represent, but it is evident that to have a patch of a different colour at the tip of the fore wing would render the creature much more conspicuous.

Figure 50, number 6, is the "Painted Lady" in which the brown and grey of the fore wings are repeated at the tip of the fore wing, while the brilliant pink and yellow are concealed.

Figure 50, numbers 8 and 9, are two specimens of the "Grayling" or "Rock-eyed Underwing." The markings of the hind wing vary a good deal and in exactly the same manner do the markings of the fore wing vary to correspond, both at the tip and along the front margin.

Figure 50, number 10, is the common little butterfly variously called "Small Heath" and "Least Meadow Brown." In this, when closed, the brown and grey are repeated at the tip, while the yellow and orange and the eye spot of the fore wing are concealed.

Figure 52 is the "Marbled White" in which the pale and thin-lined pattern of the hind wing is repeated at the tip of the fore wing, while the darker colouring of the fore wing is concealed. This is more obvious in the American form which has a brown lined pattern on the hind wing exactly repeated at the tip of the fore wing. I do not know what the markings in the American species may represent, but it may not be a wild conjecture that the object of the pattern in the English butterfly is indicated by the surroundings which I have given it, and that it conceals the creature by imitating the dead panicles of grass which abound in those dry places near woods where the butterfly is so often to be found, and on which it frequently settles.

We do not see the full force of any argument till we look at it (so to speak) from the opposite side; and this detail in protective colouration is clearly brought out by the cases where it is not needed. Contrast, for example, the underside of the wings of the "Comma," "Large Tortoise-shell," "Peacock," where the protective colouring is spread over the whole of *both* hind wings, with the repetition of the hind wing pattern in "Small Tortoise-shell," "Red Admiral," and so on.

It is curious that in *Anosia menippe* Hübner—a butterfly which is now sometimes caught in England and which is said to be protected by a nasty taste—the paler colour of the hind wings is repeated in a patch at the tip of the forewings, while the colour of the rest of the fore wings resembles that on the upper surface. The detail seems to indicate that the bright brownish-yellow may not in these cases be *warning* as had been supposed. On that supposition it would seem difficult to find a reason (and a reason *must* exist) for this curious bit of repetition.

Figures 53 & 51 are two species of the leaf butterflies whose likeness to dead leaves is now so familiar to us all. These, of course, do not fold the fore wing behind the hind wing, and there is, therefore, no reason for any repetition of the hind wing pattern. The tip merely displays a little imitation of a fungus.

The head of the insect is placed between the wings and hidden, when it is at rest. This puts out of sight the conspicuous eye, which would perhaps tell a tale, so complete are the arrangements for concealment.

An interesting point here occurs: most dead leaves hang down; do the Kallimas take that position or do the leaves of the trees on which they rest retain the upright position when dead? I have not seen this noticed by the authors on the subject.

The Nyctalemon Moth of the Andaman islands evidently represents a dead leaf, as it has an imitation of a midrib throwing an imitation shadow on one side, and has also a tail to represent the stalk. But most moths appear to rely on the upper surface of their wings for concealment. Many of them, as the so-called "Underwings," have their brilliant colours on the upper surface of the hind wings and conceal these, when they are resting, with the fore wings, which are protectively coloured. This no doubt applies to some butterflies whose wings are coloured in the same way.

The "Skippers" form a group half-way between the Moths and the Butterflies. Our "Dingy Skipper" is said to rest with the wings folded over its back in the exact position of a noctuid. Now the "Dingy Skipper" shows no sign of any repetition at the tip of the fore wing of any special colour on the hind wing: but the "Large" and the "Small" Skippers both show the usual repetition of the hind wing colouring. How *they* rest I am not certain.

Every one will, I am sure, agree that sufficient proof has been given of the existence of this curious and minute arrangement of Nature for the protection of these little creatures; but it is in all such cases to be noticed that there is often some little imperfection in the work of protection. It seems as if Nature in Evolution was sometimes actuated by two or more contradictory plans, which she has to harmonize as best she can. There is the tendency to some protective resemblance, but there is also the tendency to brilliance of colour or design for the purpose of recognition by or attraction of the opposite sex; and, lastly, there seems to be a real tendency to develop colour in special places, as, for example, along the nervures of Lepidoptera, as in the "Green-veined

White," "Black-veined White," and so on, a tendency which is also, no doubt, responsible for the frequent coincidence of markings on both sides of the wings, as in the "Brimstone," "Clouded Yellow," "Apollo," and so on.

Such tendencies are obviously opposing ones; and one is often lost in admiration at the wonderful methods by which Nature has reconciled them, often producing the most perfect protection and at the same time the greatest beauty. It is conceivable also that in such a case as that of *Danais chrysippus* the upper side of the wings may have warning colours while the under side, where the yellow of the hind wings is repeated at the tip of the fore wings, as in *Anosia menippe*, may be protective, to guard against inexperienced enemies who do not know that they are unpalatable for eating, and so would kill or injure them in mistake, just as cats kill innumerable shrews which afterwards they will not eat.

This detail in colouring shows with what minuteness Nature carries out the plan of protective colouration and resemblance, and how small a piece of detail gives some advantage in the struggle for escape; for otherwise this little bit of colouring would not have continued. In further illustration of the minuteness observe the delicate imitation of a tear in the wing of *Kallima* (see Figure 53). Only with a magnifying glass can one see that the tear is not real, and that the wing is perfect. The effect is produced by alternate black and white markings.

The success of the protective colouring is frequently forced on the attention of the butterfly hunter, who finds that the insect he has been pursuing has disappeared from his view though he knows and sees, just too late, that it has been all the while within a very small plot of ground.

There is also another point of view which I have not seen brought forward, as to the success of this sort of protection. It is this:—That an animal *has no time to waste* in examining objects which at closer quarters might (though a little *suspicious*) turn out to be really twigs or leaves; and thus a very imperfect resemblance (to *our* eyes who have plenty of leisure for the examination) would often be sufficient, and would be preserved till in process of time a more and more perfect resemblance was evolved. If one watches a bird supplying its ravenous nestlings one can easily see that it has to do the work at full speed.

If we sometimes thus placed ourselves in the position of animals, and by imagination "identified our minds" (in E. A. Poe's phrase) with theirs for awhile, we should very often comprehend Nature better and discover more of her secrets.

CORRESPONDENCE.

A PHYSICAL PHENOMENON.

To the Editors of "KNOWLEDGE."

SIRS,—The enclosed Note on a physical phenomenon which was observed at Maymyo towards the end of last May will, it is believed, prove of special interest to your readers. The author of the note is Mr. H. M. S. Mathews, C.S.I., Commissioner of Settlements and Land Records, Burma, and is the outcome of his personal experience of the occurrence.

Maymyo is a hill station, the summer headquarters of the Government of Burma. Its geographical position is 22° 1′ N. and L 96° 29′ E.; and its height above mean sea level is three-thousand seven hundred and eighty feet. The Moon was full on 31st May at 5^h 59^m 36^s a.m., when its R.A. was 17° and Dec. 27° S.; so that the phenomenon would have been visible when the Moon was in the E.S.E., and about 20° to 40° in altitude.

The special points about the particular phenomenon are: *first*, that the luminous area behind the shadow of the head was accompanied by an entirely distinct circle of light some distance away from the luminous area, the feet standing on the circumference of this circle; *second*, that the phenomenon was seen by the light of the Moon, not the Sun.

The phenomenon is believed to be what is known as Anthelia or "Glories," the following description of which is taken from an Encyclopedia, *viz.:* "*Anthelia* are luminous rings seen by an observer on a cloud or fog which lies opposite to the Sun. They are only seen when sunshine and cloud, or fog, occur at the same time. They appear when, from an elevated position, the shadow of an observer is projected by the Sun on a cloud or fog; he sees the head encircled by a glory or luminous ring, diminishing in brightness as it leaves the head as a centre. A phenomenon substantially similar to the anthelia occurs when, the Sun being near the horizon, the observer sees an aureola surrounding the shadow of his head cast upon grass or corn moistened with dew."

Some of your readers have perhaps witnessed similar phenomena elsewhere, and any information that they can furnish on the subject would be very acceptable.

RANGOON (BURMA). J. C. CLANCEY.

NOTE.—On the moonlit nights of the last week of May, 1912, some days after the earthquake shock of the 23rd May, a phenomenon, believed to be that known as Anthelia or Glories, but novel to the observers, was seen at Maymyo.

There were heavy dews at the time and as soon as it was sufficiently dark for the moon to cast distinct shadows the observer noticed that on the dewy short grass of the lawn a patch of light appeared round the shadow of the head, while there was also an outer circle of light with the head shadow as a centre and with a radius of the length of the observer's shadow.

The patch of light or inner halo had no definite outline, but was brightest alongside the shadow of the head and was distinct over a space with about twice the diameter of the head shadow.

The illuminated band of the outer halo averaged perhaps a foot in width. It was narrower when the Moon was high, and was then bright and distinct throughout its circumference.

Both halos were white, and it was noticed that the head halo and outer halo attached to each person's shadow was visible to that person only. Another person looking over the first person's shoulder could not see that person's halo, though he could at the same time see his own distinctly.

At the time of the phenomenon there appeared to be nothing unusual in the appearance of the Moon or sky. The former was bright and the latter clear.

The phenomenon was first noticed on Tuesday, 28th May, and was observed for several nights. On the night of Friday, 31st May, at 10 p.m., it was seen by a number of persons and was then very distinct.

MAYMYO. H. M. S. M.

EXPERIMENTS ON LIQUID DROPS, GLOBULES, AND COLUMNS.

By CHAS. R. DARLING, A.R.C.Sc.I., F.I.C.

I.

Before the advent of the nineteenth century, the number of liquids available for scientific investigation was limited to water, alcohol and other products of fermentation, naturally-occurring oils, and a few obtained by chemical means. Now, thanks to the advances made in organic chemistry, the number of available liquids has been greatly increased; but although the chemical properties of the newer liquids are well known, very scanty attention has been paid to their physical properties. Hence the liquids used in the ensuing experiments, although familiar to the chemist, would probably be designated "rare" liquids by the physicist, because their constants do not appear in ordinary physical tables. The present articles will be devoted to a description of some of the remarkable physical properties of certain organic liquids, which have been investigated by the writer during the past two years, more especially with regard to the formation of drops, spheres, and columns; and the strange movements of globules on a water surface.

The Formation of Drops and Spheres.

In the issue of "Knowledge" for January, 1911, the author described an experiment for producing automatically large drops of aniline under water, the process being sufficiently slow to enable the details of formation to be seen with the naked eye. The experiment was based on the fact that aniline is denser or less dense than water at different temperatures, and from the standpoint of studying the beautiful changes in shape undergone by parting drops, suffered from the defect that the formation was not under control. In order to produce a drop which may be made to enlarge to considerable dimensions, and to break at will, it is necessary to run the liquid used into water from a vessel controlled by a tap, and to employ a liquid only slightly denser than water at the prevailing temperature. After many trials, the author has found that the liquid *orthotoluidine* is in every way suitable for the purpose. As sold commercially, this liquid has a deep red colour: is insoluble in water; and at 24°C has exactly the same density as water at 24°. Above this temperature orthotoluidine is lighter than water, whilst below 24° it is heavier; and as the equi-density temperature is near to that of the atmosphere in a room, the experiment may be conducted with the minimum of trouble.

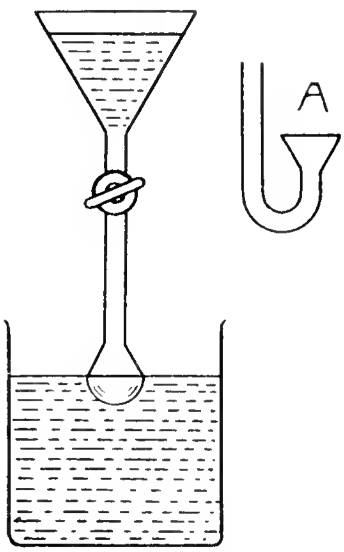


Figure 54.
Apparatus for forming large, controlled drops of liquids.

The apparatus requisite for the complete study of drops under control is extremely simple, and is sketched in Figure 54. A funnel, furnished with a tap, and having the stem widened at the extremity to a diameter of three or four centimetres, is arranged so as just to touch the surface of water contained in a flat-sided glass vessel about fifteen centimetres high, 12·5 centimetres wide, and 7·5 centimetres deep—exact dimensions being of no importance. The water in the vessel should be at a temperature of about 20°C., and orthotoluidine allowed to flow in slowly from the tap. A large drop then gradually forms at the end of the stem of the funnel, and by closing the tap at any time the outline of the drop may be examined at leisure. Control ceases when the constricted neck becomes narrow, and the drop then slowly breaks away, a secondary drop, as usual, being formed from the neck itself. The accompanying Figures—55 to 61—from photographs by the writer and Mr. B. Abel, show several stages in the formation of a drop of orthotoluidine, controlled as described. Figures 60 and 61 are specially interesting as showing the recoil after the partition of the drop, both the portion clinging to the stem and the separated drop being flattened; and the secondary drop, which is seen elongated in Figure 60, is seen to have recoiled in Figure 61. An exposure of approximately one-tenth of a second was given, the vessel being illuminated by an arc-lamp. It is easy, by this method, to obtain drops three or four centimetres in diameter, if the instructions given above be carefully followed.

An interesting modification of the experiment is the production of inverted or rising drops, which may be accomplished by bending the stem of the funnel into a parallel branch, as shown in Figure 62. The widened end is then immersed in water at about 35°C to a depth of three inches, and the tap of the funnel opened so as to allow the orthotoluidine to flow slowly. As the liquid is warmed to a higher temperature than 24°C in passing through the stem, it becomes of less density than the surrounding water; and on escaping the drops, therefore, rise to the surface. The general

FIGURE 55.

FIGURE 56.

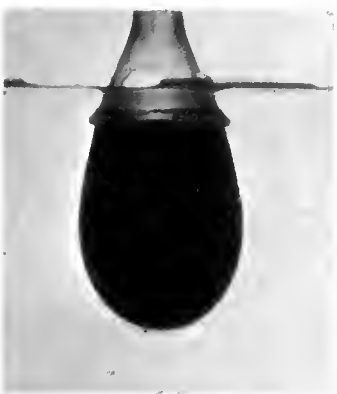


FIGURE 57.

FIGURE 58.

shape of inverted drops resembles that of falling drops, the neck, as usual, giving rise to a secondary small drop.

The production of spheres of liquids demands equality of density between the liquid and its surroundings. Formerly, Plateau's method was followed, in which spheres of oil were formed in a mixture of alcohol and water brought by trial to the same density as the oil—a somewhat troublesome proceeding. By carrying out the following instructions, spheres of liquid, of any desired size, may easily be obtained:—A flat-sided glass vessel, about eighteen centimetres (seven inches) high, is filled with water at 23°C to a height of about twelve centimetres. The correct temperature is secured by adding warm water to tap water and mixing until a thermometer shows 23°C. By the aid of a pipette a five per cent. solution of common salt in water is discharged at the bottom of the vessel, to a depth of about two centimetres, this layer preventing the sphere, when formed, from sinking to the bottom when the temperature falls. Orthotoluidine is now allowed to flow gradually into the water from a tube of one centimetre diameter, the end of which, to commence with, is placed about two centimetres distant from the surface of the layer of salt solution, but is afterwards raised gently as the sphere grows in size. In this way spheres two hundred cubic centimetres or more in volume may be formed; and, by raising the delivery-tube rapidly, the attached sphere may be separated, and will remain floating in the liquid.

The photographs shown in Figures 62 and 63 illustrate the mode of formation and the appearance of the detached sphere. In the experiment depicted the orthotoluidine was run from a burette, with a view to measuring the volume of the sphere, which in this case was one hundred cubic centimetres.

Professor C. V. Boys, F.R.S., has suggested a modification of the procedure which dispenses with the necessity of warming the water. After placing the layer of five per cent. salt solution at the bottom of the vessel, the pipette is again filled, and the salt solution discharged, in diminishing quantities, from the bottom layer upwards to within about two centimetres of the surface. The orthotoluidine is then allowed to flow into the centre of the vessel from a tube bent so as to discharge laterally; and the sphere formed will then float or sink until it finds a layer equal in density, in which it will remain at rest. It is necessary, in this case, to exercise care in grading the density of the water from bottom to top by discharging the salt solution slowly, and gradually rais-

FIGURE 59.

FIGURE 60.

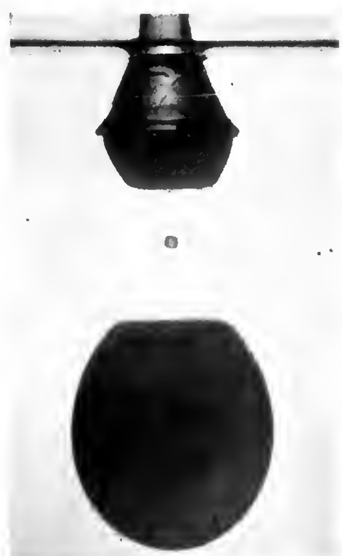


FIGURE 61.

FIGURES 55 TO 61. Seven stages in the formation of a large drop of orthotoluidine.

ing the pipette.

It may be mentioned here that certain other liquids may be used instead of orthotoluidine; for example, anisol produces spheres when run into water at 15°C. But the beautiful colour of orthotoluidine, combined with its insolubility in water, and the absence of other objectionable features, renders this liquid more suitable than any other, either for producing controlled drops or spheres. It is, moreover, relatively a cheap liquid, and should be welcomed by all who are interested in this fascinating branch of physics, as it enables phenomena, formerly difficult and troublesome to observe, to be demonstrated in the simplest manner.

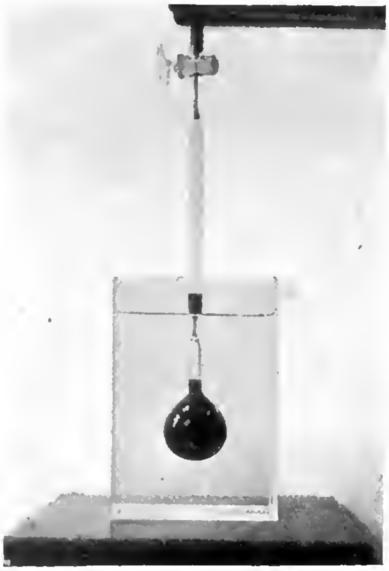


FIGURE 62. Forming a sphere of orthotoluidine.

FIGURE 63. The detached sphere floating under water.

COLOURS AND THEIR CHANGES AT SUNSET ON A TROPICAL ISLAND.

By MAXWELL HALL, M.A., F.R.A.S.

Jamaican Government Meteorologist.

IN connection with the researches into the constitution of the upper regions of the atmosphere, the following notes of the colours and their changes usually seen during the first part of the year at the Kempshot Observatory, Jamaica, may prove to be useful. The colours and their changes are best seen from January to April, before the summer heat causes great ascensional movements of vapour, and before there are many particles of water in the air, which give rise to the gorgeous colours seen in the autumnal months; the steadiness of the air throughout the nights of the early part of the year is very remarkable, so much so that even stellar photometry is rendered easy and pleasant work. The latitude of the observatory is 18° 25′ north; the elevation is 1773 feet; the mean temperature from January to April is 71°; the dew-point is 65°; so that the elastic force of aqueous vapour is 0·62 inch, and the humidity 81. The position of the observatory on a range of hills commands a view round the horizon; and the hills and country round about it are clothed with thick vegetation, so that there is but little dust in the air. Under these favourable circumstances notes were made which have been condensed into the following.

Ten minutes before sunset a pink band appears on the eastern horizon: it can usually be traced all round the horizon; but it soon disappears except in the eastern half, where it grows stronger in colour and rises up from the horizon as though on pivots at the north and south points. Underneath it a dark band of a leaden blue colour appears.

At sunset this dark band is about 1½° broad; and the pink band resting on it is about 4½° broad.

Five minutes after sunset a faint pink glow, which has spread rapidly upwards from the pink band, reaches the zenith. And looking above the western horizon where the sun went down, there is a large patch of white light; its boundaries can hardly be defined, but they give the idea of an equilateral triangle, whose sides are about 45°, its base being parallel to and somewhat above the horizon. Of course, this white light and the pink glow are easily seen by contrast with the blue and bluish-violet of the remaining parts of the sky.

Ten minutes after sunset the dark blue band, still resting on the eastern horizon, is 4° or 5° broad, and is now at its darkest; it tapers off gradually to the north and south points of the horizon. The pink band resting upon it is now 15° broad, and similarly tapers off. The pink glow has reached the white patch in the west, and begins to replace it.

Fifteen minutes after sunset the dark band is 6½° broad, and begins to fade away in grey colour. The pink band has gone. The pink glow has entirely crossed over to the west, where it is now at its strongest somewhat below the top of the former white patch.

Twenty minutes after sunset the pink glow in the west, having approached the horizon, disappears.

Thirty-five to forty minutes after sunset the colours of the spectrum are best seen in the sky to the west, all parallel to the horizon; red on the horizon, and indigo or violet 25° above. This completes the colour-changes, the subject matter of this article; but the following notes are interesting and may be added.

Fifty to sixty minutes after sunset the zodiacal light appears about 20° or 25° above the western horizon.

Seventy-three to seventy-six minutes after sunset, the band of twilight along the western horizon, or the twilight arc, as it is called, coincides more or less with the base of the zodiacal light, which makes it necessary to discriminate between them in ascertaining the greatest breadth of the zodiacal light near the horizon and the greatest duration of twilight.

The angular measures referred to above were taken by a sextant from which the telescope had been removed. The general correctness of the whole was proved by frequently watching the colours and their changes at sunrise, when the whole sequence of phenomena was repeated, but, of course, in a reverse order.

On the plains near Kingston, Jamaica, there is much dust in the air near the ground, and the phenomena are not for the most part so well seen; but in the early mornings I have there seen the dark blue band in the west as distinct or even more distinct than at the observatory.

It would appear that the surface which reflects the faint pink glow is about fifteen miles above the surface of the earth; but it would be advisable to know how far these phenomena have been observed in other uniform climates before attempting their explanation.

SCINTILLATIONS.

By E. MARSDEN.

Lecturer in Physics, University of Manchester.

IT is well known that there are three principal types of radiation from radioactive substances designated α, β and γ. The first of these types, the α rays, or α particles, are single atoms of helium carrying a double elementary positive charge and moving initially with a velocity of the order 2×10^9 centimetres per second or one fifteenth the velocity of light. Different radioactive products emit α particles of different speeds but the speed is characteristic of the product. The α particles are very easily absorbed by material substances, the swiftest known, those from Thorium C, being completely absorbed by 8·6 centimetres of air and the slowest known, those of Uranium I, only penetrating 2·5 centimetres of air at atmospheric pressure.

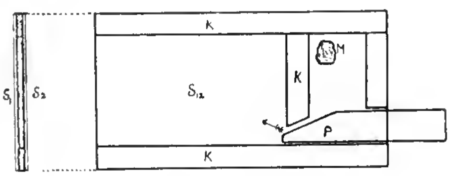


FIGURE 64.

The second type of radiation, the β rays, are known to consist of electrons or isolated elementary negative electric charges. They travel with enormous velocities varying for different products, and also for the same product, up to as much as 0·998 of the velocity of light. The β rays are not so easily stopped as the α rays, travelling on the average about one metre in air before they are stopped.

The third type of radiation, the γ rays, differ from the two preceding types in that they appear to be electrically uncharged. They are similar to very penetrating Röntgen rays, but their exact nature constitutes the battling ground of many rival theorists, for the problem appears also to involve that of the fundamental constitution of light waves. The γ rays seem to be closely connected with the β rays in much the same way as Röntgen rays are connected with cathode rays. All radioactive products which emit γ rays also give β rays, although certain products are known which emit β rays without any appreciable γ radiation.

One of the most remarkable of the properties of the various radiations is that of producing luminescence in certain substances on which they fall, and more particularly remarkable is the scintillating property of the α rays. This property was first discovered by Sir William Crookes, and independently by Elster and Geitel, in 1903, but five years elapsed before its full significance was recognised; for it is now known that each scintillation is produced by a single α particle or atom of Helium. Crookes made a screen by dusting Sidot's blende (phosphorescent crystalline zinc sulphide) on glass. On bringing up a source of radium the screen lit up with a greenish phosphorescent light which, when examined under a magnifying glass, was found to consist of a number of scintillating points of light.

Subsequent work has shown that many other substances show this scintillating property though the scintillations are generally fainter than with zinc sulphide; the best known substances being willemite (a mineral containing zinc silicate) barium platinocyanide and diamond. Many of these materials appear to require the presence of some impurity; thus pure zinc sulphide does not show scintillations while some of the purest diamonds fail to respond to any of the radium radiations. In nearly all cases also the scintillating substances appear to lose their sensitiveness under prolonged action of the α rays, and for this reason the zinc sulphide screens of Crooke's spinthariscopes after a time need renewal. Diamond and willemite are more stable than zinc sulphide, for they retain their scintillating power longer, while barium platinocyanide, on the other hand, is very rapidly transformed under the action of α rays.

It was at first thought by Becquerel and others that the scintillations produced in zinc sulphide, for example, are the direct result of the mechanical fracture or cleavage of the crystals by the α particles, since it is well known that zinc sulphide is very sensitive to mechanical shocks. Recent evidence, however, appears to discredit this hypothesis and points to the conclusion that the scintillations are in some way the result of the enormous local ionisation produced in the zinc sulphide by the α particles; for it is well known that an α particle produces about two hundred thousand ions, before its energy is absorbed.

In 1908, Rutherford and Geiger succeeded in detecting the emission of a single α particle by an electrical method and were thus able to count the α particles from a given quantity of radium. By comparing this number with the number of scintillations produced under proper conditions on a zinc sulphide screen they were able to show that practically every α particle produces a scintillation. Thus the scintillation method can be used for quantitative measurements in radioactivity and this method has since proved of very great value in such investigations; for the electrical method of counting α particles is cumbersome and requires very special apparatus. A piece of glass or other transparent material is coated with small crystals of sinc sulphide and the observations are made in a dark room with a microscope of magnifying power in the neighbourhood of fifty. A good combination is a Leitz No. 0 eye-piece with a No. 4 or No. 3 objective, while it is better to have the screen very slightly illuminated so that the eye may be continuously focused on it. The source is arranged so that the scintillations appear at a rate not greater than about ninety per minute and not less than about five per minute, these rates being generally the limits for accurate counting. In some cases it is necessary to have the source and screen in a vessel at reduced pressure owing to the limited "range" of the α particles. The scintillations are timed with a stop watch. They do not appear regularly but are distributed according to chance, and to obtain an accurate estimate a large number of scintillations must be counted—in fact, the scintillation method has given an interesting experimental confirmation of the laws of probability as applied to radioactive disintegration.

Perhaps one of the most interesting experiments with scintillations is that originally used by Geiger and Marsden in the detection of the short-lived α ray products after thorium and actinium emanations. Thorium emanation is a gaseous radioactive product emitting α particles and followed by a second α ray product whose mean life is only one-fifth of a second, while actinium emanation is similarly followed by an α ray product of mean life only one three hundred and fiftieth of a second. Figure 64 shows a "drawing room" modification of the apparatus designed by Mr. F. H. Glew.

S_1 and S_2 are two zinc sulphite screens lying one above the other and separated by thin paper strips K.K. The upper screen is very thinly coated so that it is practically transparent and scintillations on the lower screen can be seen from above. M is a source of thorium emanation consisting of a very small amount of mesothorium. The emanation diffuses beween the screens in an amount regulated by the small strip P.

Consider an atom of the emanation which disintegrates between the screens emitting an α particle which produces a scintillation on either the upper or lower screen. The atom of thorium A produced from this emanation atom has an expectation of life of one-fifth of a second before in its turn it disintegrates, and gives off a second α particle which causes a scintillation on either S_1 or S_2. Thus the result is two scintillations, one following the other with about one-fifth of a second interval. These scintillations appear on about the same area of the screens and can be observed by an ordinary pocket magnifying glass or microscope. In the case of actinium emanation the scintillations are given off with an average interval of one three hundred and fiftieth of a second, so that the interval cannot be distinguished by the eye, the result being apparently two scintillations at the same time, generally very slightly separated in position.

The scintillation method has also had an important application in the study of the scattering of α particles by matter. When a parallel pencil of α particles is incident on a thin metal foil, the individual α particles suffer deflection by the atoms with which they come in contact and the beam as a consequence becomes scattered. The distribution of α particles in the scattered beam can be observed by scintillations and from this distribution considerable evidence can be drawn as to the electrical forces inside the atoms causing the scattering. Thus it has been shown that all atoms are constituted in some respects similar to small models of our solar system. They appear to have a very strong central charge consisting of a number of elementary charges equal to half the atomic weight. This central charge appears to be concentrated within a volume extremely small compared with the size of the atom and to be surrounded by electricity of the opposite sign which on our analogy may be compared with planets.

A PROPOSED BRITISH ECOLOGICAL SOCIETY.

THE British Vegetation Committee, which was founded in 1904, has up to the present consisted only of active workers in Plant Ecology, and has met with a very large measure of success. In fact, it has had to be enlarged, and includes so many "associate members" that a new Society is being formed to take its place and push forward its work. It is felt that the organisation of a Society with a regularly published and carefully edited journal might succeed also in bringing the most scattered workers—many of whom are still outside the ranks of the Committee—into touch with one another, and would keep them informed of the progress of the subject. Such a Society might also perform a similar function for the many who are keenly interested in Ecology without themselves being active workers in the field.

It is suggested that it should be called the British Ecological Society, and that the annual subscription should be one guinea, and it must be pointed out that it is intended to have a paid Secretary and Editor, and to publish a quarterly journal containing to begin with twelve thousand words in each number, which would be sent post free to members, and sold to non-members at 3s. per number.

From a circular which has been issued by the British Vegetation Committee, and signed by Dr. W. G. Smith, of the Glasgow and East of Scotland Agricultural College, and Mr. A. G. Tansley, M.A., University Lecturer in Botany Cambridge, we further learn that the Society would meet once or twice a year in different centres, for two or three days, and that the journal would include articles and notes on methods, on special points of importance, reports of proceedings of the Society, with accounts of Ecological work in progress. It would also make a feature of prompt reviews of all important recent publications, on British vegetation as well as foreign work which has a bearing on British Ecology.

The price of the journal and the rate of subscription to the Society mentioned above are to be regarded as provisional; if sufficient promises of support are forthcoming, it will be possible to fix the subscription at much less than a guinea.

It will be of the greatest assistance to the British Vegetation Committee if readers of "KNOWLEDGE" who are interested in this proposal will communicate, as soon as possible, with the Secretary of the Committee, Dr. W. G. Smith, 9, Braidburn Crescent Edinburgh, stating whether they are prepared to join the proposed Society at a subscription of one guinea per annum; if not, whether they are willing to join at a lower rate of subscription, stating the amount they would be willing to pay; and whether they have any criticisms or additional suggestions to make with regard to the scheme proposed.

THE FACE OF THE SKY FOR MARCH.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Mar. 2	22 51·1	S. 7·3	18 51·1	S. 28·1	23 45·0	S. 1·6	1 33·7	N. 13·4	18 52·0	S. 22·8	3 45·3	N. 18·0	7 41·1	N. 20·9
„ 7	23 9·7	5·4	22 52·0	S. 9·4	0 12·2	N. 2·6	1 48·1	15·4	18 55·5	22·7	3 46·6	18·1	7 40·7	20·9
„ 12	23 28·1	3·4	2 30·1	N. 18·2	0 31·1	5·8	2 1·1	17·3	18 58·8	22·0	3 48·0	18·2	7 40·5	20·9
„ 17	23 46·4	S. 1·5	7 17·5	N. 27·4	0 38·8	7·6	2 12·4	18·9	19 1·9	22·6	3 49·6	18·3	7 40·2	21·0
„ 22	0 4·7	N. 0·5	12 5·1	S. 0·4	0 34·7	7·5	2 21·5	20·2	19 4·7	22·5	3 51·3	18·4	7 40·1	21·0
„ 27	0 22·8	N. 2·5	16 40·1	S. 27·2	0 22·5	N. 5·8	2 27·8	N. 21·2	19 7·3	S. 22·4	3 53·2	N. 18·5	7 39·9	N. 21·0

TABLE 11.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2	Saturn. P	Saturn. B
Greenwich Noon.	°	°	°	°	°	°	°	°	h. m.	h. m.	°	°
Mar. 2	−21·9	−7·2	296·1	− 5·0	−6·4	−1·9	297·0	346·6	1 43 *e*	10 17 *e*	−2·4	−24·5
„ 7	23·1	7·3	230·2	−21·0	6·3	1·9	6·0	17·5	1 59 *m*	1 35 *m*		
„ 12	24·1	7·2	164·3	−17·2	7·1	1·8	75·1	48·4	7 47 *e*	8 35 *e*	2·5	24·7
„ 17	24·9	7·1	98·4	+ 7·3	7·4	1·8	144·3	79·4	8 3 *m*	9 48 *m*		
„ 22	25·5	6·9	32·5	+21·9	7·7	1·8	213·5	110·5	3 59 *e*	8 56 *m*	−2·6	−24·8
„ 27	−26·0	−6·7	326·6	+ 7·3	−8·0	−1·8	282·8	141·6	4 15 *m*	6 0 *e*		

TABLE 12.

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Jupiter L_1 refers to the equatorial zone, L_2 to the temperate zone. T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

THE SUN continues his Northward march. It crosses the Equator $21^d\ 5^h\ 18^m$ *m*, when Spring commences. Sunrise during March changes from 6–51 to 5–42; sunset from 4–43 to 5–35. Its semi-diameter diminishes from 16′ 10″ to 16′ 2″.

MERCURY is an evening star till the 27th. It is well-placed for Northern observers. Illumination four-fifths at beginning of month, zero on 27th. Semi-diameter increases from 3″ to $5\frac{1}{2}$″.

VENUS is an evening Star, having passed its greatest elongation on February 12th. Illumination diminishes from $\frac{2}{5}$ to $\frac{1}{5}$, semi-diameter increases from 15″ to 23″. The planet is very favourably placed for observation by Northern observers till the end of the month, when the crescent grows narrow. Greatest brilliancy attained $19^d\ 3^h$ *e*.

THE MOON.—New $8^d\ 0^h\ 22^m$ *m*; First Quarter $15^d\ 8^h\ 58^m$*e*; Full $22^d\ 11^h\ 56^m$*m*; Last Quarter $29^d\ 0^h\ 58^m$*e*. Apogee

Date.	Star's Name.	Magnitudes.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.		h. m.	
Mar. 12 ...	BD + 18°347	6·9	6 28 *e*	74°	—	—°
„ 13 ..	23 Tauri	4·3	10 5 *e*	61	10 58 *e*	282
„ 13 ...	η Tauri	3·0	10 46 *e*	28	11 19 *e*	314
„ 13 ...	26 Tauri	6·6	11 8 *e*	101	—	—
„ 13 .	27 Tauri	3·7	11 18 *e*	59	0 7* *m*	284
„ 13 ...	28 Tauri	5·2	11 26 *e*	37	0 3* *m*	306
„ 16 ...	BAC 1848	5·6	1 18 *m*	88	2 7 *m*	281
„ 16 ...	49 Aurigae	5·1	4 46 *e*	108	5 58 *e*	254
„ 16 ...	51 Aurigae	5·8	7 13 *e*	39	7 52 *e*	336
„ 17 ..	ε Geminorum	5·5	7 52 *e*	142	8 52 *e*	252
„ 23 ...	BAC 4261	6·9	—	—	2 45 *m*	270
„ 23 ...	Spica	1·2	8 42 *e*	77	9 23 *e*	351
„ 24 ...	BAC 4531	6·0	2 44 *m*	158	3 40 *m*	267
„ 27 ...	BAC 5465	7·3	—	—	3 17 *m*	343

TABLE 13. Occultations of stars by the Moon visible at Greenwich.

The asterisk indicates the day following that given in the Date column.

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

Attention is called to the occultation of the Pleiades on March 13th and that of Spica on the 23rd.

$6^d\ 8^h m$, semi-diameter 14′ 43″; Perigee 21^d Noon, semi-diameter 16′ 41″. Maximum Librations, 1^d 7°N, 14^d 8° E., 16^d 7° S., 27^d 7°W., 28^d 7° N. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

MARS is a morning Star, but practically invisible.

JUPITER is still badly placed, having been in conjunction with the Sun on December 18th. It is a morning star. Polar semi-diameter, 16½″.

Day.	West.		East.		Day.	West.		East.	
Mar. 1	34	○	12		Mar. 17	432	○	1	
,, 2	$3\frac{1}{2}$	○		4●	,, 18	41	○	32	
,, 3	$\frac{3}{2}$	○	14		,, 19		○	$4\frac{1}{2}3$	
,, 4	1	○	324		,, 20	21	○	43	
,, 5		○	$\frac{1}{2}34$		,, 21	2	○	134	
,, 6	2	○	34	1●	,, 22	3	○	24	1●
,, 7	1	⊙	4	2●	,, 23	31	⊙	4	
,, 8	3	○	124		,, 24	32	○	14	
,, 9	$3\frac{1}{2}$	○	4		,, 25	1	○	24	3●
,, 10	$\frac{3}{2}$	○	41		,, 26		○	1243	
,, 11	$\frac{1}{4}$	○	32		,, 27	21	○	43	
,, 12	4	○	$\frac{1}{2}$ 3		,, 28	42	○	13	
,, 13	421	○	3		,, 29	43	○	2	1●
,, 14	4	⊙	3	2●	,, 30	43	⊙	2	
,, 15	43	○	12		,, 31	432	○	1	
,, 16	4312	○							

Configurations of Jupiter's satellites at $5^h\ m$ for an inverting telescope.

TABLE 14.

Satellite phenomena visible at Greenwich, $2^d\ 5^h\ 6^m$ IV. Oc. R.; $5^d\ 6^h\ 9^m$ II. Sh. I.; $6^d\ 4^h\ 19^m\ 44^s$ I. Ec. D.; $7^d\ 4^h\ 16^m$ III. Tr. I.; $4^h\ 58^m$ I. Tr. E.; $5^h\ 54^m$ II. Oc. R.; $13^d\ 6^h\ 13^m\ 30^s$ I. Ec. D.; $14^d\ 3^h\ 39^m$ III. Sh. I.; $4^h\ 38^m$ I. Tr. I.; $5^h\ 42^m$ I. Sh. E.; $15^d\ 4^h\ 10^m$ I. Oc. R.; $21^d\ 5^h\ 18^m$ I. Sh. I.; $6^h\ 0^m\ 46^s$ II. Ec. D.; $23^d\ 3^h\ 14^m$ II. Tr. I.; $3^h\ 20^m$ I. Tr. E.; $3^h\ 26^m$ II. Sh. E.; $29^d\ 4^h\ 29^m\ 21^s$ I. Ec. D.; $30^d\ 2^h\ 57^m$ I. Tr. I.; $3^h\ 15^m$ II. Sh. I.; $3^h\ 57^m$ I. Sh. E.; $5^h\ 14^m$ I. Tr. E.

All the above are in the morning hours.

The first eclipse of IV. occurs on the 18th; the first transit occurred February 4th.

SATURN is an evening Star, 6° South of the Pleiades. Polar semi-diameter 8″. The major axis of the ring is 41″, the minor axis 17″. The ring is now approaching its maximum opening and projects beyond the poles of the planet.

East elongations of Tethys (every fourth given). March $4^d\ 11^h{\cdot}5\ m$, $12^d\ 0^h{\cdot}9\ m$, $19^d\ 2^h{\cdot}2\ e$, $27^d\ 3^h{\cdot}5\ m$. Dione (every third given). March $1^d\ 11^h{\cdot}2\ e$, $10^d\ 4^h{\cdot}3\ m$, $18^d\ 9^h{\cdot}5\ m$, $26^d\ 2^h{\cdot}7\ e$.

Rhea (every second given). March $9^d\ 6^h{\cdot}7\ e$, $18^d\ 7^h{\cdot}8\ e$, $27^d\ 8^h{\cdot}8\ e$.

For Titan and Iapetus, E. W. mean East and West elongations, I. S. Inferior and Superior Conjunction, Inferior being to the North, Superior to the South. Titan, $3^d\ 3^h{\cdot}1\ e$ E., $7^d\ 3^h{\cdot}7\ e$ I., $11^d\ 0^h{\cdot}1\ e$ W., $15^d\ 11^h{\cdot}3\ m$ S., $19^d\ 2^h{\cdot}9\ e$ E., $23^d\ 3^h{\cdot}7\ e$ I., $27^d\ 0^h{\cdot}2\ e$ W. Iapetus $11^d\ 9^h{\cdot}6\ m$ W., $31^d\ 7^h{\cdot}4\ e$ S.

URANUS is invisible, having been in conjunction with the Sun on January 24th.

NEPTUNE was in opposition on January 14th. Its motion may be traced on the map of small stars which was given in "KNOWLEDGE" for December, 1911, page 476.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant.			Remarks.
	R.A.		Dec.	
Mar. 1—14	166°	+	4°N	Slow, bright.
,, 14 ...	250	+	54 N	Swift.
,, 18 ...	316	+	76 N	Slow, bright.
,, 24 ..	161	+	58 N	Swift.
,, 27 ...	229	+	32 N	Swift, small.
Mar. to May	263	+	62 N	Rather, swift.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 8^h to 12^h, next month 10^h, to 14^h, and so on. In the case of Algol variables, the time of one minimum is given where possible, and the period. Algol, owing to its brightness, will be given for wider limits.

ALGOL STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Minimum.
	h. m.			d. h. m.	d. h. m.
Algol	3 2	+40°·6	2·3 to 3·4	2 20 49	Mar. 3 11 58 *m*
X Carinae	8 29	—58 ·9	7·8 to 8·6	0 12 59·6	Feb. 2 0 36 *e*
S Cancri	8 39	+19 ·4	8·2 to 9·8	9 11 38	Mar. 10 11 59 *m*
S Velorum	9 30	—44 ·8	7·8 to 9·3	5 22 24·4	Feb. 28 8 27 *e*
Y Leonis	9 32	+26 ·7	9·0 to 10·6	1 16 28	Mar. 1 4 54 *e*
W Urs. Maj.	9 38	+56 ·4	7·9 to 8·7	0 4 0·2	
ST Urs. Maj	11 23	+45 ·7	6·7 to 7·2	8 19	

NON-ALGOL STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m.			d.	
V Cancri	8 17	+17°·5	7·1 to 12·8	272	Feb. 7. Nov. 6.
T Lyncis	8 17	+33 ·8	8·5 to 11·2	91	Mar. 23.
Z Cancri	8 18	+15 ·3	8·5 to 9·2	74	Mar. 29.
S Hydrae	8 49	+ 3 ·4	7·5 to 12·2	256	Apr. 1.
Y Draconis	9 32	+78 ·3	8·2 to 11	336	Feb. 23.
R Leonis	9 43	+11 ·8	5·0 to 10·2	313	Feb. 9.
Z Leonis	9 47	+27 ·3	7·9 to 9·6	59	Apr. 6.

TABLE 15.

NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

PHOTOGRAPHY OF THE MILKY WAY. — Mr. d'Esterre's results should be an encouragement to the possessors of small photographic apparatus. He has selected a limited region of the Milky Way, near the great Perseus cluster, and keeps a constant photographic patrol upon it with a six and a half-inch Voigtlander camera and some smaller instruments, also occasional visual observation with a fifteen-inch reflector. His zeal has been rewarded by the discovery of a faint Nova (87, 1911), which is interesting as being one component of a double star; also several variables. Observations of these are contained in *Astronomische Nachrichten*, No. 4623, with diagrams of the fields.

It is likely that observers who selected other regions, and followed them with the same pertinacity, would reap similar harvests.

ATTRACTION OF SUNSPOTS FOR PROMINENCES.—*The Astrophysical Journal* for November contains an interesting article by Mr. F. Slocum on the large sunspot of October, 1910, illustrated by several spectroheliograms in calcium light. The prominences round the spot appear to have been strongly attracted by it, and were seen in successive photographs to approach it with accelerated motion. Professor Hale and Mr. Evershed had previously noticed that the gases round sunspots were moving inwards, but their observations indicated that the inward motion was retarded, not accelerated. It was formerly debated whether sunspots were formed by inrushes or outrushes of gas. The new observations would seem to favour the former, but it must be remembered that an inrush at one level may be accompanied by an outrush at another. I remember being in a boat on the Thames immediately over the outrush of water from a lock-sluice; contrary to expectation a counter current carried our boat violently against the lock gate. Any violent current generally produces a backwash. In fact, Mr. Slocum finds evidence of such outward motion on a few of the plates, but it is less marked and less persistent than the inward motion.

NOVA GEMINORUM (2).—The same number of *The Astrophysical Journal* contains an interesting article by Walter S. Adams and Arnold Kohlschutter on the spectrum of this Nova. Photographic spectra on dates ranging from 1912, March 22nd to August 19th, are reproduced, and the spectrum of a Wolf-Rayet star is given for comparison with the last. It has some points of resemblance, but great difference in relative intensities of lines. The authors sum up the changes in the Nova's spectrum thus:—

(1) The continuous spectrum got steadily weaker.
(2) An increase in the number and intensity of the nebular lines. The chief nebular line, λ 5007, was first seen on April 6th, and afterwards became very strong. The second line, λ 4959, was first seen on April 22nd, and rapidly grew stronger. The nebular lines at λ 4364, 4687 also got strong in the later photographs.

Using the narrowest and best-defined lines to find the radial velocity of the Nova, they deduce a recession from the Sun of ten kilometres per second, close to the mean of the values nine kilometres, twelve kilometres, and seven kilometres found by Curtiss, Plaskett, and Küstner. They do not consider that variation in the velocity is established, though it is not impossible.

They find no evidence of the presence of radium in the Nova, which other observers had suspected.

SIGNS OF REVIVING SOLAR ACTIVITY.—It is well-known that the last sunspot cycle was abnormal: the maximum was delayed three or four years after the time deduced from the eleven year period. There was also a double maximum. It is therefore difficult to predict for the coming cycle, but we may anticipate a revival in the near future. One sign of the beginning of a new cycle is the outbreak of spots in higher solar latitudes. Mr. Maunder noted at the December Meeting of the British Astronomical Association that a spot had appeared in relatively high latitude, which might be the harbinger of the new cycle. Professor Schuster expects a distinct awakening of activity about next May. This is based on his four-year cycle of activity, whose reality is questioned by some students of the Sun. In any case we are probably near the beginning of the new cycle, and a careful watch should be kept on the Sun.

SOLAR ECLIPSES.—Our sympathies must be extended to the numerous astronomers who visited Brazil last October for the solar eclipse. Heavy rain prevented any results. An interesting account of the English expedition is given by Mr. Eddington in the January number of *The Observatory*. The eclipse was an unusually dark one, and the descent of the darkness and return of the light were both sudden.

There will be an important total eclipse in August, 1914, the central line crossing Norway, Sweden and Russia. The official British expedition proposes to go to the Crimea, but there are so many accessible points on the line that the parties are likely to be widely distributed. The British Astronomical Association will probably organise an expedition to Norway. If it prove as great a social success as that of 1896, and is favoured by kindlier skies, no one is likely to regret taking part in it.

BOTANY

By Professor F. Cavers, D.Sc., F.L.S.

BIOLOGY OF DESERT PLANTS.—Dr. D. T. Macdougal, Director of the botanical research department in the Carnegie Institution at Washington, has recently published (*Ann. Bot.*, Vol. XXVI) a further memoir on the "water-balance" of desert plants. The water-conducting tissues of flowering plants are closely connected with distensible tracts of tissue (*e.g.*, cortex and pith) which have an appreciable capacity for the retention of water in plants of even the most sparing habit and structure. As the ascending water-current passes from the root-hairs to the leaves, some of it may go into such masses of tissue forming reservoirs in the roots, stems, or leaves; this accumulated supply may be drawn out to the transpiring cells when the pressure of the solution in the cell-sap is overcome. All plants with massive stems may thus carry a large balance of water, and this stored solution may play an important part in the plant's life. The relatively largest balances are borne by some of the species characteristic of the arid regions of the south-western and southern parts of North America, some parts of South America, and the southern parts of Africa; while North Africa, Asia, Australia, and arid regions in high latitudes everywhere have but few plants with a large water-balance. The present paper deals with observations made in the Tucson region of Arizona, which has a winter rainy season and a wet midsummer, with a hot dry fore-summer and arid after-summer. The total average annual rainfall is about twelve inches only; the extremest arid effects are seen in June and July, when the humidity falls as low as six per cent. with midday temperatures of 110° F.

In desert regions the vegetation includes a number of rapidly-maturing forms, which carry out their entire life cycle during regular or irregular periods of rainfall, and which are physiologically mesophytes—plants without any marked adaptations for checking transpiration; other forms requiring much moisture occur along streams. Apart from these, the specialised forms which are more or less active during the dry seasons comprise two types—the sclerophyllous and the succulent.

The sclerophyllous type includes a large number of woody and spiny herbs and shrubs with reduced branches, restricted foliage, and hardened surfaces. These xerophytes have a very small water-balance, and the cell-sap often shows great concentration—sometimes over one hundred atmospheres of osmotic pressure. The specialisations shown by sclerophyllous forms are of a direct physiological character, and entail the least change in habit and structure.

The succulents show most of the external features of the spinose xerophytes, which may be carried to extreme limits, as in the Cacti where the entire shoot may be reduced to a short cylindrical or globose form, while there is great increase in the extent of the pith and cortex enabling the plant to carry a large water-balance. The cell-sap of succulents usually shows a comparatively low osmotic pressure—rarely more than about ten atmospheres, though it may increase greatly with desiccation.

The author describes experiments in which various plants were subjected to desiccation, and the effects of depletion of the water-balance noted. The large tree Cactus (*Carnegiea gigantea*) may survive for a year or even more without receiving additional water from the soil, but flowers are not formed in the arid fore-summer unless the plant has received its supply of water during the previous winter rainy season, nor would apical growth ensue in midsummer unless the summer rains were available. In *Echinocactus* both root development and apical growth of the stem, with some capacity for flower formation as well, were shown after one or even two years of depletion of the water-balance; individuals exposed to the full intensity of the Arizona sunlight might not survive for more than a year, though even the slightest amount of shade would greatly enhance the value of the enormous water-balance; plants in an ordinary room were in good condition after three years of deprivation of water. The flattened Opuntias may exist for two or three years without a water-supply, and may carry out seed-formation during this period; new joints may be formed, but usually at the expense of the older ones, which are destroyed during the process. In most of the plants experimented with, no notable changes in structure were shown as the result of depletion of the water-balance, except that the new organs formed were usually of minimum size. The stems of *Dioscorea*, however, showed changes tending to the sclerophyllous habit.

Five possible causes are suggested as influencing the rate of water-loss by transpiration in a succulent exposed to desiccation. (1) The increased concentration of the sap, which in the experiments was such as to increase osmotic pressures from four or five to ten or twelve atmospheres, might retard evaporation from the cell-membranes. (2) A diminution of the degree of succulence, or proportion of water per unit area of surface present, might lessen transpiration. (3) Desiccation may result in alterations in the character of the outer membranes or of any of the transpiring cell-walls of the plant. (4) Desiccation may stimulate the formation of new tissues or the alteration of existing cells in such a manner as to close openings through which water-vapour might pass. (5) The positions of the surfaces might be shifted in such manner as to vary the exposure and lessen transpiration.

With regard to (1), however, Livingston has shown that concentration of the sap, even if carried to a point where an osmotic pressure of one hundred atmospheres was attained, would not result in a retardation of more than ten per cent. in the rate of evaporation from a free water-surface; hence this factor is negligible in the present case, as the increases found were not more than five or six atmospheres.

RESISTANCE OF PLANTS TO FREEZING.—In the *New Phytologist*, Vol. VIII (1909), under the title "Vegetation and Frost," Dr. F. F. Blackman gave an interesting summary of this subject, drawn from the researches of Müller, Molisch, Mez, Gorke, and Lidforss. Müller and Molisch held that the fatal effect of freezing upon plant-cells is due to the withdrawal of water from the protoplasm; but the work of Mez went against this view. Gorke investigated the changes in composition produced by freezing either entire plants or their pressed-out sap, and showed that when water was withdrawn from the cell by freezing, the salts present became more concentrated and eventually caused the precipitation of the soluble proteins of the cell. Lidforss found that "winter-green" plants—delicate herbaceous plants which still bear green leaves in mid-winter, though showing no obvious structural adaptation for protection against cold—contain quantities of sugar in winter, this being replaced in summer (or in winter if the plants are brought into a warm room) by starch; and his observations strongly support the view that the presence of sugar retards the "salting-out" or precipitation of the proteins, which Gorke had described.

The chemical means of protection of plants against freezing have recently been investigated by Maximow (*Ber. deutsch. bot. Ges.*, 1912). He finds that the introduction of neutral organic substances, such as carbohydrates, alcohols, and acetone, into the cells of plants increases their power of resisting cold, in the case of tropical plants as well as those of temperate climates. The protective action of such substances does not stand in direct relation to the osmotic pressure and the lowering of the freezing-point—as the concentration of the substance rises, the resistance to cold increases at a more rapid rate than the lowering of the freezing temperature. Different substances differ in their effect, and of the substances tried the sugars have the greatest effect; then come glycerine, the alcohols and acetone. On the withdrawal from the cells of the protective substance which has been artificially introduced into them, the power of cold-resistance returns to its original condition; and when "winter-green" and other plants are placed for some time in water, their cold-resisting capacity is diminished.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON), F.I.C.

THE MANUFACTURE OF SUGAR FROM SAWDUST.—In a recent issue of the *Journ. Roy. Soc. Arts* (1912, LXI, 69) there is an interesting outline by Mr. A. Zimmermann, of the manufacture and utilisation of the sugar produced by hydrolysing sawdust with an acid. The methods employed in obtaining alcohol from woody fibre have already been described in these columns and the Classen process used in the production of the new commercial product "sacchulose" is based upon similar principles. The sawdust is treated with a solution of sulphurous acid in a closed vessel under a pressure of ninety to one hundred pounds per square inch, with the result that a product containing about twenty-five per cent. of sugars and a porous friable residue of modified wood fibre is obtained.

Owing to the changes in the physical and chemical structure of the material the crude product will readily oxidise on exposure to the air, and to obviate this the "sacchulose" is mixed immediately after its formation with a certain proportion of molasses or fatty matter, with the object of preventing the air from coming into contact with the sugars.

Experiments upon the use of the mixture as a feeding stuff for animals have given very good results. The trials were made upon working horses and extended over a period of six months, four lbs. of the oats in their former daily rations being replaced by four lbs. of the prepared "sacchulose." At first the animals lost in weight, but after they had become accustomed to the change, increases in weight of thirty to eighty lbs. were recorded.

Eighty per cent. of the sugars are fermentable and the original idea of the manufacturers was to produce a cheap commercial spirit which might possibly be used as a fuel for motors. The spirit obtained by fermentation and distillation of the soluble sugars is of excellent quality, and acetic acid, methyl alcohol and furfural could be obtained as by-products from the residue. A yield of thirty to thirty-five gallons of proof spirit would be obtainable from each ton of sawdust, and on this basis it is calculated that in a factory where two hundred tons a week were treated, the yearly output of spirit would be from three hundred thousand to four hundred thousand gallons. Unfortunately for the development of this side of the scheme, the restrictions of the Spirit Act of 1880 bar the way, and fresh legislation is required before anything can be done in this direction.

FABRICS OPAQUE TO X-RAYS.—It has long been known that silk can be loaded with various metallic salts, and advantage is taken of the fact in commerce to sell silk which is sometimes weighted with as much as one hundred and fifty per cent. of a tin salt. A more legitimate use of this absorptive power of silk is described in the *Comptes Rendus* (1912, CLV, 706) by M. L. Droit, who has found that by using certain lead salts for the weighting, a silk fabric may be rendered opaque to the passage of X-Rays. For example, a material thus prepared by treatment of the silk with lead phosphotannate and other salts contained sixty-eight per cent. of mineral matter, including thirty-four per cent. of lead oxide, twenty-four per cent. of tin oxide, eight per cent. of phosphoric anhydride, and two per cent. of lime and alkalies. Slight discharges of X-Rays were practically arrested by two layers of this fabric, while six layers were found a sufficient protection to the skin against the action of an ordinary discharge of medium strength. This fabric had the same protective effect as a sheet of copper 0·044 millimetres in thickness, and had the great advantage of flexibility, even when used in a thickness of several layers.

THE ODOUR OF CLAYS.—An investigation of the cause of the well-known characteristic odour of certain clays has been made by Dr. P. Rohland (*Zeit. physiol. Chem.*, 1912, LXXXI, 200). The peculiar odour which may be imparted to other substances either of a colloidal or crystalloidal character, is rendered more perceptible by moistening the clay with water or alkali solution, especially in the case of kaolin clay. It is suggested that in the formation of such clays during the weathering of granitic rocks, bacteria or other micro-organisms may have had a share in the disintegration and that the odour may be due to the presence of their dead cells. In support of this view it is pointed out, that organic matter is frequently present in kaolin clay, and plays a part in rendering it plastic. If the clay has been purified by sedimentation in water so that the organic colloidal substances have been removed, it ceases to be plastic. Kaolins rich in such organic matter are not only very plastic, but also possess the property of taking up other colloids to form loose absorption compounds. When kaolin clay is digested with a mixture of water and an aromatic hydrocarbon, such as benzene, it becomes quite impervious to the hydrocarbon, though it will still allow the water to pass.

COMPOSITION OF THORIANITE.—An examination of various specimens of the mineral thorianite has been made by Mr. M. Kobayashi (*Science Reports*, Tôhoku University, Japan, 1912, I, 201), who concludes that there are two varieties, one of which contains about seventy-eight per cent of thorium oxide, and about fifteen per cent. of uranium oxide, while the other contains about sixty per cent. of thorium oxide and thirty-three per cent. of uranium oxide. In the first of these varieties the rates of ThO_2 to UO_2 would thus be as 6 : 1, while in the second the ratio would be as 2 : 1. The remarkable discrepancies in analyses, previously published, of the composition of this mineral are readily explained on the assumption that the materials examined consisted of mixtures in varying proportions of the two varieties.

Some years ago a specimen of thorianite from Ceylon was described by Messrs. Dunstan and Jones (*Proc. Roy. Soc.*, 1906, LXXVII A, 546). This was very rich in uranium, and the proportion between the two oxides was taken to indicate that the uranium and thorium oxides were present in thorianite as isomorphous mixtures and were not in chemical combination. Mr. Kobayashi is opposed to this view on the grounds that the molecular ratios mentioned above could scarcely be accidental, and that while ignited thorium oxide is nearly insoluble in nitric acid, thorianite is fairly soluble even after ignition.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

THE SUSSEX SKULL.—A most important discovery of human fossil remains has been made by Mr. Charles Dawson in a gravel-pit near Piltdown Common, Fletching, Sussex, and described at a recent meeting of the Geological Society. The section, about four feet thick, consists mainly of water-worn fragments of Wealden ironstone and sandstone, with occasional chert pebbles, and a considerable proportion of water-worn flints. In addition to a portion of a human skull which was found by workmen, Mr. Dawson obtained half a human mandible, broken pieces of the molar of a Pliocene type of elephant, a rolled cusp of a molar of *Mastodon*, and teeth of *Hippopotamus*, *Castor*, and *Equus*, with a fragment of an antler of *Cervus elaphus*. All these fossils, including the human, were well mineralised with oxide of iron. Many of the iron-stained flints resemble the "eoliths" from near Ightham, and with them were obtained a few Palaeolithic implements of Chellean type.

The Piltdown gravel is eighty feet above the river Ouse, and less than a mile to the north of the existing stream. The authors believe that the gravel is of the same age as the contained Chellean implements. The various teeth are believed to have been derived from older gravels; but the human skull and mandible, which do not show signs of water-transportation, are assigned to the period of the deposition of the gravel. The remoteness of this period is indicated by the fact that the Ouse has since deepened its valley by eighty feet.

The human remains were described by Dr. A. S. Woodward, who suggests that they belonged to a female individual, and represent a hitherto unknown genus and species. In an appendix, Professor Elliot Smith remarks that although the brain shows a general similarity to the cranial casts of Palaeolithic man, especially those of Gibraltar and La Quina, it is smaller and more primitive in form than any of these. A most noteworthy feature is a pronounced gorilla-like drooping of the temporal region, indicating feeble development of that part of the brain which is known to be related to the power of speech. Dr. Woodward concluded that the jaw was simian in type, although found in association with a human type of skull, and in this he was supported by Professor Elliot Smith and Sir E. Ray Lankester. In the discussion Professor Keith thought that the simian character of the jaw and the primitive characters of the skull were incompatible with Chellean age. In his opinion the skull was of the same age as the mammalian remains which were admittedly Pliocene. Hence he believed that Tertiary man had been discovered in Sussex. Mr. Clement Reid was of the opinion that the Piltdown deposit, and the plateau on which it rests, belong to a base-level plain which originated about the period of the Brighton raised beach. The deposit was not Pre-Glacial or even early Pleistocene, but occurred at the very base of the great implement-bearing succession of Palaeolithic deposits in the south-east of England, and belonged to an epoch long after the first cold period had passed away.

THE MOINE GNEISS.—The new geological Survey Memoir bearing the cumbrous title, "The Geology of Ben Wyvis, Carn Chuinneag, Inchbae, and the Surrounding Country," is a most interesting production, and students of the petrology of the metamorphic rocks will find in it an excellent discussion, by Dr. J. S. Flett, of the Moine and other gneisses and schists in this area. The Memoir describes an area of four hundred and thirty-two square miles, almost all of which lies in Ross-shire and extends westward from the Cromarty and Dornoch Firths. A few small inliers of Lewisian gneiss occur in the south-west, but the major part of the district is occupied by the Moine gneisses, which are paragneisses representing a great sedimentary series originally composed of sandstones, pebbly grits, and sandy shales. The Moine is divided into four groups, of which the one supposed to be the highest in stratigraphical sequence is pelitic or semi-pelitic in composition, and is invaded by a great mass of foliated granite (augen-gneiss), with subordinate basic and alkaline varieties. All the latter were intruded into the Moine sediments prior to the movements which transformed the rocks into gneisses. This is shown by the fact that the Carn Chuinneag granite has still preserved around it an aureole of contact - metamorphism which has resulted in the production of hard, fine-grained hornfels from the original sandy shales of the Moine. The induration of the hornfels has been such that, in many places, they have completely resisted the gneiss-making movements, and are in substantially the same condition as when first formed. Although completely recrystallized these hornfels have never been deformed or sheared, and have preserved a fine sedimentary lamination. Even sun-cracks and ripple-marks have been observed on the surfaces of the bedding planes. They, therefore, prove up to the hilt the original sedimentary character of the great series of Moine gneisses which occupy so much of the North of Scotland.

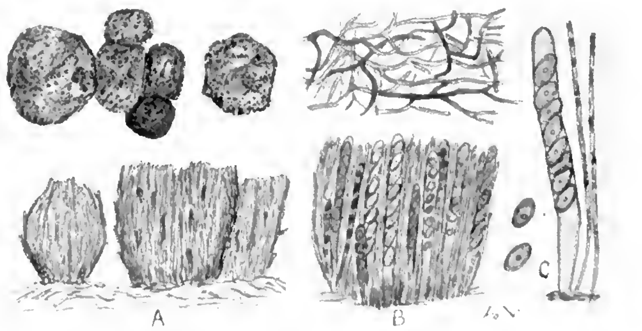


FIGURE 65. *Peziza domestica.*

MICROSCOPY.

By F.R.M.S.

A "DOMESTIC" FUNGUS.—Owing to the very wet autumn a damp spot appeared on the ceiling of a bedroom, and in a short time a small fungus developed on it. It is a species not infrequent under similar circumstances, though probably seldom identified. It begins as a cottony web-like mycelium, very delicate and invisible on the white of the ceiling, the threads composing it being without colour. On this arise minute, almost spherical, bodies, the microscope showing them to consist of fine filaments arranged side by side. As growth proceeds, these spread at the top, forming somewhat cup shaped objects, but commonly much distorted by pressure as they usually occur close together in patches. Inside they are packed with *paraphyses*, long hair-like objects, and *asci* (plural of ascus) narrow sacs, each containing at maturity eight oval thin-walled *sporidia*, arranged in one row; when ripe they measure from sixteen to eighteen μ long, by about eight μ wide, and are then ejected by means of any change of temperature or moisture. The little fungi are usually pale salmon pink, but sometimes are white, though apparently differing in no other way. This species is named *Peziza domestica*, as it is most commonly found on damp ceilings and the plaster of walls in houses, but it occasionally arises also on burnt ground. There are some hundreds of species of the genus *Peziza*, which are in most cases elegant little cups often very minute, and grow on various objects out of doors, such as twigs, leaves, and other refuse, particularly of a vegetable character. This example is not a very typical one, as the body of it is scarcely cup - shaped, but rather sub-cylindrical with a conical base, and shows no hollow. It is small, measuring only about ·5 millimetres in diameter and frequently much less. The Pezizas are members of the Discomycetes, a very large group of the Ascomycetes, which are so named because, as in this case, the spores are formed in an *ascus*. The spores are called *sporidia* as a distinction from those arising without this organ. In Figure 65, A shows a young and mature specimen seated on the mycelium; above is sketched a surface view showing the irregular form caused by crowding. At B is a sectional view of the fungus on a larger scale, showing the asci with sporidia in various stages of growth, among the numerous paraphyses; above is some of the web-like mycelium; and at C an ascus with sporidia, two paraphyses and two free sporidia, all more highly magnified.

JAS. BURTON.

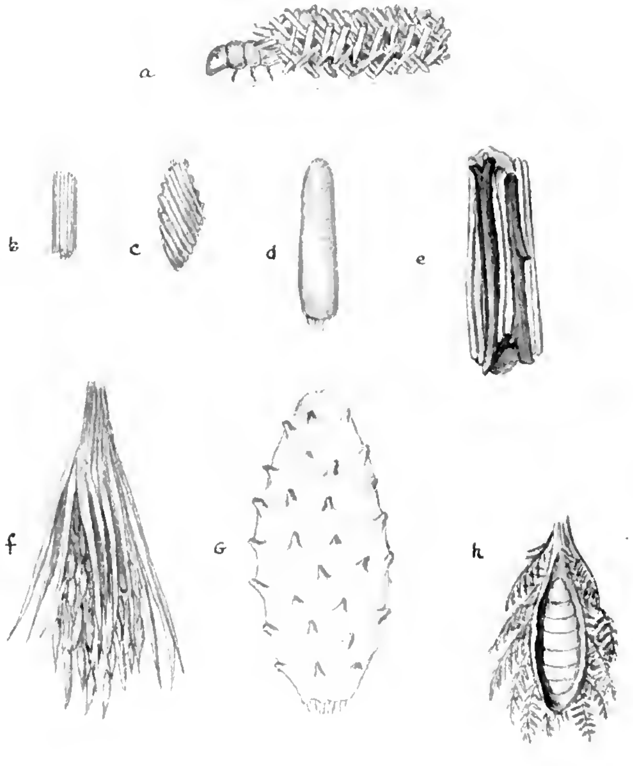


FIGURE 66. Natal Psychidae (natural size).

PSYCHIDAE.—The caterpillars of the Psychidae are amongst the most curious and wonderful to be found in the insect world, since they make and live in houses of marvellous construction which they carry about with them wherever they go. These houses differ in shape and material in different species, and though our British examples are small and inconspicuous, some of those found in South Africa and India reach a length of over three inches. Our illustration gives a selection of typical forms from Natal, drawn natural size. Of these, Figure 66A shows a caterpillar with its head and first three segments protruding from its house, the rest of the body remaining inside. In this manner it walks about and feeds, always dragging its house with it, which in this instance is formed externally of small sticks cut into short lengths symmetrically arranged and fastened together with silken threads. The inside is lined with a smooth blanket of silk, quite closed at one end, but having a door at the other end constructed of a number of stiff pieces of dried grass fastened round the edge of the blanket and attached to it in such a manner that when the occupant retires within, it can close them down and cause them to interlace so effectually that not even the smallest of insect enemies could gain admittance. When night approaches the caterpillar suspends its house from the branch of a tree by a silken cord, and then, retreating inside, closes the door and snugly reposes in its blanket until the morning. Some which I kept alive in a box, found at first some difficulty in thus suspending themselves from the glass cover, but this was at length overcome by making a lattice-work path of silk across the underside of the glass along which they were able to walk and from which they hung their houses every evening. A number of eggs laid by the moth of one species on the flowers of one of the Compositae hatched out as the flowers were maturing, and the larvae, one thirtieth of an inch in length, immediately began to cut up the feathery pappus and constructed the most perfect little houses, which they somehow managed to enlarge as required by their growth, without alteration of the original design. In Figure 66B, the house is made of pieces of the stems of fine grass arranged in parallel lines. Figure 66C is apparently made of some kind of fibre worked together obliquely and partly covered with silk. Figure 66D is presumably made of fine fibres but is so completely covered with silk as to prevent them from being seen. Figure 66E is formed of two kinds of sticks fastened together lengthwise. Figure 66F is chiefly constructed of the dried spikelets of grass overhung with a roofing of grass leaves. Figure 66G is obviously made of sticks, the ends of some of which are seen projecting through a thick covering of silk, and Figure 66H, consisting chiefly of the small dried leaves of a Mimosa, has been cut open, showing the chrysalis inside.

The natives of Southern India, where Psychidae similar to Figure 66A are not uncommon, regard these creatures as the embodiment of the souls of men who having during their human lives been addicted to the stealing of firewood, are passing their next period of existence attached to a bundle of sticks. The Kaffirs of Natal, however, have given them the common name of Mahambanendelwhana, which, being translated, means "he that goes with his little house." Friends who sometimes complain of the long names given to insects by entomologists, will possibly think that this is no improvement.

R. T. L.

ON THE RELATION OF APERTURE TO POWER IN THE MICROSCOPE OBJECTIVE.—That opticians are human they would themselves admit, and to supply what the public demands is the essence of business with them as with everyone else. Moreover, competition is keen, and hence each tries to give his customers a better bargain than can elsewhere be obtained.

Now, by a "better bargain," the microscopical customer only too often understands objectives of higher numerical aperture, since stands, eyepieces, and condensers of similar quality are now much the same price everywhere. But A puts into his a two-third inch of N.A. ·30 and a one-sixth inch of ·88, B gives N.A. ·28 and ·74 respectively, whilst C gives ·25 and ·65 for these same lenses. The one-twelfth oil immersion is almost invariable everywhere nowadays, being of about N.A. 1·30, and costing five pounds.

In the above case A would often get the order, the tyro arguing that increased N.A. meant more resolution, and therefore better results. It is altogether forgotten that behind everything is the human eye, and that this admits of improvement within but narrow limits. Let us see what those limits are.

The standard distance for ordinary eyesight is ten inches. Most people can with but little practice, by the aid of a rule divided into tenths, prick off divisions as small as the one-hundredth part of an inch. We may take this as fairly easy.

Now let us go a step further and ask how closely can we read a millimetre scale? Remember a millimetre is practically one twenty-fifth of an inch. Can we without a vernier, or lens or any other extraneous aid, read it closer than to one-fifth of a division, *i.e.*, one hundred and twenty-fifth of an inch? Very few would say that this was possible with ease, and, above all, certainty. Rule, *e.g.*, a few lines of different lengths. Obtain a glass scale with millimetre divisions on the lower surface (so as to avoid parallax) then measure the lines and put the measurements down on paper. Ask others to do the same, and you will find that the fifth of a millimetre is about the average of good ordinary eyesight, and that even if one has large powers of accommodation and can, for instance, read ordinary print at, say, five inches distance, yet the millimetre scale will still defeat us if we attempt to read it closer than fifths.

Let us go elsewhere for confirmation. Vega forms the brightest of a small triangle of stars distant from each other less than two degrees. The one N.E. of Vega is ϵ Lyrae, a noted double double. Most people cannot see it double at all. Many astronomers can separate them without artificial aid. Smyth says: "The naked eye sees an irregular-looking star near Vega, which separates into two pretty wide ones under the slightest optical aid. "So," adds Webb, "I see it, and probably most observers," but notes that Herschel, Bessel and "many others have divided it with the naked eye." The distance is three minutes twenty-seven seconds. This angle corresponds almost exactly to one hundredth of an inch at a distance of ten inches.

Now let us return to the microscope. In Mr. Conrad Beck's Cantor Lectures on "The Theory of the Microscope" page 40, we read, "It is generally considered that for every one hundred magnifying power the numerical aperture should not be less than about ·2 N.A.

Now, a numerical aperture of ·2 should resolve nineteen thousand three hundred lines to the inch. With a power of one hundred we must be able to separate lines $\frac{19300}{100}=\frac{1}{193}$ of an inch. This agrees well with Professor Abbe's calculations, which are based on the assumption that the human eye can distinguish intervals, having an angle of two minutes or $\frac{1}{172}$ at ten inches. Mr. E. M. Nelson puts the ratio as a magnification of one hundred to ·26 N.A. Now, ·26 N.A. will resolve twenty-five thousand lines per inch. In this case, therefore, we get the limit of resolution of the eye itself given as two hundred and fifty lines per inch. Professor Abbe's researches date from 1874–5; Mr. Nelson's opinion dates from 1883; whilst Mr. Conrad Beck's lectures were given in December, 1907.

We may approach the solution of the question by asking at the very commencement what eyepiece magnification and what tube length must we predicate? As regards the latter we have no choice, the six-inch tube (one hundred and sixty millimetres) being now almost universal. Eyepieces, too, are now almost universally the same and give, with the one hundred and sixty millimetres tube, powers of 3, 4, 5·5, 7, and 9. Professor Abbe gives the upper limit of eyepieces as ten with N.A.·10 and only four with N.A.·90. His researches, as I have just said, date from 1874 when the substage illumination, at least on the Continent, was of the most primitive description. At the present day, whilst the experienced worker confines himself as far as possible to low and medium eyepieces, he does not hesitate to use the higher if required to reveal structure. Much, however, depends on his objectives.

Passing over the lower power lenses, which are used only as finders, we come to those useful medium powers ranging from the one-inch to the half-inch or four-tenths of an inch, which consist usually of two doublets.

These admit abundance of light and often possess a working distance equal to three-quarters of their focal length. They can scarcely be said to be used for highly critical work and will bear an eyepiece magnification of at any rate more than ten. Professor Abbe gives such moderate powers an eyepiece amplification of 5·5 to 9 and since his day the excellence of objectives has advanced all along the line thanks to the Abbe-Schott glass and other causes, so that nowadays every objective of four-tenths of an inch or lower will bear an eyepiece magnifying ten on the one hundred and sixty millimetres tube. Even then we must be careful as to the illumination or we shall only get a foggy glare.

Dry objectives of high power ranging from, say, one-quarter of an inch to one-tenth of an inch now almost invariably consist of a hemispherical front with two correcting systems of lenses behind. It is not easy to make such a combination much lower than ·60 N.A. and they range as a general rule from ·60 to ·90 N.A. It is with these that the greatest improvement of all has taken place. The new optical glass, and especially the use of fluorite in one of the back combinations, have led to such an advance in the colour corrections of these series that nowadays one can often scarcely see the difference between them and the apochromatic, so inconspicuous is the secondary spectrum. For photographic work, with the monochromatic screen, they are equally as useful as the much higher-priced lenses. Their spherical correction is excellent, at any rate up to nearly ·90 N.A. We, however, begin to note a falling-off in the quality of the image under the higher eyepieces, though nearly all stand an eyepiece of ×10 with little or no deterioration. It may be said that photographs show that such powers will give good definition up to nearly fifteen times their initial power. But in photography there are no *muscae* to disturb the sight, and the effect is, above all, cumulative. Even for photography this limit is never exceeded, except for well-marked objects like such diatoms as are well within the resolving power of the objective.

We may, therefore, take it that one hundred and twenty-five lines to the inch is about the average power of resolution for the ordinary eyesight, and that an eyepiece magnification of ten can be used with any objective of the present day consistently with perfect definition and sufficiency of light.

We must now endeavour to find out the initial power of the objective suitable for each numerical aperture. This is fairly obvious.

An objective of ·13 N.A. will resolve twelve thousand five hundred lines to the inch according to the well-known tables of the Royal Microscopical Society, the accuracy of which have never been impugned. To accomplish this the objective must have an initial power of ten which, multipled by ten (the power of the eyepiece), and then by one hundred and twenty-five (the limit of resolution of ordinary eyesight), gives us the twelve thousand five hundred required.

Now an objective with an initial power of ten must be of sixteen millimetres focus, *i.e.*, two-thirds of an inch. Thus, a sixteen-millimetre objective should possess an aperture of ·13. The lowest usually made at the present day is ·20 N.A., so that it has a large surplus of aperture, and would resolve nineteen thousand two hundred and eighty-two lines to the inch with an eyepiece magnifying 15·4 times. As a matter of fact, it is easier to make a sixteen-millimetre objective of the higher N.A. than as low as ·13 N.A., which latter could only be done easily by using a single achromatic triplet which would not bear an eyepiece of more than × 7.

We may now construct a table of magnifications of the corresponding N.A., and of the focus of the objective required to obtain that magnification with an eyepiece amplification of ×10.

Magnification.	N.A.	Focal length of Objective.
100	·13	16·0 mm.
200	·26	8·0 „
300	·39	5·33 „
400	·52	4·0 „
500	·65	3·2 „
600	·78	2·67 „
700	·91	2·3 „

The point to be observed is that the above are the minimum figures really required. As we have said, it is not easy to make objectives of as low a numerical aperture as the first five, owing to optical difficulties. Nor would an addition of reasonable amount be objectionable, so long as proper working distance be kept in view. It is, however, useless to give us a four-millimetre (one-sixth) objective of N.A. ·88, as its aperture could not be fully utilized except by employing such high power eyepieces or lengthening the tube as would utterly break down the critical character of the image. Anything above ·52 N.A. for such an objective is of little or no value, and if working distance is sacrificed to obtain a higher aperture it is worse than useless. As a matter of fact ·65 N.A. is the lowest aperture in which such a lens is made. Fortunately, opticians are beginning to see this, and we have now objectives of this focus beautifully corrected with a working distance of one millimetre, thus allowing them to be used with Thoma-Zeiss Haemocytometer, or with thick covers.

It will be said that greater aperture means more light, but in these days of efficient condensers this is no desideratum. As a general rule, the light nowadays is oftener too much than too little.

Besides, we sacrifice depth of focus, which is too often confounded with working distance, but which really varies inversely with the N.A. Thus, in two six-millimetre objectives of ·62 and ·92 N.A. respectively, the former would possess a depth of focus of 1·6, the latter that of 1·1 only, or one and a half times the latter—an important point, especially in microphotography.

It may be added that the one-twelfth homogeneous immersion usually sold cannot be improved upon either in aperture or power, as will be seen if the reader will carry on the figures in the above. It possesses a good proportion of aperture to power and reasonable working distance, considering the aperture.

It will be asked what size would the disc of confusion be with such low apertures? The usual formula being employed, we have $\frac{100}{95000 \times \cdot 13} = \frac{1}{123 \cdot 5}$ inch which is at any rate a safe limit above the conventional one-hundreth part of an inch.

With Mr. Conrad Beck's formula rigidly applied, we have the following table:—

Magnification.	N.A.	Focus of Objective with Eyepiece 10.
100	·20	16·0 mm.
200	·40	8·0 „
300	·60	5·33 „
400	·80	4·00 „
500	1·00	3·20 „

A power of four hundred and fifty would thus be the limit for dry objectives of ·90 N.A. The circle of confusion with this series would be the one hundred and ninetieth part of an inch.

With Mr. Nelson's formula we get:—

Magnification.	N.A.	Focus with Eyepiece 10.
100	·26	16·0 mm.
200	·52	8·0 „
300	·78	5·33 „
400	1·04	4·00 „

His circle of confusion would thus be the two hundred and forty-seventh part of an inch.

Comparison of the above with Professor Abbe's figures is not easy, since, as we have said, he decreases the power of the eyepiece as that of the objective increases, but no formula is given for the relationship between the two. They are simply the results of experiments made in 1874 on several objectives. Professor Abbe's paper was read on June 14th, 1882.

The following extract only from his table will suffice.

N.A.	Total magnification.	Magnification of eyepiece.	Magnification of objective.	Focus of objective.
·10	53	10·0	5·3	47·2 mm.
·20	106	8·2	12·8	19·4 „
·30	159	6·7	23·7	10·5 „
·40	212	5·6	37·9	6·6 „
·50	265	5·0	53·0	4·7 „
·60	317	4·6	68·9	3·6 „
·70	370	4·3	86·0	2·9 „
·80	423	4·1	103·2	2·42 „
·90	476	4·0	119·0	2·10 „

That this table does not agree with modern practice will probably be admitted. That modern objectives will bear higher eyepieces than the last six or seven of the table will probably also be allowed. This, however, is no fault in the table itself, which I cannot doubt was correct for most objectives of 1874. It is due to Professor Abbe himself that we are able to use new formulae for new objectives. The Abbe-Schott glass it is that enables the modern optician to make a dry one-tenth of an inch objective almost as perfect as the inch or the two-thirds of an inch. Professor Abbe's table shows us only the better the result of his investigations in both the theory and practice of the construction of objectives. Thus, we reject most of his tables as too low. We must reject Mr. Nelson's as too high. There remain Mr. Beck's and my own. The latter are, as I have explained, the minimum that can be adopted with safety, and some may prefer for a magnification of one hundred an aperture of ·15, or even ·17, but the former would be ample for even "spotting" diatoms, giving a circle of confusion of about the one hundred and forty-third part of an inch.

The point to be noted above all is, that for good working distance and depth of focus the lower the angle the easier the work. Empty amplification is a great mistake, empty aperture is a greater, and much more expensive and equally valueless.

A four-millimetre objective, *e.g.*, of N.A. ·65 or ·74, is far more convenient than one of N.A. ·90 which will only work over No. 1 covers, whilst the former have working distances of a full millimetre. But the craze for "angle" is still with us, and many would rather take a quarter of an hour in coaxing a quarter-inch to resolve Angulatum than put on a one-twelfth inch and do it in one minute. Where, however, the student wants efficiency, convenience and moderation in price, he will get low angles for dry objectives based on N.A. ·15 per one hundred magnification. A one-sixth inch that will not work over any cover, even a No. 3, is a nuisance in a laboratory, and an unnecessary nuisance, too.

Meanwhile, opticians laugh in their sleeves and play to the gallery, and above all rake in the coin that foolish men throw away. If their clients will spend two pounds on a two-thirds where one pound would buy an equally useful one, or three pounds on the one-sixth where thirty shillings might have sufficed, they cannot complain. Meanwhile the student has wasted two pounds ten shillings: that is, half the cost of a good one-twelfth inch oil immersion which some day he must buy. Let him remember that useless aperture is a useless possession.

There is also another matter which these investigations bring out, and one which is of great practical importance, namely, the limit of useful magnification, and on this we must touch briefly.

At present the highest numerical aperture is 1·50. It will therefore be seen that if for every one hundred of magnification we allow a numerical aperture of ·20, the highest useful power will be seven hundred and fifty. Anything beyond that reveals no further structure, according to Mr. Conrad Beck's formula. With him agrees Professor Abbe. By Mr. Nelson's formula, the limit of useful power will be only $\frac{1\cdot 50 \times 100}{\cdot 26} = 577$, a much lower figure.

Let us now take facts. Most opticians make a two-millimetre semi-apochromatic of N.A. 1.30 at £5, and one of N.A. 1·40 at a varying price. They are, of course, oil immersions. The resolving power of the former is about one hundred and twenty-five thousand, and of the latter, one hundred and thirty-five thousand, as given in the tables. By photography these limits may be extended to one hundred and sixty-five thousand and one hundred and seventy-seven thousand eight hundred respectively.

The test diatom, *Amphipleura pellucida*, varies but slightly in its markings between ninety-five thousand and one hundred thousand lines per inch. It also varies a little in other ways, some being strongly marked, others being more feeble and difficult.

Now, we have several photographs of this diatom taken by acknowledged masters, with every appliance at their disposal. These photographs ought to show about thirty-three per cent. more than can be seen visually, so that what is not there in the photograph is almost certainly beyond the limits of ordinary vision.

In Dr. Spitta's "Microscopy," we have on Plate IV, Figure 2, a photo of the diatom with a Zeiss two-millimetre apochromatic of N.A. 1·30×750. This photograph, then, ought to show as much as the eye would see with the same objective, and under a magnification of one thousand. It shows fine lines only, and Dr. Spitta tells us in his text that this is what such an objective should show, and I do not for one moment doubt that this is all we ought fairly to expect. But notice, we have got above our theoretical limits of useful magnification and still get only lines shown.

In Messrs. Leitz's Catalogue of Photomicrographic Apparatus, another photograph is found taken with an apochromatic two-millimetre objective, the N.A. of which is not given, but is either 1·32 or 1·40. The magnification was one thousand one hundred and fifty, and a deep blue screen was used, needing an exposure of six minutes. This would give us as much as the naked eye, ×1400 or so. Still we get lines only, and again I insist that I do not doubt we see all that can be expected. There is a faint suspicion that the lines are serrated as if nearing resolution, but that is all we can say. But again notice, we have got to nearly twice the old theoretical limits of useful magnification and still get lines only.

We turn again to Dr. Spitta's volume, and on Plate VI, we find a magnificent photograph "taken (using blue light) with a Zeiss two-millimetre apochromat N.A. 1·40 × 2,800." He also notes that the dots are about the one-hundred-thousandth part of an inch diameter" and that "these are very difficult to see without the use of oblique green light, even when employing the finest objective. A first-class semi-apochromat should then show the dots furnishing an image almost as good as that afforded by the apochromat," and so on. I may add, the diatom is mounted in realgar, and is a picked specimen of the well-marked type. The magnification shows as much as one of three thousand five hundred does visually, *i.e.*, nearly seven times the old theoretical limit; and now we get fresh structure, namely dots.

Thus, the old theories must be revised, or at least modified; seven hundred and fifty is not the extreme limit of useful magnification. We may increase it to at least $\frac{1\cdot 50 \times 100}{\cdot 13} = 1{,}154$, or perhaps even to $\frac{1\cdot 50 \times 100}{\cdot 10} = 1{,}500$, with advantage. Our objectives will in this latter case be of much lower aperture, especially compared with the focus. but this is no difficulty, and the wise student will still use a low aperture for the usual two-thirds (sixteen-millimetre) objective, one of N.A. ·65 to ·75 for the one-sixth inch (4·2-millimetre), and one of as high as he can afford for the one-twelfth inch (two-millimetre) oil immersion. From the last alone he will expect the utmost resolution. The others will show him all that the eye can see without unduly forcing them by high oculars, and altogether he will have a battery that will save his eyesight, his patience and his pocket, and that will, above all, never disappoint him or fail to show him all that can be shown.

The specialist may go a step further and obtain a one-sixteenth inch oil immersion for the very highest power, not in place of the one-twelfth inch, but to supplement it and to prevent the use of too high an eyepiece. But it will be a luxury and not a necessity—a specialist's motor compared to the general practitioner's gig. For general work he will find low apertures and medium eyepieces give him everything that he can wish, and that the craze for higher apertures is the mark of the dilettante and not of the worker, of the ignoramus and not of the savant.

E. Ardron Hutton, M.A.

PHOTOGRAPHY.

By Edgar Senior.

PHOTOGRAPHY WITH A PIN-HOLE. — Having for some time past devoted a considerable amount of attention to the above, it was thought that the subject might be found interesting to readers of "Knowledge" generally, as well as to those in search of methods, more or less novel, for obtaining photographs. Of course, it is not for one moment claimed that the definition given by a plain aperture—or so-called pin-hole—even approaches that of a high-class lens, yet the results are by no means fuzzy or blurred, as the illustration, Figure 67, from a pin-hole photograph taken by Mr. Alfred S. Gannon, the subject being "St. Brelade's Church, Jersey," testifies. Then again, as we do not in nature meet with that uncompromising sharpness which so many photographs exhibit—a plain aperture will, in many cases be found to give more artistic results, possessing those qualities termed by artists "atmosphere," "breadth of effect," and so on, and in the case of the photographing of buildings it is to be highly recommended, since the image will be an exact facsimile of the object, with an absence of that distortion so frequently seen in photographs of a similar character. The one great drawback attending the use of a pin-hole in place of a lens is the protracted exposure necessary, which so limits its usefulness that, generally speaking, it is only in still-life subjects that its application is really possible. On the other hand, one of the advantages frequently claimed for the use of a plain aperture in place of a lens is the readiness with which the size of the image may be varied, merely by moving the plate nearer to, or further from it, without the definition appearing to suffer to any appreciable extent by so doing, the only alteration being in the amount of subject which is included, and which is dependent upon the relationship between the length of the plate and its distance from the aperture. Both theory and practice, however, agree in showing that the sharpest image is obtained when a definite relationship exists between the distance of plate and size of aperture, and although diminishing the aperture may improve the definition up to a certain point; beyond this the reverse would be the case, a result explainable on the undulatory theory of light. It therefore appears that the size of the aperture "for the best results" is regulated by the distance of the plate from it, and the wavelength of light employed in taking the photograph. We have before us as we write a photograph of a point of light taken with a pin-hole of one hundredth of an inch in diameter: the image is shown as a bright centre surrounded by eighteen alternately bright and dark bands (due to diffraction). A second photograph, taken with a larger aperture, shows an image of the same point of light, as a bright centre surrounded with only one dark band, with a faint indication of the formation of the first bright one. This photograph exhibits the limit to the size of the aperture for that particular distance of plate, as if it be diminished beyond this, each point in a luminous object would give rise to a spot surrounded by alternately bright and dark rings, which would impart a confused appearance to the photograph. The size of aperture that will give the best definition from fulfilling the above requirements has received the attention of more than one eminent writer, and is given by the equation:—

$$D = 2\sqrt{\lambda L}$$

where D is the diameter of aperture required, λ the wavelength of light, and L the distance of the plate from the aperture.

Figure 67. St. Brelade's, Jersey.

From a pin-hole photograph by Alfred S. Gannon. Diameter of aperture $\frac{1}{50}$-inch, distance of plate 6 inches, exposure $1\frac{1}{2}$ minutes.

When employing light of maximum photographic activity the following formulae by Sir William Abney may be used:—

$$D = \frac{1\sqrt{L}}{120}$$

D and L being measured in inches. Taking nine inches as the distance of plate, the size of aperture would be found:—

$$\frac{\sqrt{9}}{120} = \frac{3}{120} = \frac{1}{40} \text{ inch.}$$

Table 16, giving the diameters of aperture best suited to the distance of plate, has been calculated from these formulae.

Diameter of Aperture.	Distance of the Plate.
$\frac{1}{60}$ inch.	4 inches.
$\frac{1}{50}$ inch.	6 inches.
$\frac{1}{40}$ inch.	9 inches.

Table 16.

We now come to the question of the exposure required; but this need not present any real difficulty if we remember that the rule which governs it generally equally applies here, and that it may, therefore, be obtained from comparison with a lens aperture of known value. Thus, suppose it is desired to know what exposure is necessary to be given with an aperture of one-fiftieth inch in diameter, to a plate at six inches from it, in comparison with a lens of six inches focus and stop three-quarters of an inch in diameter (f/8). By the rule, the exposures would be as $(\frac{1}{50})^2$ to $(\frac{3}{4})^2$ or $\frac{1}{2500}$ to $\frac{9}{16}$, so that the plain aperture requires 1406·25 times longer exposure. Therefore, if the subject required one-fifteenth of a second when using the lens whose aperture was three-quarters of an inch in diameter, by substituting the pin-hole whose diameter was one-fiftieth of an inch, the required exposure would be one minute thirty-three and three-quarter seconds. It is therefore evident that the required exposures may be readily calculated from the intensity ratios of the apertures. In determining the exposure by this method, the distance of the plate should be the same in both cases, as the exposure required varies as the square of this distance.

In order to avoid any calculations at the time of taking the photographs, it is advisable to draw up a table of the exposures required with plain apertures compared with those of a lens, when used under various conditions; such as speed of plate, condition of light, time of day, time of year, distance of object, and so on. With regard to the photographs themselves, they may be said to possess a charm peculiarly their own, while at the same time the method of production is of the most simple and inexpensive kind.

In making these apertures for use, the writer employs both brass and aluminium foil (preferably the former) as the material, piercing the holes by means of fine needles, care being taken that any slight burr round the edge is carefully removed by rubbing on an oil-stone, so that there is no appreciable edge to interfere with the passage of light through them. By examination from time to time under a microscope of moderate power their condition is observed, and when satisfactory the aperture is measured, and the foil containing it mounted up in a frame of blackened card for use.

ZOÖLOGY.

By Professor J. Arthur Thomson, M.A.

PROPORTIONS OF SEXES IN EARWIG.—H. H. Brindley finds that the proportions of the sexes differ considerably in different localities in the same year and sometimes differ considerably in localities quite near each other. The proportions may differ appreciably in the same locality in different years. This may be due to variation in the extent to which the males survive the winter. There is a slight suggestion that the percentage of males is higher on small islands. The evidence that the characters of the soil or vegetation or altitude affect the proportions of the sexes is exceedingly slight. The normal length of life of earwigs is unknown. Adult males are found somewhat rarely in the early months of the year.

COLOUR OF FISHES.—The epidermis of fishes is delicate and transparent. All the colour is in the dermis, and it usually occurs in separate pigment-cells. These usually show numerous radiating processes, and the pigment can be spread out over a large surface or concentrated in the centre. This depends on the expansion or contraction of the mobile protoplasm of the pigment-cells. According to the pigment they contain,—black, or yellow, red, and so on—the pigment-cells are called melanophores, zanthophores, erythrophores, and so on. Then there are other cells containing spangles of the waste-product guanin, which are called iridocytes or guanophores. They cause the silvery, metallic, or iridescent appearance familiar on many fishes. But Professor Ballowitz has recently discovered in the weaver and some other bony fish, a new kind of chromatophore, not a single cell, but a group of cells. Each melaniridosome, as he calls them, is a cluster of iridocytes with an encapsuled central melanophore, which sends its ramifying processes through the capsule in complicated courses.

PARENTAL CARE AMONG ANTARCTIC ECHINODERMS.—It is well-known to zoölogists that many of the Antarctic sea-urchins, sea-cucumbers, and other Echinoderms show parental care, keeping their young ones sheltered about their bodies and that in a striking variety of different ways. Professor Ludwig has recorded ten cases of parental care in Echinoderms from warm waters, and twenty-nine from the Antarctic. Out of twenty-four different species of coastal sea-urchins from the Antarctic, Mortensen reports that no fewer than fourteen show parental care, and eleven of these are littoral. The puzzle is why this habit, which is rare among Echinoderms as a class, should be so common in the Antarctic. An answer has been suggested by Hjalmar Ostergren (*Zeitschrift wiss. Zool. C.* 1912). He points out, first of all, that the numerous sea-cucumbers which exhibit parental care in the Antarctic, belong to families which are known elsewhere to exhibit the same peculiarity. He points out, in the second place, that the distribution of land and water in the south is quite different from that in the north, and that for coastal Echinoderms everything is against the success of free-swimming larvae. The low temperature of the water and its low salinity tend to bring about a shortening of the life-history or at least a suppression of free-swimming larval stages. In point of fact, only three or four cases of free-swimming Echinoderm larvae are known from Antarctic seas.

CORRESPONDENCE.

SQUARING THE CIRCLE.

To the Editors of "Knowledge."

Sirs,—In a letter in the November issue of "Knowledge," "Geoma" gives a method of "squaring the circle," stating that the perimeter of a circle of unit diameter is equal to that of a certain triangle. This amounts to no more than the statement that $\pi=\sqrt{5}+1$ approximately. This is not in itself a good approximation to the value of π and it would be quite easy to draw a triangle whose perimeter gave a much closer approximation. But, however close the approximation, we should be no nearer "squaring the circle" by geometrical methods.

3, St. John's Road, Oxford. R. J. POCOCK.

THE FOURTH DIMENSION.

To the Editors of "Knowledge."

Sirs,—Referring to recent letters on this subject which have appeared in "Knowledge," I have been rather struck by the fact that few of your correspondents seem to have clearly distinguished between what is possible, what is imaginable, and what has a real physical analogy and bearing. The argument that the existence of one or two dimensions implies a third, and the third implies a fourth, and so on *ad infinitum*, seems to me utterly without value from the following very simple consideration. Objects and space of one and two dimensions only *are purely mental* abstractions. All bodies to be seen at all or even clearly apprehended, in my mind, must have three dimensions, neither more nor less. The geometrical point must have some bigness, some (however small) depth; the line must have at least a slight breadth and thickness (*i.e., three* dimensions, though one greatly predominates, and the others may be disregarded *except the fact of their existence*). It is a result of *experience* that three numbers are, in general, necessary to define the position of any point with regard to any other; in algebraical language, the x, y, and z coördinates. If one of these coördinates, say the z, be, or *is assumed to be*, the same for all points, we have the x and y coördinates only, the coördinates of *plane* geometry, and lastly, for a common y we have all the *ideal* points lying on a straight line (the axis of x or any straight line parallel to it in the plane xy, $z=0$ or C). This, in common sense language, is *all* that the whole thing means, as we have pointed out elsewhere (*Quest, English Mechanic*, and so on).

By the algebraical methods of coördinate geometry a vast body of geometrical theorems has been shown to have algebraical parallels, and conversely, theorems applying to curves and surfaces in general have been discovered by the application of analysis to the coördinates x, y, and z. It is possible (and has actually been done) to introduce a fourth coördinate, w, or, indeed, any number of fresh coördinates, and by algebraical methods to deduce theorems of great beauty and interest, but the results will have no *geometrical* *parallels.* Some mathematicians have even discussed some problems of motion, using the three coördinates, x, y, and z, and the fourth w to represent a fourth dimension, and their results are given in dynamical works, just as we find problems as to the motion of bodies under laws of force differing from that of nature (inverse cube, inverse fifth power, direct distance, and so on) set for the edification and *amusement* of students. Of a somewhat different character is the question as to the *curvature of space*, which, *we are told*, may possibly be *some day* detected by astronomical observations. At present, however, we find that the Euclidian "homaloidal" space agrees most closely with the space of *experience* and is the simplest concept, but there are other concepts which within the limits of observational error give results differing but little therefrom. If some day the existence, say, of stars with negative parallaxes be definitely ascertained "lying on the other side of nowhere," some mathematicians may regard this as a proof of the non-Euclidian nature of our space, but meanwhile astronomers generally will be likely to find a simpler explanation.

F. W. HENKEL, B.A., F.R.A.S.

WALTHAMSTOW.

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—I notice in the November number of "KNOWLEDGE," that Mr. John Johnston still continues the (as I think) unprofitable exercise of criticising a theory, with the arguments for which he has not taken the trouble to acquaint himself. Mr. Johnston says that "Our experience of dimensions gives us the law that where there is one there must be three, but it gives us absolutely nothing else. There is nothing in it to lead us to believe, or even to suggest to us, that there are other dimensions." On the other hand, I say that the existence of any number of dimensions (say n) implies the existence of one more dimension $(n+1)$, and so on, *ad infinitum*. In support of that statement I have brought forward certain arguments, to which I have referred Mr. Johnston. Now, these arguments of mine may involve a fallacy. I may have misapplied the principle of the continuity of natural law, or committed some other logical mistake. If so, I am quite willing to relinquish a belief in the real existence of the fourth and higher dimensions; since this belief does not form an integral part of my philosophy, but is merely an appendage thereto, supported only by its own specific arguments. But if this be the case, let Mr. Johnston point out the fallacy in my argument; not content himself with making bland assertions and negations without first finding out what this argument is. If Mr. Johnston does not wish to do this, then let the correspondence cease, since it is only a waste of time and the valuable space of your journal; for I must confess I am not sufficiently anxious to convince Mr. Johnston of the correctness of my views as to the fourth dimension to the extent either of restating them in a letter, or of sending Mr. Johnston a gratuitous copy of my book.

H. STANLEY REDGROVE.

THE POLYTECHNIC,
REGENT STREET, LONDON, W.

P.S.—Reading Mr. Johnston's letter my eye caught that of its companion signed "Geoma." I thought that Professor De Morgan had annihilated the last circle-squarers, and that the species was now extinct. "Geoma" may easily satisfy himself of the inaccuracy of his "theorem" by measuring the diameter of a cylinder with calipers and its circumference with thread, since it is quite easy to get the value of the ratio (π) by this means correct to two places of decimals: that is, $3 \cdot 14$. Of course, as I expect all your readers know, it has been *conclusively* proved by the higher mathematics that the value of this ratio is an incommensurable quantity, and that to five places of decimals its value is $3 \cdot 14159$.

A BAROGRAPH RECORD.

To the Editors of "KNOWLEDGE."

SIRS,—The wet weather we have experienced since the 15th of July, though that day was fine and bright with us, is, probably, a fair sample of the kind of weather that originated the legend of St. Swithin. My Barograph has been comparatively unchanged during this period of rain and wind, but the accompanying record (see Figure 68) of a thunderstorm here on the night of May 11th and 12th last, is quite unprecedented during the last ten years and may be worth notice in your columns.

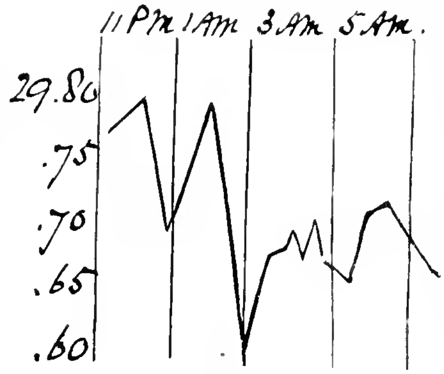


FIGURE 68.

JOHN GLAS. SANDEMAN.

WHIN-HURST, HAYLING ISLAND.

ON COOKED FOODS.

To the Editors of "KNOWLEDGE."

SIRS,—I read with much interest, the article in the October number of "KNOWLEDGE," by Katharine I. Williams, but would like to ask how her values would stand if the vegetables were cooked conservatively and did not come in contact with the water in the process.

It is not denied that the old-fashioned method of cooking vegetables is wasteful and foolish in the extreme.

A. GAUBERT.

13, SHAFTESBURY ROAD,
HORNSEY RISE, N.

SCHOOL SCIENCE SOCIETIES.

ONE of the topics discussed by the Association of Public School Science Masters at their meeting, held at the London Day Training College, on the 8th and 9th of January, was the aims and uses of School Science Societies. The general principles were dealt with by Mr. W. M. Hooton, of Repton, and after considering the general advantages of such societies and their kinds, he spoke of the limitations imposed by organised games, which, very many will agree, stand greatly in the way of the boy whose tastes and inclinations would lead him to acquire knowledge first hand and in his own way. Mr. Hooton emphasised the point that, in his opinion, organised games did not so much use up the time of the boys as their energy, and left them too tired for other pursuits. In either case the result is the same. With all due respect to Mr. Hooton's contention, we think that a trustworthy boy who would prefer taking a ramble in order to study some scientific subject as a hobby, to playing games should be allowed to do so. Mr. Hooton also testified to the good training obtained by boys in preparing lectures and illustrations. Mr. F. C. Headley, of Haileybury, when discussing School Natural History Societies, dwelt on the need for unspoilt country to be within easy reach. He said that at private schools many boys with a definite bent for Natural History had the enthusiasm starved out of them. Liberty and leisure, he claimed, were important things. Some of the leading boys should be enlisted as supporters, and it should be made clear to them that Natural History leads on to the study of evolution and to many difficult problems, and is not merely an amusement for little boys.

Geological Societies were advocated by Mr. C. I. Gardiner, of Cheltenham; Photographic Societies, by Mr. T. H. Oldham, of Dulwich, and Astronomical Societies by Mr. G. Hewlett, of Rugby.

SOLAR DISTURBANCES DURING DECEMBER, 1912.

By FRANK C. DENNETT.

December was very cloudy, and hence the record is somewhat imperfect, no less than eleven days having been missed completely. On six days (2, 3, 8, 9, 10, and 28), the disc was apparently free from disturbance, and on one, the 23rd, only faculae were seen, spots being visible on the remaining thirteen. The longitude of the central meridian at noon on December the 1st, was 54° 36′.

No. 24.—First seen in a faculic disturbance a little way on the disc from the eastern limb on the 12th, a spot with tiny pores. some before and some behind it. On the 16th it showed two distinct umbrae. The larger spot had seemingly broken into two next day, and on the 18th was much less conspicuous, not being seen after.

No. 24*a*.—This disturbance, certainly connected with the last, appeared some 50,000 miles in front of it, on the 16th—if not on the 15th—a spot with some pores round. On the 17th two dark penumbral spots had developed almost midway between the southern components. On the 18th the rear spot of this group had formed, nearly equal to the leader. On the 20th, both these spots were still visible, but on the 22nd only the leader remained amongst a quantity of faculic matter, whilst this spot was not to be seen on the 23rd, only the faculic remains of the outbreak. The length of No. 24 was 30,000 miles, *a*. 45,000, and the double group 82,000 miles.

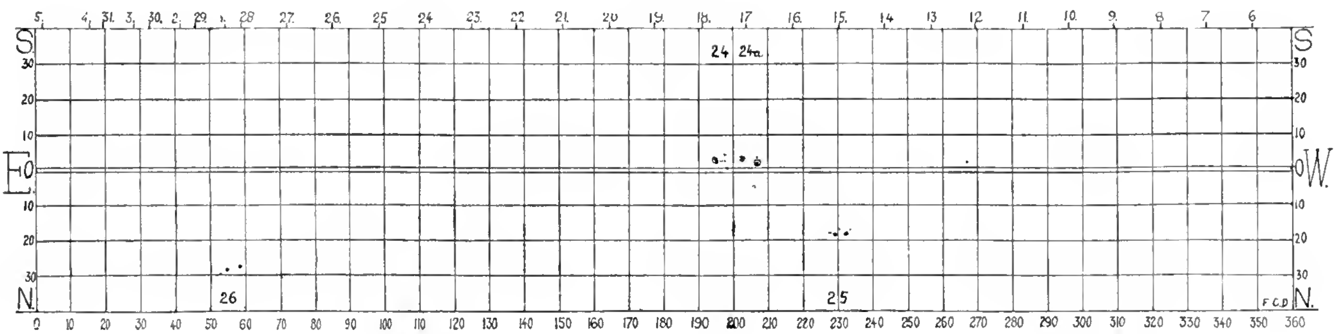
No. 25.—A group of spotlets and pores, 35,000 miles in length, seen on December the 17th, only one of which, the leader, was found next day. Its place was marked on the 20th by a faculic area.

No. 26.—A group of spotlets and pores, 46,000 miles in length, first seen on the 29th, which changed its appearance considerably during its visibility, being last seen amid faculae close to the north-western limb on January 3rd.

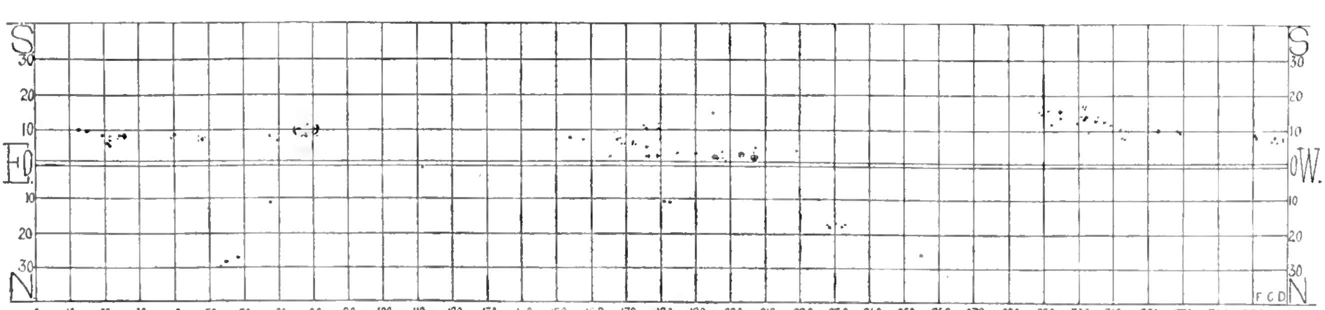
During the past year only 27 outbreaks of spots have been recorded, one being of a secondary character. Of these, 22 have appeared in the southern hemisphere, and only five in the northern. It is somewhat singular that in December, 1911, a little disturbance broke out in 23° N. Latitude, and now again in December, two disturbances have made themselves visible, one in 17°, the other in 27° N. Latitude. These may prove to be the forerunners of a new cycle of solar phenomena. The second chart shows the distribution of the spot disturbances during the year. The collection of disturbances into groups is again a noticeable feature in the southern hemisphere. One chain of activity extends from 350° to 82°, and another from 153° to 220°, and a third from 228° to 330°, many of the second group drawing very near the equator. Of the 333 days upon which the Sun has been observed, spots were recorded on 108, faculae were seen on 99, whilst on the remaining 126 the disc presented an unruffled surface.

Our monthly chart is from the combined observations of Messrs. J. McHarg, A. A. Buss, E. E. Peacock, W. H. Izzard, and the writer.

DAY OF DECEMBER, 1912.



DISTRIBUTION OF SPOT-DISTURBANCES DURING 1912.



SOME EFFECTS OF THE HOT, DRY SUMMER OF 1911

By LIONEL E. ADAMS, B.A.

It was natural to expect that the exceptional tropical heat and the drought of the summer of 1911 should produce some effect on the fauna and flora of our island, which is only at rare intervals subjected to such conditions, and this expectation has been fulfilled.

Perhaps the most noticeable feature of the season was the phenomenal abundance of wasps. On August 16th a neighbouring keeper and I took sixteen nests in two fields, through which the river Mole flows. By the way, the quickest and altogether most effective method of taking wasps' nests is by means of a solution of two ounces of cyanide of potassium to one and a half pints of *hot* water, cold water failing to dissolve the cyanide. One pound of cyanide costs three shillings at the chemist's, which amount will make enough solution for fifty nests. A wineglassful should be poured into the entrance holes of the nests. Then watch—you will see the wasps continue to come in for an hour or two, but *vestigia nulla retrorsum.* When all have entered, the nest may be safely dug out; but if left till the next day the fumes of the poison will have evaporated, and the wasps hatched after that will be found alive and stinging. A great advantage of this method is that it can be carried out in daylight and without much danger of being stung.

In contrast to the abundance of wasps was the comparative scarcity of flies. This was due to two causes; first, they are the prey of wasps, but perhaps more especially because the drought had deprived the manure and refuse heaps of the moisture necessary for the well-being of the fly larvae.

A great abundance of the Peppercorn Oak-gall was noticed in Surrey by Sir Jonathan Hutchinson and Dr. T. A. Chapman, and recorded by the latter in the September number of the *Entomologists' Record and Journal of Variation.*

In the same number Dr. Chapman and other entomologists record an unusual abundance of *Pieris rapae*, the Small White Butterfly, and also an unusual proportion of small individuals of this species as well as of *P. napi.* Dr. Chapman explains that this dwarfing is caused by the heat forcing the larvae to maturity and pupation before they had time to eat enough to grow to their normal size, and not by any deficiency of food.

Also, in the same number of the journal, another observer notices an insufficient colour supply and albinism whole and partial in the genus *Colias* in Switzerland.

In certain gardens in Reigate there was practically no aphis, though their enemy, the ladybird, was also scarce.

Owing to the drought land snails on which the thrushes feed remained in hiding, and a friend of mine found in Northamptonshire several thrush "anvils" (that is, stones on which the birds break the shells to extract the animal) surrounded by broken shells of the large water snail, *Limnae stagnalis*—a most unusual food of thrushes.

The keeper above referred to, and some of the neighbouring farmers, informed me during the drought, that they found thrushes and other birds dead, presumably on account of scarcity of worms and slugs.

I fully expected to find an unusual number of dead shrews along the roads and lanes, but to my surprise I found far fewer than usual. However, as I happened to be trapping shrews throughout the summer and autumn a great number passed through my hands, and I noticed that their coats were markedly paler than usual, and that about twenty-five per cent. had white ears, whereas the normal percentage of white-eared specimens is four or less.

Moles were affected by the drought in a curious manner. From three different sources I heard the same story of dead moles being found about the lanes and fields in large numbers. These had died of starvation.

One farmer of a hundred acres made a practice of going out with his dogs at night to hunt moles, and killed over a hundred in this way. It is usual for moles to come to the surface during the nights of summer and early autumn after worms; but last season they fared badly in two ways—worms were scarce from want of dew and rain, and, moreover, the ground was caked hard and difficult for worms to work through. Also, when once above ground, the moles found a similar difficulty in burrowing out of sight before their enemies were upon them.

In our Reigate garden and all round the neighbourhood the Jerusalum artichokes (*Helianthus tuberosus*) blossomed.

Early in August the leaves of various trees turned yellow and began to fall. The bracken began to fade at the same time, and by August 20th there were several large patches of dead bracken on the heaths in Surrey.

During the present year Yuccas have been abnormally prolific in bloom, and one of the gardeners at the town's public gardens attributes this to the heat of last year "ripening them up."

A paradoxical incident occurred which was exceedingly puzzling till the probable explanation occurred to me. Two springs which had run dry at the beginning of August started running again at the end of the month, although there had been no more rain. I could only account for this by supposing that more cracks had gone on developing in the dry ground till water was reached further back in the water-bearing bed.

THE PROBLEM OF THE MOON'S ORIGIN.

By B. G. HARRISON, F.R.A.S.

THE air of mystery which always enshrouds the Moon compels even the most unreflective of us to speculate upon its past history. A world devoid of life, one pictures the vast upheavals and intense convulsions that must have taken place to have moulded the landscape into its present chaotic form, which bears witness to its former tempestuous existence. Seen through the telescope, one is impressed by the sense of utter loneliness and desolation that seems to prevail everywhere, while the apparent permanence of each feature on the lunar surface makes one wonder how long this changeless aspect has continued. Indeed, there are few problems connected with astronomy so fascinating as that of the origin of our satellite, more especially since any knowledge of its past would be of infinite assistance in helping us to frame the general theory of cosmical evolution.

Apart from the fact that the Moon is our nearest neighbour and the most familiar of all the celestial bodies, the evidence of its formation is considered to be of a far more conflicting nature than in the case of any other portion of the solar system, and for this reason alone presents features of the greatest interest.

There are, of course, only two ways in which our satellite could have attained its present position. It may once have been a minor planet which ventured too near the Earth and was consequently captured by the latter ; or else it must at some remote period have formed part of our globe and have been separated from it by rapidity of rotation. Before considering these alternatives in detail it will be perhaps as well briefly to outline the most usually accepted hypothesis of planetary evolution.

The general features of Laplace's celebrated nebular theory are well known. This illustrious mathematician suggested that our system was originally a nebulous cloud or "firemist" of glowing gas, which gradually contracted, throwing off rings in the process. From these rings the planets were evolved and the nucleus eventually condensed to form our sun. Laplace himself advanced this theory with considerable mistrust, and recent research has caused several modifications to be made in his hypothesis.

In the first place, the original high temperature with which he endowed his nebula is now considered unnecessary. It is realised that the actual contraction of the gaseous mass would provide all the heat required to account for the present observed temperature of the sun and planets, even after due allowance is made for loss by radiation entailed in the process. Secondly, it is thought very improbable that the nebula could ever have had a sufficiently rapid rotation to detach the rings. Even if these were detached, the result has not been quite what we should expect. Theory demands that the width of these rings should be infinitesimal, since otherwise the outer portion would revolve more rapidly than the inner and thus upset their dynamical equilibrium. As the acceleration of rotation would probably proceed at a uniform rate there should have been a vast number of these situated at intervals bearing a fixed ratio to each other, thus giving the transformed nebula a perfectly symmetrical appearance. Even if it were possible for the rings to condense into planets, which seems doubtful, we should expect their masses to bear a more constant proportion to one another than is actually the case. Perhaps a still more unfavourable argument to this idea of our system's development lies in the fact that amongst the vast numbers of nebulae which have been discovered, none afford any convincing evidence of concentric ring formation.

It is generally far more easy to detect faults in the theories of others than to provide a thoroughly satisfactory hypothesis in their place, and critics have found the case in point no exception to the rule. Nevertheless, numerous suggestions of more or less merit have been advanced from time to time, but as space will not permit of their consideration in detail, we will confine ourselves to outlining what is perhaps the most feasible theory of planetary evolution. To do this it will be necessary to go back an epoch further than Laplace did, and consider the actual formation of the primordial nebula. It is thought probable that this was caused by the near approach of another star to our sun, which at that remote period may have been simply a dark body. It is by no means necessary for an actual collision to have taken place, since the disruptive action caused by the different portions of each sphere being at varying distances from the common centre of gravity, and thus being pulled with unequal force, may have been quite sufficient to tear them both apart and scatter a portion of their contents into surrounding space.

Now there are three possible courses for matter thus ejected to pursue. Either to follow a path by which no return to the system would ever be possible, to fall back to the Sun itself, or to revolve around him in elliptical orbits. If our luminary were travelling in a straight line, and in the absence of any other perturbing force, all matter would follow one of the first two courses, according to the force of ejection. It is necessary, therefore, to assume that either owing to the action of the disturbing stranger, or else through collisions amongst themselves, the paths of some of the particles were altered, and they were forced to permanently revolve round the Sun, thus forming our embryo solar system. It is probable, in any case, that a large proportion must have followed one of the other alternatives, and so have either increased the temperature of our luminary, or else have been lost to the system for ever.

We imagine that the Sun was rotating before the initial catastrophe occurred, since this motion would give a preponderance of direct revolution amongst the ejected particles, although it is likely that that of a large percentage may have been retrograde. This diversity of motion would naturally cause frequent collisions, and in this way other small centres of gravity would gradually be formed. As these centres increased in size, their attraction would deflect neighbouring particles from their original course and cause them to revolve round them. Further collisions would ensue amongst the captured fragments, involving a consequent loss of energy, and they would thus be slowly drawn nearer to, and finally upon, their various centres of attraction, while the dismembered remains of the original sun, being in the centre of the nebula, would succeed, owing to their superior mass, in gathering up the greatest portion of the scattered contents.

We may thus endeavour to picture to ourselves our system slowly evolving, a vast aggregation of particles of various sizes, extending far beyond the present orbit of Neptune and becoming more and more scattered as the distance from the common centre increased. Occasionally we should witness the collision of two fragments, and the consequent generation of light and heat, and we should also observe the increased frequency and violence of these collisions in the vicinity of the Sun. Although individually presenting every diversity of movement, these particles would in the aggregate present a certain orderly sequence, and a series of vortices would be noticeable revolving round the Sun in the same direction as its own rotation, the larger ones lying in substantially the same plane: that of the disturbing star's approach. The general appearance of the system would closely resemble the spiral type of nebulae which have been revealed to us in such numbers by the telescope and the photographic plate in recent years. It is a significant fact that all these nebulae consist of two arms emanating from a central nucleus at diametrically opposite points. So far as we are aware the only force capable of producing this symmetrical appearance is that of disruptive tidal action, since, were the coils thrown off owing to rapidity of rotation, jets of matter would be ejected from every part of the circumference, and if by explosive force from indiscriminate points on the surface.

This, then, is the modern idea of the primordial nebula, a somewhat different one from the conception of Laplace, insomuch as it consists of independent particles revolving round a common centre of gravity in elliptical orbits instead of a slowly rotating sphere of glowing gas. It also has this advantage, in that it presents a complete cycle of events, from star to nebula and from nebula to star. This is analogous in our conception of the infinite to the difference between a circular and a straight line. There is less difficulty in imagining the former as endless than the latter, although the origin of either may be equally incomprehensible to our finite minds.

It must not be imagined that the hypothesis here outlined is entirely satisfactory, but as there appear to be fewer drawbacks attached to its acceptance than to that of most of the theories that have been advanced from time to time, it is generally considered probable that our evolution proceeded somewhat on these lines. Accordingly, it would appear natural that the planets and their satellites were both formed by the capture and aggregation of smaller particles in the same way. The lesser whorls would control the particles in their immediate vicinity, but would themselves be under the attraction of the larger vortices, just as these would in their turn be controlled by the Sun.

It is, of course, mathematically impossible for one body to capture another without the intervention of a third force. This may be illustrated by the case of a comet approaching our solar system. If the former is a wanderer from interstellar space it is obvious that although the solar attraction will enormously increase its velocity as it draws nearer, after the comet has passed perihelion, the Sun will only be capable of controlling the same speed as it was able to impart, and the visitor will leave the confines of the solar system with its original momentum unimpaired. If, however, the comet passes near one of the planets, the attraction of the latter may more than counterbalance the initial velocity of the comet, and thus change its hyperbolic orbit into an elliptical one. Another means whereby a portion of the wanderer's energy could be dissipated is by moving through a resisting medium. This is a more satisfactory method of accounting for the capture of a satellite than by means of a third attractive force, since the latter would as often free the satellite from the control of its primary, as assist in making it captive.

The capture theory, therefore, demands as a necessary condition the existence, at all events in the past, of a resisting medium. Professor See, to whom the development of this hypothesis is due, considers, and not without reason, that the presence of this medium was very probable. For it is almost certain that the vast quantity of gases which would have been liberated with the more solid matter at the birth of our solar system, would have existed in the free state as a nebulous cloud for untold aeons before combining with these solid elements, or forming the atmospheres of the various worlds in the course of evolution. This would render it possible for a satellite entering the sphere of a planet's influence to be eventually retained by the latter, and would also have the effect of decreasing the satellite's orbit. It would at the same time cause an eccentric path to become more circular, since a circle encloses a larger space than any other curved line of equal length, and a body can consequently revolve round a certain area with less expenditure of energy if moving in a circular orbit than if travelling in one of any other form.

Now, the sphere of the Earth's influence extends to a distance of over nine hundred thousand miles, so that any small body revolving within this distance would be entirely under the Earth's control, and since the Moon is less than two hundred and forty thousand miles away, its position, and the circularity of its orbit, could most easily be accounted for by this supposition. The same remark applies to all the known satellites of the other planets, which are in every case well within the space controlled by their respective primaries, and which, with the exception of the outer ones of Jupiter and Saturn, have remarkably circular orbits.

Owing to the unique nature of the Saturnian system it has frequently been typified as an example of cosmical evolution. Thus, at the time when Kant and Laplace framed their theories, the rings were thought to consist of gas, and, therefore, to corroborate them. The rings have since that time been conclusively proved to be formed of vast numbers of independent particles revolving round their primary, but were still considered to be a satellite in course of formation. Edouard Roche, a French mathematician, has, however, shown that it is impossible for a satellite to exist within 2·44 radii of its primary, owing to the strain imposed by the attraction of the latter. It is, therefore, probable that if a resisting medium exists in the solar system, a satellite may have actually been brought by its influence within the proscribed area and been torn to pieces, the rings thus being an example of the end rather than the birth of a world.

The thesis of possession by capture would consequently account for the presence of the satellites under the control of their various primaries in the most likely manner. Indeed, were it not for the conflicting testimony offered by our Moon, there could be but little diversity of opinion on the subject. It will be as well, therefore, to examine the evidence regarding our own domestic system somewhat more fully. There is, of course, only one other possible way to account for the present position of our satellite, which, if it has not been captured, must have been formed by fission of the Earth, and this latter theory seems to have met with almost universal acceptance ever since the time of Anaxagoras, 500 B.C. Now, there is one unusual feature about the Earth-Moon system favourable to this hypothesis, namely, the relative sizes of its two constituents, which are in the ratio of eighty-one to one. If we except Neptune and his satellite, about which some doubt exists, the nearest approach to equal masses in the other planetary systems is to be found in that of Saturn. His largest satellite, Titan, is but the one four thousand seven-hundredth part of his mass, and there is a still greater discrepancy in the relative sizes of all the other satellites to their primaries. This peculiarity of our Moon might, therefore, seem to imply a different origin from that of other satellites, although, if it ever revolved against resistance, there is no dynamical reason why our Earth should not have captured such a comparatively large globe.

There are, however, several objections to the fission theory. In the first place, it would be necessary for the Earth to have attained a sufficiently rapid rotation to have overcome the force of gravity by centrifugal force. The alternative to this would be to assume that the rupture was caused by tidal strains, in the same way as that suggested in the evolution of the solar system. Now, if this had happened, two streams of matter would have been ejected and formed a small spiral nebula. It is extremely unlikely that all the meteorites forming the coils would have only condensed into one other body, since we should expect a miniature solar system of our own, with some satellites considerably nearer than the lunar orbit, and others further off. Moreover, the presence of the disturbing element would have to be accounted for. Unlike the strange star which is supposed to have caused the birth of the primordial nebula, this second sphere would probably be unable to escape from the control of the Sun, and as it would necessarily be of considerable size to cause the requisite amount of damage, its presence could almost certainly be detected; for even were it now beyond the range of our telescopes, we should in all likelihood notice its perturbing effect on the outer planets. As we know of no such body, we are forced to discard this surmise and fall back upon a rapid rotation as the only cause of fission.

It has been calculated that, in order to overcome the adhesion of its particles by centrifugal force, our planet would have to possess an axial rotation of two hours and forty-one minutes. The only means of obtaining this enormous velocity would be by contraction from a nebulous condition. To appreciate this process it is necessary to understand what is involved in the term "moment of momentum." It is well known that momentum is the product of the mass and velocity of a body, and "moment of momentum" denotes its rotary power round an axis. If we neglect outside influence it is manifestly impossible to alter its amount in a rotating body, however much the latter expands or contracts. Whatever it loses, therefore, in decreasing size, is compensated by an increase in angular velocity, or in other words, in a contracting body, rotating freely in space, the angular velocity varies inversely as the square of the radius.

Now, this increase is considerably in excess of the additional speed required by the particles of a body to counteract the increase of centripetal force, due to their nearer approach to the centre of gravity. Thus, although the Earth is thirty times nearer the Sun than the planet Neptune, its angular orbital velocity is only one hundred and sixty-five times that of the latter, whereas the contraction of a rotating sphere to one-thirtieth of its original diameter would result in an increase of 30^2 or nine hundred times its initial angular speed.

If, therefore, the Earth were sufficiently diffuse, and its original rotational velocity were rapid enough, it would be quite possible for it to disintegrate when sufficiently contracted. Unfortunately, we cannot be at all certain that the rotation of the Earth has ever been much more rapid than at present; although, could any evidence be advanced in its favour, it would remove one of the greatest objections to the fission theory. It might be expected that the earth would still show some signs of the distortion of its surface which a more rapid rotation would involve; but it is rather significant that no facts of any convincing nature exist to testify to this either in physics or geology. It is, of course, possible that time may have obliterated any evidence that has been left us, but it is by no means certain to have done so.

Although this is not a very conclusive argument it is nevertheless unfavourable to the idea of a rapid rotation, and if we examine the other members of the solar system for any evidence regarding the original length of our day, the result is equally unsatisfactory.

(To be continued.)

REVIEWS.

ANTHROPOLOGY.

Malta and the Mediterranean Race.—By R. N. BRADLEY. 336 pages. 1 Map, 54 Illustrations. 9-in. × 6-in.

(T. Fisher Unwin. Price 8/6 net.)

Mr. Bradley's book is crammed full of interesting facts, contentions, and suggestions, and bears out Professor Sergi's theories to a very considerable extent. From a glance at the title one might think that the work had little relation to our own country, but it would seem that English people are largely of the Mediterranean race, though by no means of so pure a type as the existing Maltese; but it is said that judging only from the looks of the men and women with grey or blue eyes, one might imagine oneself in Ireland instead of Malta. The chapter showing the traces of the Semitic language which are to be found in our own is particularly important, and the illustrations given by no means exhaust the results of Mr. Bradley's researches. The "ash" tree has the same name in Arabic and comes from the word ash, meaning "to nest," as it is a favourite nesting tree; "dally" is from the Arabic "dall" to be coquetish with; "merry" is not much changed from the Arabic "marih," to be lively. The Arabic "silak" meaning spun thread, by the loss of the "a" becomes "silk," and in the same way "atan," to macerate hides, becomes "tan." Mr. Bradley goes carefully into the monuments of Malta, the dolmens, which he looks upon as imitation caves, and the secondary burial of human bones after the removal of the flesh, common to Malta, Sicily, Crete, and Ancient Egypt. There is also much attractive matter with regard to designs, to ladies' dress, to the characteristics of the ancient and the modern Maltese, and that in times gone by, as at present, stout people were admired is shown by the discovery of steatopygous figures. The connection between Kaffirs and the more northern peoples which gave rise to the Mediterranean race is discussed, and allusions made to the votive axe in stone and copper, which is common throughout the Mediterranean. The examples of polished axe amulets seen in Figure 68, which we have borrowed, are from Malta.

By the courtesy of *Mr. Fisher Unwin.*

FIGURE 68.

Polished Axe Amulets of Hal Saflieni, Valletta Museum.
(From "Malta and the Mediterranean Race.")

Mr. Bradley shows, from an examination of old and recent skulls, that the Maltese were and are very pure examples of the Mediterranean race. Many of the subjects dwelt upon are illustrated, and after a short account of Maltese folk-lore, short heads are compared with long. It is common knowledge that these two types exist side by side in this country, and we quote the following observations which Mr. Bradley has made on two of his friends: "I call to mind my longest-headed friend, now no longer living; a man of generous emotions and strong sympathies and antipathies, his fancy led him to lengths from which extrication was difficult, and his changeableness, dependent on his moods, made his conduct alarmingly inconsistent. Yet, when once you knew him well, he was the most loveable of men. Moreover, he was a genius and a poet. I have studied, too, a short-headed acquaintance with much interest; he has no pretentions to brilliance, and never launches forth into enthusiasms or ecstasies. But he is perhaps the most punctual, conscientious, trustworthy person I know. He is, above all things, a safe man, and his greatest merit is his efficiency."

W. M. W.

ASTRONOMY.

The Story of the Heavens, Part I.—By SIR R. S. BALL, M.A., LL.D., F.R.S. In 14 monthly parts. 48 pages. 18 illustrations. 9½-in. × 6-in.

(Cassell & Co. Price 6d. net.)

The parts received initiate a new edition of this already well-known book, which first appeared about twenty years ago in a very similar form.

The part before us consists of forty-eight pages with plates and a large frontispiece or chart, in blue, of the northern heavens; so that we may expect a book of about seven hundred pages. From our experience of the early edition, the book was much too thick for convenient handling, by day or by night, so we had it bound into *two* volumes of about one and a quarter inches thick, and they form books that can be used by a child or when reclining in a chair. May we express our wishes strongly to the author and publishers that they will consent to adopt the plan of dividing the book into *two*;

there need be only one good index at the end of volume II., and a title-page to each; the pages might and should run on. As we use books for many hours daily we offer this suggestion, and feel sure that the step would be in the right direction and none would regret it; the increased cost would be very trivial, the convenience very great. Books for use are made far too heavy and thick nowadays.

As to the contents; the story is naturally told in the author's most pleasant, entertaining and well-known way, and it comes from a master hand. Judging by the experience of the previous edition the whole ground of astronomy in its popular aspect will be covered. The part before us does not indicate how far the subject has been re-written or revised to date. In future parts that may be judged. In several departments of astronomy, mainly solar and stellar, immense progress has been achieved by that ubiquitous handmaid—photography, and we hope that the advancements may be frequently introduced into the text and plates.

We heartily commend the book to all those who love to read, and to know more about the objects and worlds beyond our own puny Earth.

F. A. B.

Astronomy.—By F. W. DYSON, LL.D., F.R.S. 118 pages. 60 illustrations. $6\frac{3}{4}$-in. $\times 4\frac{1}{2}$-in.

(J. M. Dent & Sons. Price 1/- net.)

This is one of Dent's Scientific Primers, edited by Dr. J. R. Green. The little book before us is virtually a condensed second edition of the author's larger work upon the subject published in 1910. The only portion that has been materially curtailed is Chapter VIII, on the Fixed Stars, which has been reduced to a microscopical quantity of *six* pages. The bulk of the book consists of three chapters, forty-four pages of historical astronomy, naturally condensed, but replete with information very much to the point and interestingly given; the fourth Chapter we might call the practical chapter, as it relates to the instruments with which astronomers work; the next forty-four pages form Chapters V, VI, and VII. and include the Sun and Solar System, with information to 1908, and numerous illustrations.

Thus we have in about a hundred pages a concise history of astronomy for more than two thousand years, with few omissions of the important facts which form the eras of astronomical progress, in a neat form and size for the side-pocket, if needed, and a few ounces in weight only; also at such a price that half-a-dozen can be bought and given to friends at a cost of a novel.

We advise the reader to study the author's preface, which contains the appreciation—a courtesy often omitted by authors in general—of the author's obligations to other astronomers in enabling him the more readily to produce this excellent little primer, which might well be used as a school book and by teachers themselves. We heartily recommend it, and may the healthy vigour of its youth enable it to reach the maturity of manhood's age.

F. A. B.

CHEMISTRY.

A Treatise on General and Industrial Inorganic Chemistry.—By DR. E. MOLINARI. Translated from the Italian by E. FEILMANN, Ph. D., F.I.C. 704 pages. 279 illustrations. 3 plates. 10-in. $\times 6\frac{1}{4}$-in.

(J. & A. Churchill. Price 21/- net.)

This book is almost monumental in its scope, for it covers the whole ground of inorganic chemistry, historical, physical, and especially industrial. In some respects it suffers from this fulness, and some of the sections show indications of their severe compression into a single volume of seven hundred pages.

This criticism, however, does not apply to the description of manufacturing processes, which, with few exceptions, are dealt with at length. In fact, the scheme of the book is to unite the applications of chemical reactions more closely with the theoretical aspect than is usual in text books of chemistry. Full details are, therefore, given of the plant used in the modifications of various industrial processes, and the book not only gains in interest by this plan, but is also valuable as a source of reference for the technical chemist and patent agent.

In most instances the descriptions of the manufacturing processes are up-to-date, but this is not invariably the case. For example, the account of the artificial mineral water industry is very meagre and not entirely accurate. A historical error may also be noted in this connection. It is stated (p. 228) that "the first scientific factory for mineral waters was founded on a scientific basis in 1821 by Dr. Struve at Dresden." This is incorrect; for as far back as the year 1780 artificial mineral waters were scientifically prepared and sold by Professor Bergman in Sweden; and in 1790 a factory for their manufacture was established, also on a scientific basis, by Paul in Geneva.

Another subject that receives too little attention is the chemistry of the rare earths, which is only dealt with very briefly, and in this direction the book would not be a good guide to anyone in search of the latest information.

An excellent feature is the description of the uses to which the various chemical products are applied, and the statistics of the values of the quantities annually manufactured or exported. Naturally, the chemicals of Italian origin receive the fullest treatment, and among the subjects discussed in connection with them is a most interesting account of the present position of the sulphur industry, and its progress since the establishment of the State *Consortio Italiana* to regulate the supply and distribution of sulphur.

The book is excellently printed and illustrated with good diagrams, while the translation is well done. It has deservedly reached its third edition.

C. A. M.

GEOLOGY.

The Work of Rain and Rivers.—By T. G. BONNEY, LL.D., F.R.S. (Cambridge Manuals of Science and Literature.) 144 pages. 19 figures. $6\frac{1}{2}$-in. $\times$ 5-in.

(The Cambridge University Press. Price 1/- net.)

To the present generation it seems amazing that the formation of river-valleys was once ascribed to anything rather than the rivers which occupy them. Yet, as Professor Bonney shows in the last chapter of this entertaining little book, the true explanation of river-valleys is only a recent addition to scientific knowledge, and the earlier geologists (with the exception of Hutton and a few others) were content to believe that the valleys were made for and not by the rivers. Professor Bonney rightly ascribes to J. B. Jukes the honour of settling beyond question the modern view of the work of rivers in excavating their own valleys; but he perhaps rather exaggerates the influence of the eccentric Colonel George Greenwood, and his book "Rain and Rivers." The rest of the book follows the accepted lines, and while containing little that is new, describes the work of rain and rivers in a way that is bound to excite the interest of the reader. The nature of the treatment may be indicated by the chapter headings—Carving and Carrying, The Making of Valleys, The Transport and Deposit of Materials, The History of a River System, Man's Learning of Nature's Lesson. The author does not approve, as we learn in a footnote, of the modern and extremely convenient terminology which we owe to the genius of Professor William Davis. His illustrations of river-action and history are largely drawn from the Alps, and in the absence of sketch-maps are occasionally not very easy to follow. There is something wrong with the statistics on page 73, where it is stated that a thousand tons of carbonate of lime, if re-converted into chalk, would form a block measuring two feet by three feet at its end and eleven feet in length.

G. W. T.

Preventable Cancer. A Statistical Research.—By ROLLO RUSSELL. 167 pages. $7\frac{3}{4}$-in. $\times 5\frac{1}{4}$-in.

(Longmans, Green & Co. Price 4/6 net.)

The above volume well deserves careful study. The writer is not a medical man, and, therefore, when speaking of the nature of cancer, is wisely content to quote from various authors whose views agree more or less closely with his own. Then follow some very valuable and carefully-prepared statistics regarding the increase of cancer, its geographical distribution and its relation to trades and occupations, and lastly come the author's conclusions which are perhaps best given in his own words, "The malady shows a real and regular increase in all civilised countries during the last fifty years." "Apart from exceptional customs it scarcely exists among peoples and in districts and countries where the diet is cool, and frugal, without irritating or stimulating adjuncts, the use of water as the staple drink is of effect in immunity." Of the various substances taken as foods, the following are regarded by the author as tending to the production of cancer "fermented liquors, animal and other proteids in long and continuous excess, highly salted and toxic foods and drinks, hot foods and drinks much above blood temperature, and apparently highly acid drinks, such as sour wine and some metals or minerals, of which arsenic is an acknowledged example." A critical examination of the figures quoted by the author makes it very difficult to arrive at any other conclusion than that which we have quoted above. The author is to be warmly congratulated on the very careful way in which he has collected and arranged his statistics.

S. H.

The Doctor and the People.—By H. DE CARLE WOODCOCK. 312 pages. 7¾-in. × 5-in.

(Methuen & Co. Price 6/- net.)

In the volume before us we have a series of short essays on everything that appertains to the work of the general practitioner, the doctor of the people. The hospitals, contract practice, the Poor Law, and a host of other subjects, not excluding the National Insurance Act, are all discussed from the point of view of the enlightened general practitioner. "The provincial doctor, and even the Metropolitan, is, like the French peasant, letting the world's controversies rage while he attends to a hundred daily duties of his practice. Sometimes he assists at a tragedy that he cannot prevent, sometimes at one that he can. He is an easy target for the caricaturist, but he does not read the caricature; or if his attention is arrested when Mr. Bernard Shaw attacks him in a whirlwind of wit, he remembers that in the last twenty-four hours he has saved, quite possibly, more than one life. Such is the man I have wished to portray." Again and again have we taken up the book, intending to review it, but so full of interest have its pages been that we have been compelled to continue reading. Some chapters we have read again and again, so excellent is the style in which these are written. The author is no Utopian, but at least some of the faults of our present system he is unable to pass over. Our Poor Law comes in for a large share of reproof, and terrible are his tales of the work of the Poor Law doctors. The infirmaries suffer little better at his hands. "These Poor Law hospitals have been and still are under-staffed; the nurses have not held the highest rank in the nursing world; the doctors have in many cases ceased to be scientific and have become swamped in the small details of hospital management." The admission of medical students and the provision of a staff of visiting consultants to these institutions is strongly advocated.

To the doctor and his patient alike we most heartily recommend this book.

S. H.

PAINTING IN NORTH ITALY.

A History of Painting in North Italy from the Fourteenth to the Sixteenth Century.—By T. A. CROWE and G. B. CAVALCASELLE. Edited by TANCRED BORENIUS. 3 vols. 1339 pages. 207 illustrations. 9-in. × 6-in.

(John Murray. Price £3 3s. net.)

The three volumes in which Messrs. Crowe and Cavalcaselle deal with the history of North Italian painting is the complement of their larger work on the history of painting in Italy, which has been for many years in course of republication, and, like it, has been long out of print. Together they form an invaluable and exhaustive compendium of information on Italian art, with which no student can dispense. Crowe and Cavalcaselle pursued their labour of love in the intervals of important official work, and at a time when photography was in its infancy, when handbooks were unknown, when frescoes and paintings now collected in public galleries and museums were still mouldering in the inaccessible remote churches and convents for which they had been painted, a prey to damp and neglect. Those who have read carefully all the republished volumes can only marvel at the industry, the knowledge, the insight, which amounted to genius, in this monumental work. Despite the accumulation of data of various kinds, of lost and forgotten archives, of recovered paintings, which have come to light since its first appearance, editors and commentators of Crowe and Cavalcaselle have astonishingly little to add to or to detract from their decisions. Oftener, where in the then state of knowledge they could only conjecture; subsequent investigations have confirmed their conclusions; while their masterly summaries of the relationship of the art of a painter to his predecessors and successors, and their penetrating criticism, have remained unsurpassed. The volumes which deal specially with painting in North Italy begin with the impetus given to Venetian art by Fabriano and Pisano, and by the Bellini; the paintings of the Bellini, their artistic position and influence, occupy the greater part of the first volume. The second volume opens with the school of Squarcione, whose curious career is unique in the history of painting. A tailor by trade, Squarcione turned his commercial instincts into the channels of art. Acute enough to observe that the religious impulse in art was giving place to the classic revival, he collected models of antiquity, and formed a school of painting for their study. Artists came to it from far and near, and Squarcione derived great kudos from exhibiting their productions under his own name. Among them was the great Mantegna, whose work, like that of many of the later Florentines, bears the impress, in something sculpturesque in its character, of the classic models he had studied. With Volume III we have reached that most mystic and poetic of painters, Giorgione. One special value of these volumes is that the authors have included the artists of many small towns, such as Vincenza, Ferrara, Friuli and Brescia, minor schools which still have their place in the history and development of art.

E.S.G.

PHILOSOPHY.

Modern Problems.—By Sir OLIVER LODGE. 320 pages. 8-in. × 5-in.

(Methuen & Co. Price 6/- net.)

The modern problems which Sir Oliver Lodge considers, are chiefly those of philosophy and sociology. Since Professor William James developed the philosophy of pragmatism, with its basic idea that there is no other definition of truth than that "Truth is useful," a great many philosophic doctrines, as well as theologic speculations and scientific hypotheses have been examined by this touchstone. It was, in fact, from a contemplation of the mutable hypotheses of science—mutable in the sense that theory is useful only as it relates facts and must continually accommodate itself to newly-discovered ones—that the basic postulate of pragmatism arose. Sir Oliver Lodge, who is a philosopher almost before being an investigator, and who at any rate has never separated the two rôles, supplies for the pragmatists several solutions of problems in scientific paradox which have engaged their attention. For example, in the essay on "The Nature of Time," he points out that while it might be plausible to argue that, if we regard time as made up of discontinuous instants, we can have no real existence except in the present instant, yet that these "puzzles about duration and succession, about co-existence and sequence, are avoided, or greatly minimized, by recognizing that our direct primary form of apprehension is not either space or time, but *Motion*." From time he goes on to argue, very usefully it seems to us who have wandered rather confusedly between the opposing battalions of the Pragmatists, the Rationalists and the Intellectualists, that we must have arrived at our conceptions of the Universe by utilization and development of notions derived from our primary and direct sense-perceptions of Motion, of Speed, and of Force. Other essays deal with the philosophy of M. Bergson; with the definition of wealth; with social reforms, and with one of Sir Oliver's most practical contributions to the community's immediate well-being—Smoke Prevention.

E. S. G.

PHYSICS.

The Principia; or the First Principles of Natural Things. To which are added the Minor Principia and Summary of the Principia.—By EMANUEL SWEDENBORG. Translated from the Latin by JAMES R. RENDELL, B.A., and ISAIAH TANSLEY, B.A. With an Introduction by ISAIAH TANSLEY, B.A., and a Foreword by SIR WILLIAM BARRETT, F.R.S. 2 vols. 1340 pages. 104 figures. $8\frac{1}{2}$-in. $\times 5\frac{1}{2}$-in.

(The Swedenborg Society. Price 21/- net.)

Swedenborg is best known, perhaps, by his later philosophical and theological works. But during the last few years an increasing interest has been taken in his earlier works on natural science, it having become apparent that he anticipated some of the important discoveries and theories of modern times in physics and cosmology. This excellent and carefully prepared translation of Swedenborg's *Principia* will, therefore, be welcomed by all physicists and cosmologists who are interested in the history of science. Swedenborg conceived of nature as the expression of the Divine Will, but according to him, this Will always operates according to fixed laws of order and sequence. Consequently, although Swedenborg, as a philosopher, took a transcendental view of nature, regarding it as a miracle; as a worker in science he treated nature as a machine, and attempted to work out a complete theory of natural phenomena based on mechanics and geometry. His position in this respect, is somewhat similar to the attitude of that particularly clear thinker of the present time, Dr. C. Lloyd Morgan.

Whenever experimental facts were obtainable, Swedenborg utilised them. But experimental science was in its merest infancy in Swedenborg's day, and consequently he was frequently obliged to argue *a priori*. This led him, in his *Principia*, to make assumptions, which, nowadays, would not be allowed. Nevertheless, his genius was far in advance of his time, and enabled him more than once to get at the true explanation of phenomena. He was the first to put forward the concept of a vortex-atom. He regarded light as produced by undulations in the ether (a theory already put forward by Huygens, but discredited by Newton). He also regarded heat and electricity as having an etheric origin. His explanation of the reason of the magnetisation of iron, by stroking with a magnet, is perfectly correct; and his words on this point might, as Sir William Barrett points out in his valuable and appreciative Foreword, be those of a modern student. Moreover, his explanation of the orgin of the solar system must be regarded as an anticipation of the theory of Laplace. Indeed, Swedenborg seems to have been a man of extraordinary mental abilities, whose works have been too much neglected. An Appendix containing critical and explanatory notes by Professor Very adds to the value of the present translation.

H. S. REDGROVE.

RADIOACTIVITY.

Radioactive Substances and their Radiations.—By E. RUTHERFORD, D.Sc., F.R.S. 699 pages. $8\frac{3}{4}$-in. $\times$ 6-in.

(The Cambridge University Press. Price 15/- net.)

It is eight years ago since Professor Rutherford published what was rightly regarded as the authoritative work on the emanations of radioactive substances, and from that volume many which have been written since are largely derivative. In 1904 the theory of the disintegration of the atom, of which Rutherford made use to explain the phenomena of the expulsion of atoms and electrons, and of rays as yet not entirely accounted for, was still under discussion. Lord Kelvin was not entirely convinced; and there was an alternative theory, not without advocates, which was that the energy of radium was first taken in from an external source, and was than transformed into radioactive energy by a kind of surface osmosis. Professor Rutherford's answer to this suggestion was to dissolve a speck of radium bromide in a solution of radium chloride which was a thousand times the speck of radium's bulk, and then to show that there was no alteration in the rate or quality of the radiation such as there should have been if the radiation had been dependent on external sources of energy.

One recalls the experiment as something almost archaic, so soundly now does the disintegration theory seem established. But it is of importance to notice the rate at which confirmation of the theory grew. Confirmation was given to it by the increasing knowledge of the transformations which radium and other radioactive substances underwent, because it was evident that the mechanism of transformation was the same or similar in succeeding cases, and with the accumulation of instances it became clear that the idea of unstable atoms disintegrating under the influence of a disturbance to the units of their atomic systems, was the only one which would cover all the cases. In 1905 twenty of these transformations in radioactive substances were known. The number now is thirty-two, and Professor Rutherford remarks that there is some evidence to show that a few transformations still remain undetected. They are not easy to find, because the transformations are so extremely rapid: and in consequence the lives of the elements produced by them are extremely short. Radium has a life of respectable proportion, though it is so far below the career enjoyed by its venerable ancestor Uranium: but the one thousand seven hundred and sixty years which are the "half-life of radium," are a comparative immortality by the side of the lifetime of that element derived from the emanation of thorium, whose life is only fourteen-hundredths of a second, or of the actinium derivative, the lifetime of which is one five-hundredth of a second.

These are some of the results of the eight years of investigation conducted in every physical laboratory of the world, and summarised in what is, in all respects but that of theory, a new volume. The eight years, however, besides affording a vast amount of information, have been fecund in new methods and in new ideas. The most singularly useful of the new methods is, perhaps, that due to the discovery of ways of counting single α particles. This has not merely extended the knowledge of the α particle, but it has been of the greatest importance in obtaining accurate data for the calculation of a number of important radioactive quantities and atomic magnitudes. It must not be forgotten that it is since 1904 that physicists have learnt to weigh the negative corpuscle.

Again, the discovery of the recoil of radioactive particles when an α particle has been expelled, has proved to be useful as a means of separating radioactive substances: it has also furnished a new kind of corpuscular radiation for study. The importance of secondary radiations; the light they throw on a possible positive particle of electricity; the nature of gamma rays and their probable identity with Röntgen rays—these are the things which are now of most importance in the study of radioactivity. To them all, as well as to the influence which emanations of radioactive substances exert on the electrical state of the atmosphere, Professor Rutherford gives exactly the right kind of judgment and consideration. His new work is one of those which are inevitably and indubitably standard works: and the only corollary we could have wished to add to it would be a more extended consideration of Professor Bragg's theory on the nature of "electric doublets" and the Röntgen rays.

H. S. REDGROVE.

YEAR BOOKS.

Who's Who. 1913.—2,226 pages. 8⅝-in. × 5½-in.

(Adam & Charles Black. Price 15/- net.)

"Who's Who" comes to us this year in an enlarged form, and contains no less than twenty-five thousand biographies. Its great usefulness is made thereby still greater, and the chances of anyone not finding within it what they seek are considerably lessened. As would be expected, many men of science are included, and the records of their lives, brief though they are, make very interesting reading. Some of them seem to consider that they have no need for recreation, and probably that is true of many enthusiasts, but others, like the generality of people, tell us how they get relaxation. One well-known zoölogist gives as his recreations, conversation in clubs and tricycling. An American evolutionist boldly states that he gets his recreation in work. A distinguished German physicist spends his spare time in climbing the Alps, to which passion he says he has clung for almost his whole life. "Who's Who" should be on the shelves of every intellectual person and in every office of any importance.

Whitaker's Almanack, 1913.—By Joseph Whitaker, F. S. A. 1,036 pages. 7½-in. by 5-in.

(Price 2/6 net. Paper 1/- net.)

Almost everything that can be said in praise of "Whitaker" has been printed in the many years during which it has been before the public. The valuable astronomical information which it contains would entitle it to a notice here, even if on its general merits it did not claim its annual welcome. To us, perhaps, its greatest usefulness lies in giving us the names of various officials who carry on the scientific and educational work of the Government, and that is but one point among many thousands which others have come to appreciate.

Whitaker's Peerage, 1913.—854 pages. 7½-in. × 5¼-in.

(Price 5/- net.)

With Whitaker's Almanacks comes "Whitaker's Peerage," which is of a convenient size, reasonable price, and handy to use, because it has one alphabetical list of everyone who has a title or who has gained a decoration.

The International Whitaker, 1913.—529 pages. 7¼-in. × 5-in.

(Price 2/- net.)

The "International Whitaker" is a new year book, which gives information something similar to that of the old "Whitaker" with regard to our colonies and the various countries of the world. As may be imagined, it is particularly intended for English-speaking people, and it contains an interesting biographical note concerning the originator of "Whitaker's Almanack," which it is to supplement, but not to supersede. We anticipate for it a most successful career.

ZOÖLOGY.

Spiderland.—By R. A. Ellis. 108 pages. Numerous plates. 7¾-in. × 5¼-in.

(Cassell & Co. Price 3/6 net).

As would doubtless be judged from its title, this popularly written book is intended for young people, and we may add that it will fulfil its object. Its author's claim that there are few books dealing with the life of spiders is a good one; occasionally in nature study volumes a chapter may be devoted to the creatures in question, and the writer of this notice when a boy found that they were one of the things that could be studied with interest and advantage in a town garden.

By the courtesy of *Messrs. Cassell & Company.*

Figure 69.

A Sectional Web spanning an open doorway. (From "Spiderland.")

In "Spiderland" a very clear description is given, when dealing with structure, of the conformation of the spinnerets, and not the least attractive parts of the book are those which are concerned with the weaving of snares.

Occasionally one meets with a sentence which sounds more effective than accurate: as, for instance, in the one which states that spiders "banquet on the ruddy drops that warm the hearts of their insect prey." Moreover "protective resemblance" is the proper term to use when speaking of the likeness of the spider to its natural surroundings. It is difficult to "mimic" a flower or a twig. The author has been allowed to make use of the writings of the late Dr. McCook, and the following incident recorded by him is given :—"An Englishman, being pursued by Red Indians, sought refuge in the hollow of an old tree. While hiding there he saw a spider begin to weave her web over the entrance. Within a very short space of time the orb was completed and the little weaver took her station in the centre. No sooner had she done so, than a Red Indian came by. He approached the hollow tree, tomahawk in hand, but noticing the web with the spider in the centre, naturally concluded that there was no tenant there."

There are many excellent illustrations and the volume altogether forms a valuable addition to a boy's or girl's collection of "nature books."

W. M. W.

Wild Life.—Edited by DOUGLAS ENGLISH. Volume I, Number 1. 64 pages. Numerous illustrations. 12¼-in.×9¾-in.

(The "Wild Life" Publishing Co. Price to subscribers, 17/6 for six months, 30/- for twelve.)

Wild Life is a new illustrated monthly magazine of which the letterpress is to be based solely on first-hand observation, and the illustrations are to be from photographs alone. It is the outcome of the widely-spreading cult of Nature photography, and, more immediately, of the exhibition of the work of the Zoölogical Photographic Club, held at the offices of the Zoölogical Society last summer. The first number now before us is most excellent, and it is probable that the future ones will be even better; for an editor, as he proceeds, becomes more and more critical with regard to the perfection of the photographs which he chooses, and the way in which they are reproduced. Mr. Farren's photographs and account of the nesting Egrets, which flourish not more than a three-days' journey from London, are delightful. We reproduce, by permission, one of the photographs taken by Mr. Douglas English to accompany his remarks on "The Wild Cat" (see Figure 70). Dr. Francis Ward's observations and pictures illustrating "Photography under Water" are very interesting, and there is much good work by other well-known photographers. Two of Mr. R. B. Lodge's "Eagles" are noteworthy; the third is too obviously touched up, and his Griffon Vultures are not successful. The carrying of the letterpress right across the wide page gives a certain style to the publication, but the lines are too long for easy reading. *Wild Life* marks an epoch in the modern study of Nature, and we wish it every success.

W. M. W.

From a photograph *by Douglas English.*

FIGURE 70. The Wild Cat.

(From "Wild Life" by the courtesy of the Editor.)

NOTICES.

BIRDS IN AVIARIES.—Those who are interested in the acclimatization of foreign birds will find a good deal of interesting matter in Mr. Wesley T. Page's "Aviaries, and Aviary Life," in which many of the birds, with nests which have been built in this country, are illustrated. It is published by the Avian Press, Ashbourne.

FORMALIN AS AN INSECTICIDE. — Experiments have been made at University College, Cork, to determine the insecticidal power of formaldehyde. Various strengths from ·01 to 2 per cent. were used, but the results, we learn from *The Irish Naturalist*, show that any efficacy which formalin might possess as an insecticide is more than counterbalanced by its injurious action on the plant.

EGG OF THE GREAT AUK.—Mr. Thomas Parkin contributes to *British Birds* for January an account of the very finely marked egg of the Great Auk, which was sold at Stevens's, on November 21st, 1912, for two hundred and twenty guineas, to Messrs. Rowland Ward, Ltd. It was the property of Mr. W. Sheppard, of Bristol, in 1807, and purchased by Mr. Shirley, of Ettington, about 1820. It was put up for auction in 1910, when Mr. E. L. N. Armbrecht bought it for £262 10s.

PAUL RAINEY'S EXPEDITION TO SOUTH AFRICA.—The most remarkable set of moving pictures obtained on Mr. Paul Rainey's expedition are now on view at the Holborn Empire, in London, and cannot fail to interest anyone who takes the trouble to go and see them. The naturalist would, of course, be most pleased with the striking films obtained near a water hole, which show several rhinoceroses, two giraffes, a family of elephants, numerous deer, monkeys, and many birds. Sportsmen would appreciate the hunting of cheetahs and lions by means of dogs, and it must be added that Mr. Reginald Carrington's descriptive lecture is most lucid and explanatory.

SECOND-HAND INSTRUMENTS.—More than fifteen hundred pieces of scientific apparatus for sale, or on hire, are given in Mr. C. Baker's current list of second-hand instruments. We have often alluded to the usefulness of these catalogues and commend the present issue to our readers. On one of the advertisement pages we notice the announcement of a new one-sixteenth inch oil immersion objective, the price of which is £6 10s.

PORT ERIN BIOLOGICAL STATION. — Professor Herdman's Annual Report of the work done at Port Erin Biological Station is always interesting, and the twenty-sixth one which has come to hand is particularly valuable because it contains a number of maps, charts, and plans of Port Erin Bay and the neighbourhood, prepared for the use of advanced students or research workers, on which they can record localities and captures.

BRITISH ASSOCIATION ADDRESSES.—A correspondent signing himself O.B.L. sends us the following note.—"I see from the *Publishers' Circular* an announcement to the effect that Messrs. Longman are publishing 'The only authorized address of the President of the British Association' delivered at Dundee. From this are we to assume that the copies of the address sold by the association to the members at Dundee, and that the version which appears in the Annual Report in about a year's time, are unauthorised ?"

HORNIMAN MUSEUM LECTURES.—The following Saturday afternoon lectures will be given at the Horniman Museum during February.—

Feb. 1st.	"Tools and Weapons of the Old Stone Age"	Dr. H. S. Harrison (Curator of the Museum).
,, 8th.	"The Gun-flint Industry of Brandon: a Survival of the Stone Age"	Mr. Edward Lovett (of the Folk-Lore Society).
,, 15th.	"Japanese Ivories and Designs" ...	Mr. A. R. Wright, F.R.A.I.
,, 22nd.	"The Day's Work of a Root"	Dr. E. Marion Delf.

HINTS ON PHOTOGRAPHY.—We have received from Messrs. Charles Zimmermann & Company the "Agfa" handbook, which is published by the photographic department of the Actien-Gesellschaft für anilin-fabrikation, Berlin, containing a number of chapters by well-known English photographers on such subjects as time development, rodinal for the development of gaslight papers, and exposure meters. Messrs. Zimmermann will send a copy on receipt of a penny stamp.

EGYPTIAN LEGENDS. —The forthcoming book in Mr. Murray's "Wisdom of the East" Series is "Ancient Egyptian Legends," translated by Miss M. A. Murray, the well-known lecturer on Egyptian Literature, of University College, London. The author has given a free rendering of the fascinating legends of the ancient Egyptian Gods, Isis, Osiris, Horus, Ra, telling of their loves, battles, prayers, adventures, and sacrifices, which are likely to appeal to a wide public, while at the same time in her notes on the subject she has made provision for the more serious student.

MEDICAL BOOKS.—Messrs. Adam and Charles Black will, in future, publish the following medical books which were formerly issued by Mr. James Currie, Edinburgh.—"Handbook of Medical Treatment; A Guide to Therapeutics for Students and Practitioners, with an Appendix on Diet," by James Burnet, M.A., M.D., M.R.C.P.E.; "Manual of Medical Jurisprudence, Toxicology, and Public Health," by W. G. Aitchison Robertson, M.D., D.Sc., F.R.C.P.E., F.R.S.E.; Second edition, with thirty-nine illustrations, crown octavo. "The Pocket Clinical Guide," by James Burnet, M.A., M.D., M.R.C.P.E.; "The Pocket Prescriber," by James Burnet, M.A., M.D., M.R.C.P.E.

A PHILATELIC MICROSCOPE. —We have received from Mr. Harold Cheavin a description of the inexpensive microscope which he has designed for philatelic workers, and recently exhibited before the Royal Microscopical Society. The microscope will prove useful in examining small details which are of great importance to stamp collectors, and by a simple adjustment, water-marks may be made out as well as the texture of the paper used. It is also very easy to fit the microscope into the front of a camera from which the lens has been removed, and so to take any photo-micrographs that may be required. The instrument is made by Messrs. Watson & Sons, but all communications should be addressed to Mr. Cheavin, Somerset Road, Huddersfield.

THE PRESERVATION OF FLORA AND FAUNA.—It will be remembered that at the Dundee meeting of the British Association in September last the President of the Zoölogical Section, Dr. P. Chalmers Mitchell, F.R.S., took as the subject of his address: "The Preservation of Fauna." At the close of the meeting the General Committee passed on to the Council, for consideration, a resolution, which has now been adopted, in the following terms:—"That the British Association for the Advancement of Science deplores the rapid destruction of fauna and flora throughout the world, and regards it as an urgent duty that steps should be taken, by the formation of suitably-placed reserves or otherwise, to secure the preservation of examples of all species of animals and plants, irrespective of their economic or sporting value, except in cases where it has been clearly proved that the preservation of particular organisms, even in restricted numbers and places, is a menace to human welfare.

THE ALCHEMICAL SOCIETY.—The first general meeting of the Alchemical Society, which has been formed for the study of the works and theories of the Alchemists in their various aspects, was held on Friday evening, January 10th, at the International Club, Regent Street, W. The Hon. President of the Society is Professor John Ferguson, M.A., LL.D., F.I.C., F.C.S., and amongst other notable members we may mention Mr. H. Stanley Redgrove, B.Sc., F.C.S., Mr. Arthur Edward Waite, Mr. W. Gorn Old, Mr. Philip S. Wellby, M.A., and Madame Isabelle de Steiger. At the meeting a lecture was delivered by Mr. H. Stanley Redgrove, B.Sc., F.C.S. (whose "Alchemy, Ancient and Modern," is well known to students), on "The Origin of Alchemy." The lecturer pointed out that the alchemists in the past had been too harshly condemned as half charlatans, half fools. As he said, although some of them were of this nature, many of the alchemists were men of fine intellect and inspired in their studies with noble ideals; and he suggested that, in spite of the fact that their assumptions led them into many fantastic errors, they did seem to grasp certain fundamental facts concerning the universe of very great importance. But, even supposing their theories to be utterly wrong, it was still necessary to account for the fact that they gained almost universal credit. Why, asked the lecturer, did the alchemists adopt such views concerning natural phenomena? Here, he said, was a proper subject for scientific investigation. His reply, which he illustrated at considerable length, was that the alchemists started with two assumptions: (1) the truth of mystical theology, especially the doctrine of the soul's regeneration; and (2) the truth of the statement that natural objects are the symbols of spiritual verities. They, thus, reasoning *a priori*, attempted to explain natural phenomena by the application to them, by analogy, of the principles of mystical theology.

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

MARCH, 1913.

ELECTRIC WAVES.

By W. D. EGGAR, M.A.

MIDDLE-AGED people, like the writer, may still be found who will answer, when asked the meaning of the word *electron*, that it is the Greek name for amber. This is admittedly true, but it will probably be unsatisfactory to the questioner, who will be expecting much more up-to-date information. Modern text-books, if we may include anything published within the last twenty years as modern, will suggest many different definitions of the sub-atomic bodies on which Dr. Johnstone Stoney, with a somewhat misplaced generosity, bestowed the title of electron. They are centres of strain in the ether, cathode rays, β-particles, bricks of which atoms are built, ends of Faraday tubes. The mass of an electron is given as $6 \cdot 1 \times 10^{-28}$ grammes, and its radius as 10^{-13} centimetres, and some persons with a taste for figures may feel some small satisfaction in this information.

It is still open to anybody to form any conception that he may find possible of the ultimate structure of space; but certain facts about the aether are becoming part of our common life, and are even a subject of inquiry for a Parliamentary Committee. Whether we regard an electron as a whirlpool in a continuous medium, or as the terminus of a Faraday tube in an aether of which the structure is fibrous, there seems to be no question that movements of electrons are accompanied by a disturbance of the adjacent medium, and that this disturbance travels along the medium, whatever its structure, with a velocity of 3×10^{10} centimetres, or approximately one hundred and eighty-six thousand miles per second.

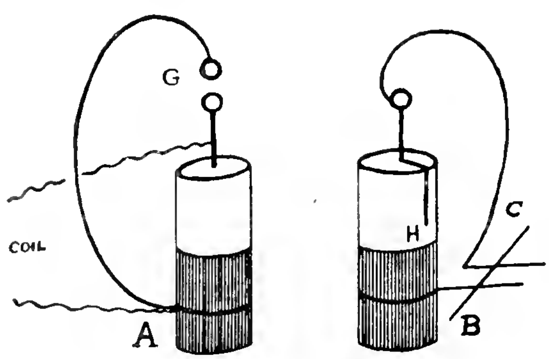


FIGURE 71.

Wireless telegraphy is accomplished by a succession of electric, or electro-magnetic disturbances, propagated as waves through space. It is remarkable that Britain had furnished the theory of these waves before their existence was demonstrated practically on the Continent. Sir J. J. Thomson, in "The Encyclopaedia Britannica" (XIth Edition), points out that Lord Kelvin, in 1853, proved from theory that the discharge of a Leyden jar must be oscillatory. Feddersen proved it by experiment. Clerk Maxwell proved that, on his theory, electro-magnetic waves must travel through space with the velocity of light. Hertz, in 1887, demonstrated the existence of these waves, employing as the source of disturbance an oscillatory spark-discharge. He found that such a discharge would produce small sparks between the ends

FIGURE 72.

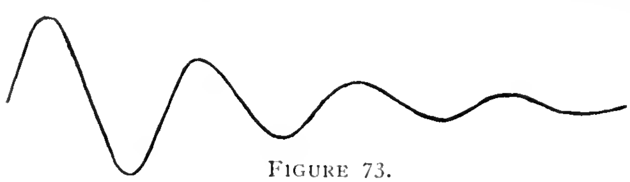


FIGURE 73.

of a copper wire bent nearly into a circle.

It has been said already that the discharge of a Leyden jar is oscillatory. Lodge devised a method of obtaining a persistent oscillatory discharge, and of tuning a receiver for it. The transmitter consists of

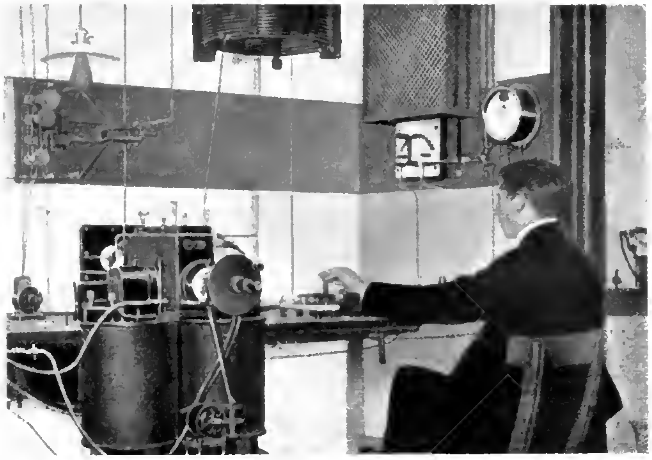


Figure 74.
Transmitter at the Lyngby Station.

a Leyden jar A. (Figure 71) with a bent wire nearly connecting the outer and inner coatings, which are themselves connected to the terminals of an induction coil. When the coil is working, a persistent series of oscillatory sparks crosses the air-gap G. The receiver is another Leyden jar B, also with a bent wire, with an air-gap H, the planes of the two bent wires being parallel to each other and at right angles to the line joining the centres of the jars. The sliding piece C can be adjusted so that when A is at work sparks pass across the gap H. A very slight displacement of C causes the sparks to cease.

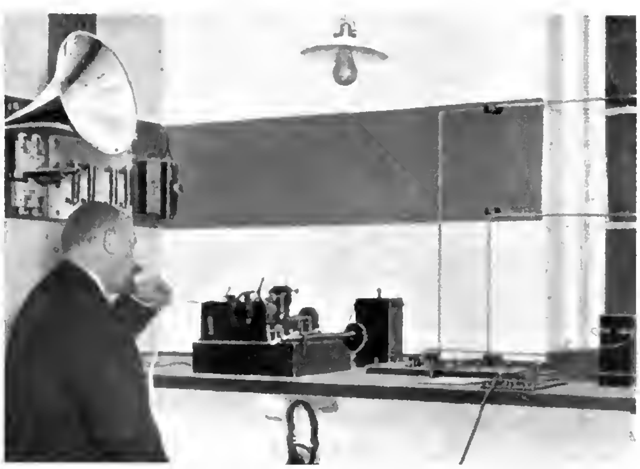


Figure 75.
Receiver at the Lyngby Station.

Now, although such a transmitter and receiver can be made very perfectly *in tune* with each other, such a receiver is not sufficiently sensitive for long-distance work. Electric waves produce various other effects which can be employed to detect their presence. Branly discovered that the resistance between loose metallic contacts is diminished when electric waves fall on them, and the detectors made on this principle are known as *Coherers.* Rutherford found that a bundle of iron wires magnetized to saturation was demagnetized by the alternating currents caused by electric waves. Marconi's magnetic detector employs this discovery in the form of an endless flexible iron wire, made to move round and round by clockwork under permanent magnet poles; the changes in the magnetization caused by the electric waves induce currents in a telephone receiver. Such detectors can be tuned to show maxima effects for waves of particular lengths, but the effects do not cease completely for other wave lengths.

It has been said that the electric waves generated by the discharge of a Leyden jar may be compared to the sound waves produced by a pistol-shot. Perhaps it would be fairer to compare them to the waves produced by a drum-tap. There is at least a very rapid damping of the waves, *i.e.*, a rapid falling off in their intensity, although the wave length, *i e.*, the distance between successive crests, may remain the same. (See Figure 73.) The waves of a sound of a drum would produce in the groove of a gramophone record hills and valleys similar to those shown in Figure 73. The record of a tuning fork, however, would be more like Figure 72. So would the record of an organ pipe, so long as a stream of air is being driven across its embouchure. Analogies are sometimes misleading; but in seeking analogies between different kinds of waves we are not likely to go far wrong if we bear in mind the main characteristics of all wave motion and the main specific peculiarities of each kind.

In all wave motion we find the following characteristics, among others :—

(i) The disturbance takes time to travel from one place to another. Electric waves travel one hundred and eighty-six thousand miles per second, waves of sound in air about one thousand one hundred feet per second.

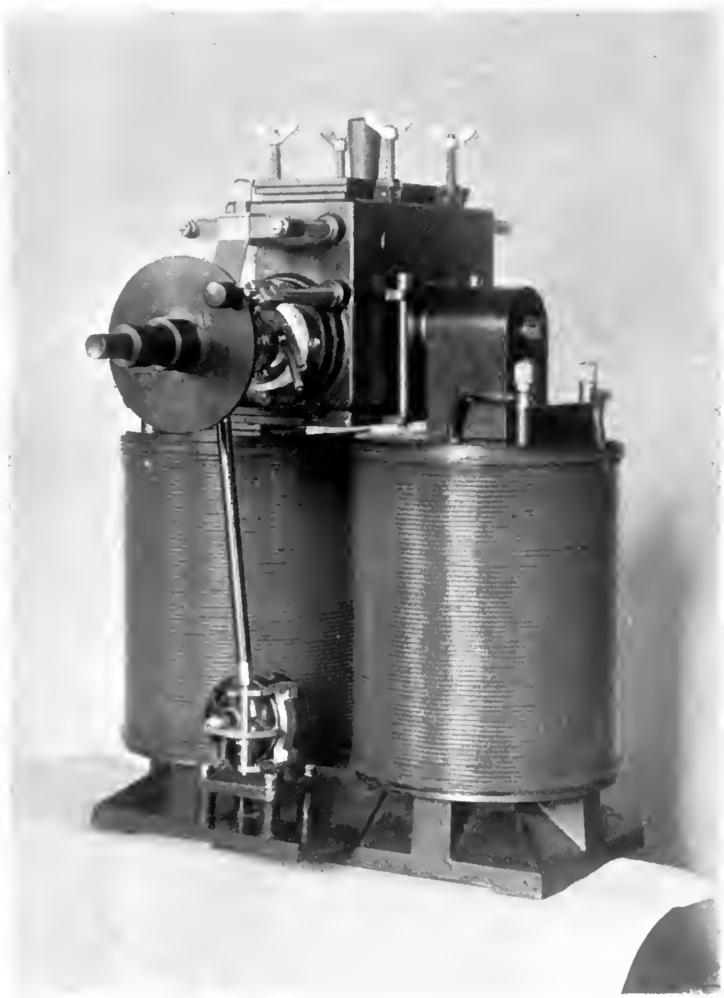
(ii) A medium to transmit the disturbance is necessary. The medium for electric waves is generally spoken of as the aether; sound usually travels to our ears in air.

(iii) When waves follow each other at regular intervals and fall on some system capable of being disturbed by them, then if that system has a natural period of vibration corresponding to the period of the waves, it will be caused to vibrate in sympathy with them. This phenomenon is known as resonance, and numerous familiar instances of it might be recalled.

(iv) The velocity of the waves, the wave length, and the frequency are connected by the equation $V = NL$. For instance, let us take a tuning fork giving two hundred and seventy-five vibrations per second; the waves travel with a velocity of one thousand one hundred feet per second; therefore, the space between each wave and the next will be four feet. Again, suppose an electric oscillator sending out one million waves per second. The wave length must be three hundred metres, since the velocity of propagation is 3×10^{10} centimetres per second.

The frequency of an ordinary alternating current is far too low to produce waves of sufficient energy for use in wireless telegraphy. In 1899 Duddell discovered the following phenomenon:—When a condenser of suitable capacity is connected through a self-induction coil in parallel with an electric arc which is being fed by direct current, the arc will, under certain conditions, become musical. At the same time there is set up in the self-induction an alternating current, having the same rate of vibration as the note produced by the arc. In other words, part of the direct current is transformed into an alternating current of constant amplitude, the energy absorbed being supplied by the direct current.

A very close analogy to Duddell's musical arc may be found in a flue organ pipe. Here the note is produced by the vibrations of the air column in the pipe, whose dimensions determine the pitch of the note. These vibrations would die away, or be *damped*, very rapidly but for the energy supplied by the continuous current of air blown across the embouchure of the pipe. This air current is directed against a sharp edge, and must pass either inside or outside it, thus creating either a compression or a rarefaction at the end of the pipe. The natural frequency of the pipe causes the air current to be turned alternately inwards and outwards, and the note is maintained, the air current supplying the energy and paying the piper, the organ pipe calling the tune.



From a photograph *by W. Duddell.*

FIGURE 76.
A Twelve Kilowatt Generator.

By this method Duddell obtained a high rate of alternation: that is to say, up to thirty or forty thousand oscillations per second. Even this rate is too low for wireless telegraphy, and the energy far too feeble. In 1903, however, Professor Valdemar Poulsen, of Copenhagen, succeeded in obtaining a much higher rate of oscillation by surrounding the arc with an atmosphere containing hydrogen. Hydrogen, with its high atomic velocity, possesses great thermal and electrical conductivity, and no doubt its cooling influence makes it possible to use higher power. Poulsen further discovered that a strong magnetic field placed transversely to the arc had the effect of giving a definite shape to the arc and thus making the oscillations more constant, as well as making it possible to increase the potential difference greatly in proportion to the length of the arc. By these two devices Poulsen has obtained alternations as rapid as one million per second.

It is claimed for the Poulsen-Pedersen system of wireless telegraphy that it is capable of being tuned with greater precision than any spark system. If a tuning fork in vibration is held over an open piano, only one wire will show resonance. On the other hand a pistol shot will make all the wires vibrate at the same time.

Another claim is that a speed comparable with that of submarine cables can be attained by the Poulsen automatic transmitter (Figure 74). With this, as in the Wheatstone instrument, the message to be sent is represented by a series of holes punched in a continuous paper strip, those on one side of the central line representing dots, and those on the other side dashes. This strip is fed into a rotating contact maker, and by means of the holes the continuous waves of the arc are cut up into lengths, short for the dots and long for the dashes. The aërial wire at the receiving station picks up these wave trains, and transmits them to a crystal rectifier consisting of particles of galena and tellurium in contact, which permits the current to pass, in one direction only, through a "string" galvanometer. A shadow of the string is projected on to a moving strip of sensitive paper, which passes on into developing and fixing baths, so that a permanent record of the vibrations of the string is obtained, similar to that of Lord Kelvin's siphon recorder, which is shown in Figure 75, at the bottom of page 82.

The system has been tried successfully between Lyngby, in Denmark, and Cullercoats, at the mouth of the Tyne, a distance of six hundred miles. Whether it will work as well between Ireland and North America remains to be seen.

FIGURE 77. Poulsen Masts, San Francisco, California (U.S.A.)

The merits of the various rival systems are still *sub judice*. The brief sketch of one of them which we have given may be helpful to some who are interested in following the evidence.

RESEARCH DEFENCE SOCIETY.

WE have received the following appeal from the Officers of the Research Defence Society and have much pleasure in commending it to the notice of our readers.

To the Editors of "KNOWLEDGE."

SIRS,—It is said that the fifth year, in the life of any Society, is the critical period of its fortunes. The Research Defence Society was founded on January 27th, 1908. To all who are interested—and who is not?—in medical research, we beg you to let us say that the Society has its hands full of work, and only wants more money to do more work. Much has already been done, by lectures and by distribution of literature, to bring home to people the truth about experiments on animals in this country, and the great value of them, not only to mankind, but also to the animal world. The expenses of our Society are heavy; but the good results of our work are extended far and wide. We have lately opened a Bureau and Exhibition at 171, Piccadilly (opposite Burlington House). We are exhibiting pictures, portraits, charts, anaesthetics and inhalers, germs in pure culture, tsetse flies and mosquitoes, and so forth. This little exhibition, every day and all day long, displays to "the man in the street" the facts of the case. We are the only Society which is doing work of this kind; but, of course, it cannot be done without money. Our record for the last four years gives us the right to hope for a great increase of our Membership, and of our funds, in the coming year.

DAVID GILL, President.
F. M. SANDWITH, Hon. Treasurer.
STEPHEN PAGET, Hon. Secretary.

21, LADBROKE SQUARE, W.

THE INFLUENCE OF AGE ON THE VITALITY AND CHEMICAL COMPOSITION OF THE WHEAT BERRY.

By R. WHYMPER.

THE knowledge that the vitality of a living thing decreases with the passage of time is so imprinted in the human mind that all our life is spent, consciously or unconsciously, in prolonging the end which must come or in preparation against that time.

But the fact that there must be an end to all living things does not restrain but rather stimulates both our efforts in unravelling the mystery which surrounds the very existence of life and our imagination in regarding a thing which has possessed life even beyond the span of years allotted to man.

A tortoise of four hundred years is an object of respect, a giant oak of some one hundred and fifty years is venerable, and both by reason of their vitality command greater regard than a lifeless rock which has existed more or less of constant appearance and consistency since the world began.

With the passing of life, decay of the material sets in eventually: sooner if the organic matter is readily decomposable and under suitable conditions: later if the matter is more resistant or under conditions which tend to prevent the action of moisture, air and bacteria from having full play.

Thus animal remains rapidly decompose when exposed to air under ordinary conditions, though, as in the case of bodies carefully dried or specially treated with antiseptics, they may remain in a state of preservation for a considerable period of time.*

FIGURE 78.
Mummy Wheat, longitudinal section.

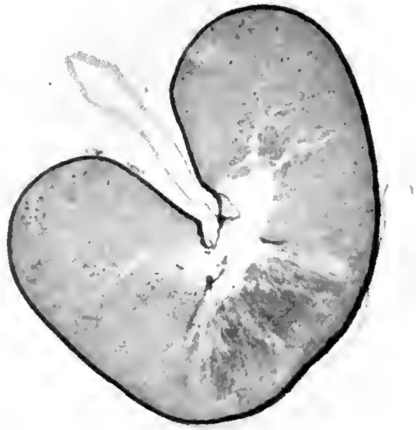


FIGURE 79.
Mummy Wheat, transverse section.

Vegetable matter containing much cellulose is obviously less liable to rapid decay than that containing easily fermentable components such as cooked starch and sugar; this can be readily seen in such cases as the bread and cake found in the tombs of the ancient Egyptians and which are now composed of little else than the husks of wheat and other cellular tissue.

It was the custom of the ancient Egyptians to provide their mummied dead with articles of use and personal property as well as with food such as bread, meat, wine, cakes and wheat, as means of refreshment during their trying journey to the world "beyond the sunset" and it is owing to this religious custom that we owe many of our most treasured ancient Egyptian relics. It is to be hoped that the food placed with the dead was found sufficiently sustaining to last over the long period of time which elapsed before the wandering soul again found rest in the body, and which, if Herodotus is to be believed, was about three thousand years, or at least that it was never failing in quantity like the "widow's cruse."

The quality of the food stuff, however, after the same lapse of time, leaves a good deal to be desired, though the wheat with which the present paper is chiefly concerned is remarkable for the few changes that have taken place within the berry.

* It may be of interest at this point to mention that I have in my possession a raw beef steak placed in "vacuo" in glass in 1889 and which to all appearance is in a remarkably good state of preservation. My uncle, the late Mr. Edward Whymper, and Mr. Hicks conducted a number of experiments with "vacua" in that year, chiefly in connection with the standardisation of aneroid barometers.

The beef steak in question was one of their many experiments and my uncle always displayed great interest in this unique object, which was found at his death in his bedroom at Teddington, where I remember it many years previously.

The following observation is attached to the glass vessel containing the meat, and, apart from the appearance of a few rose clustered crystals which have separated out, it is the only indication that the piece of steak is not fresh.

"*April 30th, 1904.*—This piece of Rump Steak was sealed up in "vacuo" on January 7th, 1889. Originally it occupied about four-fifths of the length of the tube. It has constantly shrunk, but it is only in the last few months that I have noticed the appearance of the fungoidal growth."

The meat now occupies less than one-tenth of the volume of the tube and the supposed fungoidal growth is in reality a crop of crystals.

FIGURE 80.
Wheat of the year 1852, longitudinal section.

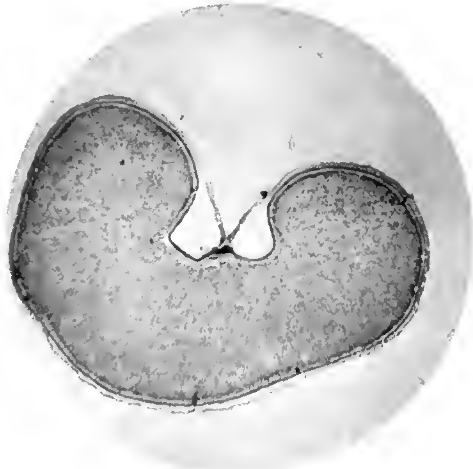


FIGURE 81.
Wheat of the year 1852, transverse section.

The most stable of the articles of food found in the ancient Egyptian tombs is wheat, and it would certainly add fuel to the fire of imagination, if from the wheat grains of a date somewhere about the time of the supremacy of Joseph in Egypt could be grown a crop of corn whose life had lain dormant for so many centuries.

In cases where authentic Mummy Wheat has been used, all attempts to secure germination have failed, though it will not be without interest briefly to review some of the failures and supposed successes in growing wheat and other seeds which were known to be of great antiquity, and to examine the possibility of the existence of life after so many ages.

The conditions which regulate the speed of germination can only be said to be indirectly connected with vitality since, in many cases, whilst germination is the exhibition of vitality, the causes which retard germination are purely physical characteristics of the seed.

Thus, certain seeds with thick impervious integuments, such as clover, which under favourable circumstances germinate within one or two weeks, may be found quite sound and dry internally though kept continuously wet on the outside for many years. In such cases it seems that a scratch is sufficient to cause almost immediate germination by allowing the moisture to penetrate the protective outer coating.

The appearance of strange plants in newly-turned earth removed from excavations, has been attributed to this power in seeds of lying dormant till, by the friction with the earth, the tough integument has been entered and the moisture allowed to reach the embryo.

The older the seed the lower is the probable vitality of that kind, and it is, of course, a well-known fact that the older seed, with the life still in it, requires greater coaxing to bring about germination, and that the plant resulting from it is more weakly in its growth.

In considering wheat, therefore, say three thousand years old, whilst it is certainly not impossible to imagine that it may, if kept for that time under ideal conditions, still be capable of germination, it is hardly to be expected that it should show signs of life, seeing that the conditions under which it has passed so many years in the Egyptian tombs, though good, were still such as would allow decay to set in, and a certain amount of air and damp to assist the decomposition.

The thickness and impenetrability of the outer husk or covering is the chief governing factor for the duration of vitality in seeds under equal conditions of environment.

According to the most recent researches* the power of germination of barley and wheat is but little affected during the first five years, but thereafter a rapid loss of vitality occurs and proceeds at an increasing rate till, in the tenth year, no living seeds remain.

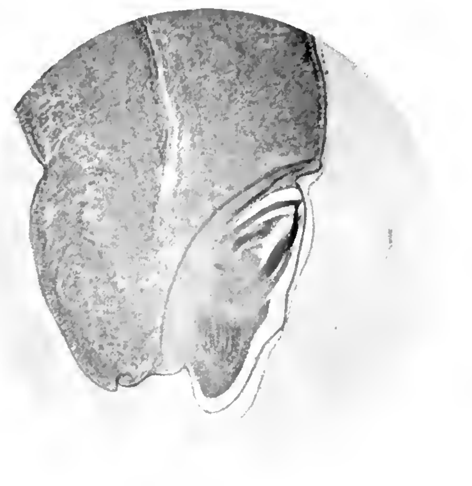


FIGURE 82.
Wheat of the year 1853, longitudinal section.

FIGURE 83.
Wheat of the year 1853, transverse section.

* W. Carruthers, *Roy. Agric. Soc.*, 1911, p. 168.

The seeds under discussion were kept in paper bags in a drawer of the laboratory, and, therefore, may be presumed to have been subjected to fairly constant conditions of moisture and temperature.

Oats kept under similar conditions maintained their vitality for from five to seven years longer and, taken in conjunction with previous observations, may be said to supply the key to the results of the long list of experiments made by Carruthers. "The difference between wheat and barley on the one hand, and oats on the other, is the greater protection afforded to the embryo of the oats by the fact that in its case the glumes, which fall off as chaff in the wheat and barley, remain attached to the seed."

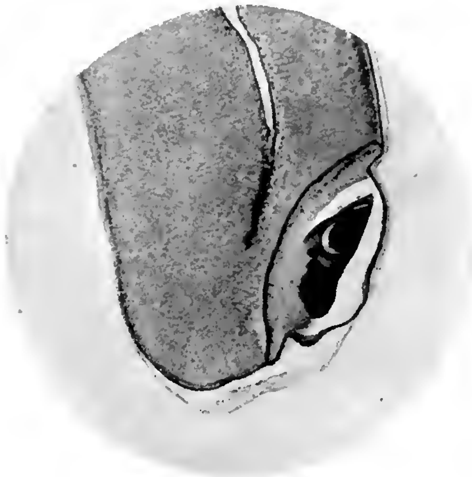


FIGURE 86.
Rivet Wheat, longitudinal section.

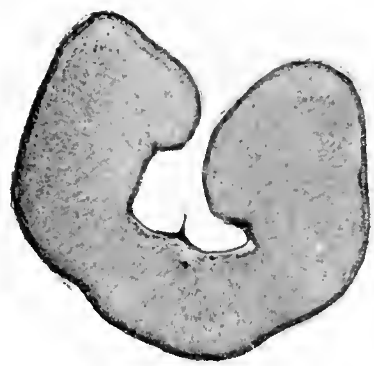


FIGURE 87.
Rivet Wheat, transverse section.

The cause which decides whether germination or death shall result in the embryo of a seed is the balance between heat and moisture.

Heat is, perhaps, the greater factor, if it is possible to speak so of two essentials, in deciding germination, whilst moisture may be said to govern vitality.

By this is meant that whilst moisture without heat, or heat without moisture, is incapable of producing germination, yet the heat optimum applied to a seed with a minimum of moisture, is more likely to produce germination than a maximum of moisture present with a minimum of heat. In the other case, moisture must be present in the embryo plant if life is to be retained, though air-dried seeds have been exposed for some days to a temperature very far below freezing point, or, again, to an upper limit of about 130°F without life becoming extinct.

It would perhaps be more correct to say that in the case of germination, the balance between heat and moisture is finer than when the death of the embryo within the seed alone has to be considered, when, though the loss of moisture beyond a certain point means death, the temperature to which the seed is subjected may be varied within very wide limits without appreciable loss of vitality.

In the case of genuine Mummy Wheat, that is wheat found in the tombs of Egyptian mummies of known antiquity, heat existed without the necessary moisture to bring about germination, and the gradual desiccation of the berries reduced the moisture content of the embryo below that with which life within the seed remained possible.

The same cause brought about the death of the seeds examined by Carruthers, who states that it was no "chemical alteration produced by temperature, but the steady loss of moisture going on continually at ordinary air temperature."

After life is extinct the changes which take place within the wheat grain are more chemical than bacteriological in the case of Mummy Wheat at any rate, for the presence of such powerful antiseptics as bitumen and essential oils (both of which are very apparent in the smell of the Egyptian Mummy Wheat here examined) is sufficient to prevent the action of moulds or bacteria.

The exact nature of these changes will be discussed more fully in a later section.

The Mummy Wheat

FIGURE 84.
Wheat of the year 1854, longitudinal section.

FIGURE 85.
Wheat of the year 1854, transverse section.

examined was found in a tomb at Deir-el-Bahari of an estimated date 1500 B.C., and, assuming that the harvest season of that date was a fair one, the berries probably contained some 12 per cent. of moisture when placed beside the dead. At the time of analysis about three thousand four hundred years later, it contained 10·69 per cent. of moisture and, in its passage across the sea from the very warm climate of Egypt to the comparatively moist atmosphere of England, it certainly picked up at least the odd 0·69 per cent. The loss of the 2 per cent. of moisture and its vitality are the only outstanding features which distinguish this most ancient wheat from that of the last season's harvest. The increase in acidity and loss of gluten strength, though pronounced, are comparatively insignificant and are due to the two main causes.

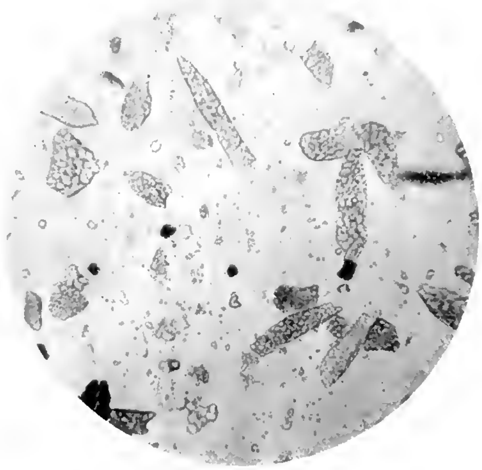


FIGURE 88.
Flour obtained from the Mummy Wheat.

In a previous paper* the writer has observed that under good conditions of germination about 35 per cent. of its weight of water is absorbed by the wheat berry, and it is conceivable that with a constant temperature such as is found in the subterranean tombs of the ancient Egyptians life might have been perpetuated within the berries by the continual existence of, say, another ten parts of water in every one hundred parts of the wheat, over that which was actually present, an additional quantity which would not have encouraged germination.

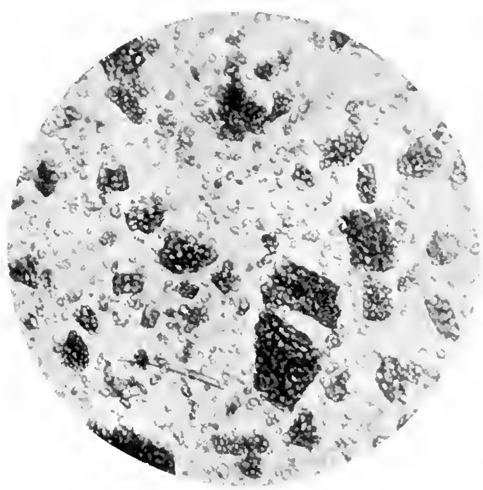


FIGURE 89.
Flour obtained from Rivet Wheat.

Under the existing heat and humidity conditions of the tomb the tendency of the wheat was to impart its moisture to the surrounding air, and thus the moisture content of the wheat was reduced below the minimum which was capable of supporting life for even beyond ten years, and the grains may be assumed to have lain for some three thousand four hundred years without the power of reproducing their kind.

It is reasonable, therefore, that the wheats of such recent dates as 1852, 1853 and 1854 should show but little variation in chemical composition over their kind of last year's harvest. Indeed there are not sufficient chemical differences between all the samples of wheat analysed to show that the loss of that potent factor, Life, has taken place, nor even do the analyses show more divergent results than would be obtained from modern wheats of different varieties.

The experiments of Carruthers, already referred to, have for ever buried the alluring possibility of genuine Mummy Wheat reproducing its kind or even of a ten-year-old wheat from presuming to emulate the efforts of a new born; but it is probable that under the correct conditions which it is hoped will be found when the result of the experiments on hand are completed, and which, after all, are nothing more than rational, the vitality of wheat will be extended and the natural process of decay arrested till it is conceivable that dormant life may be prolonged beyond even the three thousand years which have passed over the head of the Mummy Wheat now under examination and of its accompanying and honoured dead, who by this time is, according to Egyptian belief, again the proud possessor of a soul, though probably exhibited under a glass case to the vulgar gaze of an inquisitive and unbelieving public.

PREVIOUS ATTEMPTS TO GERMINATE SEEDS OF ANCIENT ORIGIN.

It has already been pointed out that in different seeds the duration of vitality is very variable. Thus it is quite well authenticated that the seeds of the Nelumbo (water lily) have sprouted after having been kept dry in a herbarium or museum for one hundred and fifty years, whilst on the other hand the seeds of wheat have been shown by Carruthers in a paper already mentioned to have lost their vitality at the end of ten years when kept dry under normal conditions. Even among one class, such as the cereals, the duration of vitality in the seeds is very variable, as will be seen by Table 16 taken from Carruthers' paper:—

*VII. Internat. Cong. App. Chem., 1909, and Milling, March 18th, 1911.

Table 16. Percentage of Seed Germinated each Year.

Seed.	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911
Barley	99	99	98	95	90	77	25	?	19	—	—	—	—	—	—	—
White Wheat ...	100	97	92	94	?	88	75	?	29	—	—	—	—	—	—	—
Red Wheat ...	99	98	95	88	94	80	79	55	51	—	—	—	—	—	—	—
White Oats ...	100	99	99	99	98	99	99	95	97	69	57	49	12	0	—	—
Black Oats ...	97	97	96	94	90	98	92	94	95	88	76	68	34	32	2	—

Nor can this be taken as the last word on the subject, for the preservation of vitality is, of course, dependent upon a number of factors, the chief of which are :—

(*a*) The character of the season and the ripeness of the seed when harvested.

(*b*) The percentage of moisture in the seed.

(*c*) The place of storage.

The varying results of other experimenters on the duration of vitality among cereals confirm this statement, and to quote two instances:—Loudet, who made trials in 1856–7 with wheat of the years 1853–1856 inclusive, obtained the following results:—

Wheat of 1853, per cent of seeds germinated	0
,, ,, 1854, ,, ,, ,, ,, ,,	51
,, ,, 1855, ,, ,, ,, ,, ,,	73
,, ,, 1856, ,, ,, ,, ,, ,,	74

whilst Haberlandt, on the other hand, obtained results more comparable with Carruthers, thus:—

Table 17. Percentage of Seeds Germinated in 1861 from the Years—

	1850	1851	1854	1855	1857	1858	1859	1860
Wheat ...	0	0	8	4	73	60	84	96
Rye ...	0	0	0	0	0	0	48	100
Barley ...	0	0	24	0	48	33	92	89
Oats ...	60	?	56	48	72	32	80	96
Maize ...	0	?	76	56	?	77	100	97

Dealing with Mummy Wheat, which should be very much older than those just discussed, there have been many experimenters who are said to have succeeded in bringing about germination. Of these the most notorious is the Count Sternberg,* who (it is said) received the grains of wheat from a trustworthy traveller, being assured that they were taken from a sarcophagus. Two of these grains are supposed to have germinated, and though the majority of well-informed people must realize that there was some imposture, probably on the part of the Arabs, the belief in the existence of vitality in Mummy Wheat is still strong, owing to the publication of Count Sternberg's paper, and the constant repetition of his statement in non-scientific journals, that, even up to the present time, a very large number of people who do not study the probabilities is prepared to combat any statement to the contrary.

When the array of experimenters with Mummy Wheat, or wheat of even more recent date, is reviewed, and when it is realised that in almost every case of wheat over ten years old, germination does not result, the probability of Count Sternberg's success can be at once dismissed.

Vilmorin, Dietrich† and many others besides the present writer have attempted to grow genuine Mummy Wheat and always with the same negative results. Soaking in oil, as recommended by Count Sternberg, and nearly every means reputed to favour germination have been employed but without success, and the same methods applied to the wheat grains of the years 1852, 1853, and 1854, were equally unsuccessful. After proper exposure to moisture, the space that should be occupied by the germ has been found to be filled with a slimy putrefying liquid which was quickly covered by a crop of mould.

It is useless to describe the methods applied to the grains in order to induce germination, and it is proposed to enter at once upon the results of the chemical and microscopical examination to which they were subjected, and to draw from them such conclusions as may be of scientific and commercial value.

Experimental Results.

The five wheats examined were as follow:—

Mummy Wheat, circ. 1500 B.C. The grains of this sample were dark rusty red in colour and fairly plump though the end containing the germ was shrivelled and wrinkled. Twenty-seven grains of an average sample of this wheat weighed one gramme (See Figures 78 and 79).

On crushing for chemical and microscopical examination the grains rapidly disintegrated and formed a very fine powder, so that it was with difficulty that a loss of the very light portions was prevented. The fine powder immediately after crushing was very irritating to the nostrils and smelt strongly of bitumen.

The grains are believed to be of Emmer wheat from the appearance amongst the sample of what seems to be a complete head of the wheat bearing only two grains.

Wheats of 1852, 1853, 1854, were all samples of White Wheat, that of the first two years showing medium plump grains (thirty-four to the

* Count Sternberg in the Journal, *Flora*, 1835, Page 4.

† Dietrich, Hoff. Jahr. 1862-3, Page 77.

gramme). The last year's sample was particularly plump and numbered twenty-two grains to the gramme. (See Figures 80–85).

Wheat of 1911 was a sample of Rivet Wheat grown in Huntingdonshire of plump grains which numbered twenty to the gramme. (See Figures 86 and 87).

On treating the whole grain flour (crushed in the laboratory) with water, that from the Mummy Wheat produced a thin paste without any strength of dough whatever. The apparent stickiness and lack of elasticity led the writer to believe that a considerable amount of soluble dextrin and possibly sugar would be found. This assumption proved to be unfounded on analysis.

The flours from the wheats of 1852, 1853 and 1854 showed plenty of elasticity on doughing with water, and had not suffered apparently in "strength" through deterioration of their gluten by long storage.

The lack of a sufficiency of the sample of Mummy Wheat prevented any investigation into the state of its nitrogenous compounds, which, though still present in considerable proportions, had completely lost the physical characteristics of wheat gluten.

Microscopical Examination.

In a previous paper, by means of transparent sections taken through the wheat berry, the writer was able to show the changes and direction of change taking place in the grain during germination. It was hoped that sections of the wheats here under examination, taken in a similar manner, would reveal certain structural changes which might be expected to have taken place during the passage of so many years. Examination, however, shows that the actual structure of the germ remains unchanged, and that only the coalescence of the minute cells has resulted. In the wheats of 1852, 1853, and 1854, the germ remains unaltered in appearance.

Closer examination of the endosperm of the Mummy Wheat reveals the decomposition of the cementing material which binds the bundles of starch together, and, consequently, the extreme friability of the wheat grains when crushed, and the lack of adhesiveness of the resulting flour when doughed, are accounted for. The actual starch grains are not affected in any way, and it may be assumed, therefore, that no diastase had penetrated into the endosperm as would occur on incipient germination.

As will be seen from the acidity figures of the ground berries there is no great increase in sourness in the wheat grains up to fifty years, but a very pronounced increase in the more ancient Mummy Wheat.

This fact is interesting in the light of Professor Bell's experiments with stored flours, made in 1907, and other experiments made in America in the two following years.

The general indication of these tests showed that the increase of acidity was more pronounced in the case of low-grade than high-grade flours, and was due chiefly to the action of acid-producing bacteria which have ready access to stored flour.

It was further proved that dampness was the prime factor which favoured the production of acidity, whilst temperature was of little or no account.

In normally air-dried wheats, sufficient moisture does not exist to produce acidity rapidly, and the protective covering of the husk is thick enough to stay for a considerable period the action of aërobic acid-producing bacteria.

As soon as the husk is capable of being penetrated by air, either from the slow growth of moulds and smaller fungi on the exterior of the grain or from chemical oxidation, the growth of the acid-producing bacteria within the berry is favoured.

It is of further interest to note that increase of acidity is accompanied by reduction of the gluten strength, a fact which has been noted by Wood and others who found that even N/1,000 solutions of hydrochloric acid and varying dilutions of other acids such as phosphoric, oxalic, acetic, lactic, citric and tartaric, were capable of producing degradation of the gluten and a corresponding reduction in the "strength" of the dough.

The most prominent feature of the microscopical examination of the flours produced from the wheats under discussion was the appearance of long, sharp-pointed angular pieces, into which the oldest wheat fell when crushed. (See Figure 88).

The shape of the particles is entirely different from those produced from normal wheat, or from the wheats up to fifty years of age. (See Figure 89).

This is accounted for by the decomposition of the binding proteid matter and by the cleavage which has taken place when the grain is crushed along the lines of the proteid matter which binds the bundles of starch granules, rather than along the non-proteid divisions which separate the starch-proteid groupings.

It is without doubt correct that in normally aged and dried wheat the first cleavage is along the lines of the parenchymatous cellulose, by means of which the endosperm is divided up into groups of starch granules embedded in gluten. These groups are, as a rule, angular and also four-sided, and are readily distinguishable from the sharp-pointed and tapering pieces into which the endosperm breaks up when the Mummy Wheat is crushed.

(*To be continued.*)

THE PROBLEM OF THE MOON'S ORIGIN.

By B. G. HARRISON, F.R.A.S., F.R.G.S.

(*Continued from page 74*).

The system consists of seven principal planets, besides our earth, in various stages of evolution, and rotating at different speeds, but the conditions affecting each one are so diverse from those of our own globe that no satisfactory analogy can be drawn. It is true that the rotations of Jupiter and Saturn are exceedingly rapid, but this is just what we should expect if the theory of planetary formation previously outlined is correct, since the larger planet would have a larger moment of momentum than would be derived from its extra mass alone, owing to the more rapid circulation of particles caused by greater gravitative force in its vortex during the planet's evolution.

Another objection to the fission theory of the Earth is the difficulty of understanding how it would be possible for a concrete mass the size of the Moon, torn away from the Earth by rapidity of rotation, to hold together under the disruptive strain imposed by the mutual attraction of the two bodies when in close proximity.

Thus it seems, so far as we are aware, that the origin of the lunar terrestrial system by capture offers none of the difficulties that we have to contend with in the fission theory, and if we accept the nebular hypothesis outlined earlier in this article, would seem the most natural and concordant way of accounting for the present position of the Moon.

Nevertheless, weighty though the objections are to the theory of the Moon ever having formed part of the Earth, our satellite offers a very remarkable piece of evidence in favour of this supposition.* This evidence consists in the action of tidal friction. The manner in which the Moon raises tides by differential attraction is too well known to require any explanation here. If no tidal friction existed, high water would always be on those parts of the Earth's surface directly under the Moon. As, however, water is not perfectly frictionless, the rotation of our globe carries these aqueous bulges to a point somewhat in advance of the Moon's orbital position, and they consequently act as a brake on terrestrial rotation. Since it is impossible for one body to retard another without a corresponding acceleration in its own motion, it follows that the energy lost by the Earth must be transmitted to the Moon. This has the effect of increasing its orbital force, and under the influence of centrifugal action driving it further away from us. As, however, this force is only tangential, and the action of recession involves motion against the more powerful pull of direct attraction, the actual orbital velocity is decreased, and the additional energy transmitted becomes entirely potential. Thus we see our day and lunar month both slowly increasing in length, although not at the same rate. Conversely, in earlier times both must have been shorter. If this decrease had been a measurable quantity in historic times, we should be able to detect it from the record of the early eclipses; for although it is necessary to have the utmost accuracy in the majority of astronomical observations if they are to be of any value, in this case the knowledge of the locality in which the eclipse was observed would to a great extent compensate for the lack of precision in the record of its actual time of occurrence. Yet it appears that there is no conclusive information to be obtained from this source, and its absence makes us feel certain that retardation of rotation must now be an exceedingly slow process. Nevertheless, this is no proof of its non-existence, and since the loss of energy by friction varies inversely as the sixth power of the distance, any reduction of the Moon's orbit would involve a vast increase in the retardation of our axial rotation.

It is possible, therefore, to imagine a time when our day was only half its present length, and to calculate, by deducting the energy which the Earth has since that time transmitted to the Moon, what the length of the month would have been at the same period. At the present time the rate of increase of the day is more rapid than that of the month, and, consequently, if we work *backwards*, we find the month shortening less rapidly than the day. This relative progression continues until a time is reached when there were twenty-nine days to the month, instead of 27·3 as at present. This is a maximum, and it has been mathematically demonstrated that there could never have been more than this number of days during one revolution of the Moon. Remote though this period must actually have been, it is yet comparatively recent when we consider the vast time necessary for the entire process required by this theory, and may be regarded as a crisis in our satellite's history. Before this epoch the month must have decreased more quickly than the day, and, still travelling backwards, we can trace the Moon in the course of ages moving ever faster in a huge spiral path. Rapidly, now, though the acceleration of the Earth's rotation must have proceeded, the Moon continued to gain upon it until eventually both were revolving together,

* The following theory is due to the researches of the late Sir George Darwin, F.R.S., from whose papers on the subject the figures and general particulars have been obtained.

the Moon close to the Earth, and each permanently presenting the same face to the other. Now, when this period was reached, both day and month would have occupied some time between three and five hours. It has been previously mentioned that the speed of rotation necessary to render the Earth unstable, owing to centrifugal force, would be about two and three-quarter hours, so we have now arrived at an epoch when our planet would barely be able to hold together. It is assumed that the earth must at this time have been, if not actually in a molten condition, at least considerably more plastic than it is at present. Even now the tidal action of the Sun is shown by the difference between spring and neap tides, and the more plastic the condition of the Earth the more effective would this be. It is thought probable that when our globe was rotating at this speed the forced period of the tide would be in close agreement with its free period, which would have the effect of increasing the height of the solar tides sufficiently to render it quite possible for the Earth to break up under the combined strain, and thus give birth to the Moon.

The principal difficulty which confronts us is our inability to understand how it would be possible for the latter to hold together under the strain imposed upon it by the attraction of the Earth, and it is suggested that the Moon was thrown off as a flock of meteorites until it reached a sufficient distance to allow it to condense into one body. Nevertheless, this suggestion is not very satisfactory, since the meteorites would necessarily be at varying distances from the Earth, and so would be travelling at different velocities to preserve their equilibrium. This would have the effect of scattering them all round their orbit, and so tend to nullify their power of creating tidal friction. However, if this difficulty is put aside, the facts brought out by Sir G. H. Darwin's analysis are really remarkable, and it seems more than difficult to ascribe this wonderful coincidence to chance, especially as the eccentricity of the Moon's orbit and the obliquity of the ecliptic also harmonise with this theory. If the Moon originated in any other way the chances are enormously against the mutual reaction of the two bodies being exactly as we find them. To make this clearer let us assume the present position of the Moon and the length of our day to be unknown, but that we had evidence of our satellite having originated in the way just described: then, by calculating the force of tidal action, we should find that this would be just sufficient to have driven a body of the Moon's dimensions to a distance of two hundred and thirty-nine thousand miles, and reduced the rotation of the earth to its present period of twenty-three hours fifty-six minutes.

It is interesting to pursue this theory further, and try to penetrate our planet's future in the same way as we have endeavoured to trace its past history. For, if no lunar energy is being lost by motion against resistance, the length of the day must be increasing more rapidly than that of the month. Consequently, we foresee a time when our day is twice its present length, and the month containing only eighteen of these days. Mathematical analysis enables us to penetrate still further, until we reach a period when the day and month are again equal, but instead of being only four hours long, they extend to about fifty of our present days. There is also this difference that, whereas in the former case the Moon was revolving in a state of unstable equilibrium, in the latter it is dynamically stable. The time required before the two bodies can reach this condition is so vast that it passes human comprehension, and it is more than likely that some third factor will have interposed before the requisite period has elapsed. However, if the system is still behaving in its present orderly fashion, it is possible to forecast the final act in this drama. We have reached a time when the Earth and Moon are revolving as if bound together by steel bars, and consequently causing no tidal friction in each other.

Nevertheless, the action of the Sun will continue to affect the Earth, and the latter will consequently commence to rotate more slowly than the Moon revolves. This will cause a recurrence of tidal friction between the two bodies, but with this difference, that now the protuberance caused by the Moon will be behind it instead of in front. This will naturally have the opposite effect on the lunar orbit and will gradually draw the satellite back in ever decreasing spirals, accelerating the Earth's rotation in the process, until it finally returns to the surface of the latter. This time however there will be no chance of the Moon's rebirth, as the earth will have lost so much energy owing to solar friction that even in the event of the Moon having encountered no resistance in its celestial journey, and so being able to return the whole of the energy transmitted to it by the Earth, the latter's rate of rotation will still be slower than at its birth.

There is one more point to be considered, namely the movement of Phobos, the inner satellite of Mars. The motion of this satellite has frequently been advanced as a proof of the former rapid rotation of its planet. and so indirectly of the Earth.

It was discovered in 1877 by Professor Hall, and was found to revolve round its primary in seven hours thirty-nine minutes at a distance of less than four thousand miles from its surface. As the Martian day exceeds our own by more than half an hour this system appears to be absolutely unique, and its discovery electrified the whole astronomical world. It has been suggested, therefore, that this system has been evolved by fission, and has already reached its final stage with its day longer than its month; the rotation of Mars having been reduced to its present period by solar tidal friction. It is unlikely, however, that this can be the case, since the comparative weakness of the solar tides on the planet, and the exceedingly small orbital momentum of the satellite, present very considerable difficulties to the supposition. Moreover, the phenomenon can quite well be accounted for by the theory of capture in a resisting medium, since owing to its minute size a proportion of its momentum would be more easily lost, and it might thus have been brought to its present position close to the planet by revolving against resistance. This suggestion gains weight from the fact that there are known to be over six hundred similar bodies to the two Martian satellites, revolving between that planet and Jupiter, and it seems quite likely that two of these asteroids may at some time have come within the sphere of the planet's influence and so have attained their present positions.

Apropos of these satellites, it is interesting to dwell for a moment on the remarkable verification of prophecy brought to light by their discovery. At the time when "Gulliver's Travels" was written a good deal of ridicule had been cast upon contemporary astronomical research, and for purposes of satire Dean Swift caused Gulliver to relate how, in the island of Laputa, astronomers had discovered two satellites to Mars, one of which revolved around him in ten and the other in twenty-one and a half hours. Forty years ago such a phenomenon would have been considered quite impossible and only a flight of the wildest imagination, and when it is considered that the laws of chance would be almost infinity to one against the fulfilment of the prophecy it renders its realisation all the more remarkable.

We will now briefly recapitulate the arguments for both hypotheses of lunar origin. The whole subject turns on the question of a resisting medium. If this still exists it would invalidate the calculations of the Moon's motion previously described, and would render the probability of its having been captured almost certain. This theory, indeed, appears to have no very great drawbacks attached to its acceptance, and, according to the supposed origin of the solar system, to be most concordant with it. Moreover, there is an outstanding inequality in the movement of the Moon which up to the present has defied the utmost efforts of astronomers to assign to any known cause, but which might be accounted for by the effects of orbital motion against resistance. Supporters of the fission theory, however, have to contend with many very real difficulties, amongst them to account for the Earth ever having had the necessary rotational velocity, and even if this is conceded, the difficulty of understanding how lunar disruption could be prevented until the Moon attained to a sufficient distance to revolve in safety. On the other hand there is the wonderful evidence in its favour just detailed and which, if it is a coincidence, must be regarded as one of the most extraordinary in the annals of astronomy. It must also be remembered that the ability of tidal friction to retard rotation is an established fact, as shown by the Moon's own rotation, the only doubtful factor being the *time* required to produce any effect.

Our satellite would gain an additional interest if the capture theory is ever proved to be correct, since there seems to be a greater fascination in scrutinising a world having an entirely different origin from our own, than in merely looking upon a fragment of our earth. Let us hope that some day the mystery may be cleared up, and that we may know more concerning the past history of our companion and nearest neighbour in the cosmos.

CORRESPONDENCE.

AN "IDEAL" MUSEUM AND ITS GUIDE.

To the Editors of "KNOWLEDGE."

SIRS,—The "Provincial Curator," in his contribution to "KNOWLEDGE" of January, does an unintentional injustice to the Trustees and Curator of the London Museum. The "Guide to Kensington Palace" is, apparently, a reprint of a former edition in which have been included some notes on the London Museum by the author, but these notes have no authority from, and were never submitted to, or revised by, those responsible for the London Museum and its arrangement. Your contributor has, perhaps, been misled by this "guide" into thinking that the series of objects are not chronologically arranged, but this is a mistake so far as the rather limited arrangement of the cases in their present temporary home will permit.

If your contributor would call again at the London Museum and ask for the Curator, or one of his assistants, he would have much pleasure in explaining to him the motive and system of arrangement and in receiving from him any suggestions for their improvement.

GUY FRANCIS LAKING, M.V.O., F.S.A.,
Keeper and Secretary.

THE LONDON MUSEUM,
KENSINGTON PALACE.

[Our Contributor "A Provincial Curator" did say (see "KNOWLEDGE" for January, page 16) that the Keeper and Secretary of the London Museum did not write the Guide, and now we learn that it was never even submitted to him. On the face of it, this behaviour seems to be foolish and discourteous as well as detrimental to the best interests both of the museum and of the author of the Guide, who, we think, should come forward and give some explanation.—EDS.]

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—In reply to Mr. H. Stanley Redgrove's letter in the February issue of "KNOWLEDGE," I may say that it is not necessary for me to see his book, nor for him to state in detail his argument for the real existence of the fourth and other dimensions. What he has already stated is quite enough, namely, that his argument is that the existence of one dimension implies that of a second, a second that of a third, a third that of a fourth, and so on. I have pointed out that experience—direct perception of some kind—is the only possible basis of our knowledge of what exists, and that this experience gives us the law that where there is one dimension there must be three, but that it gives us absolutely nothing else—nothing whatever to support an argument that the existence of one dimension implies that of a second, and so on.

JOHN JOHNSTON.

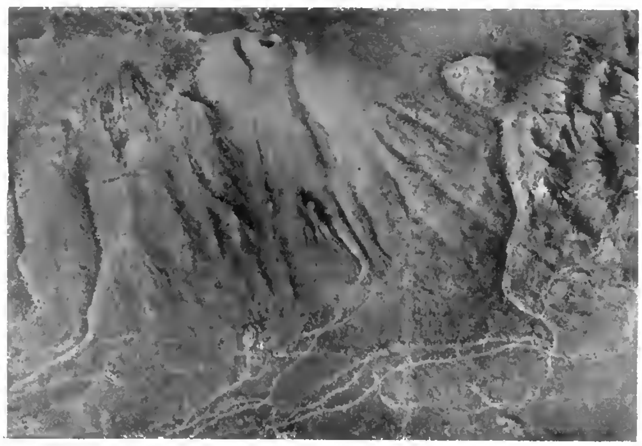
HENDON, N.W.

THE RECENT ERUPTIONS OF THE ASAMA-YAMA (JAPAN).

By CHARLES DAVISON, Sc.D., F.G.S.

THE eruption of the Usu-san in 1910, of which an account is given in "KNOWLEDGE" for May, 1912, was by no means of unusual violence, but was interesting from the extraordinary rise of a new mountain more than six hundred feet in height, with which the volcanic operations were closely connected. The Usu-san is situated in the northern island of Hokkaido. Some four hundred and fifty miles to the south-south-west of the Usu-san, near the centre of the main island of Japan, is another volcano, larger in size and much more violent and devastating in its outbursts. The Asama-yama is well known in Japan as the most active of all its volcanoes, and as the scene of an eruption which ranks as one of the greatest yet known to us. This took place in 1783, and, as is usually the case, was followed by a prolonged period of quiescence, which at last seems to be drawing to a close. Numerous explosions during the last few years, with a marked increase of frequency in 1911, tremors and local earthquakes in large numbers, and a gradual rise in the floor and the crater, these are all premonitory symptoms of a coming period of violent eruption, and possibly of disaster, at some epoch which may be close at hand, but can hardly be delayed for many years.

The Japanese Government is fortunately alive to the danger that awaits them. By the timely precautions of the police in the summer of 1910, the eruption of the Usu-san was attended by no loss of



From a photograph of a model.

FIGURE 90.
The Volcano, Asama-yama.

life. Very different was the fate of the dwellers on and around the Taal Volcano in Luzon in January, 1911. Here, the early signs of the coming eruption were neglected, no attempts were made to remove the inhabitants, with the result that eleven hundred

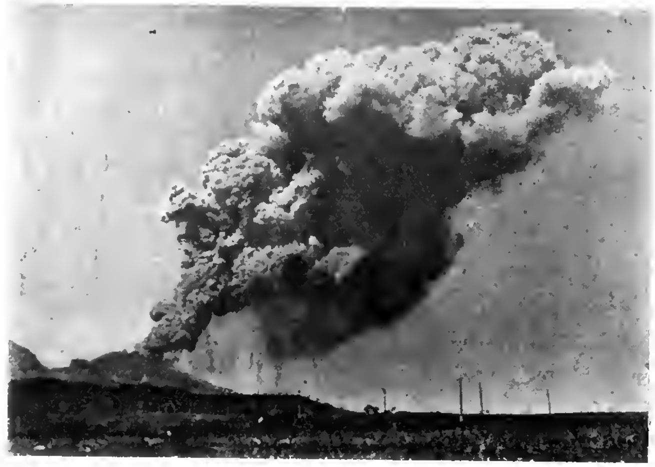


FIGURE 91.
The eruption of Asama-yama, May 8th, 1911.

lives were lost in a single night. A watch on the Asama-yama has already been set. On its south-western slope, a seismological observatory has been erected, every throb of the volcano is being recorded, and, under the guidance of Professor Omori, the able director of the Seismological Institute in Tokyo, the observers have learned to distinguish between the tremors resulting from the volcanic explosions and those which are unattended by visible efforts. Professor Omori has recently made three ascents of the mountain and has studied the detonations which have accompanied the explosions and the areas within which the ashes have been deposited. The results of his enquiries are contained in a valuable memoir,* of which a brief summary is given in the following pages.

The position of the Asama-yama is indicated by the small triangle in Figures 92 and 93. It rises from a plateau-region to a height of eight thousand one hundred feet above sea-level. As the height of its base is three thousand nine hundred feet on the north, and three thousand six hundred feet on the south side, the mountain proper is still more lofty than the present cone of Vesuvius. The crater is nearly four hundred feet in depth and about a quarter of a mile in diameter. The form of the mountain is shown in Figure 90, which is reproduced from a photograph of a model of the volcano, and in Figure 91, which represents the eruption that took place on May 8th, 1911. From Figure 90 it is evident that the present crater is surrounded on the west side (that is, to the left in the figure) by the remains of the wall of an old crater once about a mile in diameter.

* The eruptions and earthquakes of the Asama-yama: Bulletin of the Imperial Earthquake Investigation Committee (Tokyo), Vol. VI, 1912, pages 1–147.

The earliest known eruptions of the Asama-yama occurred in the years 685 and 1108. For this period of its history the chronicle is obviously incomplete. With the year 1527, the eruptions were renewed, and at the same time the record becomes less imperfect. The eruptions occurred in groups separated by intervals of repose. From 1527 to 1532 there were three eruptions, from 1596 to 1605 four, from 1644 to 1669 twenty, from 1704 to 1733 sixteen, from 1754 to 1783 five, and from 1803 to 1889 there were nine eruptions.

Of these fifty-nine eruptions, the greatest was that which occurred in 1783, the year of the great Calabrian earthquakes. This eruption, which lasted altogether for eighty-eight days, began on May 9th. For some time it consisted mainly of loud detonations, occasionally accompanied by strong explosions. But these were by no means continuous, there being intervals of quiet, one of which lasted for nearly three weeks. On June 28th, the explosions became more violent. A month later, ashes fell in Yedo (now Tokyo, eighty-five miles distant), where the people, not knowing the cause, wondered why houses and doors were shaken while the ground remained quiet. On August 2nd, the violence of the explosions reached its maximum, large quantities of red-hot stones and sand were projected from the crater. On the 4th, the rain of ashes was so dense that, even in distant towns, lanterns were used during the daytime in the streets. The next day, the eruption attained its climax. In the morning, after many violent explosions, a huge mass of molten lava and hot mud broke through the north wall of the crater and flowed rapidly down the northern flank of the volcano. This lava, after the lapse of more than a century, is still fresh in appearance; there are few signs of weathering, no vegetation covers it, and the rock still preserves the fantastic shapes into which it was thrown at the time. The total volume of this lava is about one-fourteenth of a cubic mile, or thirty times that of the present crater of the Asama-yama.

The lava-stream, however, stopped short of the villages, and, therefore, caused no loss of life or property. The great torrent of volcanic mud was more destructive. Descending with a velocity, which at first was not less than sixty miles an hour, it swept down the ravines and overwhelmed the villages along its course, the loss of life rising as high as eighty per cent. of their inhabitants, and amounting altogether to that of one thousand one hundred and sixty-two persons.

Professor Omori estimates that the district covered by the ashes is about one hundred and forty miles in length, sixty-two miles in width, and not less than four hundred and twenty-five square miles in area. As the layer of ashes was five or six inches deep at a distance of thirty miles, diminishing to one inch at Tokyo, the total volume of the ashes ejected, quite apart from that of the lava and volcanic mud, must have amounted to one-sixth of a cubic mile, or at least sixty times the volume of the present crater.

The disastrous effects of this eruption are connected by Professor Omori with the long period of quiescence which preceded it. For fifty years previously, the calm was broken only by a few small explosions. During the last two or three years of this period, smoke entirely ceased to issue from the crater, the floor of which was gradually raised almost to the level of the crater rim. It was due to the shallowness of the crater in its final stage that the immense mass of lava and volcanic mud broke through the containing wall and flooded the surrounding country.

For more than a century after this great outburst the Asama-yama remained almost undisturbed. In 1803, there were three slight eruptions, followed by others in the years 1815, 1866, 1869, 1875, 1879, and 1889, altogether nine eruptions, none of much account. Since the latter year, however, they have greatly increased in frequency. In 1894, six eruptions took place; in 1899, four; in 1900, seven; in 1901, six; in 1902-1907, six more; in 1908, five; in 1909, seven; and in 1910, ten. In the following year, 1911, there were no fewer than forty eruptions, all but three within the first four months of the year. In these estimates, minor detonations and explosions are omitted. Of the sixty-two eruptions during the four years 1908-1911, there were four of considerable strength, namely, those of May 31st and December 7th, 1909, December 2nd, 1910, and May 8th, 1911. The appearance of the mountain on the last of these occasions is shown in Figure 91. The characteristic features of these eruptions will be referred to later.

After the eruption of 1783, the crater of the Asama-yama was probably very deep and its diameter less than at present. The first attempt to measure its depth was made by Professor Milne in 1887. A rope was stretched across the crater. On this a pulley was run out with another rope that could be lowered vertically, supplied with thermometers at the end. When these had been lowered seven hundred and thirty-five feet, thermometers and rope were burnt, showing that the base of the crater had been reached. In June, 1911, Professor Omori made another attempt to sound the crater. On this occasion, but little smoke issued from the floor of the crater, and it was possible to see when it was reached by the heavy weight lowered from a part of the crater rim where the wall was vertical. The depth was found to be about three hundred and fifty feet, and this result was confirmed by measurements made with a theodolite. Thus, in twenty-four years, the floor of the crater has risen about three hundred and eighty feet, so that, after the lapse of another such period, if the rate of elevation should continue uniform, the floor will be brought up level with the margin of the crater.

During the first two months of 1911, seismographic observations were made at a temporary station at Ashino-taira, on the south-west flank of the mountain, at a height of six thousand three hundred feet above sea-level. From January 9th to February 28th, thirty-nine earthquakes were registered. All of them were extremely slight, only six being sensible without instrumental aid. According to Professor Omori, they belong to two types of movement. In one, the shock consists only of minute quick vibrations: in the other, it begins with slow movements, mingled after a few seconds with quick vibrations. The shocks of the first type originate at a depth of two or three miles below the base of the volcano; the vibrations resemble those of ordinary small local earthquakes, and they are probably due to the formation of fissures caused by the underground expansive force. The earthquakes of the second type were invariably the results of volcanic explosions. They began with a preliminary tremor lasting about two and a half seconds, which Professor Omori regards as due to the disturbances occurring just before the actual explosion, such as the formation or extension of an underground crack. The slow vibrations, which follow the tremor, are probably of "the nature of a bodily oscillation and due to the first bulging up and the consequent outward forcing of the mountain mass at the moment of the explosion."

The detailed study of the eruptions of the last few years has led Professor Omori to some interesting conclusions. Among the most valuable are those which relate to the propagation of the detonations resulting from the more important explosions. These have been heard at places on the east coast at a distance as great as one hundred and eighty miles from the volcano, and no doubt would have been

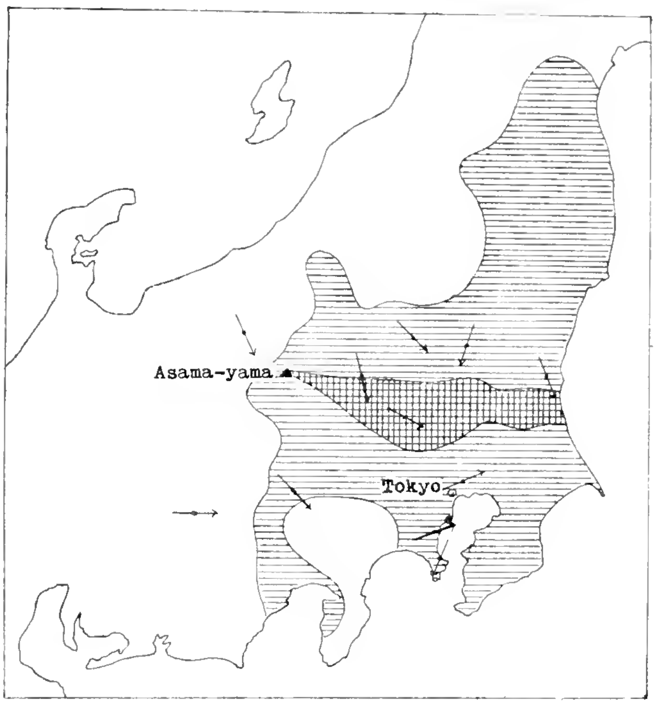


FIGURE 92.
The sound of the eruption of Asama-yama on December 7th, 1909, was heard on the lightly-shaded area, ashes fell on the darkly-shaded region.

heard farther if there had been land in this direction. There are some curious anomalies in the forms of the areas over which the detonations were audible. In most cases, the area is of the form indicated by the lightly shaded portion in Figure 92, which represents the region throughout which the sound of the

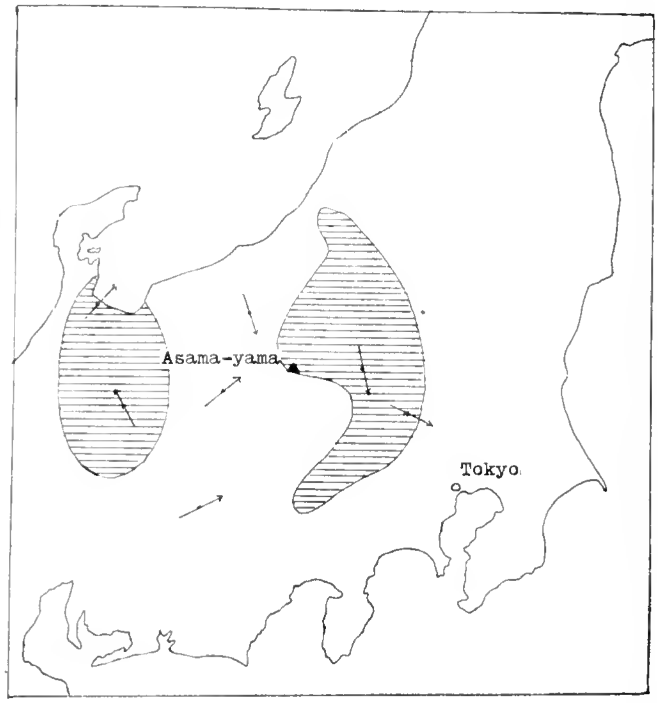


FIGURE 93.
The shaded portions show the two areas in which the sound of the eruption of Asama-yama was heard on December 25th, 1910.

eruption of December 7th, 1909, was heard. In Tokyo (eighty-five miles from the volcano), the detonation was loud and like that caused by a powder explosion, shaking the houses strongly, although there was no movement of the ground. The sound was heard at a distance of one hundred and ten miles to the south, and one hundred and seventy miles towards the north-east. Towards the west, however, the sound-area extended but a short distance, for the detonation was inaudible at places only fifteen miles to the west, and twenty-five miles to the north-west of the mountain. The darkly shaded area represents that within which ashes were precipitated. It is a lens-like zone, about one hundred and twenty miles in length, extending from the Asama-yama in a direction a little south of east. The arrows show the direction of the surface wind at the time of the eruption. In some cases, this agrees roughly with the principal direction in which sound and ashes were carried; in others, it is almost at right angles to this direction. The ashes, moreover, travelled at the rate of about fifty miles an hour, while the velocity of the surface wind was generally less than twelve miles an hour. It will be noticed, also, that the area of ash-precipitation is roughly symmetrical with respect to the sound-area. It is, therefore, clear that the sound and ashes were carried by the upper winds, which appear to have a fairly uniform direction for the greater part of the year between east-north-east and east-south-east, tending as a rule in the latter direction. The height of the carrying currents Professor Omori estimates at about five or six miles, this being the height generally reached by the smoke-column during the explosions of the Asama-yama.

In two cases, the form of the sound-area is still more remarkable, for it consists of two detached portions. The shaded areas in Figure 93, represent these portions for the eruption of December 25th, 1910. One portion includes the Asama-yama near its western margin, the other lies about fifty or sixty miles to the west. It will be noticed that the direction of the surface-wind was north-west in the eastern portion, and south-west in part of the other, so that there is no connection between the form of the sound-area and the direction of the surface-wind. Here, again, the anomalous form of the area must therefore be connected in some way with the trend of the upper winds.

A somewhat similar anomaly was observed in the audibility of the minute-guns which were fired from battleships lined at Spithead, when the body of her late Majesty Queen Victoria was borne from Cowes to Portsmouth. At places in the immediate neighbourhood of Spithead, and as far as fifty miles from it, the guns were almost or quite inaudible. From sixty to eighty or ninety miles they were clearly heard, so clearly that at a distance of eighty-four miles, labourers in the fields put down their spades and listened. Beyond ninety miles, records were less numerous, but one came from near Woodbridge, in Suffolk, at a distance of one hundred and thirty-nine miles, the regularity of the booms of the minute-guns allowing no doubt as to the observation.*

In the neighbourhood of Spithead and Portsmouth, the wind at the time was from the west or north-west, or "offshore"; at the great distances at which the sound was heard the wind was southerly. Since the velocity of the wind increases, as a rule, with the height above the ground, it follows that, in the direction from which the wind is coming the sound-rays are bent upwards, and pass over the heads of observers at a moderate distance. In the opposite direction, they are bent downwards, so that sound-rays which started upwards at a moderate angle are brought down again to observers at a considerable distance. Thus, the sound-rays were first of all refracted by contrary winds over the heads of observers between ten and fifty miles, and were afterwards brought down by favourable upper currents so that the reports were clearly audible from sixty to more than a hundred miles from Spithead. It is probable that a similar explanation may be given of the two detached portions of the sound-area in the case of the explosions of the Asama-yama.

*On the audibility of the minute-guns fired at Spithead on February 1st [1901]: "KNOWLEDGE," Volume XXIV, 1901, Pages 124-125.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

THE OCCULTATION OF THE STAR MAYER 588 BY JUPITER'S THIRD SATELLITE, GANYMEDE, 1911, AUGUST 13TH.—This very rare phenomenon was predicted by Herr Banachiewicz, and observed at several stations in South America, Professor Ristenpart having circulated requests to observers with a view to deducing the dimensions of Ganymede. Thirty-two had volunteered to help, who were spread over thirty-seven degrees of latitude, from Arequipa, S. 16°, to Punta Arenas, S. 53°. Several observers noted that the disappearance and reappearance were sharply defined, and could be accurately timed. The time intervals give chords of the disc of Ganymede in various latitudes, and the surprising fact emerges that it must be considerably larger than was hitherto supposed. The observations are best satisfied by an elliptical outline, with equatorial radius two thousand three hundred and thirty-one miles, polar radius two thousand one hundred and thirty-one miles. Dr. Ristenpart does not, however, attach great weight to the ellipticity. Ganymede would appear to be as large as Mars, whereas former estimates made it only equal to Mercury. One puzzle that the new result affords is the very low density that it implies. The mass of Ganymede is one thirty-ninth of the Earth, or one quarter of Mars, so if its size is equal to Mars its density is only one quarter as great, or, roughly, the density of water. It is true that the density of Saturn is still less, 0·7 of water, but the visible globe of Saturn is believed to be largely vaporous, which is unlikely to be the case with Ganymede.

THE SPECTROSCOPIC BINARY 9 CAMELOPARDALIS.—Several observers have noted abnormal behaviour of the calcium lines in the case of spectroscopic binaries. For example, Hartmann in the case of δ Orionis, Daniel, Schlesinger, Duncan and Slipher in the case of β Scorpii, find that the H and K lines of calcium do not share in the large displacement of the other lines, though they have probably a small displacement of their own. The suggested explanation is that the calcium vapour is not in the stars, but surrounds them as a cloud. Mr. O. J. Lee, at Professor Frost's suggestion, selected 9 Camelop. as a suitable star for further investigation of this question (*Astrophysical Journal*, January). Its declination is 60° North, and it culminates at midnight in December, so that very long series of photographs can be taken. Further, the H, K lines are strong and well defined. He deduces that the period of oscillation of the calcium lines is the same as that of the other lines viz., eight days, but the amount of oscillation less. He concludes that the calcium vapour forms an ellipsoidal sheath round the principal star, and that the spectroscopically effective regions are near the zero velocity points. He deduces for the joint mass of the system only one four-hundredth of that of the Sun, or two and a half times that of Jupiter. This seems an improbably small mass for so distant a body (its parallax is given as ″·026, implying a distance of one hundred and twenty light years), but the author admits that some of his assumptions are tentative. In any case, the existence of external calcium clouds in the case of several spectroscopic binaries has been rendered highly probable.

A MEASURE OF SOLAR RADIATION FROM FREE BALLOONS.—The same publication contains an account by Professor Very of an interesting research: the service that free balloons have rendered to meteorology in giving records of temperature, and so on, at heights inaccessible to man. They have now been used to carry a Crova actinograph, and so obtain a measure of solar radiation in a region where atmospheric absorption is greatly diminished. He gives the following determinations of the solar constant in calories per square centimetre per minute at different heights:—

1·5 calories at sea-level (winter).
2·00 „ at 4,420 metres (Keeler, Mount Whitney).
2·86 „ in the isothermal layer at 13,700 metres.

He concludes that the true value is 3·5 when there is no atmospheric absorption.

It is considered by some authorities that the solar constant may itself vary by quite appreciable amounts, independently of the action of our atmosphere. Professor Abbott suggested simultaneous observations at distant stations to test this. If they frequently varied together, the cause would probably be in the sun itself, not in our atmosphere. I believe that such a comparison is now being carried out between stations in Africa and North America.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

STRENGTH OF TENDRILS.—It has long been known that after a tendril has grasped a support it becomes much stronger and produces increased hard tissue; but the details have not hitherto been worked out satisfactorily. In an interesting paper, Brush (*Bot. Gaz.*, June, 1912) states that passion-flower tendrils exposed to tension, and having also formed contact with a support, had a much higher breaking strength (over one thousand grammes) as compared with tendrils in contact only (six hundred and fifty grammes) and free tendrils (one hundred and ninety grammes). Tension increases strength of tendrils sometimes by as much as fifty per cent. in the middle third of its length. By radial pressure, obtained by means of a mercury column in a rubber tube enclosed by the tendril, an increased breaking strength was obtained (nine hundred and ninety as compared with seven hundred and thirty grammes). The breaking strength of the tendrils was found to be increased by contact, pressure, and tension. As regards the internal structure it was found that the wood cells are increased both in number and thickness as the result of contact, and that the walls of the pith cells are thickened in consequence of tension. Just how contact, tension, and pressure act as stimuli it is difficult to say, but it is probably by bringing about increased hydrostatic pressure.

LUMINOUS BACTERIA AND FUNGI.—Professor H. Molisch has revised and enlarged his well-known work on luminosity in plants ("Leuchtende Pflanzen"; Gustav Fischer, Jena, M. 7.50). Since the publication of the first edition, eight years ago, various writers, notably Professor Molisch himself, have contributed to the knowledge of luminous phenomena in plants. Many of the cases of so-called luminosity in plants are due merely to reflection of light which is brought to a focus by lens-shaped cells, or are brought about by iridescence or by the presence of fluorescent substances; but real phosphorescence—the emission of light when the plant is placed in total darkness—is found in certain bacteria and fungi. By isolating the bacteria which cause the phosphorescence of meat and fish (*Bacterium phosphoreum*, *Bacillus phosphoreus*, and so on), and cultivating them in nutrient jelly in tubes and flasks, Molisch obtained a "bacterial lamp" with which he obtained some excellent photographs, some of which are reproduced as illustrations in his memoir. This "living lantern" can be used for a photographic dark-room or as a night light, since the light is strong enough to enable one to read a watch or to make out large print quite readily. The light is steady and lasts for several weeks, its intensity being about one candle-power per thousand square yards of the gelatine plate culture. It appears probable that the phosphorescence of these bacteria is due to the production by the bacterial cells of a phosphorus-containing organic compound ("photogen") of a proteid or phosphatid nature, which in the presence of oxygen and water undergoes slow oxidation—probably by means of an oxidising ferment (oxidase). The light dies out if oxygen is withdrawn from the culture or if the bacteria are dried, and reappears on admitting oxygen and moistening the culture again. The author discusses the cases of luminosity that have been described in various flowering plants; for instance, on sultry nights light is occasionally emitted by flowers, but this is either an electrical phenomenon comparable with "St. Elmo's fire"—a faint glow seen at the tips of masts and trees in thundery weather, and due to the dissipation of atmospheric electricity in the form of a brush discharge—or it is attributable to the presence of small phosphorescent insects which had been overlooked by earlier writers on "luminous flowers."

HETEROSTYLED FLOWERS.—In a considerable number of plants there occur long-styled and short-styled flowers, as in the Primrose and other species of *Primula*, and in some cases (as in the Purple Loosestrife) there may even be three forms of flower with three lengths of stamen and style. There is an interesting relation between the size of the pollen grains and the length of the stigmatic hairs in these flowers, the rule being that the longer the stamen the larger are the pollen-grains, and the longer the style the longer are the receptive hairs on its surface. Heterostyly raises several interesting problems in heredity as well as in floral mechanism, and Stevens (*Bot. Gaz.*, April, 1912) has investigated the development of the pollen and the other points in the life history of two heterostyled plants—Buckwheat and *Houstonia coerulea*. He found that in eighteen hours after "legitimate" pollination (pollination of long-styled with short-styled) an embryo began to develop, while in three days after "illegitimate" pollination (pollination of short-styled with short-styled or long-styled with long-styled) the pollen-tubes had not reached the egg. Under natural conditions, therefore, there would be very little chance of illegitimate pollination resulting in fertilisation. The author gives various details of the cytology and embryology in the two plants he investigated. He found that in the development of the pollen-grains the chromosomes in the reduction division are about twice as large in the short-styled form, and that in the long-styled form also the central chromosome is considerably larger in one daughter-nucleus than its mate in the sister nucleus. He compares this with the "accessory chromosome" which is regarded as being the "sex determinant" in the evelopment of the male germ-cells of certain insects.

GERMINATION OF ORCHIDS.—Some interesting observations have recently been made on the fungi which are associated with the roots of many orchids, forming a "mycorhiza" or symbiotic (mutually beneficial partnership) association between the fungus and the orchid. Burgeff and Bernard have shewn that the seeds of various tropical orchids will only germinate if the right micro-organisms are present. By isolating and cultivating the spores or the "spawn" (mycelium) of these fungi, pure cultures of the appropriate mycelium can be made and used for mixing with the sphagnum and fern compost in which the seeds are grown, the seed-pans and the rain-water used for watering are sterilised, and successful sowings are thus ensured.

XEROPHILOUS ADAPTATIONS IN MOSSES.—Grebe has published (*Hedwigia*, Band 52, 1912), a useful summary of the adaptations of mosses for protection against drought. He limits the use of the term "xerophyte" to those mosses which grow in situations where they are exposed to fairly prolonged periods of drought, are dependent upon atmospheric moisture, and are not protected against drought by other factors of the environment such as shade and damp atmosphere. Warnstorf regards dependence on atmospheric moisture, as opposed to that of the soil, as the chief criterion of xerophily in mosses, but Grebe points out that various mosses in shaded woods grow on tree trunks and yet are not xerophilous, being protected against drought-periods by their shaded and humid habitat. Many of the mosses of shaded woods, however, are more or less xerophilous in structure, and grow high up on trees, whose crowns admit a good deal of light. In general, xerophilous mosses are so constructed that they rapidly absorb rain-water and dew, and retain it for long, once it is absorbed.

The majority of xerophilous mosses grow on rocks and trees. They occur from the coast up to the high Alps, the Grimmias and Andreaeas being the last representatives of the cryptogamic vegetation seen in ascending the highest hills. The effect of a dry continental climate is seen in general scarcity of mosses rather than an increase in the proportion of xerophilous species. The author then indicates the chief adaptations shown by mosses for retaining moisture or reducing transpiration. The chief xerophilous adaptations of this kind in the sporogonium are absence or shortness of the seta, causing the capsule to be sessile, or nearly so, and therefore enveloped by the upper leaves of the moss-plant; downward curvature of the seta, causing the young capsule to be plunged among the leaves — later the seta becomes erect for spore-dispersal; the presence of warty outgrowths or papillae on the seta; the presence of a large calyptra in some mosses covering the entire capsule; the hair-clad type of calyptra seen in the Polytrichaceae and Orthotrichaceae; the sheltered position of the stomata, especially in species of *Orthotrichum* with furrowed capsules and the stomata in the furrows, or in *Polytrichum* with stomata in the deep ring-like groove between capsule and apophysis.

The moss-plant itself, or gametophyte, naturally shows a far wider range of xerophilous or drought-resisting characters. These adaptations include, above all, perhaps, the cushion-like habit, the plants being aggregated to form a spongy mass, which holds water by capillarity; hyaline hair-points on the tips of the leaves; reduction in breadth of the leaf-blade, and corresponding increase of the cylindrical midrib; leaves more or less hollowed out or rolled up, undulate, wrinkled, or folded—all these arrangements providing cavities for the retention of water by capillarity; sheathing leaf-bases, as in *Polytrichum*; papillae and mammillae (solid and hollow outgrowths respectively of the leaf-cells); presence of water-storing tissue in the leaf; thick-walled leaf-cells; increase in number of layers of the lamina to two or more; strengthening of the leaf-margin; development of plate-like outgrowths or lamellae on the upper side of the leaf; presence of filamentous outgrowths (paraphylls) and dense covering of rhizoids on the stem; hygroscopic movements of the leaves.

ALPINE MOSSES AND LIVERWORTS.—Apart from the familiar moss-carpet of woods, and the bogs largely made up of bog-mosses (species of *Sphagnum*), and the woolly fringe-moss (*Rhacomitrium*) on moorlands, various mosses and liverworts play an important part in the vegetation of certain areas, chiefly in alpine districts.

Under the title "*Anthelia*: an alpine-arctic plant association," Dr. W. G. Smith (*Scottish Botanical Review*, April, 1912) gives an interesting account of a plant association which is characteristic of the higher Alps, and which was noted on Ben Lawers during the international phyto-geographical tour of this country last summer. This association is of special interest as one in which several liverworts and mosses play the part of pioneers in colonising a substratum which owes its origin in the first place to topography, and in the second to the action of running water. Towards the summit, where the grassy turf becomes more limited, and the most conspicuous vegetation consists of the woolly fringe-moss, sedges, and other mat-forming plants, there occur dark patches, represented on the summit ridge by larger tracts of almost black mossy crust. These patches and tracts are known to Swiss botanists, two of whom were with the party and pointed them out, as "Schneetälchen," which may be translated as "snow-flushes."

The formation of these "snow-flushes" has been traced in Switzerland and Tyrol, where the rocks and soil, uncovered by the melting snow, are often covered with flowers, while the snow still lies a few yards away. As melting proceeds the snow-water soaks through the turf, forming a system of temporary watercourses in troughs of undulating ground, and along the foot of slopes and escarpments, while the rain-water in summer tends to follow the same course. On gentle slopes or flats and in depressions, the force of the flow is not sufficient to carve out channels, as happens on steep slopes, but the water wanders slowly through the turf and deposits accumulated suspended matter as a sediment. The snow-water carries the dust it gathers on lying snow, mineral particles, and plant fragments, and collects other materials in trickling over the surface; snow-dust may contain fifty per cent. of organic matter, and as this with the mineral matter is laid down among remains of last year's vegetation, a rich soil is built up.

The vegetation of the snow-flush begins with flowerless plants, and these may remain as the dominant vegetation. Apparently the pioneer plant is the liverwort *Anthelia*, not only on Ben Lawers and other Scottish mountains, but also in the Alps, Scandinavia and Spitzbergen. This liverwort lies close to the surface, and in the fresh, moist state forms a bluish-green carpet, but in summer is often dry and dark brown or almost black; it is often coated with the threads of a fungus, and these occur also in the rooting-hairs of the liverwort—doubtless forming a mycorhiza or mutually beneficial partnership between the two plants. Alpine species of the moss-genus *Polytrichum* also occur in the snow-flushes; these mosses can withstand periodical submergence, and soon grow through the shallow deposits of sediment laid down, so helping to bind these deposits into a humous turf, while their close, compact growth also enables the tufts to withstand periods of drought. The snow-flush is an open association into which species of flowering plants from neighbouring plant communities migrate—Dr. Smith gives lists showing that several of these species are identical with those found in snow-flushes in the Alps.

On collating the accounts given by different observers, so as to obtain an outline of the evolution of the snow-flush vegetation, we find that *Anthelia*, probably preceded by algae and other lower organisms, forms a humous turf; *Polytrichum* follows later, and more or less takes the place of *Anthelia*; later still, *Salix herbacea* or *Alchemilla* assumes chief place, and so on. The successive stages of vegetation probably indicate stages in the evolution of the habitat, since the later vegetation will tend to give it increased stability; in time the accumulation of sediment, humus, and vegetation may be such that the snow-water is diverted to new situations, where the sequence will begin over again; and during the various phases other species secure a footing, and flourish well or ill according as the habitat suits them. The snow-flush is, therefore, a series of migratory associations. Crampton, whose important paper on the vegetation of Caithness was recently summarised in these columns ("Knowledge," May, 1912, p. 187), has defined such formations as follows (*Scottish Botanical Review*, 1912): "Migratory formations are of comparatively short persistence on the same habitat, which sooner or later undergoes change or destruction, with renewal elsewhere. Their associations tend to rapid degeneration from plant invasion. All stages of progressive successions are encountered."

AIR-CHAMBERS IN LIVERWORT THALLUS.—The Marchantiales, doubtless owing to the common occurrence of the familiar *Marchantia* and *Lunularia* on the soil in flower-pots, garden paths, and so on, and *Fegatella* beside streams, are often taken as typical of the Liverworts (Hepaticae), though in reality they form a relatively small division of that group, the majority of Hepaticae being differentiated into slender stem and thin leaves. At any rate, the thalloid Hepaticae are usually selected by teachers of Botany as being the typical forms, and *Marchantia polymorpha* is one of the most frequently studied of plant types. As so often happens, even the most familiar types repay renewed investigation by those willing to take the trouble and to remain unbiassed by the oft-repeated descriptions copied from text-book into text-book.

The air-chambers which occupy the upper portion of the tissue in the thallus of the Marchantiales, each chamber, in typical cases, opening to the atmosphere by a pore in the centre of its one-layered roof, were described by Leitgeb in

1879 and 1881 as arising in the same way as the cavities in which the sexual organs (antheridia and archegonia) are sunken, namely, by upgrowth of the surrounding tissue of the thallus. In the simplest case (seen in most species of *Riccia*), the chambers are simply deep vertical canals, believed by Leitgeb to arise as the result of upgrowth of the superficial cells of the thallus as filaments, each filament being in contact with its neighbours at certain points so as to bound these air-canals. In the majority of Marchantiales, however, the chambers become widened out as the thallus grows, and are roofed over, the roofing layer arising, according to Leitgeb, by lateral outgrowth of the uppermost cells of the vertical plates that form the side-walls of the chambers; while in some cases the originally simple chamber is partitioned up by secondary plate-like ingrowths.

In 1907, Barnes and Land (*Bot. Gazette*, XLIV.) examined a number of Marchantiales, and claimed that in all cases the chambers arise by splitting between internal cells of the thallus, in exactly the same way as the intercellular air-spaces in the leaves, and so on, of the higher plants.

Pietsch (*Flora*, Band 103) has published the results of his careful investigation of the *Riccia* thallus, the chief species dealt with being *R. glauca* and *R. fluitans*. He has followed in detail the segmentation of the initial cells at the growing-point and the origin of the air-chambers, which in *R. fluitans* are wide and covered by a roofing-layer in which a pore may or may not be present. His descriptions and figures leave little doubt that Barnes and Land are right in their interpretation of the mode of origin of the chambers; but it may be added that Leitgeb's own figures are, as is usual in his work, extraordinarily accurate considering that he had not the advantages of modern microtome technique at command, and that it was simply in the interpretation of what he saw that he erred in this instance. Indeed, even after the publication of the paper by Barnes and Land, it appeared to the present writer, from examination of slides similar to theirs, that Leitgeb's interpretation might still be the correct one, in the case of *Riccia glauca* at any rate. However, the elaborate work of Pietsch appears to settle the question definitely. As this author points out, the view put forward by Barnes and Land that each chamber in the Marchantiaceae arises from a single primary cell ("mother-cell") can hardly be accepted, for according to their description and diagram the vertical septa between neighbouring chambers would be two cells thick, while as a matter of fact these partitions are but one layer in thickness.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON.), F.I.C.

LUMINESCENCE ANALYSIS.—In Lehmann's fluorescence microscope, which is used with ultra-violet light, there is a special screen to protect the eye from injury. A description of this instrument and of the uses to which it may be put in analysis is given by Dr. O. Wolff in the *Chem. Zeit.* (1912, XXXVI, 1039). For example, it has been found that the particles in crude potashes that show a red fluorescence consist of potassium sulphide, while the blue fluorescent particles are mainly composed of compounds of organic and mineral matter.

Again, this instrument shows that the orange fluorescence of mercuric chloride is caused by the presence of particles of mercurous chloride, the fluorescence of which disappears on heating. If mercuric chloride is chemically pure it does not fluoresce, but traces of calomel may be detected by the luminescence test in many of the preparations on the market, although they would escape detection by chemical tests. When pure mercuric chloride is re-sublimed in a tube, the orange fluorescence will appear, showing that traces of calomel are produced in the process.

In like manner, pure anthracene shows a blue fluorescence, but when impure fluoresces green, owing to the presence of a substance showing a yellow fluorescence.

FORMATION OF PETROLEUM PRODUCTS.—It is highly probable that a process of filtration through porous media has played a part in the natural fractionation of petroleum, and this separation was attributed by Day to the differences in the speed of the diffusion of the different constituents through the capillary passages between the granules of porous earths. From the recent experiments of Gurwitsch, however, (*Petroleum*, 1912, VIII, 65) it appears more likely that the separation is due to the attraction or absorption of the petroleum compounds by the particles of the porous earth. Thus, when the same oil was filtered through different porous media, the fractionation followed a very different course; while, on the other hand, filtration of a benzine solution of a petroleum product through a siliceous earth termed floridin gave exactly the same result as when the solution was shaken with the earth, 9·9 per cent. of the constituents being retained in each case.

The results of treating a white vaseline for four hours at a high temperature with forty per cent. of floridin were very interesting. The original vaseline contained 9·35 per cent. of paraffin wax, and had a viscosity of 6·7 degrees in Engler's apparatus, but after the treatment the paraffin wax had fallen to 6·80 per cent. while the viscosity had risen to 12·6 degrees. It thus appears that, contrary to the generally-accepted view, treatment of petroleum products with adsorbent agents may cause an increase in their viscosity.

POISONOUS GASES FROM OIL FIELDS.—Mr. H. S. Shrewsbury records a case of a man being killed by breathing the gas at the bottom of a pit beneath a derrick at an oil well near Pitch Lake, Trinidad (*Analyst*, 1912 XXXVII, 486). A sample of the gas issuing from the top of the well was found to have the following composition:—Sulphuretted hydrogen, 0·2; carbon monoxide, 1·9; unsaturated hydrocarbons, 4·4; saturated hydrocarbons, 7·8; carbon dioxide, 20·9; hydrogen, 31·4; and nitrogen 33·4 per cent.

Since 0·1 to 0·15 per cent. of sulphuretted hydrogen is fatal to human life, while 0·15 per cent. of carbon monoxide is dangerous, and 0·4 per cent. of that gas will destroy life in a short time, it will be seen that the gas issuing from the oil well was extremely poisonous, and that even when mixed with about forty-three per cent. of air, as it was at the bottom of the pit, it would kill in a short time. The gas issuing in bubbles from the small channels and pools of water on the Pitch Lake, and that given off by the pitch itself, had the same tarry and sulphuretted odour as the poisonous gas from the oil fields. It is remarkable, however, that small fishes live in the pools, through which this poisonous gas is constantly bubbling.

It is suggested that this emission of poisonous gas from oil fields is probably not an uncommon occurrence, and that now that attention has been called to the danger, suitable precautions may be taken to prevent accidents.

REDUCTION OF METALLIC CHLORIDES BY SODIUM.—A communication by Mr. M. A. Hunter to the Eighth International Congress of Applied Chemistry (1912, *Orig. Communications*, II, 125) gives an account of the results obtained by reducing certain chlorides with metallic sodium in a steel bomb. The chlorides of titanium and beryllium were rapidly reduced to the metallic form, and beads of the metals were deposited on the walls of the bomb. In the case of titanium, in particular, the metal was pure and could easily be separated. Neodymium chloride also yielded the metal, but in a condition in which it could not readily be separated from the other substances.

Silicon chloride was also reduced with difficulty to silicon, while compounds of carbon, such as carbon tetrachloride and sulphide, yielded elementary carbon mainly in the amorphous state, though also containing a little graphite and a microscopic amount of colourless crystals agreeing in properties with crystalline carbon. Among the by-products of the reaction were sodium carbide and carbon hexachloride.

USE OF COPPER SULPHATE FOR PURIFYING WATER.—Several years ago an account was given in these columns of the good results obtained by using copper sulphate to remove vegetable growths from large reservoirs in the United States. Since then the process has been adopted in many other places, and in the *Journal for Gas Lighting*, 1912, CXIX, 507, Mr. G. Embrey describes the results of his experience with this method of purification at the Gloucester reservoirs, the water of which had become coloured and had acquired a fishy odour owing to the growth of *Chara vulgaris*. Experiments showed that as much as one part of copper sulphate per million could be used without rendering the water poisonous to fish or to human beings, but in practice a third of that quantity proved sufficient to destroy *Chara* and similar low forms of plant life.

This proportion of the salt was sprinkled over the surface of the water in the form of a fine powder, which sank to the bottom before dissolving. By this means the maximum action of the copper sulphate was brought to bear at the place where it was most needed. The water, after standing for a period of three to seven days, had lost its colour and unpleasant odour, and showed no copper remaining in solution. By treating the reservoirs in February, when only the diatoms were present, the subsequent development of *Chara*. and confervoid growths was prevented. The trout in the water were not affected by the treatment, but the destruction of the vegetable matter caused starvation of the roach. The copper added to the water was partially deposited in the form of red cuprous oxide on the stones, and was converted into black cupric oxide by exposure to the air.

Higher forms of vegetation are not injured by such proportions of copper; for it was found that algae could be destroyed in watercress beds without injury to the plants.

THE MANUFACTURE OF CARBON BLACK.—In the United States a sharp distinction is made between "lamp black," the soot deposited when an oil or resin is burned in a limited supply of air, and "carbon black," which is obtained by applying a cooling surface to a burning flame. A description of the process used in a factory producing about ten thousand pounds of carbon black a day is given by Mr. G. L. Cabot in a paper read at the Eighth International Congress of Applied Chemistry (*Original Communications*, 1912, XII, 13).

The bulk of the carbon black in the American trade is derived from natural gas, which is ignited as it issues from the ground, and consumed in rotating burners which pass beneath fixed cooling plates, upon which the soot is deposited. Most of the attempts to produce the black from petroleum oil are stated to have been commercially unsuccessful.

Carbon black as scraped from the plates has a specific gravity of about 1·7 after removal of the "air" with which it is impregnated. It is much superior in tone to ordinary lampblack, since it possesses a rich "bloom," which makes it a highly-prized pigment for the preparation of the best kinds of printing ink and stove polishes. Lampblack, on the other hand, is mainly used for colouring leather, unvulcanised rubber and oil cloth, and in the manufacture of paints. Its chief source is tar oil, which when burned in furnaces of special construction provided with cooling chambers, yields from fifteen to thirty-five per cent. of its weight of lampblack.

GEOLOGY.

By G. W. Tyrrell, A.R.C.Sc., F.G.S.

GEOLOGY OF DARTMOOR.—An interesting Memoir with this title has been issued by the Geological Survey, and describes an area of two hundred and sixteen square miles in Devonshire, including the greater part of Dartmoor. The geology is, of course, mainly that of the great granite mass forming Dartmoor, which is intrusive in rocks up to Carboniferous in age. It probably forms a gigantic laccolite whose upper surface slopes gently under the adjacent sediments. Patches of contact-altered Carboniferous rocks have been found a mile within the granite boundary, and these afford data from which the general dip of the granite below the sediments can be estimated. Near Petertavy and Marytavy the angle is from twenty-three degrees to thirty-two degrees, and its smallness accounts for the great width of the metamorphic aureole in that district.

The Dartmoor granite is a coarsely porphyritic rock with large phenocrysts of white felspar which are arranged in fluxion-streams near the boundary with the sediments. Tourmaline is present in most parts. Topaz and cordierite also occur, but much less frequently. The Dartmoor granite is of a more normal type than the other western granites. It is less acid and has suffered less from pneumatolysis. It may be described as a biotite granite, or granitite with accessory tourmaline, whereas the other granites from the West of England usually contain abundant muscovite in addition. Its felspars are of more basic composition, and oligoclase is frequently present.

The great mass of the Dartmoor granite and its slow cooling has led to extensive contact-metamorphism in the adjacent sediments. The average width of the contact-aureole is one mile, and as a large variety of sediments of Carboniferous and Devonian age are involved, a correspondingly large variety of types of hornfels, spotted slates, and tourmalinized rocks occur, and shew many different stages of recrystallization. On the south and south-east the argillaceous sediments have been converted to fine cordierite-hornfelses. Andalusite slates and chiastolite slates also occur. A special belt of dark shales is always the parent rock of the latter. The impure calcareous sediments which are found within the aureole are especially susceptible to contact-alteration, and give rise to a variable series of calc-silicate hornfels, of which the most interesting are the scapolite-bearing types.

The spilite lavas and intrusive greenstones which occur in the Devonian and Carboniferous rocks are intensely contact-altered where they appear within the limits of the aureole. The spilite-hornfels are fine-grained banded schists containing abundant hornblende, with biotite, felspar, quartz, and occasionally much epidote. In both the spilite and greenstone-hornfels occur certain minerals, notably tourmaline and axinite, which must be ascribed to pneumatolytic origin.

IRON-ORES AND BAUXITES OF NORTH-EAST IRELAND.—The iron-ores and bauxites, which form a prominent stratified zone in the midst of the Tertiary basaltic series of north-east Ireland have been described by Professor Cole and his coadjutors on the Geological Survey of Ireland in a recently issued Memoir. These rocks are coloured bright red, and are conspicuous at the Giant's Causeway, where they separate an upper series of massive columnar lavas from a lower series of thinner flows. They were formed by the weathering of the lavas during a quiescent period of the Antrim volcanoes. The materials of the interbasaltic zone are pisolitic iron-ores, laterites, and bauxite clays. The typical downward succession in Antrim is (3) pisolitic iron-ore; (2) "pavement," a material with a false stratification due to coloured streaks of basaltic decomposition, and varying from a siliceous iron-ore to a lithomarge; (1) lithomarge, a decomposed basalt still retaining the joint structures and showing the spheroidal weathering of the original rock. The pale bauxite clays in Antrim have been derived from rhyolites, although the formation of bauxite from basic igneous rocks has been proved in other localities. They overlie the pisolitic iron-ore when they occur. The whole of the deposits may be compared with the products of the process of laterization now going on in many tropical regions, and resulting in the very variable material known as laterite. The first chapter of the Memoir, by Professor Cole, is a valuable summary of views of laterite-formation. He comes to the conclusion that the laterites and lithomarges of north-east Ireland must be regarded as examples of soils and subsoils formed under more or less tropical conditions in a region of seasonal rains.

MICROSCOPY.

By F.R.M.S.

A RARE (?) ALGA.—Many species of the Oscillatorias are among the most common examples of low plant life. Some of them may be found in nearly every pond and pool of water, on heaths and open spaces, while on wet muddy paths, at the base of walls, and round trees they frequently show as a dark bluish-green stain. In these cases they appear under the microscope as fine threads of some shade of green, indistinctly divided into numerous short cells, and when sufficiently free exhibit the gliding and *oscillating* movements which have given rise to their name. But the family contains also some more specialized members which are less often met with. In October last, I came across a solitary example of one of these, clinging to a piece of *Myriophyllum* in a pond on Hampstead Heath. In it a number of separate threads (trichomes) are enclosed in a sheath-like case of gelatinous matter; they are somewhat twisted and form a rope-like object. Individually, they do not differ in any respect from many species of

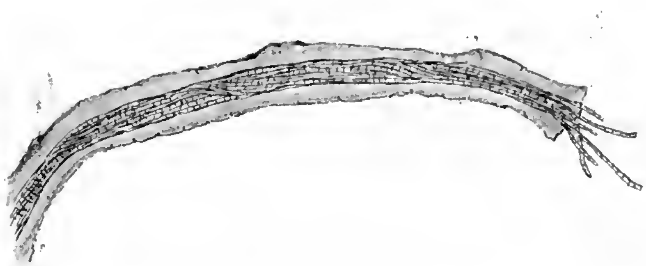


FIGURE 94.
Microcoleus subtorulosus Bréb.

oscillatoria, but movement must be very restricted from their close apposition and confinement within the investment. It evidently belongs to the genus *Microcoleus* Des., 1823 (*Cthonoblastus*, Kützing 1843). West says of *Microcoleus* —"The filaments are simple, terrestrial or aquatic in habit, and are furnished with a conspicuous hyaline sheath. This sheath is more or less cylindrical, not in any way lamellose, and its apex is generally diffluent. The trichomes are numerous, closely aggregated within the central part of the sheath, and often spirally interwoven." My specimen agrees very well with his *M. subtorulosus* Bréb, the thickness of the trichomes being, as he states, about 5μ, the breadth of the entire organism, including sheath, from 75 to 80μ. He says "Plants of this genus are very rare in Britain." Dr. Cooke, "British Freshwater Algae," and "Introduction to Freshwater Algae," gives three species not corresponding very satisfactorily with West's; this specimen seems to resemble his *M. terrestris* most nearly. The chief difference in the descriptions is that he appears to imply that *Microcoleus* is frequent instead of rare; he says of its habitat, "on moist naked ground" and "on the naked ground by roadsides," and so on. I have only met with the plant once before, and on neither occasion in any quantity, but it may occur more often in other parts of the country than near London. If any of the readers of "KNOWLEDGE" have been fortunate in coming across it in greater abundance, a note with some details would be welcome to me, and the Editor would, no doubt, be good enough to insert it in "Microscopy." Figure 94 represents almost the whole of the specimen referred to, the remainder being somewhat broken and disorganised.

JAMES BURTON.

QUEKETT MICROSCOPICAL CLUB, January 28th.—A. A. C. Eliot Merlin, F.R.M.S., sent for exhibition a photomicrograph at ×320 of *Coscinodiscus heliozoides* showing "pseudopodia," from a preparation by J. D. Siddall.

"Some notes on the Discoid Diatoms" were contributed by W. M. Bale, F.R.M.S., of Victoria, Australia. The paper is a survey and criticism of the principal characters which have been utilised in the discrimination of species in some of the best known genera of the discoid diatoms. *Coscinodiscus*, *Actinocyclus*, *Asteromphalus*, and *Actinoptychus* are dealt with.

A paper on "British Freshwater Planarians (Rhabdocoelida)" by H. Whitehead, B.Sc., was read. While the British *marine* Turbellaria have been monographed by Professor Gamble, the *freshwater* forms of this country have received but little attention. The classic monograph on the group Rhabdocoelida is by von Graff. These organisms vary in length from about one to twelve millimetres. They are generally found in ponds, lakes and ditches. The body is more or less transparent, is slightly flattened and provided with cilia. There is a mouth, a pharynx, and a sac-like gut. The position of the mouth varies and affords a valuable generic character. The excretory system consists of renal organs which in some cases are somewhat complicated in character. The nervous system is simple and comprises a two-lobed brain and a pair of nerves running along the body close to the ventral surface. Pigmented eyes are sometimes present, and a statocyst (organ of equilibration) is occasionally found. Reproduction is usually sexual. The animals are hermaphrodite, but the male organs ripen first. Freshwater Turbellaria undergo no metamorphosis. Reference was made to the green chlorophyll-containing cells found in some species. Professor Keeble has proved that in an allied marine form, *Convoluta*, there is mutual benefit from the association of these green cells (zoöchlorellae) with the animal. The Rhabdocoels are very difficult to prepare in a satisfactory manner as permanent objects. The most successful method is as follows:—The specimen is placed in a watchglass with a little water, the bulk of which is withdrawn by a pipette. A drop of Lang's fluid is then delivered from a pipette on the side of the watchglass and allowed to run over the animal. After remaining in the fluid for ten to fifteen minutes, the specimens are removed to forty-five per cent. spirit, and are afterwards passed through alcohol of increasing strengths, stained with borax-carmine, and mounted in Canada balsam in the usual way.

In a note on *Pleurosigma angulatum*, E. M. Nelson, F.R.M.S., stated that in spite of previously expressed opinions, the apertures in the lower membrane of this and allied forms can be unmistakeably seen below the intercostals of the upper. Objective used was a Leitz one-twelfth apo. of 1·4 N.A.

C. F. Rousselet, F.R.M.S., read a note on "Some Rotifers from Devil's Lake, North Dakota, U.S.A."

A DARK GROUND ILLUMINATOR.—Mr. E. M. Nelson, F.R.M.S., has recomputed a dark ground illuminator (see Figure 95) which is particularly useful for the examination of living bacteria. It is claimed that it produces a brilliantly illuminated object on a velvet black background. It can be used with both dry and immersion objectives, but the numerical aperture of the latter has to be reduced by a small stop placed just above the back lens. A funnel stop is recommended, which can be fitted to any immersion objective at a trifling cost, and can be taken out quite easily when not required. The great point of the illuminator is that whereas those at present in use require a powerful arc-lamp, Mr. Nelson's can be used with an ordinary oil lamp and a bull's eye condenser, provided that the work is done in a darkened room. Mr. C. Baker, who is producing the illuminator, recommends a Nernst lamp with a Nelson Aplanatic bull's eye condenser attached, but incandescent and petrol gas lamps can also be used.

FIGURE 95.

ON THE RELATION OF APERTURE TO POWER.—A theory founded upon mathematical fact there is no gainsaying, yet, while admitting the theory, one need not always accept the proposed application of the principle. All praise is due to Mr. E. Ardron Hutton for the care with which he has prepared his article, under the above title; for his clearness in marshalling his figures, yet when it comes to marching under his banner I find his colours are not mine.

With his strictures upon opticians, each, according to him, striving, in large apertures of the micro-objective, to offer better bargains than his fellows, I am not concerned. True, my own reading of their catalogues does not confirm these, but the makers are quite capable of defending themselves, and need no help from my pen. Then, however, he goes on to say: "In the above case A (from offering the largest aperture) would often get the order, the tyro arguing that increased N.A. meant more resolution and, therefore, better results. It is altogether forgotten that behind everything is the human eye, and that this admits of improvement within but narrow limits."

With the inference he draws from this I am entirely at issue. The tyro does get more resolution and better results out of the larger aperture, within, of course, certain well-defined limits, though I doubt whether A is foolish enough to give it for nothing. I confess, indeed, to finding it a little difficult to follow Mr. Hutton in his arguments to prove the contrary. Certainly there are limits to the ability of the eye to separate lines beyond a certain fineness apart. I cannot, however, see the connection of this with the microscope, when the very object of the instrument is to carry on definite vision still further and further than the unaided eye can command.

Up to a certain point I agree. I admit, taking his words: "An objective of 0·13 N.A. will resolve twelve thousand five hundred lines to the inch. . . . To accomplish this the objective must have an initial power of ten, which, multiplied by ten (the power of the eyepiece), and then the one hundred and twenty-five (the limit of resolution of ordinary eyesight), gives us the twelve thousand five hundred." Granted, that if such an objective were constructed, which with the ten-power eyepiece would resolve just these number of lines, and no more, granted also the limit mentioned of the observer's vision, he would not be able to pick up details in the object of still more fineness. Even if the objective had double the N.A., could resolve, in fact, lines of double the fineness, and these in the object; with the ten-power eye-piece they would still remain invisible. In this last case, however, what is to prevent the tyro from clapping on a twenty-power eyepiece, when they would at once be seen? For myself, I can separate two hundred and fifty lines to the inch, yet it often occurs that details invisible under an eight-power eyepiece become clearly defined under an eighteen or even twenty-seven. But, then, I do not confine myself to objectives with narrow apertures. To construct, indeed, an objective with an N.A. so limited as to show things under a ten-power eyepiece only; then another of double the N.A. to be able to resolve structure of double the fineness, and no more, under the same conditions; would be, to my seeming, to emulate the man who cut two holes in the door for his cats to go through, the larger one for the mother cat, the smaller for her kitten, oblivious of the fact that the larger aperture would suffice for both. Here, as in other things the greater includes the less.

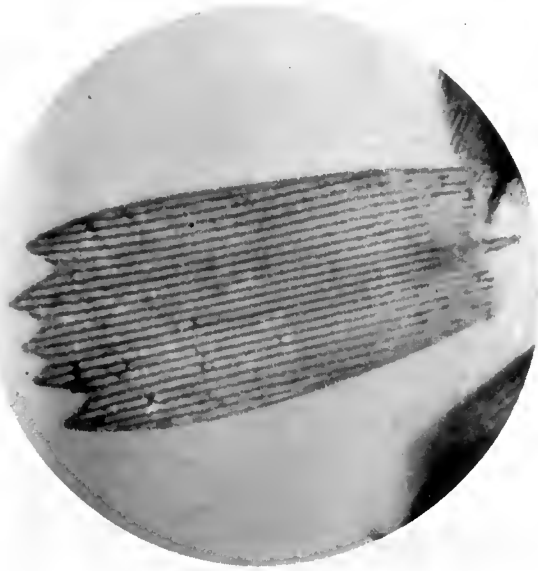


FIGURE 96. A scale of Butterfly, *Vanessa atalanta*, magnified four hundred and seventy diameters. Taken by an objective of 0·17 N.A.

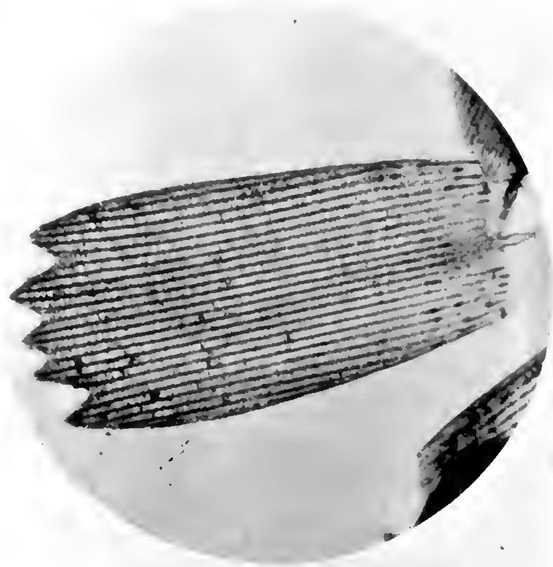


FIGURE 97. The same scale taken by Swift & Son's new two-thirds inch apochromatic objective of 0·30 N.A. Magnified four hundred and seventy diameters, as before.

A micro-objective with reserve of aperture is a whole battery of lenses in itself, the progress from lower to higher magnification being made by changing the eyepieces instead of the objectives. Five eyepieces ranging from four to twenty-seven powers will give, with a two-thirds inch objective, on a seven-inch tube, magnifications of from forty to two hundred and seventy diameters.

I am assuming, of course, that the lenses are good; also that deep eyepiecing refers mostly to the low and medium powers. With an oil immersion one-twelfth inch I have never been able to work with advantage with anything higher than a twelve-power eyepiece, calculated upon a ten-inch tube. Here, again, I find myself at issue with Mr. Hutton. He says, when speaking of medium-power lenses, ranging from the one-inch to the half-inch or four-tenths of an inch:—"These admit abundance of light, and often possess a working distance equal to three-quarters of their focal length. They can scarcely be said to be used for highly critical work, and will (not ?—T. F. S.) bear an eyepiece magnification at any rate more than ten." Then:—"So that nowadays every objective of four-tenths of an inch or lower will bear an eyepiece magnifying ten on the one hundred and sixty millimetres tube. Even then we must be careful as to the illumination, or we shall only get a foggy glare."

To me this statement is truly astonishing, since, if there is one thing more than another which distinguishes these low and medium powers from the highest, it is their capacity to stand deep eyepiecing. Why, some of my lower powers only begin to do their work when under a twenty-seven eyepiece. This especially applies to a new two-thirds apochromat of Swift and Son, just acquired, of 0·30 N.A.; also to a half-inch of theirs of 0·50 N.A., and a B.B. of Zeiss of the same aperture, all in my possession. I only speak of my own glasses, but others, no doubt, of other makers, will do the same. Knowing what my own lenses will do under my own microscope, it would almost seem that Mr. Hutton's labours had ceased with compiling his figures, and that he had taken no further trouble to verify his conclusions. I should be sorry to misrepresent him, yet what is one to think when theory and fact are so far apart as here?

Happily, the micro-camera is ready to come to our aid to judge between us, and let the microscopical readers of "KNOWLEDGE" be the umpires. True, in theory, photography is supposed to confer extra resolving power upon the micro-objective, yet in practice I have never found it so. In this opinion also, I am confirmed by Mr. Andrew Pringle, whose authority on the subject is second to none. I remember many years ago attending a lecture on Photo-micrography given by him before the Photographic Society, now the Royal. After the lecture a gentleman asked a question as to the increased resolving power photography gave, instancing examples in the sister science, where more stars were seen upon the negative than in the telescope. A facetious gentleman among the audience called out: "That depends upon the plates," meaning, of course, the more holes in the plates the more stars. Mr. Pringle's sober answer was that although he had often seen details of structure upon the negative not noticed in the microscope, when he referred back to the microscope they were always there visually. If I may refer to a matter touching myself personally, I may say that though, according to the Psalmist past the age of man, my eyesight is as good as ever it was. What the plate can see, I can see in the microscope, and that is the way I test it.

The photo-micrographs here given, then, may be taken as true representatives of what was seen, and not seen, in the microscope. Figures 96 and 97 are from a butterfly's scale, Figure 96 being taken with a lens of 0·17 N.A., the outside limit Mr. Hutton will allow for a two-thirds inch. Figure 97 by my own two-thirds apochromat of Swift, N.A. 0·30, both magnified four hundred and seventy diameters, or forty-seven times the initial power of the objectives on a seven-inch tube. Now, can anyone hesitate for a moment in deciding which picture shows the most detail? Photographically, in the quality of the prints there is not so much difference. When we come to examine them, however, we find that while Figure 96 shows only the ribbing running from end to end of the scale, with just indications of the coarser cross ribbing at the tip; in Figure 97 the cross striations are crowded from end to end. Neither can it be said of the second that the magnification (equal to a forty-seven power eyepiece) is too much for clear definition in the print, nor again that the image has broken down, or is foggy. I would not for a moment, however, let it be thought that the objective, by which the first print was taken, is a bad one. Indeed, it is very good, but, of course, cannot show structure beyond the limits of its aperture. One might as well expect a pony to do the same work as a dray horse.

So much for the lower and medium powers. I now beg to deal with another statement concerning some of the higher, and am sorry to say that to deal will be also to disagree.

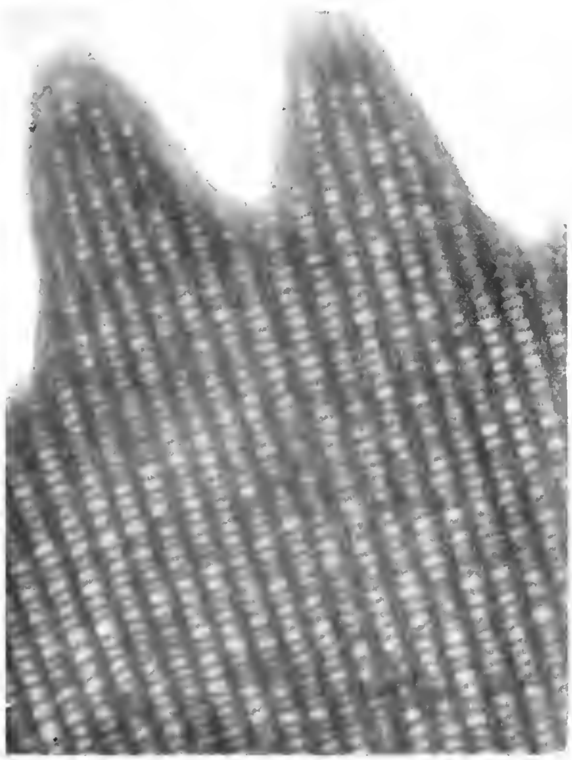


FIGURE 98. Part of a scale of the same Butterfly, magnified one thousand five hundred diameters. Taken by a half-inch of Swift & Son's, of 0·50 N.A., abnormally magnified to compare in size with Figure 99.

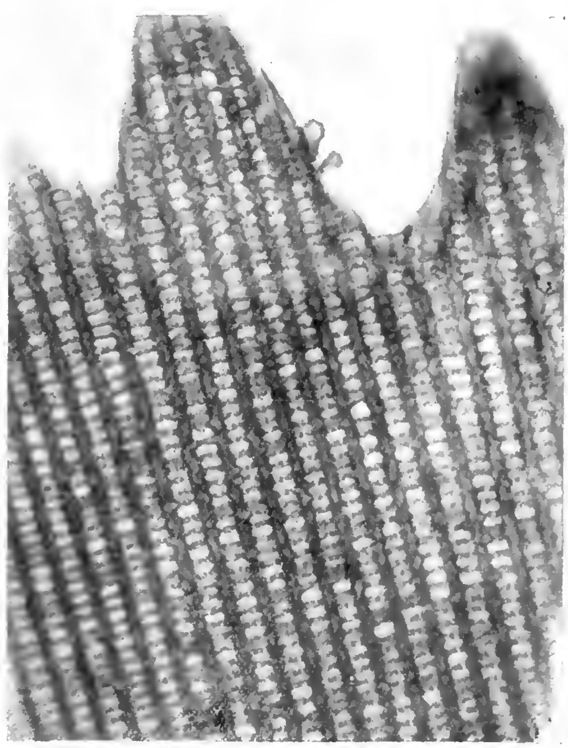


FIGURE 99. The same part of the same scale, magnified one thousand five hundred diameters to show bosses on the cross ribs. Taken by a one-sixth inch of Swift & Son's, of 0·85 N.A.

Mr. Hutton's ideal aperture for a four millimetre (one-sixth inch) is 0·52 N.A., and he says: "It is, however, useless to give us a four millimetre (one-sixth) objective of 0·88 N.A., as its aperture could not be fully utilised except by employing such high power eyepieces, or lengthening the tube, as would utterly break down the critical character of the image. Anything above 0·52 N.A. for such an objective is of little or no value, and if working distance is sacrificed to obtain a higher aperture it is worse than useless."

Here, again, we can bring photography in as an impartial, though striking, witness in the case. I am lucky also in being able to reproduce the image of the same object by the two apertures, or nearly so, he mentions. Figure 98 was taken by a half-inch of 0·50 N.A., and Figure 99 by a sixth-inch of 0·85 N.A., both of Swift. The first falls two points below Mr. Hutton's ideal, it is true, the other, three points below the one he reprobates, yet I doubt whether it will affect the definite picture in either case. Both are taken at twenty-five times the initial power of a one-sixth, being, so far as the half-inch is concerned, equal to the initial power of seventy-five times upon a ten-inch tube. My sole object in this last was that the two objects of the same size might be compared, fifteen hundred being far past the point, on this glass, of useful magnification.

Figure 98, however, teaches a useful lesson in another way. Practically, there is not much more seen of the structure than is shown in Figure 97, simply long girder ribs with short ones at right angles between. In Figure 99 one sees that the cross ones are beaded, pointing to further structure in the scale. This beaded appearance is due to little bosses, which, rising from the cross ribs, support a structureless membrane on the top. Now, the half-inch being of 0·50 N.A. gives a slight hint of this structure, though not enough to be of much service, as it appears under a low eyepiece. So far, however, from a deep eyepiece helping, it only obliterates entirely what was but slightly indicated before. The reason is not far to seek. Assuming that a twenty power eyepiece is substituted for the one of ten, each point of structure has only one quarter of the light. This being now insufficient to stimulate the optic nerve, the picture is lost altogether.

The failure to define, however, by the glass of 0·50 N.A., which is so well shown by the N.A. of 0·85, is not all due to the want of resolving power in the former. Could the little bosses be isolated from the cross ribs they would be seen by the smaller N.A. readily enough. But here, with the larger aperture of the one-sixth inch comes in another valuable quality, seemingly not appreciated by Mr. Hutton. It does not consist of the depth of focus he speaks of. Rather this is its opposite, allowing two structures, one superimposed upon the other, and but a little apart, to be separated optically. In the words of Dr. Abbe, a wide aperture then becomes an optical microtome. In conclusion, I have not met all his points, but have already written enough, I think, to give a good opening for the discussion which I hope will follow.

T. F. SMITH.

THE ROYAL MICROSCOPICAL SOCIETY.—At the meeting held on February 19th. the new President, Professor Sims Woodhead, took the chair for the first time. Mr. E. J. Spitta gave a very interesting account of the lenses formerly belonging to Joseph Lister, which had been presented to the Society by the Executors of his son, the late Lord Lister. Many of the lenses were of great historical interest. Some of them had been made by Joseph Lister himself, others appeared to be the first examples produced by well-known makers. Among the manuscripts which accompanied the apparatus was a paper which, so far as Mr. Spitta had been able to determine, had never been published, in which Joseph Lister, had in a marvellous way anticipated the work of Abbe carried out forty or fifty years later. A remarkable feature of the lenses made by Lister himself was the high polish which had been given to them. This is more to be wondered at seeing the methods which had to be adopted.

Mr. C. Lees Curties exhibited, on behalf of Mr. H. Waddington, a striking series of slides illustrating the development of the Fairy Shrimp (*Chirocephalus diaphanus*). These included the egg and several examples of the nauplius in various stages, as well as the young shrimps and preparations illustrating parts of the full-grown animal. Dr. Shillington Scales read the notes which were sent with the slides, from which it appeared that the crustacean while of only occasional occurrence in England generally, was not uncommon in parts of Cornwall. To the list of localities mentioned, Mr. Wilfred Mark Webb added Eton, Mr. D. J. Scourfield one near Oxshott, while Mr. John Hopkinson mentioned a record for Hertfordshire.

Mr. D. J. Scourfield described the use of the centrifuge in pond-life work, pointing out that organisms could be obtained from water that was apparently free from them by the use of this apparatus. He said that in the past it had been taken up rather as a substitute for fine nets, but it should be looked upon as supplementing them.

Another feature which contributed towards making a most attractive meeting, was the exhibition of Desmids by members of the biological section of the Royal Microscopical Society.

TAKING CINEMATOGRAPH PICTURES WITH THE MICROSCOPE.—We have received a very useful booklet entitled "Guide to Photo-micrography." It is published by Mr. E. Leitz, and it was primarily prepared for users of apparatus supplied by him. In the first place we are told how to set this up, and to make photographs with the camera put vertically and horizontally. Special apparatus for photographing insects, large sections, and solid objects, is illustrated and described. The photographic side of the work is dealt with as is also the making of cinematograph pictures. Altogether the Guide is a very valuable help to those who wish to take up photo-micrography in connection with their work or as an attractive hobby.

ORNITHOLOGY.

By WILFRED MARK WEBB, F.L.S.

A SWALLOW RINGED IN STAFFORDSHIRE AND RECOVERED IN NATAL.—On May 6th, 8911, Mr. J. R. B. Masefield ringed two swallows (*Chelidon rustica*) which were nesting in the porch of his house, Rosehill, Cheadle, Staffordshire. In the summer of 1912 he again caught the swallows nesting in the porch but found that only one of them bore the ring which he had put on in the previous year. On December 23rd, 1912, a swallow was caught in a farmhouse eighteen miles from Utrecht in Natal, and this proved to be the bird which did not return to Cheadle in that year. Mr. Harry Witherby, who records the occurrence in *British Birds* for February, thinks it extraordinary that a swallow breeding in the far west of Europe should have reached the south-east of Africa. He finds it is quite impossible to theorise on a single recovery of this kind but tells us that we must be content at present with the bare fact, probably the most startling one that the ringing of birds has as yet produced.

FIGURE 100.
A New Nesting Box for Nature Study Observations.

NESTING BOX EXHIBITION.—A very successful exhibition of nesting boxes, held during the first fortnight of February in the offices of the Selborne Society, was organised by the Brent Valley Bird Sanctuary Committee. The nesting boxes which, when they were first designed, were described and illustrated in "KNOWLEDGE" (Volume XXXIV, page 99), have now reached a stage at which they are not capable of very much more improvement, for they have been modified in the light of experience and the less successful forms have been dropped. There was nothing, therefore, very novel to be seen, though one box was interesting. Instead of being made from a small log, it is cut from half a tree trunk (see Figure 100). This gives it a flat back, and it is very suitable for hanging on a wall, amongst ivy, for instance. The top lifts off for observational purposes, and instead of being fixed by nails driven through metal plates the box can be hung on a single hook. It is specially intended for nature study observations, and for use in school gardens and playgrounds, for it can be put up out of reach and taken down for examination by the teacher quite easily when required. As was seen at the Children's Welfare Exhibition, country children are able to make very excellent observations on birds which build in the open, and the use of nesting boxes gives them, as well as their town and suburban cousins, a chance of studying the nesting habits of those birds which customarily rear their young in holes. Another contrivance worthy of mention is an experimental box, made, with the idea of attracting tree-creepers, from a slice of a curved branch, the object being when it is attached to a tree to make it appear as if it were part of the actual trunk.

THE LATE STAY OF SWIFTS.—Mr. H. B. Booth, in *The Irish Naturalist* for February, criticises the expression used in previous notes on the Swift—"*despite* the coldness of August, and the summer, the Swifts did not depart." He says that the writers should have said *because* of the cold August and Summer, for his observations go to show that with the members of this species the date of their departure is fixed more by the forwardness of their young brood, and their ability to undertake the long journey, than by the state of the weather, or of their food supply at the time of leaving. As a matter of fact, in the finest summers and consequently when there is a large supply of winged insect food, the colony usually breaks up a day or two earlier than in colder and wetter seasons. It must be obvious that in the former case the young ones would be better fed, and come to maturity earlier.

PHOTOGRAPHY.

By EDGAR SENIOR.

REVERSED NEGATIVES.—For certain photographic processes, such as single transfer, carbon, and photo-mechanical printing, negatives are required in which the image is reversed as regards right and left, in order that the finished impression may appear in its correct aspect. The production of negatives of this nature may either be accomplished directly in the camera or indirectly by stripping the film from its glass support and turning it, or by reproduction from ordinary negatives. By the first method the reversal is generally obtained through the use of either a metallic mirror placed at an angle of forty-five degrees with respect to the axis of the lens, or by means of a right-angled prism, from either of which the image is obtained by reflection; in the latter, from the hypotenuse surface of the prism; and in the former, from the silvered surface of the mirror. As both of these pieces of apparatus are expensive, and, especially in the case of the mirror, easily damaged, a plan very frequently followed, and which, at the same time, is capable of giving good results, is to reverse the position of the sensitive plate in the dark slide. When working in this manner it is, of course, necessary to turn the focusing screen, for the purpose of making allowance for the difference in the image plane due to the thickness of the glass.

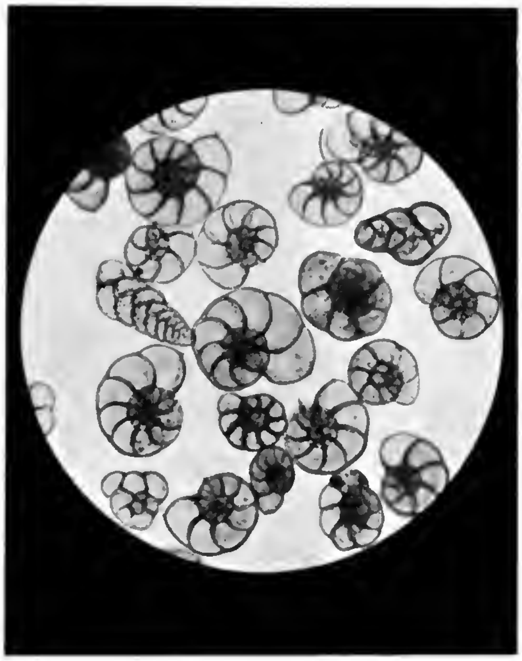


FIGURE 101.
Print from the original negative.

By the second method the film itself is stripped from its glass support. This may be accomplished in several ways. In the case of collodion negatives a coating of india-rubber dissolved in benzole is applied to the plate, and when this is dry (which only requires a few minutes) a film of stripping collodion is applied and allowed to become dry; the negative is then placed in a dish of water containing acetic acid, when, after several minutes immersion, the film begins to loosen from the glass, from which it finally floats free, and may be turned and floated on to another piece of glass which has received a coating of gelatine. We have also found the "Lotus stripping films" made by Messrs. Mawson & Swan very satisfactory, in which case the negative is permanently removed from the glass and used as a film. When gelatine is the medium in which the image is formed its removal from the glass plate is not so easily accomplished, apart from the expansion (which is often unequal) which the gelatine undergoes, and the consequent distortion of the image when transferred to another plate. A method was introduced years ago in which the gelatine plate was placed in a solution of fluoride of soda and citric acid, and although this method was found useful, the expansion was considerable and increased with the quantity of citric acid in the solution. To counteract this the application of a film of plain collodion was often resorted to. Owing to the evil results attending the operating with wet films, methods of stripping dry were introduced, the film being first thoroughly hardened by formalin in order to lessen its adhesion to the glass plate. For this purpose the following formulae due to E. Valenta may be employed:—

Formalin	...	150 minims.
Water	...	7 ounces.

The negative is allowed to soak in this solution for ten minutes, after which it is dried and coated with enamel collodion. The collodion film should be a thick one, and, when set, is well washed, and the negative cut through with a sharp knife about one-eighth of an inch from the edge of the plate all round. After drying the film with filter paper, the stripping is proceeded with, and, when accomplished, the negative is immersed in the following bath:—

Alcohol...	...	2 ounces.
Glycerine	...	2 ,,
Water ...	...	35 ,,

On removal from this solution the film is laid, collodion side down, upon a piece of glass which has been rubbed over with a little of the glycerine mixture, when a piece of filter paper is laid on and a roller squeegee gently applied, after which the plate is stood up and allowed to dry spontaneously. By the third method the reversed image is obtained by reproduction from an ordinary negative. This may be accomplished in several ways, one of which is to place a dry gelatine plate in contact with the negative in a printing frame, and expose to a strong source of light (sunlight) for a sufficient length of time to obtain a reversed action of light. A better plan, perhaps, is to employ the method adopted in the case of the example shown in Figure 101, which is due to Mr. Bolas:—A gelatine dry plate was soaked for three minutes in a four per cent. solution of potassium bichromate, after which it was rinsed for a few minutes in a bath consisting of equal volumes of alcohol and water. The superfluous liquid having been removed by means of filter paper, the plate was allowed to dry in the dark. When dry it was exposed under the negative from which the print in Figure 101 was made, for a time that would be required to obtain a carbon print from the same. After removal from the printing frame the plate was washed until free from the bichromate, and the image then developed by means of pyro and soda. After fixing and washing a negative in which the objects depicted were in the reverse aspect of the original negative resulted, and from which the print in Figure 102 was made. The

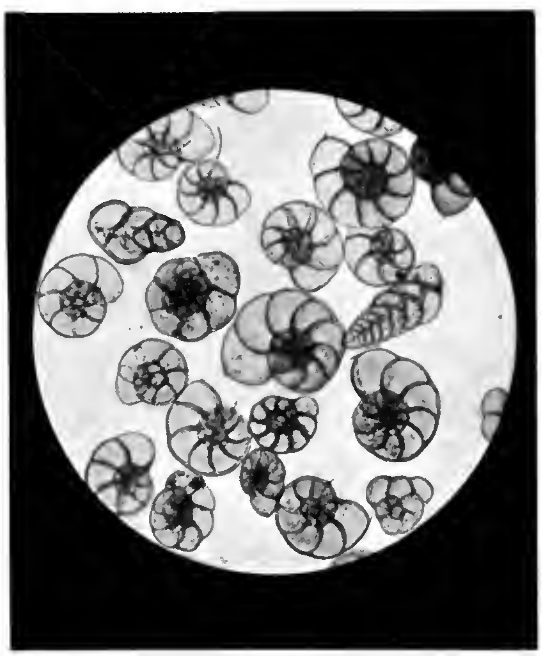


FIGURE 102.
Print from a reversed negative.

process itself is simple and with ordinary care is capable of giving good results, as is shown by the example.

ADON TELEPHOTO LENSES.—We have received from Messrs. J. H. Dallmeyer, Limited, a notice to the effect that the manufacture of the "Junior Adon" lens has been discontinued since February 1st, and that they will, therefore, be unable to execute any further orders for them. The manufacture of the well-known adjustable form of Adon telephoto lens, as well as the large Adons, working at F4·5, F6 and F10, for which the demand is very great, owing to the large scale of pictures and simplicity of manipulation, will be continued as before. The rapid fixed-focus Adons are meeting with great success, not only in their use on reflex and other hand-cameras, but as portrait lenses as well.

ZOÖLOGY.

By Professor J. Arthur Thomson, M.A.

FEEDING HABITS OF SERPENTS.—Raymond L. Ditmars, curator of reptiles in the New York Zoölogical Park, gives an interesting account of his observations on the feeding habits of snakes. They are exceedingly captious and sensitive. Changes of temperature and light, too much public inspection, the artificial environment, and so on, affect their nerves, and they go off their food on slight provocation. None are vegetarian; the majority like birds and mammals; a few are insectivorous; the sea-snakes confine themselves to fishes; some eat frogs, lizards and other snakes; some of the smaller forms condescend to earthworms. There are many specialisations in connection with feeding, one of the best known being that of the African egg-eating snake, *Dasypeltis scabra*, which swallows eggs three times the diameter of the thickest part of its body. The jaws are almost toothless, but a few posterior teeth enable them to grip the food. There is alternate gripping and engulfing, and the egg slips into the gullet. There it is cut by the knife-like points of the inferior processes of the vertebrae which project into the gullet. By this remarkable adaptation all wastage is avoided. The empty shell is afterwards passed out again—an absolutely unique habit. In other snakes that feed on eggs, the shells are broken by the snake forcing its throat against the ground. The fragments of the shell pass down to the stomach and are quite dissolved. In the Indian *Elachistodon westermanni* there is a structural adaptation similar to that of *Dasypeltis*, but there seems to be no certainty as to its use. Mr. Ditmars gives circumstantial details as to the diet of a large number of types, and leaves us with a vivid impression of the range of diversity in a single sub-class. What a contrast, for instance, between the diminutive worm-snake (*Glauconia*) of tropical South America, which lies unconcernedly inside the ant-hill devouring the larvae, and the huge Boa or the Anaconda, lurking in the jungle growth along the river banks on the watch for a passing peccary, capybara or agouti. An interesting general point is that with few exceptions there is an abrupt and entire cessation of feeding on the part of gravid females.

A MOTH'S LOVE SIGNAL.—Many experiments have been made to try to settle the much-discussed question whether insects hear or not, but they have not yielded satisfactory results, except in the way of showing that there are many sounds to which insects which are credited with the power of hearing pay no attention whatsoever. It is difficult, however, to believe that all the instrumental music of crickets, grasshoppers, cicadas, and the like falls on deaf ears; and Dr. Karl Peters suggests that the experiments that have yielded negative results have been too much restricted to sounds that have no biological significance to the creatures experimented with. He gives an instance, which he has carefully studied, which very strongly suggests that there may be hearing in the strict sense, and that the production of a sound may be utilised in love-making.

His observations relate to an Alpine moth (*Endrosa* or *Setina aurita* var. *ramosa*) which is abundant at Arolla, at a height of about two thousand five hundred metres. The males fly about actively; the females are sluggish and sit mostly on the tussocks of grass, where they are very inconspicuous. The males are able to produce a cracking noise, which is peculiar to them, and the females respond to this, even when they cannot see the males, by vibrating their body and wings. The reaction on the female's part begins when the male flies overhead or settles down close by; it stops when the sound stops. It seems difficult to avoid the conclusion that the female hears the male's love signal. It seems likely that sight plays a rôle on his part, and that the tremulous, vibrating movements of the female attract his attention.

RELATION OF HEART-WEIGHT TO MUSCULAR EFFORT.—A. Magnan finds that birds with relatively small wings and very numerous strokes per minute, have a relatively heavier heart than those with larger wings and more sailing power. Similarly, in Mammals, the proportion between weight of heart and muscular development is greater in Carnivores than in Herbivores. For while Herbivores can keep going a long time they have not usually that capacity for intense muscular effort which Carnivores show. It may be noted, however, that Magnan does not deal with horse or chamois or antelope, in which intense muscular effort is well known. It is interesting to notice that the proportion in the deer, the only large Herbivore measured, is more than double that of the rabbit. The highest proportion is found in bats which have such strongly developed pectoral muscles and "violent effort in their flight."

SLEEPING INSECTS.—Karl Fiebrig has made for many years a study of insects (in Paraguay), which exhibit definite sleep-attitudes, quite different from ordinary resting attitudes. The insects remain motionless and stiff, as if in a trance. Very characteristic is the clinching of the mandibles which close upon the supporting object. The whole weight of the body is often supported by the mandibles, no assistance being given by limbs or wings. In many cases of "sleep" the whole pose is unusual, being upside down or in some way reversed. The sleeping condition may be artificially induced by changes in the illumination. When "asleep" the insects are very callous as regards temperature, wind, touch and the like. The sleeping pose is often of protective value.

FIDDLER-CRABS.—A. S. Pearse has made an interesting study of the fiddler-crabs (five species of *Uca*), which swarm on the mud-flats at Manila. They live together in enormous colonies, but there is no social life in the true sense. In fact, they are extremely individualistic and pugnacious. "Each individual jealously guards the area about his own burrow, and immediately attacks any invader of this territory." The burrow is the centre of activities, and the association for the place where it is situated is very strong. The great chela of the male is used as a weapon in fighting, and Mr. Pearse cannot agree with Colonel Alcock that it is used as a signal to charm and allure the females. A very interesting description is given of the way in which the crabs carry mud away from the burrow and close the opening with a plug when they go into their retreat.

NEW RHIZOCEPHALAN.—Mr. F. A. Potts describes an extraordinary parasitic Crustacean, *Mycetomorpha vancouverensis* n.g. et sp., a new representative of the Rhizocephala. It occurs on the ventral surface of a shrimp, *Crangon communis*, and has a flat mushroom-like body of a pale yellow colour, with the borders fringed with numerous short lobes. Colourless, absorptive roots extend into the host below the nerve cord. The mantle cavity is full of *Cypris* larvae. No trace of a male organ or of larval males was to be seen, and it is suggested that the reproduction may be parthenogenetic. The same may be true of *Sylon* and *Sesarmoxenos*, two other strange Rhizocephala.

CORRESPONDENCE.

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—I am glad to take this opportunity of replying to Mr. F. W. Henkel's letter on the above, because he appears to have a definite argument to offer on the subject. This argument, if I mistake not, is that experience only gives us solid bodies, which we, somewhat arbitrarily, divide up into three dimensions, *i.e.*, that the concept of a three-dimensional body is not, as the term implies, a synthetic product, but is given immediately by experience; whilst the concept of a one-dimensional object (*i.e.*, a line) is not an element out of which the former concept is built, but is the product of analysis. Consequently, says Mr. Henkel, any argument based on the real existence of one-dimensional objects is fallacious, because such objects do not in fact, really exist. But . . . . in fact, I have a string of buts. First of all, I would ask Mr. Henkel what he understands by existence. What criterion of real existence can he offer which denies reality to that which exists in mind? But to leave aside the question of epistemological idealism, surely Mr. Henkel will not deny the existence of one- and two-dimensional objects as *aspects* of three-dimensional objects; and if this be so, there is nothing in his argument to prevent a belief that three-dimensional objects are merely aspects of four-dimensional objects, and so on *ad infinitum*. And that is exactly what I have suggested. Moreover, are all the objects of experience three-dimensional? I think not. Who has ever seen a three-dimensional body? I have not. What I only see, and what, I think, Mr. Henkel only sees, are flat, coloured surfaces (*i.e.*, two-dimensional). We simply infer them to be three-dimensional, because that is the idea we gain through our sensations of touch and motion. Indeed, by combining our sensations of touch and motion with our sense of duration, we may be said to experience four-dimensional objects—my experience, for example, tells me that the paper on which I write has length, breadth and thickness, and also duration in time, *i.e.*, it has *four* dimensions.

It is best, I think, to look at the subject from the point of view of motion. Experience tells me that I can move (to some extent at least) in an indefinite number of directions in space, but these may all be resolved into three (but not less) directions. The reality of the fourth dimension merely implies the possibility of movement in a new direction irresolvable into these three directions. As I have suggested above, time may be this direction: its apparent difference from the spatial directions being due to the fact that we are forced along time with no option of any other movement so long as that direction is concerned, and that we seem to have practically no power to see in the direction of time (unless, perhaps, memory is a sort of time-sight, and prevision be a fact).

THE POLYTECHNIC, REGENT STREET, LONDON, W. — H. S. REDGROVE.

SOLAR DISTURBANCES DURING JANUARY, 1913.

BY FRANK C. DENNETT.

JANUARY was poorly favoured with suitable weather for the solar observer. Seven days (4, 10, 11, 19, 23, 29 and 30) were missed entirely. On eleven days (5, 6, 8, 9, 12, 13, 20, 21, 22, 24 and 28) the disc appeared free from disturbance, bright or dark. The longitude of the central meridian at noon, on January 1st, was 6° 12′.

No. 26.—A group belonging to December, which continued visible until January 3rd, and so appeared on the chart last month.

No. 1.—A group of two spotlets and two pores first seen on the 14th, in a faculic disturbance approaching the western limb. Next day only one pore was seen within a ring of faculae, very near the limb. The group appeared to be 50,000 miles in length.

No. 2.—On the 16th, an elongated faculic cloud well round the south-eastern limb was seen to contain a spotlet with a gray companion closely north of it, and a minute pore a little ahead. It remained visible as a hazy pore on the 17th.

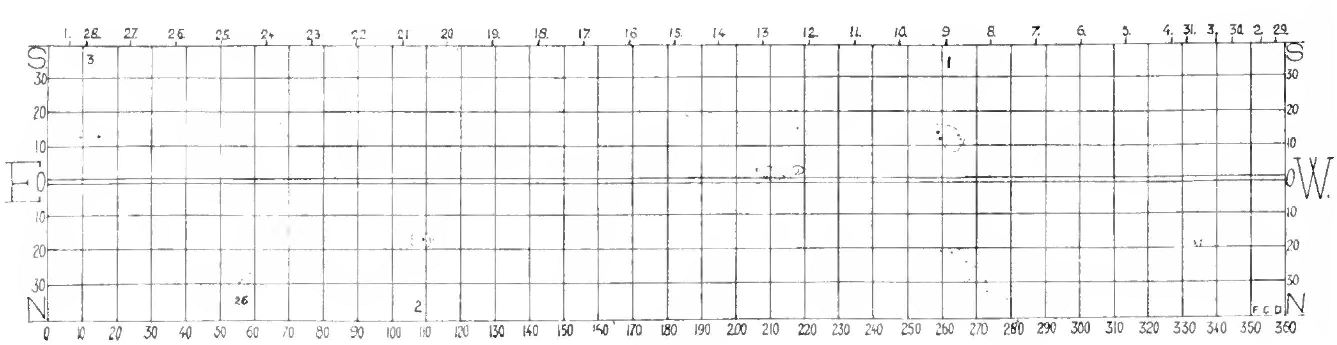
No. 3.—On the 25th, two spotlets were visible, and also on the 26th, but the distance between them had increased to 37,000 miles. On the 27th two pores were seen but not nearly so far apart, and there were traces of a minute point nearly in the place of the rear spotlet, but none were observed after.

The faculic display was also very little. On the 7th some was visible within the eastern limb, probably the remains of groups 24 and 24*a*, which is shown on the chart, longitude 206°–220°, as seen again on the 17th and 18th. On the later date less conspicuous faculae were recorded, but not measured, within the north-east and south-west limbs. On the 26th there was a bright knot at longitude 334°, 18° North latitude. On the 31st some faculic spots appeared in 30° North latitude between longitudes 41° and 51°, a little within the north-western limb, and doubtless were the remains of the disturbance which produced No. 26.

The helpers whose observations have contributed to the preparation of our chart are Messrs. J. McHarg, A. A. Buss, E. E. Peacock, W. H. Izzard, and the writer.

Erratum.—On p. 69, line 9 below the first chart, in the second column, for 228, read 288.

DAY OF JANUARY.



AUXETIC ACTION ON SPORES OF A NEW SPECIES OF *POLYTOMA*.

By AUBREY H. DREW.

Author of "The Life History of a New Monad."

Polytoma uvella was originally described by Ehrenberg, and subsequently studied by Dallinger and Drysdale. Saville Kent also did valuable work on this organism, and described a variety differing from the type by the possession of a red spot on the body, and consequently called *Polytoma ocella*. Dr. Dallinger referred to the organism as the Acorn Monad, and he and Drysdale were able to complete its life-cycle, while Saville Kent also added to our knowledge in this direction by showing that the knob-like appendages at the roots of the flagella, as described by Dallinger and Drysdale, were really in the nature of loops. Since the work of these observers little more has been done with regard to these organisms, nor has any new variety been described. In May, 1910, I had the good fortune to examine some Monads strongly resembling *Polytoma uvella*, and, indeed, at that time I classified them as such; but in February, 1911, I again came across the organism in a vegetable infusion, and noting after careful examination some peculiarities about it, I determined to study it further. I discovered with comparative ease that the organism was certainly a variety of *Polytoma*, as asexual reproduction was a division into four; and on carefully working out its life-cycle, I observed several very striking differences from *Polytoma uvella*, thus proving beyond a doubt that the organism was quite a new one. On account of its very striking granular appearance, I suggest that it should be named *Polytoma granulosa*. (See Figure 103.) This organism varies somewhat in size, but the average is between one fifteen-hundredth to one twelve-hundredth of an inch in length, the body is ovate, and is invested with a distinct cuticle, enclosing uniformly granular contents. A contractile vacuole is present, which is situated at the anterior end. The flagella are two in number, arising from the internal protoplasm, and piercing the envelope. They are equal in length, and exceed the body length of the monad. Occasionally they are crossed over each other, giving the roots a V-shaped aspect. Motion is rapid, but rather irregular, the flagella being used as the arms are in swimming, though the former are frequently not vibrated synchronously; hence irregularity in motion arises. The organism possesses a circular nucleus. This is situated about the centre of the body, but in ordinary individuals is invisible, owing to the granular contents. The nutrition is apparently mainly saprophytic, but is also holozoic at certain periods in the development of the organism. Reproduction is interesting, and takes place in the following manner. On studying a normal form it will be found in the course of time that a slight constriction is appearing in the granular sarcode, dividing the contents into two equal parts. This constriction deepens, and the contents retract somewhat at the equator of the organism. Soon two spherical masses of protoplasm are formed by this constriction. (See Figure 104.) During this process the monad is usually actively swimming, but now it generally comes to a standstill, and fixes itself anterior end downwards on the slide, and rapidly vibrates its flagella. Meanwhile each divided half undergoes a similar process of division, the fission this time being more or less transverse. Soon four granular masses are formed within the envelope, being arranged in a cruciform manner. Motion now usually ceases, the flagella being cast off, and the envelope with its contents alone remaining. A delicate membranous cuticle now forms around each of the products of fission, and minute flagella are developed, which commence to vibrate. Finally the separate organisms force their way out, leaving the envelope behind them, the entire process usually taking three or four hours. The method of anisogamic reproduction is far more difficult to ascertain, and requires careful and continuous observation over a length of time. If this condition is complied with, it will be seen that sooner or later a somewhat larger form in which the granular contents have retracted from the posterior end, and with the nucleus strongly developed, comes into contact with a normal form. The two adhere by the posterior ends, swimming being continued. (See Figure 106.) In the course of an hour or two motion usually ceases, both organisms adhering to the slide while the flagella continue in vibration. In about ten hours the two organisms gradually melt together, forming an oval sac which slowly becomes spherical. The sac is very granular and shows the two vestiges of the envelopes, which do not participate in the fusion. These vestiges are as a rule washed away from the sac by currents in the water, but occasionally persist adhering to it. The sac remains in this condition for many days, but it will be found that the contents are gradually merging into one another, forming an irregular mass of sarcode within. A constriction now appears in this sarcode, and division slowly takes place, two equal and slightly granular bodies of an oval shape being formed. An envelope appears around these organisms, and finally they acquire flagella, and, after a varying period, they escape, leaving the remnants of the sac. The completion of this process takes from five to eight days.

When I had worked out the life-history of the organism thus far, I naturally imagined that I had settled the whole life-cycle, and it was only by chance that I found that there was more to learn. These researches had been carried to this point in the summer of 1911, but being desirous of ascertaining conclusively whether the products of conjugation were ever more than two, I again made a series of observations in October, 1911. I then was fortunate enough to discover that there was a third method by which a winter resting spore was formed. Two organisms, both having their posterior ends comparatively free from granules, come into contact,

FIGURE 103.
Polytoma granulosa sp. nov.
Normal free swimming form.

FIGURE 104.
Stages in division.

FIGURE 105.
Last stage in division and form prior to conjugation.

FIGURE 106.
Conjugation.

FIGURE 107.

FIGURE 108.
Stages in formation of winter resting spores.

FIGURE 109.
Sac formed from conjugation.

FIGURE 110.
Natural division in winter spore.

FIGURE 111.
Winter resting spores.

FIGURE 112.
Induced division in spores by Suprarenal Extract and Atropine.

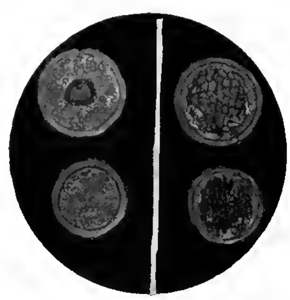


FIGURE 113.
Controls and spores showing division. (Suprarenal gland and Cadaverine).

FIGURE 114.
Free forms from induced divisions.

All the figures are magnified 1000 diameters, except 111 which is enlarged 500 diameters.

and immediately adhere, the contents coalescing very rapidly, and give rise to a swelling between the remains of the two envelopes. Finally, a round sac is formed, with rather thick walls, and finely granular contents, with what is apparently a small bubble in the centre (see Figures 111 and 113). Practically every monad in the late autumn forms these sacs, reproduction by fission not taking place. In the course of some weeks the bubble-like body is absorbed, leaving the finely granular contents surrounded by the thick-walled sac. To study these spores further, they must be kept continually moist on a live slide of some sort through the winter, when it will be found that towards spring the contents are gradually retracting from the sac wall, and, if at this stage the organism is very carefully watched day by day, it will be found that a division of the sarcode is taking place, in similar fashion to the ordinary one already described. Soon, the two organisms separate, acquire envelopes and flagella, and then the sac wall appears to give way, and finally they are liberated. If one of the free organisms is followed, it will be found to gradually increase in size till reproduction by fission takes place. The discovery of these winter resting-spores is important, as it explains how these organisms can survive the winter. I had previously noticed that normal forms were never to be observed during the winter months, and was now possessed of the explanation. During the autumn of the present year I was engaged in the further study of these spores, when it occurred to me that they formed a very suitable subject for testing the supposed action of Auxetics. Auxetics are substances discovered by Dr. H. C. Ross in 1909, while engaged in cancer research. Dr. Ross, and his colleagues at the Lister Institute, have shown that certain chemical bodies are developed during cell-death, and that these bodies act as excitors of cell-reproduction. Dr. Ross was further able to observe for the first time the division of human leucocytes by the action of these substances. Auxetics can be divided into two classes, natural and artificial. The natural auxetics are obtained from dead animal matter, especially material rich in lymphocytes. The artificial auxetics are bodies which contain the Amidine group, such as Theobromine, Caffeine and Acetamidine. Dr. Ross showed in addition that alkaloids were excitors of amoeboid action in leucocytes, and also that they acted as augmentors of auxetics. It had been suggested by critics that the mitotic figures obtained by Ross and his colleagues were artefacts, and I determined to experiment on the resting spores already described. Using a live slide containing spores through which a slow current of water could be passed. I accordingly prepared a solution containing four cubic centimetres of a concentrated extract of suprarenal gland, ·2 cubic centimetres of a one per cent. solution of atropine sulphate and ·5 cubic centimetres of a five per cent. solution of sodium bicarbonate. This was made up to ten cubic centimetres with distilled water, and the spores were kept continuously moist with this solution. In the course of forty - eight hours a slight constriction appeared in the sarcode which gradually deepened, and finally actually division took place, the products separating. (See Figure 112.) Controls containing no auxetics gave negative results. Working again with a very concentrated suprarenal extract augmented by the action of a one per cent. solution of Cadaverine I found that out of a total of forty-three spores in one field thirty-seven had undergone division within forty-eight hours. I was not, however, satisfied with this, as I was anxious to see whether the fully-developed organism could not be obtained from the spore. I accordingly worked with the solution just described, but kept the slide in the incubator at 25°C., examining the same at intervals of two hours. Division had commenced in forty-eight hours, in eighteen out of twenty-five in one field and the fully-developed organisms were formed after another thirty-six hours in seven of these eighteen; three spores actually discharged their contents, which swam away apparently normal in all respects. (See Figure 114.) I have also been able to obtain evidence of division upon auxetic jelly, containing stain, the full description of which is contained in "Induced Cell Reproduction and Cancer," by H. C. Ross (London: John Murray). This action of auxetics on these spores is extremely interesting, as it raises the point whether the former may not be necessary to cause the latter to develop in the spring. Pond water usually contains decaying vegetable and animal matter, and hence auxetics are probably present in solution. Whether it also contains augmentors one cannot yet say, though I am making experiments in this direction. From my own observations on these spores I am convinced that mere change in temperature will not explain the development in the spring, for spores may be incubated at summer temperature and still refuse to develop. Whether, with the advent of spring, auxetics and augmentors are formed in pond water in large quantities, and thus cause the dormant life to awake, is a point still to be settled, but in the light of present knowledge it appears extremely probable that the answer is in the affirmative.

I was afterwards able to improve the technique, and found that divisions could be more certainly induced if the water containing the spores was placed in small glass tubes, and the solution containing the auxetics then added. These tubes are then corked and placed in the incubator, and kept at 25°C for forty-eight hours, when portions of the contents may be examined from time to time. The possible production of auxetics in stagnant water is interesting, as cancer is often stated to be more prevalent in districts where stagnant water and decaying vegetation are present.

In conclusion, I have to express my indebtedness to Messrs. Watson & Sons, who kindly placed two of their new holoscopic objectives at my disposal, viz., a two millimetre immersion and a four millimetre dry, with the help of which several of the illustrations were made.

THE FACE OF THE SKY FOR APRIL.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 18.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Apr. 1	0 41·0	N. 4·4	21 10·6	S. 20·5	0 8·8	N 3·3	2 31·0	N. 21·9	19 0·6	S. 22·4	3 55·2	N. 18·6	7 39·9	N. 21·0
,, 6	0 59·3	6·3	0 47·8	N. 6·1	0 0·1	N. 0·9	2 30·5	22·2	19 11·6	22·3	3 57·3	18·7	7 39·9	21·0
,, 11	1 17·6	8·2	4 59·4	N. 27·8	23 59·1	S. 0·6	2 26·1	21·9	19 13·4	22·3	3 59·5	18·8	7 39·9	21·0
,, 16	1 36·0	10·0	0 56·9	N. 15·9	0 5·7	S. 1·0	2 18·2	21·0	19 14·8	22·3	4 1·7	19·0	7 40·1	21·0
,, 21	1 54·6	11·7	14 21·8	S. 17·4	0 18·4	S. 0·5	2 7·8	19·6	19 15·9	22·2	4 4·1	19·1	7 40·2	21·0
,, 26	2 13·3	N. 13·4	19 11·6	S. 27·5	0 36·0	N. 0·9	1 55·7	N. 17·8	19 16·7	S. 22·2	4 6·6	N. 19·2	7 40·5	N. 21·0

TABLE 19.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2	Saturn. P	Saturn. B
Greenwich Noon.	°	°	°	°	°	°	°	°	h. m.	h. m.	°	°
Apr. 1	−26·3	−6·5	260·0	−16·1	−8·2	−1·8	352·2	172·8	10 2 *e*	7 13 *m*	−2·8	−25·0
,, 6	26·4	6·2	194·6	−21·4	8·4	1·7	61·7	204·1	10 18 *m*	4 17 *e*		
,, 11	26·4	5·8	128·6	−5·6	8·6	1·7	131·3	235·4	8 24 *m*	5 29 *m*	2·9	25·2
,, 16	26·1	5·4	62·6	+18·7	8·7	1·7	200·9	266·8	4 20 *e*	2 33 *e*		
,, 21	25·7	5·0	356·6	+17·7	8·8	1·7	270·6	298·3	4 36 *m*	1 41 *e*	−3·0	−25·4
,, 26	−25·1	−4·6	290·5	−6·7	−8·9	−1·7	340·2	329·8	10 22 *e*	2 53 *m*		

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Jupiter L_1 refers to the equatorial zone, L_2 to the temperate zone. T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

THE SUN continues his Northward march. Sunrise during April changes from 5–38 to 4–37; sunset from 6–31 to 7–19. Its semi-diameter diminishes from 16′ 2″ to 15′ 54″. A small partial eclipse of the Sun on the 6th, is visible in Alaska and surrounding regions.

MERCURY is a morning star, well-placed for Southern observers. Illumination one-thirtieth on 1st, one-half on 30th. Semi-diameter diminishes from $5\frac{1}{2}''$ to $3\frac{1}{2}''$. Greatest Elongation, 27° West on 25th.

VENUS is an evening Star, till the 24th, when it is in inferior conjunction with the Sun, 6° North of it. Its semi-diameter is then $29\frac{1}{2}''$. It is of interest to see how near conjunction it can be followed. Sometimes the unillumined disc appears darker than the surrounding sky. Venus is 4° N. of Moon on evening of 8th.

THE MOON.—New $6^d\ 5^h\ 48^m e$; First Quarter $14^d\ 5^h\ 39^m m$; Full $20^d\ 9^h\ 33^m e$; Last Quarter $28^d\ 6^h\ 9^m m$. Apogee $2^d\ 8^h e$, semi-diameter 14′ 45″; Perigee $18^d\ 5^h e$, semi-diameter 16′ 29″. Apogee $30^d\ 1^h e$, semi-diameter 14′ 47″. Maximum Librations, 11^d 6° E, 12^d 7° S., 24^d 6° W., 25^d 7° N. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

TABLE 20. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.		h. m.	
Apr. 9 ...	66 Arietis	6·1	7 40 *e*	45°	8 29 *e*	293°
,, 11 ..	BAC 1648	6·4	6 51 *e*	66	7 53 *e*	296
,, 12 ...	BAC 1746	6·5	0 52 *m*	98	—	—
,, 17 ...	BD+12°2211	6·6	0 23 *m*	189	—	—
,, 18 ...	80 Leonis	6·4	2 50 *m*	139	3 40 *m*	280
,, 21 ...	BAC 4682	6·5	3 7 *m*	57	3 41 *m*	353
,, 22 ...	BAC 4923	5·7	0 39 *m*	69	1 28 *m*	345
,, 23 ...	π Scorpii	3·1	2 26 *m*	116	3 41 *m*	277
,, 27 ...	Lacaille 8248	7·0	—	—	2 32 *m*	180

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

MARS is a morning Star, but practically invisible.

JUPITER is still badly placed, having been in conjunction with the Sun on December 18th. It is a morning star. Polar semi-diameter, $18\frac{1}{3}''$.

TABLE 21.

Day.	West.		East.	Day.	West.		East.
Apr. 1	41	○	2● 3●	Apr. 16	4	○	132
,, 2	4	○	123	,, 17	41	⊙	3
,, 3	412	○	3	,, 18	42	○	13
,, 4	24	○	13	,, 19	41	○	32
,, 5	13	○	42	,, 20	43	○	12
,, 6	3	○	124	,, 21	3241	○	
,, 7	32	○	4 1●	,, 22	32	○	14
,, 8	31	○	4 2●	,, 23		○	1324
,, 9		○	1324	,, 24	1	⊙	34
,, 10	12	○	34	,, 25	2	○	134
,, 11	2	○	134	,, 26	1	○	234
,, 12	1	⊙	24	,, 27	3	○	124
,, 13	3	⊙	12	,, 28	321	○	4
,, 14	342	○	1●	,, 29	32	○	14
,, 15	43	⊙	2●	,, 30	4	○	32 1●

Configurations of Jupiter's satellites at 3^h *m* for an inverting telescope.

Satellite phenomena visible at Greenwich, $1^d\ 3^h\ 9^m$ II. Oc. R.; $4^h\ 40^m\ 15^s$ III. Ec. R.; $4^d\ 5^h\ 16^m\ 11^s$ IV. Ec. D.; $6^d\ 3^h\ 33^m$ I. Sh. I.; $4^h\ 51^m$ I. Tr. I.; $7^d\ 4^h\ 25^m$ I. Oc. R.; $12^d\ 3^h\ 54^m$ III. Tr. E.; $13^d\ 4^h\ 3^m$ IV. Tr. E.; $14^d\ 2^h\ 45^m\ 15^s$ I. Ec. D.; $15^d\ 2^h\ 11^m$ I. Sh. E.; $2^h\ 56^m\ 58^s$ II. Ec. D.; $3^h\ 29^m$ I. Tr. E.; $17^d\ 3^h\ 13^m$ II. Tr. E.: $19^d\ 2^h\ 32^m$ III. Sh. E.; $4^h\ 34^m$ III. Tr. I.; $21^d\ 4^h\ 38^m\ 57^s$ I. Ec. D.; $22^d\ 1^h\ 47^m$ I. Sh. I.; $3^h\ 3^m$ I. Tr. I.; $4^h\ 5^m$ I. Sh. E.; $23^d\ 2^h\ 39^m$ I. Oc. R.; $24^d\ 2^h\ 56^m$ II. Tr. I.; $3^h\ 10^m$ II. Sh. E.; $26^d\ 3^h\ 25^m$ III. Sh. I.; $29^d\ 3^h\ 41^m$ I. Sh. I.; $30^d\ 1^h\ 1^m$ I. Ec. D.; $1^h\ 45^m$ III. Oc. R.; $4^h\ 30^m$ I. Oc. R.

All the above are in the morning hours.

SATURN is an evening Star, 6° South-east of the Pleiades. Polar semi-diameter 8″. The major axis of the ring is 39″, the minor axis 17″. The ring is now approaching its maximum opening and projects beyond the poles of the planet.

The planet is too near the Sun for convenient observation of the satellites.

URANUS is a morning star, but badly placed, having been in conjunction with the Sun on January 24th.

NEPTUNE was in opposition on January 14th and is stationary on April 4th. Its motion may be traced on the map of small stars which was given in "KNOWLEDGE" for December, 1911, page 476.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant.			Remarks.
	R.A.	Dec.		
Mar. to May	263°	+	62°	Rather swift.
April 12 to 24	210	−	10	Slow, fireballs.
,, 16 to 25	301	+	23	Swift, streaks.
,, 18 to 23	189	−	31	Slow, long.
,, 20, 21	261	+	36	Swift, bluish white.
,, 20 to 22	271	+	33	Swift, conspicuous shower.
,, 20 to 25	218	−	31	Slow, long paths.
,, 30	291	+	59	Rather slow.
April to May	103	+	58	Slow, yellow.
April to May	296	+	0	Swift, streaks.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 10^h to 14^h, next month 12^h to 16^h, and so on. In the case of Algol variables, the time of one minimum is given where possible, and the period. Algol, owing to its brightness, will be given for wider limits.

TABLE 22.

ALGOL STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Minimum.
	h. m.			d. h. m.	d. h. m.
Algol	3 2	+40°·6	2·3 to 3·4	2 20 49	Apr. 4 0 57 *m*
ST Urs. Maj	11 23	+45 ·7	6·7 to 7·2	8 19 0	

NON-ALGOL STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m.			d.	
S Leonis	11 7	+ 6°·0	9·0 to 13	$189\frac{1}{2}$	May 4.
R Comae	12 0	+19 ·3	7·3 to 14	$361\frac{1}{5}$	June 8.
SU Virginis	12 1	+12 ·9	8·8 to 13	205	May 10.
T Virginis	12 10	− 5 ·5	8·2 to 13	$339\frac{1}{2}$	May 15.
T Can. Ven.	12 26	+32 ·0	8·6 to 11·8	$290\frac{1}{2}$	Mar. 26.
R Virginis	12 34	+ 7 ·5	6·2 to 11·1	$145\frac{1}{2}$	May 4.
RU Virginis	12 43	+ 4 ·7	7·6 to 11·8	440	May 26.
U Virginis	12 47	+ 6 ·0	7·7 to 13	206·9	May 29.
RR Urs. Maj.	13 23	+62 ·8	8·6 to 13	$229\frac{1}{2}$	Apr. 3.
R Hydrae	13 25	−22 ·8	3·5 to 10·1	425	Apr. 17.
T Urs. Min.	13 33	+73 ·9	8·8 to 13	321	Mar. 26.
V Urs. Min.	13 37	+74 ·8	7·5 to 8·7	71	Mar. 28.

CORRESPONDENCE.

A PHYSICAL PHENOMENON.

To the Editors of "KNOWLEDGE."

SIRS,—Two days after reading Mr. J. C. Clancey's letter, I came across the following passage in "Memoirs of Benvenuto Cellini, written by himself," about 1558. Translated by Thomas Roscoe. Page 295:—

"Another circumstance I must not omit, which is one of the most extraordinary things that ever happened to any man, and I mention it in justice to God and the wondrous ways of His providence towards me. From the very moment that I beheld the phenomenon, there appeared (strange to relate!) a resplendent light over my head, which has displayed itself conspicuously to all that I have thought proper to show it to, but those were very few. This shining light is to be seen in the morning over my shadow till two o'clock in the afternoon, and it appears to the greatest advantage when the grass is moist with dew; it is, likewise, visible in the evening at sunset. This phenomenon I took notice of when I was at Paris, because the air is exceedingly clear in that climate, so that I could distinguish it there much plainer than in Italy, where mists are much more frequent: but I can still see it even here, and show it to others, though not to the same advantage as in France."

TRESSILLIAN P. WIGGINS.

"WOODHAM MORTIMER," LEE, KENT.

THE NEW ASTRONOMY.

To the Editors of "KNOWLEDGE."

SIRS,—I write this letter to you in the hope of publication, as it contains the following challenge to the official astronomers of Great Britain. Can they give any explanation of the Spectra of Novae, without accepting *in toto*, Professor Bickerton's theory of the "Third Body" as an inevitable consequence of the partial impact of colliding suns, which he propounded nearly thirty-four years ago? Nova Geminorum is still blazing, and a most interesting series of spectrograms from it are open for their explanation.

During 1911, some time before the star above mentioned appeared, you published, in September and October, full details of the theory of the "Third Body," what Professor Bickerton concluded would be its life history, and the evidence, a light curve and varying spectra which must accompany such a phenomenon. Let us consider what he said, and what has taken place. A Nova shines for many months, and is not the actual collision of two suns; which may be of only short duration, perhaps lasting but an hour. With regard to this point Professor Barnard may be mentioned, as he has conclusively proved that neither a collision between suns nor that of a sun and nebula would have anything similar to the characteristics of a Nova: which is negative, but has an exclusion value in demonstrating Bickerton's thesis that the Nova is the "Third Body" shorn from the grazing suns, and his claim that every known spectrogram proves it. All astronomers who have studied stellar impact, from Lord Kelvin downwards, have entirely overlooked the fact that they were regarding phenomena similar to the clash of flint and steel, in which each Nova was a cosmic spark. Professor Bickerton, alone, deduced this inductively, demonstrated it, and claims recognition upon the confirmation of all spectrograms of novae in existence. Once grasp this simple conception, and the triple mystery of these stupendous explosions called temporary stars, their thermodynamic power, unique light curve and complex varying spectra are explained in every detail. Can official astronomy otherwise account for them? The exploding "Third Body" has been entirely ignored, and one may search in vain through all recognised astronomic literature without finding any trace of its conception or comprehension; though it explains any observation ever made on a new star. One eminent astronomer though, I believe, admits there is such a thing, but only to say, "Why make such a fuss?" and deems it unworthy of further consideration. I shall await with interest any alternative explanation of the spectrograms already referred to. The accounts of the spectra from N Persei and N Geminorum in their earliest stages, the only two, I believe, ever obtained during the uprise of the light curves of novae, are similar to those of an ordinary star, with black lines, the hydrogen not having had time to escape. The next day all over the world spectra of the N Aurigae type were obtained, and the sequence deduced by Bickerton, showing the hydrogen escaping first in accordance with his theory of atom sorting and the formation of ensphering shells, vividly described in the articles in "KNOWLEDGE" referred to, was completely demonstrated, thus rendering the official enigma of these spectrograms so transparent that any intelligent child could explain them. Professor Barnard tells us he actually has seen this wonderful crimson hydrogen halo form and disappear; the first stage of the phenomenon named by Bickerton "Selective molecular escape." In a recent address given to the B.A.A., Professor Bickerton showed that in increasing perfection of detail, the South Kensington, Greenwich, Madrid, and Cambridge spectrograms of Nova Geminorum, combined with light curves, absolutely confirmed the majority of the principles of the Third Body he dynamically deduced and published a third of a century ago, and, as he aptly says, they leave no more doubt of the effect of solar collisions than the wrecked locomotives and telescoped carriages do of a railway accident. Yet official astronomy looks on in impotent silence, not apparently daring to admit the mistake of ignoring one of the greatest discoveries ever made. The scientific neglect of Bickerton's "Theory of Partial Impact" is deplorable and incomprehensible, but, unfortunately, not without precedent. To mention only the case of Mendel, thirty-four years elapsed before the value of his work was recognised, to the untold loss of humanity. It is just thirty-four years since Bickerton first published his epoch-making papers, and I hope, even now at the eleventh hour, that the generalization, for which he has sacrificed a third of his life, may be recognised as the basis of a greater astronomy and its concomitant, a valid optimistic philosophy.

SYLVESTER N. E. O'HALLORAN.

7, ALMA SQUARE, N.W.

THE ALCHEMICAL SOCIETY.

THE Second General Meeting of the Alchemical Society was held at the International Club, Regent Street, S.W., at 8 p.m., on Friday, February 14th. The Chair was taken by Mr. Walter Gorn Old, and a paper was read by Mr. Arthur Edward Waite (whose many translations of alchemical works are well known to students) on "The Canon of Criticism in respect of Alchemical Literature."

The lecturer dealt with the possible existence of a mystic element, in alchemical literature, from a very early period, side by side with the work of attempted metallic transmutation, and briefly traced its development. The lecturer further considered what is implied by the fact of this mystical element, whether it was a question of philosophical and theological doctrine or one of mystical practice and experience; and he pointed out the need of a canon by which to determine which alchemical texts are physical and which are metaphysical in their object.

The lecture and an abstract of the discussion has been published in the February number of the "Journal" of the Society.

STRETCHED FILMS OF LIQUID.

PROFESSOR C. V. BOYS' RAINBOW CUP.

By E. S. GREW, M.A.

One of the chief interests of the liquid film, as displayed, for example, in a soap bubble, is that its tenuity is such as almost to bring the observer within reach of molecules. An interest which is even more popular, and which is not on that account of less scientific usefulness, is the extreme beauty of the reflections of light from the double surface of a film. These are apparent in that commonest of objects, the soap bubble, but unless one has the manipulative dexterity of Mr. C. V. Boys a soap bubble is difficult to examine in detail or at leisure. At the anniversary meeting of the Royal Society, however, Mr. Boys exhibited a device which allows the least accomplished observer to vivisect a soap bubble, and to lay bare the changes which, owing to the progressive thinning of the film, it undergoes in its life history.

The device he has since called the "Rainbow Cup," a title which is readily explained by the most characteristic appearance of the film when stretched across the crater of Mr. Boys' Cup. The cup is a revolving brass drum, across the top of which it is easy to stretch a film or membrane of soap solution. When the drum is set spinning the film thins from its centre to its circumference, partly as the result of centrifugal action; partly, because where the upper and lower surfaces of the film join the edge of the drum a sort of suction pump action is continually going on. A film, which is practically a sandwich of liquid between two stretched skins, is always joined to a solid surface like the edge of the drum in a conical formation, roughly, thus:—

>————<,

and the V's at either end of the film are always sucking away the liquid in the film.

Figure 115.

Professor C. V. Boys' Rainbow Cup.

Now as everyone knows there is a constant play of iridescent colour on the surface of a soap-bubble. This is due to the rays of light reflected from it being reflected from the inner skin, as well as from the outer skin of the film, just as in a looking glass one may sometimes see two reflections, one image arising from the glass surface, the other from the silvered back. Consider now the case of red rays of a fixed wave length of light falling on the two surfaces of the soap bubble's film. If the two surfaces are exactly the proper distance apart, the waves coming back from the inner reflecting surface, may exactly meet and neutralise the waves reflected from the outer surface—the crests of one series of waves coming exactly where the troughs of the other series of waves are situated. If, however, the twin surfaces are "half a wave length of red light" further apart, or half a wave length of red light nearer together, the crests and troughs of the two sets of waves will not neutralise, but will reinforce one another. Thus we can easily imagine a red reflection from the film appearing and disappearing and appearing again, as the film thinned to appropriate dimensions. But the different colours of light have different wave lengths; so that when the film fails to reflect one kind of light, it may yet be reflecting another. The thickness of the film unsuitable for showing up the red or the pink may be suitable for reflecting the green: then as the film grows thinner the pink's turn comes again and the green disappears, and so into the other colours, the blues, violets, straw colours, into which during the whole of its life the film is analysing the white or yellow light falling on it.

These effects are apprehended, but are all mixed together on an ordinary soap bubble film: but in the film of Mr. Boys' revolving cup, the *regularly diminishing* thickness gives them an orderly succession. As the film becomes thinner the colours appear in circular rainbow bands in the following order, beginning with a film fifty millimetres of an inch thick:—pale green, pink, pale green, pink, bluish green, salmon colour, bright green, magenta, yellowish and then brilliant apple green, blue, purple, red, yellow, poor white, steel blue, purple, brown, straw colour, white, black. Each of these colours is related to its particular thickness of film which can be computed. The apple green is twenty millimetres of an inch thick. When the black is reached, far below the wave length of any light, the thickness of the film is only $\frac{1}{2000000}$th of an inch thick.

The black appears in a small spot at the centre of the cup (and of the spinning rainbow bands) and slowly grows. It can be made to grow faster by stopping the rotation and tilting the drum. Then the black film being thinnest and, therefore, lightest, passes upwards, to the higher edge of the drum. It continually eats its way into the other colours of the film and Professor Boys in his paper in the Royal Society's *Proceedings* surmises that the areas of black thus formed, which assume the form of lines, streams, and meandering rivers, have steep banks. In certain circumstances a deeper black is set up within their areas, and this black film may be as little as the $\frac{1}{4000000}$th of an inch in thickness. At that stage one is justified in supposing that hardly more than five hundred molecules are set end to end through the black film's thickness.

These divagations of the black aided by stopping and starting and reversing the rotation of the drum several times, are productive of a number of very beautiful patterns of colour: Persian shawl patterns, spirals, and an innumerable variety of groupings of colour. Perhaps nothing is more striking, however, than the appearance of the surface of the film when, a considerable quantity of black having been allowed to grow, the drum is again rotated. The surface then appears like the eye of some strange beast, with a huge black pupil and a rainbow coloured iris.

It will be comprehended, however, that beautiful as the colour patterns are they are neither the end nor the aim of this instrument, which enables many striking phenomena of the surface tension of films, as well as of their thicknesses, to be measured and examined. The black film's movements, for example, provide the means by which the existence of "line tension" as distinct from surface tension of a film can be made manifest. Along the margin of the black area there exists a tension of the order of $\frac{1}{1000}$th or $\frac{1}{10000}$th of a dyne, the latter amounting roughly to the nineteenth of a grain. A large number of interesting experiments illustrating the surface tension can be made; one of the most striking is that of laying a loop of hair or of spun glass on the film and of then treating the film within the area of the loop. The surface tension immediately pulls the loop into a perfect circle. Small bubbles of coal gas can be joined to the film, and in this case, as in that of the spun glass hairs, the portions taken up can be compared mathematically with the thicknesses of the film.

The "Rainbow Cup" is made by Messrs. John Griffin, of Kingsway, to whom we are indebted for the loan of the instrument from which our photograph of the film, with the central black spot, was obtained.

REVIEWS.

CHEMISTRY.

Leather Chemists' Pocket Book.—Edited by Professor H. R. Procter, M.Sc., F.I.C. 223 pages. 4 illustrations. $6\frac{1}{4}$-in. × $4\frac{1}{4}$-in.

(E. & F. N. Spon. Price 5/- net.)

This little book is not intended to take the place of a laboratory text-book, but to give in a convenient and concise form outlines of analytical methods and the various data to which the chemist may have occasion to refer in connection with leather. Among the subjects dealt with are the analysis of water, the recognition of vegetable tannins, the estimation of tannin, and the analysis of oils and fats. As a rule sufficient directions are given, but in some cases, where more detail would have been advisable, the reader is referred to the author's larger laboratory book. This is most noticeable in the section dealing with oils. For example, on page 147 the bromine thermal test is dismissed with the remark that it conveys little information not given more satisfactorily by an estimation of the iodine value. This is true; but it omits mention of the fact that the thermal method gives the result in five minutes, and is applicable to most oils and fats.

There is a useful section upon microscopical manipulation and another upon the general methods of bacteriological examination, which might with advantage be amplified.

The book, which is well printed and excellently bound in leather, should be found of constant use to the class of chemists and students for which it is intended.

C. A. M.

Radium and Radioactivity.—By A. T. Cameron, M.A., B.Sc. 185 pages. 23 illustrations. $6\frac{3}{4}$-in. × 5-in.

(The Society for Promoting Christian Knowledge. Price 2/6.)

In a book intended for readers who have little or no previous chemical knowledge we look for simplicity of language and clear description which assumes nothing to be known beforehand. These conditions are well fulfilled in this little book, which gives a most readable outline of the discovery of radioactivity and the preparation and properties of radium. Interesting chapters are also devoted to the production of energy in radioactive changes and its bearing upon the estimation of the age of the earth; to the question of the transmutation of the elements; and to the uses of radium in medicine. The book is well illustrated with photographs and diagrams, and anyone who wishes to have a summary of the present state of knowledge on this subject cannot do better than obtain a copy. In the next edition it would be an improvement if an index were added.

C. A. M.

Lead Poisoning and Lead Absorption.—By Thomas M. Legge, M.D. and Kenneth W. Goadby, M.R.C.S. (International Medical Monographs). 308 pages. 4 plates and numerous diagrams. $8\frac{1}{2}$-in. × $5\frac{1}{2}$-in.

(Edward Arnold. Price 12/6 net.)

Though the units of the International Medical Monograph series are intended chiefly for medical men and for those whose work lies along the lines indicated by the titles of the individual volumes, yet the subject of Lead Poisoning is one of such national and international importance that the text book on it by Drs. Legge and Goadby ought to find a much more general audience. There is no Industrial disease which has attracted so much attention to itself as lead poisoning, and none in which the interests of manufacture have appeared to conflict more continuously with those of the workmen. It is not easy to perceive the reason of this, unless it may be that in a number of the industries where lead is used women are employed because the nature of the occupation does not require unusual physical ability, and that the effects of lead poisoning on women, who are more susceptible to it than men, have shocked the philanthropic community. Otherwise, it would be quite easy to show that lead poisoning is the cause of far fewer deaths and disabilities than arise in many other occupations; and, compared with the number of "accidents of occupations," the proportion of cases of dangerous lead poisoning is extremely small. The smallness of the proportion becomes more marked where specific trades, such as that of painting, are considered; for, contrary to general belief, painting is one of the healthiest trades.

It is, however, when all the trades in which white lead, or carbonate of lead is employed, are considered, that the number of cases of lead poisoning rises; and the reason for this is largely to be assigned to the ignorance of the nature and causes of lead poisoning. Dr. Goadby, who contributes the bulk of the chapters relating to the pathology of the disease, makes it quite clear that while lead poisoning may arise from any cause by which lead is infiltrated into the system, the chief danger arises when lead dust is inhaled. It is important, as Dr. Legge points out, that precautions should be taken by manufacturers, and should be enjoined, and as far as possible made compulsory, on workmen, to prevent them swallowing lead with their meals or in any other way; but it is far more important that regulations such as Dr. Legge describes and prescribes for drawing off the dust by fans should be made compulsory. Dr. Legge is one of H.M. Medical Inspectors of factories, and it is to be hoped that the strong line he takes on the necessity for the highest degree of precaution in the prevention and withdrawal of lead dust by mechanical processes will be emphasised by legislation.

Dr. Goadby's chapters on the physiological aspect of lead poisoning are a piece of brilliant pathological investigation. He shows indisputably the paramount influence of the inhalation of dust, and makes out very clearly the pathological conditions which give rise to minute hemorrhages throughout the organism, finally extending to the nervous system, and giving rise to the characteristic symptoms. He describes, also, an apparent form of acquired immunity to lead-poisoning, which appears among some workers; but it is evident that while such cases present themselves, there are others in which there is a specialised sensitiveness to the lead; and it is also evident that in such cases treatment may become very difficult.

E. S. G.

GEOGRAPHY.

The Lost Towns of the Yorkshire Coast.—By THOMAS SHEPPARD, F.G.S. 329 pages. Illustrated. 9-in. × $5\frac{1}{2}$-in.

(A. Brown & Sons. Price 7/6 net.)

This book, by the able and energetic curator of the Hull Museum, covers a much wider range than is indicated by its modest title. In reality it is a very complete geography of the East Riding of Yorkshire. Since Roman times, according to one authority, a strip of land averaging three and a half miles in width, or about one hundred and fifteen square miles, has been swallowed by the sea between Flamborough Head and Kilnsea. On the other hand the destroyer is sometimes stayed and land is even wrested back from him. Between 1848 and 1893, seven hundred and seventy-four acres were lost in Yorkshire, but during the same period, two thousand one hundred and seventy-eight acres were reclaimed within the Humber estuary. Many old towns and villages, however, have been washed away; but with the aid of ancient documents and maps, the author has been able to preserve their history, and even to indicate their former sites. The records of the lost towns occupy sixteen chapters. The rest of the book is taken up by a comprehensive geography of the district, which includes notes on the geology, natural history, antiquities, architecture, administration, agriculture, and the Humber mud. The latter is a particularly interesting chapter. The book is well illustrated and has been done with a thoroughness which makes it good reading.

G. W. T.

Map Projections.—By ARTHUR R. HINKS. 126 pages. 19 illustrations. 10 tables. 9-in. × $5\frac{1}{2}$-in.

(The Cambridge University Press. Price 5/- net.)

This book is written to meet the demand of those who approach the subject from a purely geographical point of view, whose mathematical equipment is not elaborate. But in addition to a knowledge of plane trigonometry and the rudiments of spherical, some acquaintance with the process of differentiation and its meaning is required for its perusal.

There are some obscurities here and there in the book. The writer has confused his symbols for the constant of the cone (pages 10–11, 76, 78.) The definition of this quantity given at the head of page 76 requires re-statement. Non-mathematical readers are not likely to be misled by expectations of mathematical nicety of phrase, and so not all will agree that there is danger in regarding the simple conical projection at first as obtained by the development of a cone. Some points not quite clear in the book are rendered so by this method of attack. Again, readers will find it inconvenient that the mathematical treatment of the various projections in use comes quite separately from the general discussion in chapter VIII. There is necessarily a good deal of mathematics in chapters II–VI, but as this is incomplete these chapters cannot be read intelligently without continual references to chapter VIII. Necessarily, too, the tables at the end are too meagre to be of much service even to those who are not primarily interested as cartographers. No one could expect to be able by the aid of a concise text-book to dispense with regular complete tables, and possibly the space devoted to them would have been more profitably devoted to extending chapter VII, which deals with projections in common use and the recognition of them, and is one of the most interesting and useful to this class of reader.

Many of these blemishes are incidental to a book which has not had very many forerunners, and in any case faults are always easy to find. On the whole, the purpose of the work has been very fully realised and it will be an acquisition to intelligent readers of geography. It is the best of its kind we have seen, and can be most heartily recommended to those who wish to begin the study of maps. Considering the limited appeal of books of this type its price is very moderate, and the get-up is of the satisfactory nature associated with the Cambridge University Press.

A. S.

MINING.

Safety in Coal Mines.—By DANIEL BURNS, M.Inst.M.E. 158 pages. 23 figures. 1 plate. 7-in. × 5-in.

(Blackie & Son. Price 2/6 net.)

This book is written principally for colliery firemen, whose work is concerned with the safety of the mine, and on whose vigilance the lives of their fellow-workmen depend. It is intended for use as a text-book for the examination firemen have to undergo in accordance with the New Mines Act, and to furnish an account of the scientific principles which are the basis of their practical instruction. The first chapter contains a simple account of the elements of chemistry, especially in so far as gases are concerned. The next chapter describes the constituent elements of the mine gases. In the third the methods of detecting and testing the compounds and mixtures which form the mine gases themselves are described. The fourth and fifth chapters deal with air measurement and safety lamps respectively. The book is written very simply and clearly, and should well serve its intended purpose.

G. W. T.

ORNITHOLOGY.

Report on the Immigrations of Summer Residents in the Spring of 1911. Also Notes on the Migratory Movements and Records received from Lighthouses and Light-vessels during the Autumn of 1910. Edited by W. R. OGILVIE-GRANT. By the Committee appointed by the British Ornithologists' Club. 332 pages. 20 maps. $8\frac{3}{4}$-in. × $5\frac{3}{4}$-in.

(Witherby & Co. Price 6/- net.)

The introductory section of this Report (the seventh consecutive annual one on the subject) is an admirably brief and illuminating comment on the contents which follow. These, as usual, go into great details, but no attempt is yet made to critically examine or co-ordinate the voluminous material which has been printed. The editor repeats his expression of regret at being unable to reduce the size of the Report and continues to give pages of records similar to those published for previous years and well known to the student. For example, particulars are given of the arrival of the Wheatear in Southern England, during the latter half of March, and these add nothing to the general knowledge of the occurrence of this species. It is the converse that would be noteworthy in this case, namely, a month of March in which the Wheatear did not turn up in the district named. The Report schedules the majority of our spring immigrants and gives a chronological summary of the records under each species, the movements of some being also illustrated by maps. Under the other sections of the Report, further observations are also made on these species (amongst others), and it would be a distinct convenience, in the absence of any index, to give references under the scheduled bird to the pages on which any further notes on the species are to be found. We have had occasion to look up the Land-Rail (Corn-Crake) and find that in addition to the main entries on pages 148–150, there are others on pages 209, 213, 214, 255, 277 and 302, all of which have to be puzzled out by the reader himself, unaided by any cross-reference. The great scarcity of this species now in south-eastern England is well illustrated by there being no records of it from the counties of Dorset, Sussex, Buckingham, Hertford, Essex, Bedford, Huntingdon, Cambridge, and Norfolk, and only few reports from Kent, Hants, Surrey, Middlesex, Berks, Suffolk and Lincoln.

Of the autumnal movements (1910) there are particularly good accounts of the Golden-crested Wren, and of the unusual irruption of the Mealy Redpoll (*Linota linaria*), which, during October, visited in numbers the whole line of the east coast from the Shetlands to Kent and many inland places. The first record of the Magpie as a migrant to our shores is remarked upon, twenty birds having been seen arriving at Thanet (E. Kent) from the north-east on 28th September, and fifteen from the north, during an easterly gale, on 14th October.

The Scottish records, which are so fully published elsewhere, are only partially utilised by this Report, and it might prevent misleading conclusions being arrived at, if Scotland, like Ireland, was excluded from the purview.

H. B. W.

PHYSICS.

Experimental Researches on the Specific Gravity and the Displacement of some Saline Solutions.—By J. Y. BUCHANAN, M.A., F.R.S. 227 pages. 12-in.×$9\frac{1}{2}$-in.

(Neill & Co. Price 7/6 net.)

The author of this book, who acted as chemist and physicist on the memorable "Challenger" expedition, has made a close study of the subject of specific gravity for the last forty years; and the present volume is devoted to researches on saline solutions carried out during recent years by the aid of hydrometers. As usually constructed, the accuracy of the common hydrometer depends upon the correct calibration of the scale, which is marked off by reference to other standards; and hence most workers, when conducting precise work on specific gravities, employ the pyknometer in preference. Mr. Buchanan shows, however, that by standardising a hydrometer by reference to its own displacement, it is possible to secure results of a much greater degree of accuracy than is attainable by any method involving a series of weighings. Two forms of hydrometer are described:—the closed type, which may be made to sink in the liquid under trial by placing weights on the top, and which is used for the less dense solutions; and the open type, which may be weighted internally, and will, therefore, maintain its stability in the very dense solutions for which it is used. Full details of the method of standardisation are given.

The book contains the records of some thousands of observations, extending over some years, of the specific gravities of water solutions of a number of salts, ranging in strength from saturation to $\frac{1}{1024}$ of a gram-molecule per litre. Amongst the salts used are chlorides, bromides, iodides, iodates and nitrates of sodium, potassium, caesium, rubidium, lithium, barium, calcium and lead; and also various mixtures of salts in some definite proportion of their molecular weights. Many interesting relations between the specific gravities and displacements and the molecular weights are revealed as the result of accurate observations, and are shown in the form of diagrams and graphs. Of special interest is the graph on page 154, which represents the fluctuations in the increment of displacement in solutions of common salt ranging in strength from $\frac{1}{8}$ to $\frac{1}{128}$ of a gram-molecule per litre, the results indicating a series of interactions between the water and the salt at these low concentrations. It would be interesting to compare a water solution of a non-electrolyte, such as sugar, with those of salts in this connection.

An observation made incidentally with a supersaturated solution of calcium chloride is at once remarkable and suggestive. It was noted that this solution, prior to crystallisation, was in a state of unrest, undergoing a rhythmic series of isothermal expansions and contractions, which were detected by the delicate hydrometer used. Further investigation on these lines with other supersaturated solutions, and with suffused or overcooled liquids, is highly desirable; and might assist in diagnosing the cause of these abnormal states.

The effect of temperature upon the accuracy of the observations is discussed, and details given of the methods used to secure a constant temperature during the readings. A favourite working temperature was 19·5°C, which could most easily be attained and kept constant in the room. Many hints for accurate working may be gathered from the book, which may be recommended to all interested in the determination of specific gravities, and also to those engaged in the study of solutions, who may find in it suggestions for attacking the various problems from another standpoint.

CHAS. R. DARLING.

Elementary Physical Optics.—By W. E. CROSS, M.A. 311 pages. With many diagrams. $7\frac{1}{2}$-in ×5-in.

(The Clarendon Press. Price 5/- net.)

When some years ago some Royal Institution lectures were delivered on Waves and Ripples in the Air and in the Ether, the lecturer, while describing and illustrating by many examples the wave motion of light, was obliged to consign his treatment of optical problems of deflection, refraction and dispersion of light on this basis, to an appendix to his lectures, subsequently published. Mr. W. E. Cross, who is the Head Master of King's School, Peterborough, has more boldly grappled with the difficulty. It is comparatively simple in illustrating geometrical optics to convince the pupil of their validity by using the "ray," or the line, as the unit; but having been taught in such a way it will be long afterwards before the boy will have arrived at sufficient proficiency in mathematics to draw any general conclusions from the experiments presented to him. If however the idea of a wave front, or advancing trains of ripples of light be presented to him, he will understand it, but he may find a difficulty in reconciling theory with experimental effects. After all a boy can see a ray, but cannot discern a light wave.

Mr. Cross compromises. He uses the ray in demonstrating the action of lenses, mirrors and prisms, but he explains their action by the change of curvature brought about in the wave fronts, or by change of velocity, when, as in refraction, the wave passes from one medium to another. By treating a ray not as a mathematical conception, but as a narrow cone of light, isolated from the wave series of which it forms a part, but possessing none the less all the properties of light waves, he arrives at a conception which causes no confusion of ideas, and in which there is no discrepancy between experiment and theory. The idea is not only sound: it is worked out so well as to give a solidity and an interest to the pupil's conception of the nature of light such as the older method cannot impart.

E. S. G.

RADIOACTIVITY.

Studies in Radioactivity.—By W. H. BRAGG, M.A., F.R.S. 196 pages. 70 diagrams. $8\frac{3}{4}$-in.×$5\frac{3}{4}$-in.

(Macmillan & Co. Price 5/- net.)

This work by Prof. Bragg forms the latest volume in Messrs. Macmillan's series of Science Monographs. The volumes in this series are intended to represent "the expression of modern scientific work and thought in definite directions," and each volume will be by a specialist and mainly descriptive of his own contributions to the field of scientific work dealt with. They will thus be more adapted to the requirements of the advanced student than to those of the beginner. Prof. Bragg's book admirably fulfils the intention of the series, and he has very wisely not omitted to describe briefly the researches of other experimentalists, as well as his own most valuable ones, which come within the subject of the work.

Prof. Bragg's researches deal mainly with the passage of α, β, γ and X-rays through gases and solid bodies, the arrest, scattering and loss of energy of the rays, and their ionising powers; and he points out many close similarities (together with no less marked differences) in the behaviour of the three types of rays. Prof. Bragg considers that the corpuscular theory of the γ and X-rays will prove the more useful, and brings forth several interesting arguments against the ether-pulse theory. But these arguments all appear to be based on the assumption that the ionising power of the γ and X-rays is entirely due to their conversion into β rays, the latter being alone responsible for the ionisation. The experimental evidence offered for this assumption, however, seems somewhat inadequate.

H. S. Redgrove.

ZOÖLOGY.

An Introduction to the Study of the Protozoa.—By E. A. Minchin, F.R.S. 517 pages. 194 illustrations. $8\frac{3}{4}$-in.$\times 5\frac{1}{2}$-in.

(Edward Arnold. Price 21/- net.)

The recognition during the last decade or so of the extreme importance of the part played by the lowest of all animals in the economy of nature—and more especially as regards man himself—has led to the Protozoa being studied with an amount of labour and zeal never, perhaps, accorded to any other group of animals. And among those who have laboured hardest in this productive field is the author of the volume before us, who, with the true modesty of a great investigator, claims for his work only the position of an introduction to the vast subject he has made his own, and that it is not to be regarded as a complete treatise. To set forth all that is already known concerning the Protozoa would, he says, require a work many times as large. That the present volume is not intended for amateurs, goes without saying; its aim being to supply students who have at least some general knowledge of biology, with a means of taking up the study of the Protozoa in real earnest. How important to the biologist is this study may be gleaned from the single fact that, apart from all other considerations, it throws "great light on some of the fundamental mysteries of living matter—as, for example, sex."

In so wide a field it is essential to concentrate attention on particular aspects of the group, and Professor Minchin has, therefore, very wisely laid especial stress on the parasitic forms, both on account of the biological problems they present and of their intimate association with the practical needs of human life. The medical aspect of parasitic protozoans is, however, very properly left to the doctors, who are furnished by the author with a solid basis of fact upon which to work. In his concluding chapter, the author gives some most interesting speculations with regard to the origin of the Protozoa and the types which should be regarded as most closely approximating to the ancestral stock. In his opinion the nearest approximation to that stock would be "a minute amoebula-form, in structure a true cell, with nucleus and cytoplasm distinct, which moved by means of pseudopodia." To all workers on the subject Professor Minchin's volume is absolutely indispensable.

R. L.

The Childhood of Animals.—By P. Chalmers Mitchell, F.R.S. 269 pages. 36 illustrations. 12 plates. $9\frac{3}{4}$-in.$\times 6\frac{1}{4}$-in.

(Wm. Heinemann. Price 10/- net.)

The subject of which Dr. Mitchell treats in such a fascinating manner in this volume is to a great extent untrodden ground, for although we all know that caterpillars change into butterflies and moths, and tadpoles into frogs and toads, while the young of many species of mammals differ to a greater or less extent from their parents in the matter of colouring, yet the meaning of these changes and the purposes of youth have never previously, we believe, been discussed in the thoughtful and thorough manner characteristic of the present work. The basis of the work was a course of lectures delivered by the author to a juvenile audience, at the Royal Institution, during the Christmas season of 1911-12; and although the work itself is not a printed version of the discourse, yet it tells the same story, although in a somewhat different and fuller fashion, more adapted to the requirements of adult readers. Although the work makes no pretence to be a complete treatise on such a wide subject, yet it covers a great deal of the ground, and records a very considerable proportion of published observations relating to that period of the life of animals intervening between birth and maturity. To review the volume in detail is not possible within our limits of space; and we can, therefore, only refer to a few interesting points. In the chapter on the duration of youth in mammals, it is pointed out that this period is longer among the more civilised than among the lower human races, and that in the former it appears to be still increasing in length. In rhinoceroses, horses, and tapirs the length of the duration of youth appears to vary according to the bodily size of the animals; and the same also holds good among ruminants, in which, however, owing to the advanced stage of development of the young at birth, the period of youth is unusually brief. Much interesting information is to be found with regard to the colour-patterns of young mammals, as contrasted with those of their parents. In mammals, the author believes that spots were the primitive type of colouring, and that these are connected with the tesselated nature of the skin. These spots may expand into short stripes, or coalesce into longer longitudinal or transverse stripes, which undoubtedly help to render the animals inconspicuous, although this is not the cause of their development. A uniform coat, which so often replaces the spots or stripes of the young, but may occur in the first dress of the latter, is apparently a specialised development; and the same seems to be the case when vivid patches of colour, which do not correspond with structural differences in the body, replace the first coat. In the latter case the object of the pattern, which, unlike the retention in the adult of a juvenile spotted coat, is generally more pronounced in males than in females, may serve, by breaking up the outline of the body, for concealment.

The book should be studied by all naturalists, as well as by the general reader.

R. L.

Elementary Entomology.—By E. D. Sanderson and C. F. Jackson. 372 pages. 476 illustrations. 8-in.$\times 5\frac{3}{4}$-in.

(Ginn & Co. Price 8/6.)

The writers of this well-illustrated volume, who are professors and lecturers in American science colleges, have found by experience that no text-books on entomology have sufficed for their needs; and they accordingly endeavoured to produce one which shall meet the requirements of both elementary students and their teachers. In this, so far as we can judge, they appear to have attained a high degree of success; for the book, without being unduly technical, conveys a good idea of the anatomy, life-history, and classification of insects, and this, too, in a relatively small space. Of especial value are the "keys" to the important families of the various orders of insects, which are evidently drawn up with great care, and the meaning of which is in many instances made plain by the aid of explanatory diagrammatic illustrations. The dominant note of the book is, as might have been expected, the economical aspect of the subject; for the old-fashioned cabinet entomology is, at least to a great extent, dead and buried, and the modern cult devotes itself to the life-histories of insects, and their *rôle* as carriers of infection to man and animals and their injuries to live-stock and crops. The authors, however, very wisely insist that an adequate knowledge of really useful economic entomology cannot possibly be acquired merely by a more or less casual study of the common injurious insects; and they have accordingly produced a work which should enable every student to obtain a thorough mastery of the elements of the subject.

R. L.

The Evolution of the Vertebrates and Their Kin.—By W. Patten. 486 pages. 309 illustrations. 9-in.$\times 6\frac{1}{2}$-in.

(J. & A. Churchill. Price 21/- net.)

In this handsome volume Dr. Patten, Professor of Zoölogy at Dartmouth College, Hanover, N.H., records his endeavour to solve one of the greatest and most difficult problems with which biologists are now confronted. As he remarks, vertebrates suddenly make their appearance in the geological record at the close of the Silurian or the commencement of the Devonian, in the form of fully developed fishes. These are evidently a more highly organised type than any of the groups of vertebrates by which they are preceded; and it is obvious that they must have taken origin either from some of these preceding forms already known to us, by means of a strongly-marked transformation, or from other extinct types with which we are at present unacquainted. On either supposition, as the author observes, the missing links must date from the Silurian period: and considering the relatively large size of the earliest known vertebrates, it is a matter for surprise that these missing links have not yet been found. When we reach the Silurian "the main trunk of the animal kingdom, upon which the whole vertebrate stock rests, is lost, leaving, without reason or warning, a vast unknown abyss, beside which the gap between man and his immediate predecessors sinks into microscopic insignificance."

The annelids, the ascidians, *Balanoglossus* and its relatives have each been claimed in turn as the groups which came nearest to filling the gap; but Professor Patten will have nothing to do with any of them, and he pins his faith to the arachnids as representing, through the intervention of the so-called ostracoderms, the stock from which the great vertebrate phylum has sprung. And, to illustrate his views, he gives at the end of the volume an elaborate phylogenetic tree, whose roots are formed by the Protozoa, while mammals, birds, and reptiles form the topmost branches, with fishes branching off from the ostracoderms somewhat above the middle of the stem, and the latter, in turn, standing immediately above the arachnids. Not that the tree presents anything like a straight and unbroken trunk; for the ascidians. *Balanoglossus*, echinoderms, annelids, and a host of other forms, radiate out as complex lateral branches from near the base. Whether or no his views be generally accepted by morphologists, either wholly or in part, Professor Patten is to be congratulated on the completion of a most elaborate and valuable contribution to our knowledge of vertebrate evolution.

R. L.

Outlines of Evolutionary Biology.—By ARTHUR DENDY, F.R.S. 454 pages. 190 illustrations. $8\frac{1}{2}$-in. × $5\frac{1}{2}$-in.

(Constable & Co. Price 12/6 net.)

In claiming that biology should form one of the foundation stones of a modern system of education, the author points out that even an elementary study of biological theory should be preceded by a systematic course of laboratory work in zoölogy and botany. To aid students in this is the object of the volume before us, which commences with an account of a couple of primitive forms as a basis on which to explain some elementary ideas with regard to the nature of living things, and the differences between animals and plants. Then follows an account of the cell theory; while in later chapters we are introduced to the evolution of sex, variation and heredity, and the evolution of organic nature and adaptation to surroundings; while in the final chapters we have an excellent summary of the factors of organic evolution, commencing with a review of the works of the most eminent exponents of the theory of evolution, and ending with the evolutionary history of man himself. The whole subject is treated in a manner which should render the volume acceptable both to the beginner and to the student who has had some previous training; the freedom from unnecessary technicalities being a welcome feature. Among many interesting items, we have been specially enthralled by Professor Dendy's account of a peculiar organ in the head of a frog, which represents the last remnant of an unpaired pineal eye. We confess our own previous ignorance of the existence of such a structure in this well-known animal, but console ourselves by the thought that there are probably others who were in the same boat until they had read the many marvels revealed in Professor Dendy's excellent volume.

R. L.

YEAR BOOK.

Who's Who in Science—International, 1913.—Edited by H. H. STEPHENSON. 572 pages. 9-in. × $5\frac{3}{4}$-in.

(J. & A. Churchill. Price 8/- net.)

To this, the second issue of a most useful book, many additions have been made. The sections already appearing in the "Who's Who in Science" for 1912 have been enlarged, while Psychology and Geology have been added to the sciences represented. An important amplification is the list of the scientific societies of the world with their addresses and the many useful details about them. Endeavour has also been made to extend the list of the world's universities, and to supply the names of the principals, registrars and senior professors of all; but we are sorry to see that quite a long list of existing universites did not take the trouble to respond to the editor's request for information. We might emphasise the international character of the publication and say in conclusion it bids fair to be indispensable to every serious worker in science.

NOTICES.

USEFUL KNOWLEDGE SERIES.—We have received from Messrs. Hodder & Stoughton a list of new forthcoming publications, including the titles of the books coming under the above heading, as well as several for amateur gardeners and the first four volumes of the Open-air Series.

MACMILLAN'S NEW BOOKS.—The classified list of books issued by Messrs. Macmillan during the past month contains many dealing with scientific matters and education.

FRANCO-BRITISH TRAVEL CONGRESS. — It is intended to hold this congress in September, 1913, under the presidency of Lord Montagu of Beaulieu. From the proposed Agenda which has reached us, it should prove of considerable usefulness; and we notice in the first number of *France*, the official organ of the Franco-British Travel Union, which accompanies the Agenda, some interesting notes by Count Plunkett, F.S.A., on the Museums of France and Algeria.

THE JOURNAL OF THE ALCHEMICAL SOCIETY.—We welcome the appearance of a new journal, the first number of which (price 2s.) contains a paper on "The Origin of Alchemy" by our contributor, Mr. H. Stanley Redgrove, B.Sc., with a resumé of the discussion which followed its delivery. The journal is published for the Society, by Mr. H. K. Lewis, of 136, Gower Street, W.C.

A NEW COMPANY.—In future the business of Mr. J. H. Steward will be carried on by a private limited liability company under the style of J. H. Steward, Limited, at 406, Strand, London, W.C., from which address all outstanding liabilities will be discharged by the Company.

THE GOLDEN EAGLE.—Messrs. Witherby & Company, the publishers of "The Home-life of a Golden Eagle" have by special request prepared enlargements (measuring nine and a quarter by eleven and a half inches) of six of the principal photographs which were reproduced to form the plates in the book.

THE RAMBLERS' HANDBOOK.—The Federation of Rambling Clubs has issued for the first time a useful handbook containing many valuable hints and much information as to maps, houses of refreshment, ramblers' books, and so on, all for the modest price of 2d. The energies of the Union are primarily directed towards obtaining advantages for and giving help to the constituted clubs, but the good work which is done is helpful to all who ramble about the country. The Honorary Secretaries may be addressed at 25, Victoria Street, Westminster.

THE BRITISH ASSOCIATION.—For the meeting of the British Association, which will take place in Birmingham on September 10th to 17th next, the following sectional presidents have been appointed:—A (Mathematics and Physics), Dr. H. F. Baker, F.R.S.; B (Chemistry), Professor W. P. Wynne, F.R.S.; C (Geology), Professor E. J. Garwood; D (Zoology), Dr. H. F. Gadow, F.R.S.; E (Geography), Professor H. N. Dickson; F (Economics), Rev. P. H. Wicksteed; G (Engineering), J. A. F. Aspinall, M. Eng.; H (Anthropology), Sir Richard Temple, Bart., C.I.E.; I (Physiology), Professor F. Gowland Hopkins, F.R.S.; X (Botany), Miss Ethel Sargent, F.L.S.; L (Education), Principal E. H. Griffiths, F.R.S.; M (Agriculture), Professor T. B. Wood.

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

APRIL, 1913.

EXPERIMENTS ON LIQUID DROPS, GLOBULES, AND COLUMNS.

By CHAS. R. DARLING, A.R.C.Sc.I., F.I.C.

II.

LIQUID COLUMNS.

If a large drop of liquid be formed in a shallow layer of water (after the manner described in the previous article), so that the drop reaches the bottom of the vessel before parting, it will generally spread so as to take the shape of the lower portion of the vessel; and if the upper part of the drop be brought to the surface of the water, and the delivery tube be detached, a column of the liquid may form. In practice, however, it is not easy to obtain a liquid column in this manner; but by carrying out the following instructions the formation may be secured with ease and certainty:—Take a test-tube 2·5-cms. (1-in.) or more in diameter, and nearly fill the hemispherical end with water. Incline the tube, and pour *aceto-acetic ether* very gently down the side, until the level of the liquids rises about one centimetre in the cylindrical part. On erecting the tube, a column, similar to that shown in Figure 116, will be formed, the upper part being attached to the surface of the water, whilst the lower end rests on the test-tube. The curved sides of the column will be seen to possess a most graceful outline, and are bounded by water. The shape of the column thus formed may be varied by employing a wider tube, in which case the column will be relatively narrower at the top; or by gradual additions of water, which stretch the column longitudinally, causing the diameter at the middle to diminish until breakage occurs. The change produced by adding successive small quantities of water is shown in Figures 117–120, which represent four stages in the stretching of a column of *iso-butyl benzoate*. The varied outlines of the columns are extremely pleasing, and the last picture of the series shows the width at the moment of breakage, which in this case occurred during exposure, the column appearing in faint outline. After severance, the greater portion sinks to the bottom of the tube, the remainder hanging from the surface in the form of a globule. It may be added that the water should be allowed to trickle down the side of the tube, as, if dropped directly on to the column, water-bubbles are formed which impair the shape.

Figure 116.

A column of aceto-acetic ether in water.

It might be expected that any liquid slightly denser than water would, if insoluble, form columns in the manner described. This is not the case, however, for reasons which at present cannot be entirely explained. Orthotoluidine, for example, does not lend itself to these formations; and in the case of aniline a vessel of five centimetres in diameter is required, and even then it is difficult to prevent the column from sticking to the side, and so spoiling the shape. Iso-butyl benzoate, as purchased, varies considerably; the first sample procured by the writer behaved ideally, as in Figure 117, but three other specimens since obtained have entirely failed to produce satisfactory columns. Hence it is recommended, when it is desired to produce a column with certainty, to use aceto-acetic ether, which has given uniformly successful results.

*FIGURE 117.

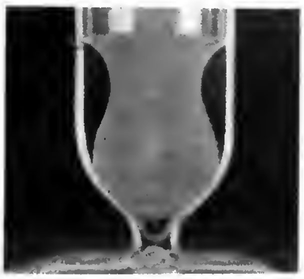


FIGURE 118.

THE MOVEMENTS OF LIQUID GLOBULES ON A WATER SURFACE.

Investigations of movements on the surface of water have hitherto been restricted to the rotation of camphor and a few other solids, and to the formation of films of oil, which spread across the surface rapidly in all directions from the spot on which the oil is placed. Whilst experimenting with aniline and orthotoluidine with a view to the formation of drops, the writer observed that the globules which floated on the surface of the water showed movements of a type not previously recorded, and for which no satisfactory explanation has yet been given. So far no photographs have been secured which give an idea of the nature of the movements in question, and hence it will be necessary to resort to drawings in order that an idea may be formed as to the nature of the phenomena. The accompanying illustrations are the work of Mr. W. Narbeth, one of the writer's students, and correctly represent certain stages; but to observe the movements to full advantage it is necessary to perform the experiments. In order to produce surface globules, a dish, ten centimetres or more in diameter, is taken—a photographic dish answers well—and rinsed several times with tap-water before it is filled. One or two drops of the liquid under trial are then allowed to trickle down the side of the vessel on to the water, when globules, sooner or later, will form. A dropping bottle or fine pipette will be found convenient for regulating the quantity of liquid, which, if too large, may obscure the movements.

When a drop of red-coloured, commercial aniline is thus floated on clean water, globules are formed which display movements best expressed by the word "twitching." What actually occurs is that the globule is stretched at first, but afterwards recoils, forming a globule of less diameter and greater depth. This alternate expansion and contraction is accompanied by the detachment of small globules from the rim, which becomes indented as shown in the largest globule depicted in Figure 121, the small globules being formed from the protuberances. After shrinking, the appearance presented is indicated by the second largest globule in Figure 121, which is shown surrounded at a distance by the small, detached globules. Finally, owing to continued partition at the rim, the diameter diminishes until, at a certain point, the movement ceases, leaving a number of small globules floating tranquilly on the water. If only a minute quantity of aniline be used, the globules may disappear entirely by spreading over the surface or by solution.

The next movement to be described is even more remarkable, and was first obtained by the author with orthotoluidine, but was only shown to perfection by one sample. Other quantities of the liquid since obtained have failed for some reason to produce equally good results; but the same movement is exhibited by the liquid *xylidine 1–3–4*. The globules formed when one or two drops of this liquid are allowed to run on the surface of water are endowed with remarkable activity. Simultaneously, all the globules above a certain size become indented on one side only, so as to resemble a kidney in shape, when each is projected violently across the surface of the water. Some of the forms taken by the globules are shown in Figure 122, in which it will be seen that in the process fragments are broken off the larger ones; and sometimes the indentation spreads to the opposite side and cuts the globule into two. A period of repose then follows, in which the globules all possess a circular outline; when suddenly, moved by a common impulse, all the larger globules again assume the kidney shape and dart across the surface. This continues until a number of small globules are left quietly floating on the surface; or the whole may disappear by spreading and solution. Sometimes the movements will continue, with increasing sluggishness, for an hour or more. The direction of motion across the surface is always away from the indentation, as if the globules were pushed by the

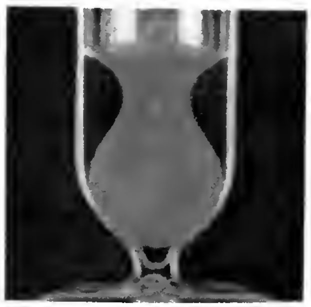


FIGURE 119.

FIGURE 120.

*FIGURES 117–120. A column of iso-butyl benzoate, stretched by adding water until breakage occurs. Four stages.

force which forms the cavity. Professor Boys has facetiously suggested that this should be termed the "kidney-disease" experiment.

The manner in which a film of liquid on the surface of water breaks into globules is shown in Figure 123, and is best observed with *dimethyl-aniline*. When a very small drop of this liquid is allowed to trickle on to water, it spreads out into a film of irregular shape, from the thin edges of which a number of small globules immediately form. Indentations then appear round the edges, which branch out into coral-like shapes, and simultaneously holes appear in the film from which similar branchings arise. The various channels unite in numerous places, thus cutting the film up into numerous small portions, each of which immediately becomes circular in outline; and by this beautiful process a film is resolved into globules in a few seconds. In order to see this remarkable movement to advantage, an exceedingly small drop of liquid must be used, and the water must be perfectly clean tap-water. The same action can be observed with *quinoline*, in which case the division occupies a much longer time; and the globules formed, after a few minutes, become perforated in the centre and remain on the surface in the form of rings, interspersed with plates containing several holes.

The surface movements described are only selected examples of a large number observed by the author: and it will be noted that the indentation of the edges of the globules or films is a common feature. There is little doubt that these indentations arise from the interplay of the tensions at work, but it is not evident why an aniline globule should be uniformly indented, whilst only one side of a globule of ortho-toluidine is attacked. The movements introduce new features which do not appear to be capable of explanation by the usual theories of surface tension.

It may be added that the movements may be shown to great advantage by the aid of a lantern provided with a horizontal stage, vessels with a bottom of plate-glass being preferably employed. Sufficient materials for showing the phenomena a large number of times can be procured at a small cost: and when once seen it will be realised how completely inadequate any verbal description must of necessity be to convey to the mind the beauties of the movements. Hence the writer hopes that all who read will try the experiments for themselves.

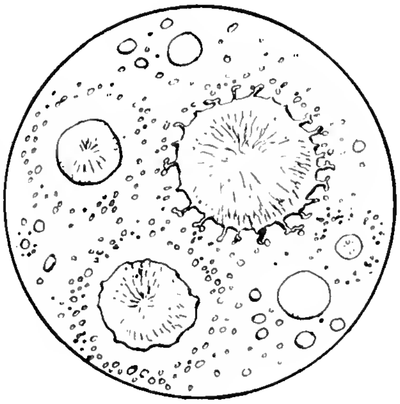


Figure 121.
Aniline globules on a water surface.

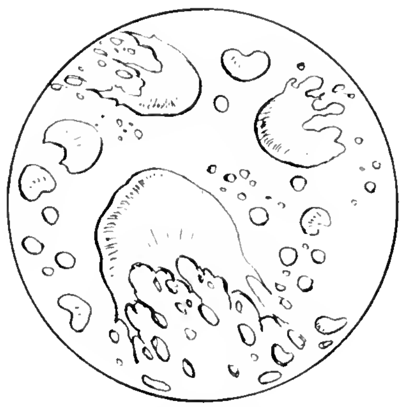


Figure 122.
Movements of orthotoluidine globules on a water surface.

Figure 123.
A film of dimethyl-aniline breaking into globules.

NEGRO MAN IN BRITAIN.

Under the auspices of the Celtic Union, Edinburgh, a lecture was delivered on the 21st of February, by W. J. Edmondston-Scott, M.A., author of "Elements of Negro Religion," in the Philosophical Institution, on "The Age of the Stone-circles: or Negro Man in Britain." Mr. David MacRitchie, F.S.A., Scotland, presided.

The lecturer discussed the many aspects of the "pre-Aryan" problem with particular reference to pre-Celtic Britain, its ethnology, history and antiquities. He showed that the deeper scientific researches descended into European Ethnology, the more and more assertive became the Negro type of physiognomy — as evidenced by the anatomical characters of the oldest pre-historic skulls,—a fact which argued the former existence of a negro race of Aborigines in Middle and Western Europe, most probably associated with a milder and more equable climate than ours; that the character and contents of Cave-deposits and River-drifts testified to general differences in Negro Culture; and that the infinite variety of Culture-stages represented from Mousterian to Neolithic and later times was just such as prevails universally throughout Modern India. He indicated how man's antiquity in Europe resolved itself into the problem of the age of India's native civilisations, whose pre-historic culture in every stage and form had been diffused over the European Peninsula at a very remote period; and how the Eastern origin of this negro species pointed to its affinities with the Kolarian Aborigines of Bengal—the only negro race in the whole Asiatic mainland—from one of whose ancient tribes, now represented by the Baske, were descended the Basques of Europe, as could be proved from the remains of their archaic speech and the vestiges of Kolarian culture among them. On linguistic and ethnological grounds the lecturer concluded that the so-called "Pre-Aryan Problem" vanished with the solution to the old-time mystery about the origin of the Basques, and was one to which the scientific study of the Kolarian languages offered the only means of solution.

FIGURE 124. The Site of the Emerald Mines.

PREHISTORIC EMERALD MINES.

By LEOPOLD CLAREMONT,

Author of "Ceylon, the Island of Jewels," "The Gem-Cutter's Craft."

IN 1812, a Frenchman named Cailliard rediscovered a series of anciently-worked emerald mines, the history of which is lost in antiquity.

They were found in a desolate mountain range which lies west of, and parallel to the Red Sea between the 24th and 25th lines of latitude.

He was one of a party of explorers sent by Mehemet Ali Pasha, to endeavour to locate the mines of Ethiopia, whence the ancients obtained their emeralds, and to which old inscriptions refer, but of which all trace had been lost. It is a matter of history that Cleopatra caused her portrait to be engraved on emeralds, and there is also the legend of Nero viewing the burning of Rome through one of these stones. Moreover, emerald jewels are to-day found in the ruins of ancient cities, and enclosed within the bindings of Egyptian mummies, so there can be no doubt that the gems were much appreciated at a most remote date.

FIGURE 125. A good geological section.

The result of Cailliard's investigations and also those of a British expedition of recent years, was the discovery of quantities of emeralds of large size but poor quality, which in every respect resemble the ancient jewels referred to above.

There is little doubt but that the Frenchman was successful in his quest, and that the mines which he found are the actual ones from which the gems were taken in ancient times. For convincing evidence that this is the case, is the appearance of the mines at the present time.

These mines, to which the name "Cleopatra Emerald Mines" has been given, are situated in a barren region traversed by several picturesque winding valleys, the principal of which is known as the Wâdy Djemel.

A wâdy is a valley formed by an ancient water-

FIGURE 126. A wády of coarse sand.

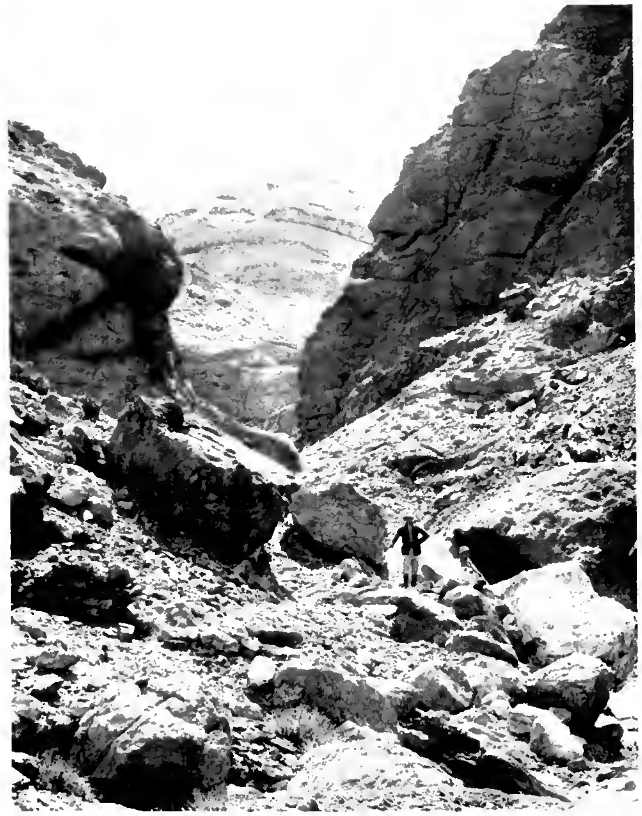


FIGURE 127. An artificial passage-way.

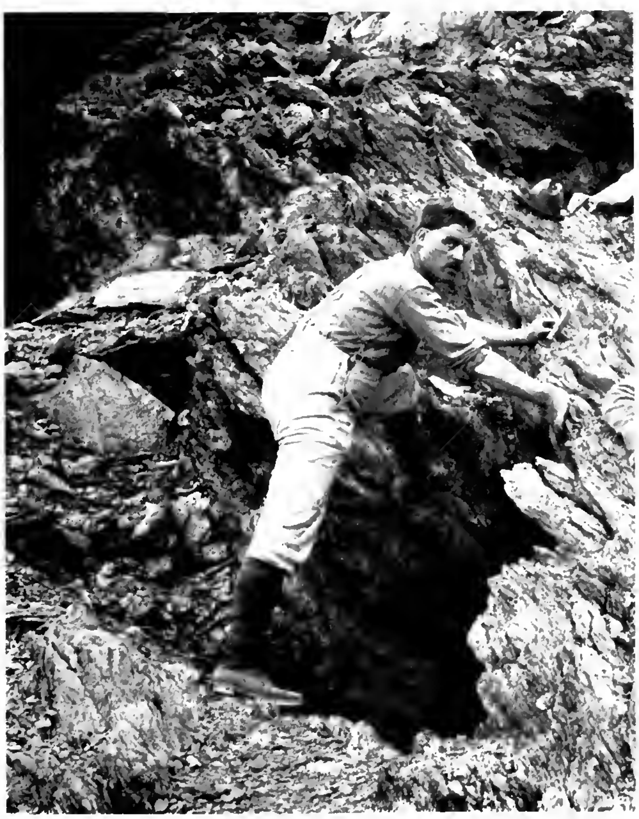


FIGURE 128. The entrance to one of the emerald mines.

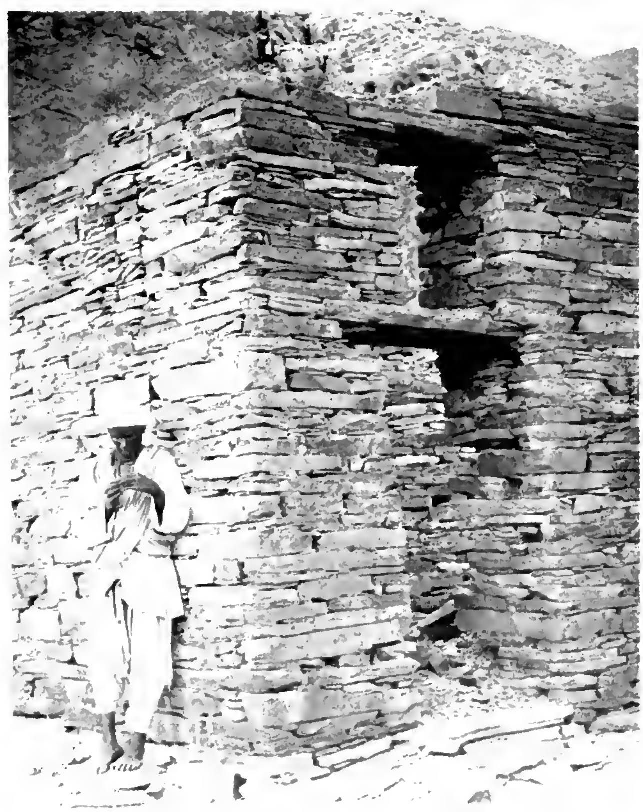


FIGURE 129. Part of one of the ancient buildings.

course which has during the lapse of ages become dry or nearly so.

The hills consist of strata of hornblende, soapstone, mica schist, talc schist and augite. It is in the mica schist that the crystals of emerald occur.

In several localities, viz.:—Sikait, Nugrus and Zebara, the schist which is a comparatively soft material, is found to be honeycombed with long subterranean tunnels and chambers, some of which are large enough to contain hundreds of men at work. Many of the small winding passages are situated one above the other, and the division between them is so slight that unless the explorer exercises great care, he will, as he crawls along, put his foot through into the tunnel below.

Figure 131.
A typical view of the mountains where the emeralds are found.

That these excavations were made anciently is shown not only by the primitive nature of the work, but by the finding of such articles as tools, lamps and baskets, which evidently were left behind by the early workers when for some unknown reason they decided to abandon the mines. Some of the cavities are shored up with wooden supports which, although apparently of great age, are still intact.

It has been ascertained that some of the objects found belong to as early a period as 1660 B.C., but the date at which the excavations were commenced is quite unknown.

There are also indications that after the workings were originally deserted, they were at several subsequent periods visited and re-worked possibly by members of a race altogether different from their predecessors. This assumption is warranted by the fact that much of the obviously later work is executed with greater skill than the earlier, and that it is followed by some of a primitive nature. It is probable that the Romans were responsible for the best of the work done.

When working the mines the workers evidently dug round or over any mass of hard rock which they came across, and in some cases they apparently were stopped altogether by some such impediment; nevertheless, the excavations represent great skill and ingenuity, combined with a colossal amount of physical toil.

A striking example of the magnitude of the work done is shown in Figure 127 depicting an artificial roofless passage-way from one part of the mine to another. In the picture the cutting may be seen immediately to the right hand side of the standing figure near the centre.

Figure 130.
Interior of ancient building showing walled-up recesses.

Signs are not wanting that at a far distant period the district in which the emerald mines are situated was the centre of a large industrious population, probably chiefly devoted to mining operations.

Numerous buildings of this ancient race still remain as lasting monuments of skill, endurance and enterprise, as will be clearly appreciated by the illustrations which are here given. The purposes for which they were erected can only be surmised after such a lengthy lapse of time, but many of them have the appearance of having been forts and watch towers, perhaps built to protect the mines from invasion, whilst others may have been dwelling-houses or barracks, and some were certainly used as temples.

For the most part the edifices consist of unshaped flattish stones, closely packed and arranged to form the walls, whilst others are hewn out of the solid rock. There are present a few examples of ancient masonry in which the stones are cemented together with no little skill, and there are also wells of considerable depth, formed of stones closely cemented in a similar manner.

A partly obliterated raised roadway or terrace can be traced extending for a considerable distance in the direction of the Red Sea.

A peculiar feature of the district is the presence of a good many crudely formed obelisks, each consisting of a huge roughly hewn mass of stone, with somewhat smaller ones lying at the base. It is probable that these once had some significance, but with what intention they were erected none can decide, although some think they answered the purposes of signposts.

On the walls of some of the buildings, especially on those of the temples, inscriptions are to be seen. Those which have been deciphered, although of great interest, do not help to solve the riddle of the mines.

The interiors of the barrack-like buildings have walled-up recesses surmounted by slabs of stone slanting downwards from the apex. Immediately below the apex is invariably to be found a stone image of a god, placed there for some reason connected with the religion of the departed race.

It is difficult to imagine a more wild region than the country surrounding these emerald mines, and yet there is a majesty of beauty in the hideous bare mountains, through which meanders a graceful wâdy of rock and coarse sand at almost every turn. (See Figure 124.)

With the exception of here and there an isolated stunted tree, there is next to no vegetation. A few wandering Bedouin Arabs, ever in search of the water, which they rarely find, form the only inhabitants of this drear spot, which thousands of years ago must have echoed with the hum of busy slaves toiling to supply their rulers with a useless gewgaw.

Dr. Max Bauer, in "Precious Stones," states that gold and topaz are found in the range of mountains in which the emeralds occur.

For information and the photographs the writer is indebted to Mr. Edwin W. Streeter who pioneered an expedition in the mines, and to Mr. Allan Forster and Mr. F. Grote, two members of his party.

TROMBIDOIDEA.

By CHARLES D. SOAR, F.L.S., F.R.M.S.

Naturalists, particularly those naturalists who study the minute forms of animal life with the aid of the microscope, have not paid much attention to the British Acarina. Why the study of mites has been so much neglected in Britain cannot be for want of specimens, for they can be found almost anywhere. One reason may be on account of their minute size, and the trouble that has to be taken to find them. Another reason is, no doubt, the dearth of literature on the subject. As yet we have only two monographs on British mites, although there are a large number of papers distributed about in the different natural history and microscopical journals. There are several acarologists on the Continent who are doing some splendid work with the mites, but they are outside the Britannic area. Nevertheless, their papers are very useful for the description and identification of what mites we find here. The water mites found on the Continent are nearly all found here in the British Isles, so it will no doubt be the same with the land mites.

Except in the case of some of the families of the Sarcoptoidea and Ixodoidea, there is nothing repulsive about the study of mites, and they all exhibit a great variety of form and colour. Their life-history is only known in a few cases, but we know by experience what a great part they play in nature's economy. There is plenty of original work waiting to be done, and it would be worth doing. There are about thirty families of the Acarina waiting for their history to be studied and written in the British Isles. Two families have been done, and done well, the Oribatidae and the Tyroglyphidae, by Mr. Michael, F.L.S., both published by the Ray Society.

Let us just glance at the super-family Trombidoidea. This is divided into six families :—

First, Trombididae, commonly called harvest mites. The small, red, velvety mites we find on our garden borders belong to this family. All the mites of this family are red, some darker than others. The body is covered with feathered hairs, according to the species. A monograph on the Trombididae has just been published by A. Berlese. He has divided the family into fifteen genera, and gives a coloured figure of each type species. Dr. George, of Kirton-in-Lindsey, has published some papers in *The Naturalist* on these mites, but the subject is only begun as yet.

Second, Caeculidae. This is a small family of rather large mites, found in moss, fallen leaves, and moist places, rectangular in shape, and with very rough legs. They are found in Southern Europe, but I have not yet seen any record for Britain.

Third, Rhyncholophidae. Several species of this family have been recorded by Dr. George in *The Naturalist*, representing different genera. There was one particularly beautiful mite, with plumes on the fourth pair of legs. It is known as *Eatoniana plumifer*, and I think was found in Jersey. It is common in Southern Europe and North Africa. I think Dr. George's record is the only one for the British Isles.

Fourth, Cheyletidae. A small family of little mites. They are distinguished by the enormous palpi attached to a distinct beak. They are animal feeders, some predaceous, some parasitic, divided into about eight genera. Two or three species have been recorded for the Britannic area.

Fifth, Erythraeidae. Quite a small family, containing only four genera. They are red in colour, quick in their movements, and very erratic in their course.

Sixth, Tetranychidae. These are well known as the red spiders. Several have been recorded for Britain. They are divided into about eight or nine genera. The genus *Bryobia* appears to be the most common.

The super-family Trombidoidea is a large one, and represents with its six families a large number of genera, but it would well repay anyone to take up any single family and work it out.

THE DOUBLE (AND BINARY) STARS.

By F. W. HENKEL, B.A., F.R.A.S.

". . . . Other Suns, perhaps,
With their attendant moons, thou wilt descry
Communicating male and female light,
Which two great sexes animate the World,
Stored in each orb, perhaps with some that live."

—*Milton* ("Paradise Lost," VIII, 148–152).

THOUGH the Copernican hypothesis of the Earth's motion round the Sun was immensely strengthened by the discoveries of Galileo, and the Newtonian theory of gravitation supplied the *modus operandi* for this motion, yet the objection of the opponents of Copernicus that the stars do not *appear* to move as they should do in consequence of that motion, long remained a serious difficulty. "Were the Earth in motion in a mighty orbit round the Sun," said they, "spectators on our planet would, without difficulty observe displacements in the relative positions of the stars during the course of the year, the nearer stars moving more and the more distant ones less, just as objects in the surrounding landscape appear to move when seen by a spectator in a moving carriage." But no such motions could be detected, and all that could be answered was that the distances of the stars are so vast that the size of the Earth's orbit is but an insignificant quantity in comparison. It was no doubt partly on account of his difficulty in accepting this explanation that Tycho Brahé was led to reject the Copernican views, since his observations had not enabled him to detect any "parallactic" change of place due to the Earth's supposed motion, and his measurements of the apparent diameters of the stars had led him to conclude that the brightest of these objects would be of enormous dimensions (greater than the whole Earth's orbit) were the Copernican hypothesis true. After the invention of the telescope it was seen that the apparent diameters of the stars were very much less than had been assumed to be the case by Tycho and others and up to the present time the true diameter of a star has never been measured, being less than the *minimum visible*, the disc seen by the naked eye being an optical illusion, an effect of irradiation.

Galileo, in one of his "Dialogues on the Systems of the World," proposed that pairs of stars seen close together in the sky should be observed and their relative position noted and distance measured throughout the year. If one of these objects be nearer to us than the other, it will be displaced and the angles and distances will change regularly in that interval of time. The same idea was suggested by others, but the first to carry out the suggestion systematically was Sir William Herschel. The latter, finding many cases where two or sometimes more stars lie close together in the sky, and supposing the brighter component was nearer to our system than the fainter one, made numerous measurements, expecting to find regular annual variations due to this supposed difference of distance—in other words, parallactic displacement.* But instead of finding this Herschel detected a regular progressive change of quite a different nature, showing sometimes that one of these bodies was describing an orbit round the other, or that both were travelling together throughout space. In his own words he "went out like Saul to seek his father's asses, and found a kingdom"—the existence of systems (of Stars) of a different and higher order from that prevailing in our own system, binary and multiple stars. A distinction was thus made between stars optically connected which merely lie nearly in the same direction, as seen from our planet, but may be as far removed from one another as they severally are from our system, and stars physically connected—systems consisting of two or more members moving round a common centre, or in nearly parallel paths in a common direction. All over the sky there are to be found cases of two or more stars lying much closer together than the average distances of the stars from one another, and perhaps as many as twelve thousand such couples are known, the *double stars*. Some of these doubles have components of nearly equal brightness (e.g., the two components of α Centauri, the nearest of all external celestial objects to our system, so far as is yet known, and the two components of 61 Cygni, the next nearest system—both of these are also *binaries*); in other cases the members are of very unequal magnitudes, like Sirius and its companion, the former being the brightest of all the stars visible to us, whilst the latter is only visible by the help of the most powerful telescope, and was not detected till 1862. In that year the late Alvan Clark first saw it with the recently finished Chicago refractor, the then largest instrument of its kind in the world. Several hundred binary systems are now known with more or less certainty, moving in elliptic orbits round common centres, the orbits in some cases being almost circular, in others very oval and "eccentric." There are also systems of three or more stars, the trinary and multiple stars. The star ζ Cancri consists of two larger and fairly close members revolving in nearly circular orbits round

* Parallax is the name given to an apparent displacement of an object due to a real displacement of the position of the observer. Technically, the parallax of a star is the angular value of the semi-diameter of the Earth's orbit (which is greater as the star is nearer), as seen from the star.

their common "centre of gravity," with a third fainter and more remote body, whilst ε Lyrae consists of two pairs of stars, and the multiple star θ Orionis, not far from the centre of the great Nebula, consists of four principal stars and two minute companions very close to two of the brighter, "to perceive *both* which is one of the severest tests which can be applied to a telescope" (Sir John Herschel), but three of the four brighter were detected by Huyghens, in 1656. Though, as we have just seen, the number of double stars known to modern astronomers, and visible through the telescope, is thus considerable, yet the angular distance of the components is too small to admit of their detection by the unaided eye in pre-telescopic days, so that though a few clusters were known to the ancients, the first double star which attracted attention seems to have been ζ Ursae Majoris, Mizar in the Great Bear, which was noted as double by Riccioli about the middle of the seventeenth century (Lewis). This was also the first star to be photographed as double, by G. P. Bond, in 1857, and also the first "spectroscopic binary," a class of objects of which we shall hear more later on. It is curious, too, that there is comparatively close to Mizar, which is of the second magnitude, a faint star, Alcor, just visible to the unaided eye, and it is said that the Arabs considered its detection as a test for keen eyesight. This star is said to be sometimes known as "Jack by the Middle Horse," Mizar being thus the "Middle Horse" pulling "Charles' Wain." Dr. Hooke, in 1665, discovered that γ Arietis consisted of two fourth-magnitude stars, eight seconds of arc apart. During the eighteenth century the well-known doubles, α Centauri, γ Virginis, Castor, 61 Cygni, β Cygni, ε Lyrae, α Herculis, and ζ Cancri were added to the list. The latter star was discovered by Christian Mayer, a Jesuit priest living at Mannheim, and shortly before his death, in 1781, he published a catalogue of all double stars known up to that date, including his own additions, making a total of eighty-nine pairs. For the first time he hazarded the suggestion that some at least of these pairs must be physically connected, a suggestion fully confirmed a few years later. As already mentioned, when first discovering and observing hitherto unknown double stars, Herschel hoped to employ them to determine parallaxes, but continued the work with other ends in view. His first catalogue contained two hundred and sixty-nine pairs, and its examination by the well-known philosophical writer, the Rev. John Michell, the "ingenious Mr. Michell" as he is called by Mr. Lewis, led him to make the following remarks. He says: "The very great numbers of stars that have been observed to be double by Mr. Herschel, if we apply the doctrine of chances, cannot leave a doubt with anyone that by far the greatest part, if not all, of them are systems of stars so near to each other as probably to be liable to be affected sensibly by their mutual gravitation, and it is, therefore, not unlikely that the periods of some of these about their principals (the smaller ones being upon this hypothesis considered as satellites to the others) may some time or other be discovered." We may assent to the conclusions, or rather to the probable meaning of their author, without committing ourselves to approval of his language. It was not, however, till 1803 that Herschel made the definite statement that some of these combinations were indeed binary, in a paper which he contributed to the *Philosophical Transactions* of the Royal Society. This he justified by his examination of the measures of *Castor*, γ *Leonis*, γ *Virginis*, δ *Serpentis*, and ε *Boötis*. Of seven hundred and two double stars contained in Herschel's two catalogues, the members were divided into six classes according to their angular distance apart.

Class I	contained	97	pairs separated	less than 4″.
Class II	,,	102	,, ,,	from 4″ to 8″.
Class III	,,	114	,, ,,	,, 8″ to 16″.
Class IV	,,	132	,, ,,	,, 16″ to 32″.
Class V	,,	137	,, ,,	,, 32″ to 60″ (1′).
Class VI	,,	121	,, ,,	over 60″.

Since Herschel's day the whole subject of double-star astronomy has been vastly extended, and our knowledge greatly increased by the labours of a host of professional and amateur workers. Amongst the foremost of these must be placed the name of F. G. W. Struve, of Dorpat, whose classic work, familiarly known as the "Mensurae Micrometricae," still remains the standard authority "for method and arrangement." This catalogue, published in 1837, contains measures of two thousand six hundred and forty pairs of stars, three fourths of the ten thousand four hundred and forty-eight measures being made by Struve himself without assistance, but during the latter part of his work he had the assistance of his son and other observatory assistants, "who entered the readings and turned the dome, but made no measures." These measures have been collected, compared and discussed with much other information relating to double stars in a volume by Mr. Thomas Lewis, F.R.A.S., of the Royal Observatory, Greenwich, published in 1906 (*Memoirs of the Royal Astronomical Society*, Vol. LVI). Struve's work comprised a general survey of the sky between the North Pole and 15°·5 declination, about 0·63 of the whole sky. His plan of work was (1) to discover and catalogue double stars; (2) to make micrometer measures of them; (3) to estimate the magnitude and note the colours; (4) to fix the places by meridian observations. Between February 11th, 1825, and February 11th, 1827, he examined one hundred and twenty thousand stars from the first to the third magnitude, and found three thousand one hundred and twelve double stars, whose distance apart did not exceed 32″.

Many of the double stars exhibit the remarkable phenomenon of contrasted colours, but it has been remarked (Proctor, "Old and New Astronomy," p. 783) that this is never the case when the two adjacent stars are of nearly equal magnitudes, and it appears to be the universal rule that when there is a contrast of colour the tint of the fainter star lies more towards the violet (more refrangible) end of the spectrum than that of the other. Thus, the brighter star being reddish or yellowish will have a green or blue companion. Sir John Herschel, who worthily continued his father's work, and also contributed what he modestly calls his "mite" towards double-star astronomy, has suggested that this complementary colouration is "probably in virtue of that general law of optics that when the retina is under the influence of excitement by any bright light, feebler lights, which when seen alone would produce no sensation but of whiteness, shall for the time appear coloured with the tint complementary to that of the brighter." There are, however, difficulties in the way of accepting this explanation in all cases, and others are inclined to regard this contrast of colours as being, in some cases at least, due to a real difference in the physical nature of the stars. However this may be, the beauty of the sights visible to the telescopist is greatly enhanced by the wonderful display of colours given by different celestial objects. It is often found that if in a double-star system the coloured star be much less bright than the other, it will not affect the latter's colour. Thus, for example, η Cassiopeiae is composed of a large white star and a fainter one of a "rich ruddy purple." A pleasing picture of the curious alternations of illumination that would be produced for the inhabitants of a planet circulating round a pair of coloured double stars may be drawn, and is given by Sir John Herschel ("Outlines of Astronomy," p. 851). Suppose a planet revolving round a red and and green sun. When the red sun rises there will be daylight, and "all will be red." Bye and bye the green sun will rise and mount higher above the horizon. The light will gradually change from a reddish tint to pure white. Later on, the red sun will set, and the remaining illumination will consequently be green. Last of all, the green sun will set, and darkness will set in. Thus we have the alternations red-day, white-day, green-day, and night, the colours of all objects undergoing corresponding variations.

It is a remarkable fact that though isolated red stars are found in most parts of the sky, no decided green or blue star has ever been noticed unassociated with a brighter companion (Herschel).

We have already stated that the orbits of binary stars round their centre of mass are ellipses, usually much more oval than the planetary orbits in our solar system, the average eccentricity of the visual binaries being about 0·5 (See "Researches," Vol. II, ch. 20), but it is a remarkable and interesting fact that the closer "spectroscopic" binaries move in much more nearly circular orbits. The application of the spectroscope to stellar astronomy has not only given us information otherwise unobtainable as to the chemical nature of the heavenly bodies, but it has also enabled us to detect hitherto unsuspected motions, and has rendered known the existence of bodies perhaps for ever invisible to our telescopes. By means of this instrument it has been ascertained that the number of binary stars is far greater than anyone had previously imagined, but that in most cases the components are too near together to be separated by the most powerful telescope. According to estimates based on the work done at the Lick Observatory, Campbell found that about one star in five of those examined proved to be a spectroscopic binary, and in certain groups this ratio was found by Frost to be as high as one third (See). The telescope discloses only the widely-separated and luminous companions amongst the systems nearest to us in space, but the spectroscope enables us to detect all attendant masses which are large enough perceptibly to disturb their luminous "fellows," whatever be their distances, thus enormously increasing our knowledge of stellar systems. When a star is approaching us the dark and bright lines in its spectrum are shifted slightly towards the violet; when it is receding they are shifted in the opposite direction, and by the comparison of well-known lines thus changed in position with their ordinary position as seen in terrestrial spectra it is possible to determine the speed of their motion. Thus, the well-known variable star, Algol, exhibits changes in its spectrum indicating that the velocity in the line of sight undergoes variations, being alternately towards and away from the Earth, and thus is confirmed the view that its variability is due to partial eclipse by a revolving dark satellite, the "stupendous dark globe." It has been shown, too, that α Virginis, like Algol, has a massive dark companion which, however, does not eclipse, as it does not come between the star and our position. Other double stars have been discovered in which both components are bright, so that at one part of their orbit the lines common to the spectra of the two stars appear double and separated, gradually closing up till they appear single and then opening out once more. Since visual binaries with known orbits are found to give variations of a similar character in their spectra and have thus come to be included in the class of spectroscopic binaries as well as "visual" ones, but so far no spectroscopic binaries first discovered as such have been resolved telescopically, we see that the difference merely consists in the smaller size of their orbits and consequent shorter periodic times of revolution of the latter. Periods of a few days, or even hours, are known for these, whilst the shortest periods for a visual binary yet known is that of δ Equulei (5·7 years) and orbits with periodic times of hundreds of years have been calculated for some of the more widely-separated binaries (γ Virginis, 182 years; σ Coronae, 340 years, Lewis). When the angular dimensions of the orbit and the parallax of the system are known, the real dimensions (in miles, kilometres, and so on) are easily calculable, and from a knowledge of the periodic time of revolution the total mass of a binary system may be obtained from the extension of Kepler's third law, assuming the motion due to an action of a gravitative character. Let M_1 and M_2 be the masses of the two components respectively, M and m the mass of the Sun and Earth.

Then
$$M_1 + M_2 = \frac{a^3}{R^3} \cdot \frac{T^2}{p^2} (M + m)$$

where T = Earth's period of revolution = 1 year and R = the semi-axis major of its orbit, the astronomical unit; a and p being the semi-axis and periodic time respectively of the stellar system. Thus our formula becomes

$$M_1 + M_2 = \frac{a^3}{p^2}$$

giving the mass of the system in terms of the Sun's mass as unity.* Thus we find the masses of many of the binary systems are comparable with that of the Sun, some being rather smaller, others considerably greater.

Of fifty-three orbits of spectroscopic binaries dealt with by Dr. See, he finds that the mean eccentricity of these orbits is considerably less than that of the visual binaries, being only 0·23 instead of 0·5, as for the latter, a point which has important bearings on Cosmogonic theory. The average period for these fifty-three systems is about thirty-seven days, but if we exclude a few long period stars, the average period of all the rest is about ten days. From the formula

$$M_1 + M_2 = \frac{a^3}{p^2}$$

assuming the average mass of the spectroscopic binaries to be about the same as that of the visual ones, and taking $M_1 + M_2 = 1$, we find the average value of the mean distance to be 0·2173 astronomical units, when $p = 37$ days or 0·09 when $p = 10$ days. Thus the average dimensions of these orbits are less than that of the planet Mercury, and it seems probable that for such orbits the efficacy of tidal friction as a possible agency in changing their forms may not be overlooked. The late Sir George Darwin, whose recent death we have to deplore, and whose researches on the problems of fluid motion and tidal friction generally are well known, was of opinion that many double stars have been generated by the division of primitive and more diffuse single stars, in a manner somewhat analogous to that in which he supposed that our own Moon came into being. Many difficulties, not altogether ignored by Darwin himself, prevent our acceptance of his views as regards the origin of our satellite, but there appears more reason to consider that the fission theory of the origin of double stars is a true one. Such fission would give rise to nearly circular orbits, and though this is not the case with the known systems, it is more true for the nearer spectroscopic binaries than for the more widely separated visual ones. But it has been shown that when two bodies of not very unequal masses revolve round one another in close proximity the conditions are such as to make tidal friction as efficient as possible in transforming the orbits. Hence we have in tidal friction a cause which may have not only sufficed to separate the two component stars of a double star system from one another, but also to render the orbit eccentric (Darwin). Thus it may be that under this influence in the course of time the orbits of the spectroscopic binaries will increase and become more eccentric, more nearly like those of the "visual" binaries. On the other hand, it is not impossible that some of these orbits may be shortening and becoming more nearly circular under the action of the resisting medium, whose long-continued action affords the best explanation yet advanced of the comparative circularity of the orbits of the planets in our own Solar system. The efficacy of tidal friction (whose tendency is to produce increase of eccentricity and distance) is greater as the mass-ratios of the bodies acting and acted upon are more nearly equal, as in the components of a double star system, and least when one mass greatly preponderates, as in our own Solar system, where the mass of the Sun exceeds that of all the planets put together more than six hundred times. "The preponderance of high eccentricities amongst the equal pairs seems to be an indication of the higher efficacy of tidal friction, or of the lesser importance of the action of a resisting medium in such systems," and so, whilst deducing one confirmation of the action of tidal friction and the resisting medium from the small size and roundness of the orbits of the spectroscopic binaries, we may find an additional verification of this theory in the larger eccentricities occurring amongst binary stars with nearly equal components. We may, too, if we please, derive important conclusions as to the relative ages of the various systems. Thus from the theoretical researches of Sir G. Darwin on tidal friction, supplemented by the long imperfectly recognised agency of the resisting medium, Professor See has for the first time succeeded in giving a reasonable account of many remarkable features in the phenomena of the starry heavens, and has securely laid the foundations and much of the superstructure of a rational cosmogony. But there will always remain "the immeasurable magnitude of the undiscovered" to humble our pride; and ever upward progress, we trust, in our knowledge of the wondrous universe of God, will not lead us to imagine that we have "solved the universe."

* The Earth's mass being only $\frac{1}{330000}$ that of the Sun, is here neglected.

SOME NOTES ON THE ANIMAL LIFE OF BLAKENEY POINT.

By WILLIAM ROWAN.

BLAKENEY POINT needs no further description after Mr. Grew's article in the January issue of this Journal. One might repeat again, however, that "the Point" is the extremity of a shingle spit, some eight miles in length. It is separated from the mainland by the "Blakeney Channel," and is a sail, at high tide, of over a mile from Morston.

The birds being the most noticeable feature of the animal life, we are describing them first. As might be expected, few of the species found in the summer are found in the winter, while in the autumn and spring many rare migratory birds pay a fleeting visit.

FIGURE 132. The Lesser Tern.

Should you visit the Point in summer, you would notice that as you approach it birds rapidly get more numerous. They all appear to be of one kind—the common tern (see Figure 133).

If you are an ornithologist, however, you will soon notice that mingled with these is a considerable sprinkling of the lesser tern. They are fishing all around, and time after time you see a bird dive into the water, rise with a little fish in its beak, and disappear over the dunes. They all seem to go in the same direction, and even when the shoal of fry, on which they are feeding, has gone out with the tide you notice stragglers making their way over the dunes. If your interest has been sufficiently aroused, you also take the same road on landing. As you climb up the side of the dunes all is quiet. You may put up a dotterel with her little chicks, or bolt a rabbit, but that is all. But as you reach the crest, and catch a first glimpse of a long shingly beach, with the open sea beyond, a cloud of birds rises in the air. The noise is terrific, and as you climb down the other side to get a nearer look, and walk underneath the great whirling mass, one bird after another with an earsplitting shriek makes a desperate swoop at your head. It is merely show, however, and you need fear no injury.

FIGURE 133. The Common Tern.

And so you have made the acquaintance of the noisiest and most important inhabitants of the Point. Their nests are strewn all over the shingle on the seaward side of the dunes. If your visit be in July, you will see many young already running about. They almost invariably crouch when you approach, and are often hard to see. Apart from their size, their black chin distinguishes them at once from the young of the lesser tern (see Figure 132). The eggs vary enormously in size, ground colour and markings. Eggs at the two extremes of the scale are often found in the same clutch. About the use of material for nest-building there seems to be no definite law. As a rule, materials are used when they are handy, and only when they are. For instance, of all the nests examined last summer on the drift line, in only one case had the birds deposited their eggs without collecting material on which to lay them. In one case the "nest" was eighteen inches across. On the open shingle one must be constantly on the *qui vive* to avoid stepping on to the eggs.

In the centre of the colony you will find nothing but the eggs and young of the common tern. The birds resent the intrusion of any stranger in a practical way. Even the rabbits have to keep clear of those dunes that the terns occupy. On the outskirts of the colony you will, however, find the lesser tern. The nests of this bird are not crowded together like those of the former, and you will only find them on the Point in one kind of shingle, composed of very small stones and sand. This is in the main found immediately above and below the highest tide limit, so that in certain years, as in 1911, when there was an exceptionally high tide in the end of June, hardly a young bird was hatched out. That year the colony consisted of some sixty pairs, or probably more. The lesser tern is almost as bold as its larger relative. The male is generally supposed not to incubate the eggs. Figure 132, however, shows him in the act, with his wife waiting for her turn. Three is usually stated to be the average number of eggs, but some forty-five nests examined the maximum number found was two.

Another bird found nesting in some numbers, though it lays earlier than the terns, and is resident the year round, is the little ringed plover (see Figure 134). You find its eggs chiefly behind the dunes (see Figure 135), and in small sheltered lows. The birds seem to object to the exposed shingle. They are extremely shy, and to secure a photograph of one needs the exercise of considerable patience. Other birds that are found nesting are larks, pipits, wagtails, red-legged partridge, sheld-duck and one pair of oyster catchers. Last year, for the first time, there were two.

Figure 134. The Ringed Plover.

All the common gulls are well represented, though none nest. Other sea birds pay short visits throughout the summer.

Should your visit fall in the winter months, you would find the Point very different. With the exception of a few gulls flapping over lazily from the mainland, no birds come near the boat as you cross. When you have landed you find that the shingle, so noisy and full of life in the summer, is now deserted and the marshes are the scene of activity. Should you hide and watch them with a pair of binoculars, you will soon notice that the waders predominate. The commoner species are curlew, dunlin, sanderling and ringed plover, with an occasional redshank, while knot occur in vast flocks, sometimes numbering over one thousand. Larks and linnets feed in the marshes in great numbers. The gulls, again, are well represented on the beach, though now may be seen an occasional huge glaucous gull. If the winter be a severe one, however, the bird life is swelled by a huge army of ducks and geese. Among the former, widgeon, mallard and sheld are the commoner. Among the latter, brent, pink-feet and barnacles. In the late autumn the swan is not an uncommon sight, while the great northern black-throated divers are of regular occurrence.

Figure 135. Eggs of the Ringed Plover.

Of the mammals, the rabbits are by far the most numerous. In summer time, when the long evenings draw gently to a close, the Point seems to swarm with them. Old and young are all out then, taking their supper in the marshes or on their moss-grown margins. As you stroll quietly along between these and the dunes, one rabbit after another bolts across your path, heading for safety to its burrow. If you turn off now to the side, and make for the marsh, many more bolt past you, till you reach their feeding ground. The first thing that catches your eye is their well-marked runs, reaching right away to where the tide is softly creeping up (see Figure 137). Everywhere you see *Aster tripolium* eaten. Its succulent leaves are not as salt as one might imagine. On the edges the Suaeda bushes are also bitten, in some cases to the ground. Still further in, towards the dunes, *Convolvulus soldanella*, covering large areas of the firmer ground, is also badly attacked.

On the crest and seaward side of the dunes are a few burrows, but they are a mere sprinkling compared with those on the other side.

Were it not for numerous tracks, one would at first suppose in winter time that the rabbits had gone, for you see none of them. Day breaks at about seven or soon after, and it is certain that there are no rabbits about then. But if you search carefully, you will find many tracks, freshly made: for the rabbits have been out earlier than you. In the

Figure 136. Glaux Lagoon.

evenings, too, they only come out after dark, when you have made yourself comfortable in your tent. Their food remains much the same now as in the summer. One interesting addition to the list must be mentioned, however. In the Glaux lagoon (see Figure 136), now filled with water, there are considerable patches of sand dug up by rabbits. They are plainly seen on this photograph, showing up dark. It was some time before the cause of this nightly exercise was found, but it eventually proved to be that the rabbits dug up the ground to reach the Glaux rhizomes for eating.

Rats are, unfortunately, quite abundant on the Point. Since the stranding of a whale on the beach, in the fall of 1910, they have been there. In 1911, they were present in such numbers and harrassed the terns so seriously, that these laid an extraordinary number of mis-coloured and mis-shapen eggs. Since then poison and traps have been kept on the go incessantly, but still they are there. This winter their tracks were wonderfully abundant round the tents. They live chiefly in the rabbit burrows.

As harmful as the rats are the two small colonies of stoats, which are now, however, almost at the point of extinction.

At least one kind of vole occurs, and as casual

Figure 137. Rabbit runs in salt marsh.

visitors seals must not be forgotten, for they often turn up and spend a few days on the Point. As many as seven have been seen at the same time.

THE ROYAL INSTITUTION.

A General Meeting of the Members of the Royal Institution was held on the afternoon of March 3rd, Sir James Crichton-Browne, Treasurer and Vice-President, in the chair. Mr. T. W. E. Davenall, Mr. P. M. Deneke, Mr. H. Trevelyan George, Mr. H. G. Gillespie, Mr. W. V. Graham, Lady Heath, The Hon. Marguerite de Fontaine Drever Joicey, Mr. J. A. Law, Rev. J. Marchant, Dr. W. A. Milligan, Mr. D. W. Moncur, The Hon. Mrs. R. Parker, Mrs. Carson Roberts, and Miss Tatlock, were elected Members. The Honorary Secretary announced the decease of The Right Hon. The Earl of Crawford, Mr. George Matthey, and Sir William H. White, Members of the Royal Institution, and Resolutions of condolence with the relatives were passed.

The following are the Lecture Arrangements at the Royal Institution, after Easter:—Dr. A. S. Woodward, Two Lectures on Recent Discoveries of Early Man. Professor W. Bateson, Fullerian Professor of Physiology, Two Lectures in continuation of his before Easter course on The Heredity of Sex and some Cognate Problems. Professor W. Stirling, Three Lectures on Recent Physiological Inquiries: 1, Protective and other Reflex Acts; 2, Equilibrium and the Sixth Sense; 3, Ductless Glands and their Dominating Influence. Professor T. B. Wood, Three Lectures on Recent Advances in the Production and Utilization of Wheat in England. Dr. E. Frankland Armstrong, Two Lectures on 1, The Bridge into Life; 2, Colour in Flowers. Professor J. Garstang, Three Lectures on The Progress of Hittite Studies: 1, Recent Explorations; 2, Religious Monuments of Asia Minor; 3, Cults of Northern Syria. Mr. Edward Armstrong, Two Lectures on Florentine Tragedies: 1, The Exile of Dante; 2, The Burning of Savonarola. Professor W. J. Pope, Three Lectures on Recent Chemical Advances: 1, Molecular Architecture; 2, Chemistry in Space; 3, The Structure of Crystals. Mr. A. M. Hind, two Lectures on 1, Van Dyck and the Great Etchers and Engravers of Portrait; 2, Rembrandt's Etchings. Professor Sir Walter Raleigh, three lectures on 1, Boccaccio; 2, Mediæval French Novelists; 3, Chaucer. Mr. H. A. Humphrey, two lectures on Humphrey Internal Combustion Pumps. Professor E. Rutherford, three lectures on Radio-activity: 1, The Alpha Rays and their connection with the Transformations; 2, The Origin of the Beta and Gamma Rays and the connection between them; 3, The Radio-Active State of the Earth and Atmosphere. The Friday Evening Meetings will be resumed on April 4, when Mr. James J. Dobbie will deliver a Discourse on The Spectroscope in Organic Chemistry. Succeeding Discourses will probably be given by Mr. C. J. P. Cave, Dr. T. M. Lowry, Professor J. Garstang, Mr. H. G. Plimmer, and other gentlemen.

THE INFLUENCE OF AGE ON THE VITALITY AND CHEMICAL COMPOSITION OF THE WHEAT BERRY.

By R. WHYMPER.

(*Continued from page 90.*)

TABLE 23.

ANALYSES OF SOME OLD SAMPLES OF WHEAT.

	Mummy Wheat Estim. 1500 B.C.	Rothamsted Wheat. 1852	1853	1854	Rivet Wheat, 1911.
	%	%	%	%	%
Moisture	10·69	16·54	8·32	12·68	12·10
Ash	0·68	0·90	0·83	1·14	2·04
Fat or Ether Extract ...	1·71	2·98	1·83	1·66	2·51
Nitrogen ...	1·686	1·799	1·915	1·549	2·023
Proteid (Nx 6·25)	10·54	11·24	12·12	9·67	12·64
Soluble Carbo-hydrates ...	3·68	3·46	5·16	5·16	4·04
Starch	68·18	60·0	68·72	66·13	66·24
Husk or Fibre ...	1·50	1·62	1·70	1·61	1·78
Acidity (taking the 1911 sample as Unity) ...	2·6	1·1	0·7	1·6	1·0

TABLE 24. COMPOSITION OF FLOURS AND OTHER MILLING PRODUCTS OF WHEAT.*

Milling Product.	Water.	Proteid Nx 5·7.	Fat.	Carbo-hydrates.	Ash.	Acidity (taking the wheat ground in the Laboratory as Unity.	Nitrogen.
							%
First Patent Flour	10·55	11·08	1·15	76·85	0·37	0·44	1·9435
Second Patent Flour	10·49	11·14	1·20	76·75	0·42	0·44	1·9544
Straight or Standard Patent Flour	10·54	11·99	1·61	75·36	0·50	0·50	2·103
First Clear Grade	10·13	13·74	2·20	73·13	0·80	0·67	2·410
Second Clear Grade	10·08	15·03	3·77	69·37	1·75	1·50	2·636
"Red Dog" Flour	9·17	18·98	7·00	61·37	3·48	3·27	3·33
Shorts	8·73	14·87	6·37	65·47	4·56	0·72	2·608
Bran	9·99	14·02	4·39	65·54	6·06	1·27	2·459
Entire Wheat Flour	10·81	12·26	2·24	73·67	1·02	1·72	2·150
Graham Flour	8·61	12·65	2·44	74·58	1·72	1·00	2·219
Wheat ground in Laboratory ...	8·50	12·65	2·36	74·69	1·80	1·00	2·219

CHEMICAL EXAMINATION.

Moisture.

The percentage of moisture found in wheat is a very variable quantity. In a personal letter from Mr. Humphries the figures for English wheat grown last year were given, and showed on an average fourteen per cent of moisture in October, 1911. In February, 1912, the moisture content had risen to eighteen per cent., and in June, had fallen to approximately sixteen per cent. Similar experience has of course been the lot of every miller, and therefore it is not surprising to find that, in the wheats of the various ages examined, the moisture content should show considerable fluctuation.

Ash.

Just as moisture in wheat and flour is a variable according to the conditions of storage, so may also the ash content of wheat be found to vary according to the soil in which it is grown.

Wheat as a general rule varies in ash content from two per cent. to about one per cent, below which it is extremely unlikely to fall.

It is, therefore, of considerable interest to notice that there is a gradual decrease in mineral matter with age, with the exception of the 1853 wheat which contains a slightly higher quantity than that of 1854, and which, in other particulars does not seem to fall into line with the wheats according to its age.

Snyder (*Bull. 85 Agric. Expt. Stn. Univ. Minnesota, 1904*) found that the percentage amount of ash in different wheat crops varies but little from year to year, and that flour made from fully matured wheat has a minimum ash content because high maturity is usually accompanied by a low ash.

This fact is forcibly borne out by the results obtained with the wheats of different ages examined by the present writer.

Fat or Ether-extract.

A specially dried Ether was prepared for these estimations and the figures may be taken as those of actual fatty matters extracted.

*Studies of Bread and Bread-making at the University of Minnesota in 1899–1900, by Harry Snyder, B.S., Washington, 1901.

It was with considerable surprise that 1·71 per cent. of Ether-extract was taken from the Mummy Wheat when compared with 2·51 per cent. from an English wheat harvested in 1911. The figures have, however, been carefully checked and confirmed.

Wheat oil very rapidly undergoes decomposition on exposure to air, De Negri finding that a sample after being kept for one year contained nearly half its weight of free fatty acid calculated as Oleic acid.

Balland (*Compt. Rend.* 1903, CXXXVI, 724) obtained some sixteen parts of Ether-soluble fatty acids with eighty-four parts of true oil from one hundred parts of fatty matter extracted by Ether from freshly-milled flour, whilst an older sample of flour gave fatty matters containing only eighteen per cent. of true oil with eighty-two per cent. of mixed fatty acids.

It is apparent, therefore, that quite a large proportion of the fatty acids obtained from wheat oil is soluble in Ether, a fact which accounts for the unexpectedly high figures obtained for fatty matter extracted by Ether from the Mummy Wheat.

There may also be a small quantity of bitumen included in the Ether-extract from Mummy Wheat.

Nitrogen and Proteid Matter.

The quantitative changes which the wheat has suffered during storage are comparatively insignificant, and such differences as are found may be said to fall within the limits for normal wheats of different varieties.

The nature of the changes undergone by the proteid matter, however, is striking in the case of the oldest wheat but quite unworthy of consideration of those grains up to fifty years of age, as has already been shown when the gluten strength of the crushed wheats under examination was discussed.

The process of decomposition of the wheat gluten is mainly biological, in that bacteria play a very important part both in oxidising the actual nitrogenous matter and in producing acids from the other components of the grain capable of degrading the gluten.

It is certain that under normal atmospheric and humidity conditions neither bacteria nor fungi could obtain a good hold on the wheat berry, but that, after the passage of a number of years, when the outer protective covering of the grain had itself become oxidised and permeable, the process of decomposition would proceed more rapidly within the grain.

The period of time necessary to bring about these internal changes is entirely dependent upon the conditions under which the wheat was stored.

There are other factors which have been shown by various experimenters to have marked effect on the physical characteristics of gluten, and which may be more or less responsible for the reduction in the gluten strength of the flour obtained from the Mummy Wheat.

The degrading effect of acids has already been mentioned, and the results obtained by Snyder would prove that a flour of higher acidity is less efficient for bread-making, owing to a lack of strength which results from a pronounced decrease in gliadin percentage.

The differences of opinion between Snyder and Wood and others are mainly as to which is "the cause" and which is "the effect" of acidity; though, for the purposes required here, it is sufficient to notice that with increase of age there is greater acidity, and, in the extreme case, a complete loss of gluten strength.

The influence of mineral salts on gluten strength determined by Wood is of great interest to the baker and miller and in cases where the flour is made into dough with water. The general action of salts is that of coagulation or binding and toughening the dough, and often overcomes the degrading influence of an acid when both salt and acid are present.

Lactic acid of all strengths was found by Wood to reduce the wheat gluten strength, and that proportional increases in the quantity of added salt to procure cohesion of the dough were then necessary.

In the case of a normally air-dried whole wheat, however, the circumstances are different, and, with the exception of the mineral matter held in immediate juxtaposition to the proteid matter, the salt solutions can have little effect seeing that, under fairly constant conditions of temperature and humidity, "flow" does not exist to any extent and that such effect as is produced is purely local.

In the process of time the action of the self-contained salts may have effect on the gluten, and it is clear from the results obtained by the present writer that sixty years is, under normal conditions, too short a period to allow any appreciable degradation of gluten to take place within the wheat berry. This may be explained by the fact that the salt content of the newer wheats is still high enough to counteract the degrading effects of the acids as they form, and that, as age increases and the salt content of the berry falls, the full influence of the accumulating acids gradually becomes more apparent.

Carbohydrates—Soluble—and Starch.

The slight decrease in the Soluble-carbohydrates with increase of age is noticeable though without importance, whilst the starch content of all the wheats examined is constant within the limits of experiment and natural variations when the differences of moisture and proteid matter are taken into account.

The starch and fibre are undoubtedly the most stable of all the components of wheat, and the granules of starch from even the oldest samples do not show pitting due to enzymic action, a fact which adds further proof to the suggestion that the flow of solution within the berry was restricted, owing to lack of moisture.

Husk and Fibre.

The percentage of husk and fibre is practically constant in all the samples of wheat examined.

In the case of the Mummy Wheat the fibrous nature was completely lost and the friable powder resulting from the crushed husk was as though the berries had been roasted.

Acidity.

The acidity of the samples has already been fully discussed under former headings.

Diastatic Power.

With the exception of that from the newest wheat the aqueous extracts of all the samples examined failed to render starch soluble. It should be of importance to determine the connection between "loss of vitality" and "diastatic power."

In a letter from Mr. Humphries it is stated that wheat more than fifteen months old is rarely used in commerce, and, consequently, the changes which have been found to take place within the berry after a period of fifty or more years are not likely to be encountered by the practical miller.

The chemical and physical alterations which take place within the wheat grain, however, are the same, only to a much more retarded extent, as those which flour undergoes during storage, and they may, therefore, be taken as a guide for the latter purpose.

Flour improves, in most respects, from the bread-making point of view over a period extending for about two months, but beyond this limit there will be a deterioration, more or less rapid according to the quality and conditions of the flour and the conditions of storage.

Evaporation of moisture will be in proportion to the amount of heat occurring during storage, and the giving out and taking in of moisture are the prime factors which influence the changes, biological and chemical, which take place within the flour.

Balland (*Compt. Rend.* CXIX, 565) found the variations in chemical composition of flour during storage, for a range of over two thousand samples, to be principally due to fluctuations in moisture content, which reached a maximum in February of about 16·2 per cent., and a minimum in August of 9·40 per cent. The lowest percentage of acid was found by the same author to be 0·013 per cent. in January, while samples drawn in August contained nearly three times that amount.

Humphries, in his researches on the conditioning of wheat (*Brit. Assoc.*, 1911), points out that the mere addition of moisture to Southern Plate wheat was not sufficient to produce a marked change on the baking qualities of the resulting flour (this flour contained fourteen and a half per cent. of moisture), but that great improvement was noticed if the flour was also conditioned by addition of further water until it contained fifteen and a half per cent. of water.

Humphries observed that the improved flour showed a marked diminution in acidity (a statement certainly not in accord with expected results, unless the additional percentage of moisture had not been taken into account), and a decrease in the percentage of ash.

The production of inorganic phosphate by the addition of water was believed to be the chief cause of improvement.

In the light of Wood's experiments on the influence of salts on gluten, the perpetual though slow passage of a saline solution, such as that of a phosphate, through the cells of the wheat berry or in flour during storage, would undoubtedly tend to retard the degradation of the gluten, which we find to have taken place only in the most ancient wheats and which is principally due to the formation of acid, and to improve the gluten of a flour by increasing the ratio of conditioning salt to degrading acid.

The moisture content is the greatest variable, whilst acidity always increases with age, the period of time taken to produce absolute "inefficiency" of the gluten being greatly retarded by the presence of salts.

The passing of the moisture in and out of the flour or grain makes it possible for these changes to take place, and the extent of the alternations determines the rate of change.

Changes due to enzymic action undoubtedly proceed when the water content of the samples is high, such as is seen, for instance, when sufficient moisture is present to induce germination*, and it would be interesting to observe the minimum amount of moisture that would be necessary for such process. It is quite certain, however, that, in the conditions under which the examined wheats existed, this point was never reached.

The minimum moisture content necessary to maintain life within the seed is another interesting figure to consider, and lies between fifteen per cent. and forty-five per cent. in the case of wheat if the action of bacteria and moulds be prevented.

In order to obtain this limiting figure, and also with a view to furthering the present knowledge of vitality and its duration in seeds, a number of experiments have been undertaken with the hope that the future examination of them may throw some certain light on the conditions that influence the retention of life within the seed. A full description of these experiments and the objects for which they have been undertaken have been reserved for a later paper, when a complete discussion on their import can be made.

Summary.

The influence of age on wheat grains is not very pronounced when measured by chemical analysis, the principal change which occurs being a marked decrease in the ash content.

This fact, which has been noticed previously by other experimenters, is mainly brought about by the absorption and expulsion of moisture under changing conditions of the atmosphere, whereby the soluble mineral matter is brought to the surface of the grains and, sooner or later, rubbed off.

* Whymper (*Internat. Cong. App. Chem.* 1909).

Increase of acidity with age is another change of importance, and it has been shown that the combination of the loss of mineral matter with an increase in acidity is largely responsible for the degradation of the gluten, which shows itself when the "strength" of the gluten is tested physically. There is no pronounced decrease in nitrogen content attending this physical change.

The chemical analysis of a wheat about three thousand years old does not show any pronounced variation from that of a new wheat except in these two items.

Nor is this of great importance when vitality is to be considered, for the bulk of the grain, the endosperm, is without life, and is only called upon to support life when germination has commenced. On the other hand, it must not be forgotten that the close proximity of the endosperm to the life-containing embryo must result in changes such as loss of moisture, being mutually felt.

When the wheat grains are examined microscopically it is apparent that those of greatest antiquity have suffered considerably at the hands of time, and that the cementing material which binds the bundles of starch together within the endosperm has decomposed, with the result that when such grains are crushed they break up into minute, sharp-pointed fragments, entirely different in appearance to those from newer wheat.

When wetted the dough produced from the flour of the oldest wheat is entirely without "strength," a fact which has been shown to result from a combination of changes, chemical and bacteriological, taking place within the berry.

It is striking that such a degradation of gluten is not noticed also in wheats of fifty years of age, but it is probable that no complete action can take place within the grain until the tough integument has been oxidised or otherwise rendered permeable to air and bacteria.

The suggestion that the vitality of wheat or of any seeds, depends upon the degree and rapidity of desiccation and the thickness of the integument is strongly confirmed; and the loss of moisture, either if too rapid or extended over too great a period of time, would tend to render the protective coating of the seed pervious at a rate more or less rapid according to the efficiency of the integument. On the other hand, the cause of the loss of vitality of wheat in ten years, which is the period recently given by Carruthers and previously by others, must be examined more closely, for neither chemical nor microscopical examination shows that there is sufficient reason for the loss of vitality on these grounds alone in so short a time.

For this reason a number of experiments covering a wide range of environmental conditions has been undertaken.

The experimental tubes, which have been prepared in triplicate, will be examined in ten years' time, and later at periods of ten years' interval if the first results should justify such a procedure.

A description of these experiments has been reserved for a later occasion.

In conclusion, I should be glad to express my thanks to Mr. Paddison who has so admirably prepared the photomicrographs for this research, to Mr. W. A. Davis for supplying me with the wheats of the years 1852 to 1854, and to my uncle, Mr. Charles Whymper, for the specimen of Mummy Wheat, the genuineness of which he has proved both to his and my own satisfaction.

Mr. A. Bradley has assisted me not a little in the practical side of this research, and especially in preparing the tubes and samples for future examination.

A HORSE AND COW IN HARNESS TOGETHER.

Oxen are still well known in most countries as beasts of burden, and horses, in spite of motor cars, may yet remain a little longer with us; but here we have in double harness not an ox, which would be strange enough, but a milch cow yoked with a horse in the hay field.

The photograph, from which Figure 138 has been made, was taken in the summer of 1909 on the golf links at Carlsbad, and the cow as every-day partner in the team did not appear to receive anything but the kindest treatment. A great deal of the work of picking up the haycocks was done by the women with the baskets, one of whom appears in the illustration.

From a photograph by *L. J. Winter-Joyner.*

Figure 138.

A Horse and Cow in double harness.

Thus the women, and not the team, did most of the work on the links by bringing their loads on their backs from various parts of the links to the cart.

THE FACE OF THE SKY FOR MAY.

By A. C. D. CROMMELIN. B.A., D.Sc., F.R.A.S.

TABLE 25.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Jupiter. R.A.	Jupiter. Dec.	Uranus. R.A.	Uranus. Dec.	Neptune. R.A.	Neptune. Dec.	Ceres. R.A.	Ceres. Dec.	Pallas. R.A.	Pallas. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
May 1	2 32·3	N.15·0	23 10·1	S. 7·0	0 57·5	N 3·0	1 40·7	N.15·7	19 17·2	S.22·2	20 40·3	S.19·0	7 40·7	N.21·0	15 49·9	S.11·7	14 48·0	N23·7
,, 6	2 51·5	16·4	2 54·2	N.20·4	1 22·4	5·6	1 39·4	13·8	19 17·3	22·2	20 40·4	19·0	7 41·1	20·9	15 45·6	11·7	14 43·9	24·4
,, 11	3 10·9	17·8	7 48·2	N.26·0	1 50·6	8·6	1 35·5	12·1	19 17·1	22·2	20 40·5	19·0	7 41·5	20·9	15 41·1	11·7	14 39·9	25·0
,, 10	3 30·6	19·0	12 17·6	S. 2·2	2 22·4	12·0	1 35·4	10·9	19 16·5	22·3	20 40·5	19·0	7 41·9	20·9	15 36·4	11·7	14 36·2	25·3
,, 21	3 50·5	20·1	16 52·2	S. 27·4	2 58·1	15·5	1 38·7	10·2	19 15·7	22·3	20 40·4	19·0	7 42·4	20·9	15 31·7	11·7	14 32·3	25·6
,, 26	4 10·6	21·1	21 27·0	S. 18·7	3 38·4	19·0	1 45·0	9·9	19 14·5	22·4	20 40·2	19·0	7 43·0	20·9	15 27·2	11·8	14 29·8	25·6
,, 31	4 30·9	N.21·9	1 3·3	N. 8·4	4 22·7	N. 22·0	1 54·0	N.10·0	19 13·0	S.22·4	20 39·9	S.19·0	7 43·5	N.20·9	15 22·9	S.11·9	14 27·2	N25·6

TABLE 26.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
Greenwich Noon.	°	°	°	°	°	°	°	°	h. m.	h. m.
May 1	−24·3	−4·0	224·4	−21·4	−9·0	−1·7	50·0	1·4	0 47 *m*	9 5 *e*
,, 6	23·3	3·5	158·4	−11·8	0·0	1·7	119·8	33·1	6 33 *e*	1 9 *m*
,, 11	22·1	3·0	92·3	+ 9·8	9·0	1·6	189·7	64·8	6 48 *m*	8 7 *e*
,, 16	20·8	2·4	26·1	+21·8	8·9	1·6	259·7	96·6	2 44 *e*	9 19 *m*
,, 21	19·3	1·8	320·0	+ 6·3	8·8	1·6	329·7	128·5	0 49 *e*	8 26 *m*
,, 26	17·7	1·2	253·8	−17·1	8·7	1·6	39·8	160·4	1 4 *m*	5 29 *e*
,, 31	−15·9	−0·6	187·7	−21·1	−8·5	−1·6	109·9	192·4	6 50 *e*	6 41 *m*

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Jupiter L_1 refers to the equatorial zone, L_2 to the temperate zone, T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

THE SUN continues his Northward march. Sunrise during May changes from 4–34 to 3–51; sunset from 7–20 to 8–3. Its semi-diameter diminishes from 15′ 54″ to 15′ 48″. Outbreaks of spots in high latitudes should be watched for.

MERCURY is a morning star till end of month, well-placed for Southern observers. Illumination one-half on 1st, full on 31st. Semi-diameter diminishes from $3\frac{1}{2}''$ to $2\frac{1}{2}''$.

VENUS is a morning star, at greatest brilliancy on 31st, $1\frac{1}{2}°$ North of Moon on 4th. Semi-diameter diminishes from 29″ to 19″. At end of month 0·3 of disc is illuminated.

TABLE 27. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.		h. m.	
May 2	Mars	—	7 19 *m*	46°	8 45 *m*	233°
,, 10	47 Geminorum	5·6	7 50 *e*	103	8 40 *e*	280
,, 10	BAC 2383	6 5	10 16 *e*	55	10 40 *e*	334
,, 13	34 Leonis	6·4	11 22 *e*	89	0 9* *m*	330
,, 16	BAC 4261	6·9	8 15 *e*	203	—	—
,, 17	BAC 4306	6·9	2 3 *m*	137	—	—
,, 17	Spica	1·2	—	—	4 30 *e*	345
,, 17	BAC 4531	6·0	10 2 *e*	176	10 40 *e*	253
,, 20	BAC 5111	6 3	1 55 *m*	123	3 2 *m*	268
,, 23	Lacaille 7730	7·0	—	—	0 57 *m*	269
,, 23	Lacaille 7759	7·0	—	—	2 39 *m*	270
,, 26	ϕ Capricorni	5·3	2 41 *m*	44	3 57 *m*	265

The asterisk indicates the day following that given in the Date column.

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

The occultation of Mars takes place in daylight, but from experience of a similar phenomenon I know that its observation will be possible with (say) a six-inch telescope if the weather is good. The occultation of Spica is also in daylight and as the Moon will have just risen it will be difficult to observe.

Being south of Sun, it is less well placed for Northern observers than it was as an evening star.

THE MOON.—New $6^d\ 8^h\ 24^m\ m$; First Quarter $13^d\ 11^h\ 45^m m$; Full $20^d\ 7^h\ 18^m m$; Last Quarter $28^d\ 0^h\ 4^m m$. Perigee $16^d\ 2^h m$, semi-diameter 16′ 15″. Apogee $28^d\ 8^h m$, semi-diameter 14′ 49″. Maximum Librations, 7^d 5° E, 9^d 7° S., 22^d 5° W., 22^d 7° N. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

MARS is a morning Star, but not yet well placed for observation.

CERES and PALLAS are well placed for observation. They are of magnitude 7 and 8 respectively.

JUPITER is a morning star. Polar semi-diameter, 20″.

TABLE 28.

Day.	West.		East.		Day.	West.		East.	
May. 1	41	○	23		May. 17	412	○	3	
,, 2	42	○	13		,, 18	43	○	12	
,, 3	41	○	3	2●	,, 19	431	⊙		
,, 4	43	○	12		,, 20	432	○	1	
,, 5	4312	○			,, 21	4^3_1	○	2	
,, 6	432	○	1		,, 22	4	○	123	
,, 7	413	○	2		,, 23	42	○	3	1●
,, 8	4	⊙	23		,, 24	421	○	3	
,, 9	2	○	143		,, 25	3	○	412	
,, 10	1	○	34	2●	,, 26	31	⊙	4	
,, 11	3	○	124		,, 27	32	○	14	
,, 12	312	○	4		,, 28	31	○	24	
,, 13	32	○	14		,, 29		○	1324	
,, 14	1	○	24	3●	,, 30	21	○	34	
,, 15		○	1234		,, 31	2	⊙	34	
,, 16	2	○	43	1●					

Configurations of Jupiter's satellites at $2^h\ m$ for an inverting telescope.

Satellite phenomena visible at Greenwich, $1^d\ 1^h\ 39^m$ I. Tr. E., $2^h\ 58^m$ II. Sh. I.; $3^d\ 2^h\ 29^m$ II. Oc. R.; $7^d\ 0^h\ 36^m\ 43^s$ III. Ec. R., $2^h\ 11^m$ III. Oc. D.; $2^h\ 54^m\ 46^s$ I. Ec. D.; $8^d\ 1^h\ 11^m$ I. Tr. I., $2^h\ 19^m$ I. Sh. E., $3^h\ 20^m$ IV. Oc. D., $3^h\ 29^m$ I. Tr. E.; $9^d\ 0^h\ 47^m$ I. Oc. R.; $14^d\ 1^h\ 37^m\ 25^s$ III. Ec. D.; $15^d\ 1^h\ 56^m$ I. Sh. I., $2^h\ 59^m$ I. Tr. I.; $16^d\ 1^h\ 24^m$ IV. Sh. I., $2^h\ 36^m$ I. Oc. R., $3^h\ 31^m$ IV. Sh. E.; $16^d\ 11^h\ 44^m e$ I. Tr. E.; $17^d\ 2^h\ 27^m\ 58^s$ II. Ec. D.; $19^d\ 0^h\ 16^m$ II. Sh. E., $2^h\ 19^m$ II. Tr. E.; $22^d\ 3^h\ 49^m$ I. Sh. I.; $23^d\ 1^h\ 10^m\ 52^s$ I. Ec. D.; $23^d\ 11^h\ 13^m e$ I. Tr. I.; $24^d\ 0^h\ 35^m$ I. Sh. E. $1^h\ 31^m$ I. Tr. E.; $25^d\ 2^h\ 14^m$ III. Tr. E.; $26^d\ 0^h\ 3^m$ II. Sh. I., $1^h\ 52^m$ II. Tr. I., $2^h\ 52^m$ II. Sh. E.; $30^m\ 3^h\ 4^m\ 46^s$ I. Ec. D.; $31^d\ 0^h\ 11^m$ I. Sh. I., $0^h\ 59^m$ I. Tr. I., $2^h\ 28^m$ I. Sh. E., $3^h\ 17^m$ I. Tr. E.; $31^d\ 11^h\ 16^m e$ III. Sh. I.

All the above, except the three marked *e*, are in the morning hours.

SATURN is invisible, being in conjunction with the Sun on the 29th.

URANUS is a morning star, coming into a better position for observation.

NEPTUNE is an evening star and was stationary on April 4th. Its motion may be traced on the map of small stars which was given in "KNOWLEDGE" for December, 1911, page 476.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant.			Remarks.
	R.A.	Dec.		
Mar. to May	263°	+	62°	Rather swift.
April to May	193	+	58	Slow, yellow.
April to May	296	+	0	Swift, streaks.
May 1 to 6	338	−	2	Aquarids, swift, streaks.
,, 7	246	+	3	Slow, bright
,, 11 to 18	231	+	27	Slow, small.
,, 30 to Aug.	333	+	28	Swift, streaks.
,, June	280	+	32	Swift.
,, to July	252	−	21	Slow, trains.
,, 18 to 31	245	+	29	Swift, white.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 12^h to 16^h, next month 14^h to 18^h, and so on.

TABLE 29. NON-ALGOL STARS.

Star.	Right Ascension.		Declination.	Magnitudes.	Period.	Date of Maximum.
	h.	m.			d.	
R Comae	12	0	+19 ·3	7·3 to 14	·361$\frac{4}{5}$	June 8.
SU Virginis	12	1	+12 ·9	8·8 to 13	205	May 10.
T Virginis	12	10	− 5 ·5	8·2 to 13	339$\frac{1}{2}$	May 15.
T Can. Ven.	12	26	+32 ·0	8·6 to 11·8	290$\frac{1}{2}$	Mar. 26.
R Virginis	12	34	+ 7 ·5	6·2 to 11·1	145$\frac{1}{2}$	May 4.
RU Virginis	12	43	+ 4 ·7	7·6 to 11·8	440	May 26.
U Virginis	12	47	+ 6 ·0	7·7 to 13	206·9	May 29.
RR Urs. Maj.	13	23	+62 ·8	8·6 to 13	229$\frac{1}{2}$	Apr. 3.
R Hydrae	13	25	−22 ·8	3·5 to 10·1	425	Apr. 17.
T Urs. Min.	13	33	+73 ·9	8·8 to 13	321	Mar. 26.
V Urs. Min.	13	37	+74 .8	7·5 to 8·7	71	Mar. 28.
U Urs. Min.	14	16	+67 ·1	7.6 to 12	327	May 29.
S Bootis	14	18	+54 ·3	7.7 to 13	273	July 9.
R Camelop	14	24	+84 ·2	7.2 to 13	269·5	June 3.
R Bootis	14	33	+27 ·1	5.9 to 12	223·3	June 19.
RR Bootis	14	44	+39 7	8·0 to 13	196·5	May 18.
Y Librae	15	7	− 5 ·7	8·0 to 11·3	365	June 12.
RS Librae	15	19	−22 ·6	6.6 to 12	217	May 20.
RU Librae	15	28	−15 ·0	8·4 to 11	314	June 24.
X Coronae	15	46	+36 ·5	8·4 to 13	246	May 13.
R Serpentis	15	47	+15 ·4	5·6 to 13	357	May 16.
RR Librae	15	51	−18 ·0	8.2 to 12·6	276.7	June 22.
Z Coronae	15	53	+29 ·5	8·9 to 14	245	May 20.
T Coronae	15	56	+26 ·2	Now 9·5		Nova Coronae.

JOHN GRAY, B.Sc.

By G. UDNY YULE.

Readers of "Knowledge" will have heard with regret that Mr. John Gray, the inventor of the curious and interesting machine for estimating mental characteristics, described in "Knowledge" of December, 1910, passed away at the end of April, 1912, as the result of an attack of pneumonia, and a a few details with regard to his career will prove acceptable.

Gray was born in 1854, at Strichen, Aberdeenshire, and was educated as an engineer at the University of Edinburgh and the Royal School of Mines, London; he obtained the Associateship of the School in Metallurgy in 1878, and the degree of B.Sc. (Engineering) at Edinburgh in the following year. In 1878 he entered the Patent Office, and at the time of his death held the position of Examiner, specialising largely in patents relating to electrical inventions. During the earlier part of his life, Gray's interests lay almost wholly in matters relating to physics and electrical engineering. He was a fellow of the Physical Society from 1879 to 1905, and an Associate of the Institution of Electrical Engineers from 1887 to 1902. For some twenty years, even to the year before his death, he was a regular and valued contributor to *The Electrical Review*. To many students of physics his book on electrical influence machines, which was published in 1890, and reached a second edition in 1903, will be well known.

Figure 139. The late John Gray, B.Sc.

His first contribution to anthropology was a paper on the history of the place of his birth, published in *The Transactions of the Buchan Field Club* for 1893. This was followed by several other contributions to the Transactions of the Club, and, with the cooperation of members of the Club, an anthropometric survey of some fourteen thousand school children was carried out on a scheme devised by Gray, the results of which were published in its Transactions in a joint review by Gray and Tocher in *The Journal of the Anthropological Institute* (1900). These Aberdeenshire surveys paved the way for the survey of the whole of the school children of Scotland. A committee was formed consisting of Sir Wm. Turner, Professor Reid, Mr. Gray and Mr. Tocher, financial assistance obtained from the Royal Society Government Grant Committee, and the survey organised and very successfully carried out by Mr. Gray and Mr. Tocher. Gray's memoir on the results was published in *The Journal of the Anthropological Institute* for 1907. Mr. Gray acted as Secretary of the Anthropometric Committee of the British Association (1902–8), and in 1903, in conjunction with Professor D. J. Cunningham, he submitted to the Interdepartmental Committee on Physical Deterioration a scheme for an anthropometric committee of the British Isles.

Gray possessed very marked mechanical abilities, and devised a number of new instruments or new forms of instrument for anthropometric work, *e.g.*, a portable stature meter, callipers, a radiometer, a perigraph or instrument for drawing contours of skulls or bones, and an adaptation of Lovibond's tintometer for analysing the colour of hair, skin or eyes. During the last few years he had been specially interested in the machine referred to at the commencement of this notice. In its first form this instrument measured the speed at which the observer ceased to see flicker in a revolving disc coloured in black and white segments, the disc being replaced in the later and improved form ("Knowledge" *loc. cit.*) by a revolving mirror reflecting alternately white and coloured light. The actual speed was very nearly constant for the same observer, but varied greatly for different persons, and seemed to exhibit remarkable relations to the mental characteristics. He was still at work on this machine at the time of his death.

That Gray possessed not only scientific abilities and skill in mechanical invention, but also great capacity for organisation, will have been evident from his work on the anthropometric surveys. This capacity he placed at the service of the Anthropological Institute, when, in 1904, he accepted the Treasurership and by untiring effort succeeded in placing the finances on a sound basis. He also acted as Treasurer of the Universal Races Congress of 1911, and at the time of his death was serving as Assistant Treasurer of the Congress of Americanists. In 1909 he was elected a foreign associate of the Anthropological Society of Paris.

A NEW GRATING SPECTROGRAPH.

By A. H. STUART, B.Sc., F.R.A.S.

THOSE of us who have read how Fraunhofer made diffraction gratings by winding silver wire of diameter ·04mm. on brass frames and then, with them, measured the wave lengths of lines in the solar spectrum with a surprising degree of accuracy, have envied little except his ***patience***. We have only envied others their ***apparatus*** when we have read of the wonderful reflection gratings made by Rowland, and the huge map of the sun's spectrum which he obtained by their aid. This map set the pace, so to speak, in this class of work, and is still of considerable value as a standard, in spite of the classical work which Michelson has done with his interferometer. It is the dealers' catalogues that are responsible for stifling our enthusiasm for work with reflection gratings, for even a small instrument of this type costs from £10 to £20. By the judicious expenditure of £1, however, I have been able to construct a spectrograph on this principle.

Figure 140 shews this instrument in diagram. S is the slit of the instrument, L is an achromatic lens (2-ins. diameter and 30-in. focal length, value 3s. 6d). Immediately behind L is placed a transmission grating (a moulded replica on glass, value 10s. 6d., gives good results), with the prepared surface as close to the lens as possible. Behind this again, is placed a plane mirror M. C is a camera-back upon which the spectrum produced is focused. The distance from L to S and L to C should be equal to the focal length of the lens L. The whole is contained in a light-tight wooden box, PQRS in figure.

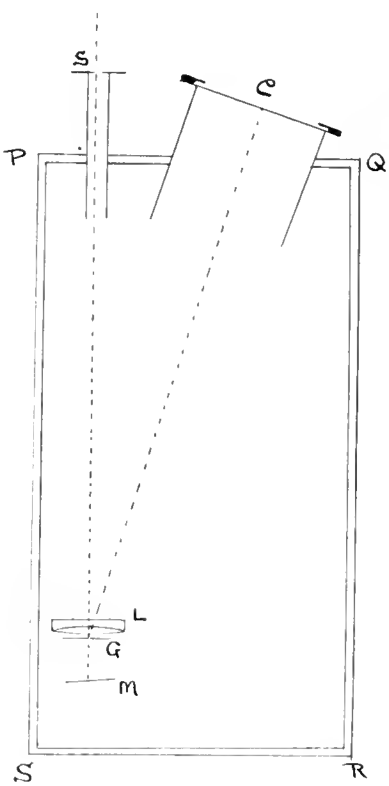


FIGURE 140.

Now in order to get the various parts of the instrument correctly fixed, it is necessary to consider in detail what happens to a pencil of light when it falls on to the grating. For our purpose we may neglect all except the spectra of the first order, and it will be convenient to consider the rays which have suffered the least deviation (with a grating the violet end of the spectrum is deviated the least). If we use a glass lens all rays in the ultra-violet beyond $\lambda = 3600$ will be absorbed. Now in Figure 141 the light travels down from S and falls on the grating G normally. A large portion of this light passes through the grating unchanged, and falls on the mirror M at A. If it meet the mirror normally it will be reflected back to the grating and a spectrum will pass out towards C. This is the spectrum which is to reach the camera. Other spectra are, however, formed, and these must be avoided. Those which are deviated to the right may be neglected, since they are absorbed by the side of the containing box (which should be blackened). When the light first falls on the grating a spectrum will be deviated to the left and will be reflected by the mirror towards B. The mirror must be so placed that this spectrum does not fall on the lens. Using a grating having 14,438 lines to the inch, the angle θ for $\lambda = 3600$ is about 14° 39′, and in order that the ray B may just miss a lens 2 inches in diameter, the mirror must be placed 3·9 inches behind the lens. There is yet another spectrum to be considered. The light falling on the grating in the first case will form a faint reflection spectrum which will, under the present conditions, be more or less superimposed on the spectrum we want to photograph. To avoid this I have found it convenient to retain the grating at right angles to the incident light, but to have the mirror slightly twisted, as shewn in Figure 140. This will separate the spectrum we want from the faint one caused by reflection from the grating surface.

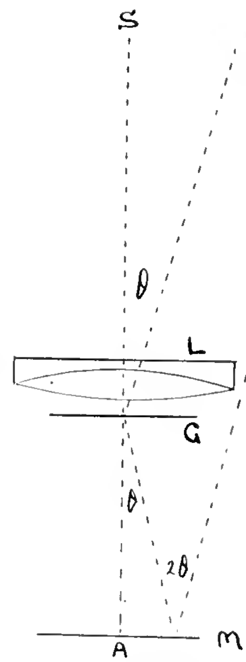


FIGURE 141.

We thus have in the camera a pure spectrum of considerable dispersion at a very trifling instrumental cost and the sacrifice of a little light.

It is wise to hang a black screen across the box, so that the lens just protrudes; this will absorb any stray reflections from the mirror.

By having a piece of wood just large enough to fit into the rebates of the camera back, and mounting in the middle of it an ordinary telescope eyepiece, the instrument may be used as a spectroscope. I have found it convenient to mount the mirror (M in Figure 140) on a turntable, and to have a long lever attachment (very much geared down) regulated from near the eyepiece. By this means a steady movement of the mirror will cause the whole of the visible spectrum to move slowly across the field of view.

SOLAR DISTURBANCES DURING FEBRUARY, 1913.

BY FRANK C. DENNETT.

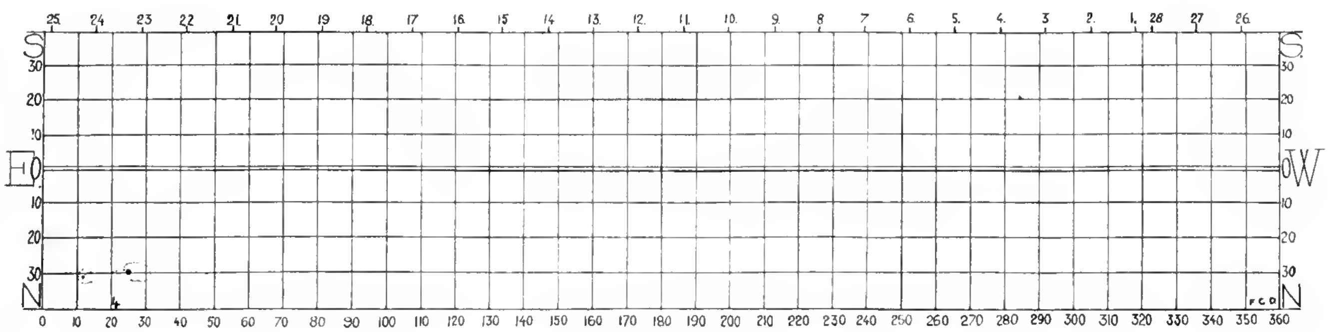
FEBRUARY has yielded a much better proportion of observing days than did the previous month. On only two—3rd and 12th—was the sun quite missed, but of the remaining days the disc appeared quite free from disturbance on no less than fifteen, as none was seen until the 18th. The central meridan at noon on February 1st, was 318° 0′.

No. 4.—On the 18th a bright faculic cloud was noted round the north-eastern limb, which on the evening of the 19th was found to contain pores. On the 20th there were three spotlets and some minute pores, but next day the leader was some 9,000 miles in diameter, and the group about 45,000 miles in length. On the 22nd and 23rd a trail of three or four pores stretched back from the southern side of the leader, and a somewhat lesser trail reached forward from the back spotlet, the group now extending over 82,000 miles. From the 24th to the 26th, only the leader was visible with a small pore closely south-east, the latter being gone on the 27th. On the 28th only the faculae remained visible in place of the group. The high northern latitude of this disturbance quite marks it as belonging to the new cycle.

Although only one disturbance has been recorded during the month, and that showing but little activity from a spectroscopic point of view, except upon the 21st and 22nd, when the C. line showed much deflection, and at one time an eruptive flocculus, it is probable that during the present year there will be a gradual but marked increase of disturbance.

The observers have been Messrs. John McHarg, C. J. Simpson, D. Booth, W. H. Izzard, C. Frooms, E. E. Peacock, and the writer.

DAY OF FEBRUARY.



NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

STELLAR PARALLAX.—An important programme in this field has been carried out at the Observatory of Yale University by Messrs. F. L. Chase and M. F. Smith. An interesting summary of the results is given in *Popular Astronomy* for February, which we reproduce below in Table 30:—

TABLE 30.

Proper Motion.	″·00 to ″·34.		″·41 to ″·54.		″·55 to ″·65.		″·66 to ″·96.		″·97 to 7″·04.		Mean.	
Magnitude.	Mean Par.	No.	Mean Par.	No.	Mean Par.	No.	Mean Par.	No.	Mean Par.	No.	Mean Par.	No.
0 to 3	″·02	18	″·10	2	″·11	3	″ —		″·20	2	″·06	25
3 „ 5	·03	9	·02	7	·11	5	·10	10	·18	7	·08	38
5 „ 7	—·01	7	·04	17	·06	19	·04	18	·09	15	·05	76
7 „ 9	—		·04	31	·03	26	·02	27	·12	15	·04	99
Means	·01	34	·04	57	·05	53	·04	55	·12	39	—	

As might be expected, the parallax increases with the proper motion. The dependence on brightness is less marked, but it is to be remembered that while the list is fairly exhaustive for the brighter stars, it only contains selected faint ones, chosen on account of sensible proper motion. The following large parallaxes were found:—

	Par.
ε Eridani	″·31
δ Eridani	·18
W.B. XVI 906	·21

The last is a faint star of magnitude 8·8, the proper motion being 1″·29. ε Eridani appears to be one of the Sun's twelve nearest neighbours.

SUNSPOTS.—Mr. Maunder contributes an interesting article on Sunspots to the January number of *Scientia*. He first points out the abruptness of the transition from spot-activity to quiescence, which is frequently accomplished in a single year. He then passes to consider Spoerer's law of fluctuation of spot zones. At the beginning of a cycle, spots break out in high north and south latitudes, and as the cycle progresses they gradually close in on the equator. There is an overlap of a year or two between one cycle and the next, equatorial spots belonging to the expiring cycle appearing concurrently with the high-latitude spots of the new one. We are now in this period of overlap, spots of the new cycle having begun to appear in December, and one in latitude 37° North having crossed the central meridian on February 23rd. Mr. Maunder considers that this fluctuation in latitude indicates that the spot-cycle is not due to external bodies such as planets, comets, or meteor swarms, but is due to some change within the Sun itself.

He further holds that since the variation in latitude synchronises with the eleven year cycle of activity, and with no other cycle, this is the only genuine cycle of sunspot change. Professor Schuster announced cycles of 4·79 years and 8·36 years from his "Periodogram" treatment of the numbers expressing the daily spotted area. But these periods do not fit in with the latitude shift of the spots, and Mr. Maunder denies their reality as genuine solar cycles. He suggests that the periodogram has indicated them since they may be times "in which the average life of a normal group of spots becomes commensurate with half the synodic rotation period of the Sun."

POSSIBLE SHORT PERIOD VARIATIONS IN THE SOLAR RADIATION.—The Mount Wilson observations having suggested that there were real variations in the Sun's radiation, it was decided that Messrs. Abbot and Angström should make observations in Algeria, while Mr. Aldrich observed on Mount Wilson. It was very improbable that any influence that was merely terrestrial would simultaneously affect these distant stations in the same manner. The results of 1911 are considered to make the variation of the Sun to an extent of ten per cent. in a period of a few days highly probable.

The weather conditions in 1912 were more favourable, and it is hoped that the observations made then will suffice to settle the question.

The *a priori* probabilities are considerably against so large a variation in so short a period. But it must be admitted that if the observations in Africa and California systematically agree, they would go far to establish its reality.

MEASURES OF THE PLANETS.—The fourth volume of *The Annals of Strassburg Observatory* contains a series of measures of the dimensions of the planets.—

	In angle at distance unity.	In miles.
Mercury	6″·431	2,893
Venus...	16 ·782	7,552
Mars	9 ·674	4,352
Jupiter, Equat. ...	199 ·04	89,553
Polar ...	187 ·23	84,242
Saturn, Equat. ...	171 ·65	77,232
Polar ...	153 ·44	69,038
Diam. of Ring	382 ·70	172,191
Uranus	67 ·90	30.550
Neptune	69 ·30	31,180

H. Samter has deduced the mass of Titan from its perturbing effect on Hyperion. Two different methods gave 1/4125 and 1/3910, Saturn being taken as unity. The accordance is good. In giving diameters in miles, Hinks' value of the Sun's Parallax, 8″·807, has been used.

The compression of Jupiter is given as $\frac{1}{16\cdot 87}$

" " " Saturn " " " $\frac{1}{9\cdot 426}$

It is curious how difficult it is to decide which of the two outermost planets is the larger. The earlier measures gave Neptune, most recent ones give Uranus, while the present series is again in favour of Neptune. The diameter of Mars is almost exactly twice that of the Moon.

BOTANY.

By Professor F. Cavers, D.Sc., F.L.S.

WEEDS OF ARABLE LAND.—Miss Winifred Brenchley (*Annals of Botany*, 1911, 1912, 1913) has published three papers dealing respectively with investigations carried out in (1) Bedfordshire on soils derived from the Chalk, Gault, Lower Greensand, and Oxford Clay; (2) parts of Somerset and Wiltshire, the Upper Greensand, Chalk, and Clay (Fuller's Earth) coming under consideration; and (3) Norfolk, on a variety of soils, including gravel, sand, loam, and clay, forming the drift deposits known as North Sea Drift and Boulder Clay, in addition to the outcrops in West Norfolk of the Chalk, Gault and Lower Greensand. The author's object was to determine the relations existing between the weeds, soils, and crops of arable land. The more important weeds are classified with their habits and relative dominance, and details are given as to the weeds of clay, chalk, sandy, and other soils. In the second paper, special mention is made of the "calcifuge" species.

It is shown that in each district investigated a definite relation exists between the weeds of arable land and the soils on which they grow. This relation may be *local*, when a weed is symptomatic of a certain soil in one district but is not so exclusively associated with it in another; or *general*, when a certain species is symptomatic or characteristic of the same type of soil in different districts. The determining factor of the association is the actual texture of the soil, and not so much the geological formation from which it is derived, except with soils overlying chalk. The crop has very little influence on the weeds occurring except in the case of seed crops, which probably smother out species which would normally occur. The weeds found in seed crops seem to be constant, and certain other plants show the same association with particular types of crop in various districts. The relative prevalence of the weeds varies somewhat in the different districts, certain species which are more or less common in one place being practically absent in another, on similar soils.

Naturally, the general relations will need more exhaustive proof than the local relations, and a true estimate will only be obtained as the field of investigation is enlarged, since each fresh observation ratifies or discounts the previous deductions. In the first two papers, dealing with Bedfordshire, Somersetshire and Wiltshire, special care was taken to select districts without drift deposits, so that the soils might be regarded in the main as derived from the geological formations immediately underlying them, *e.g.*, Greensand, Chalk, Gault. The conclusion that the geological derivation has little to do with determining the weed flora, and that the texture of the soil is a far more important factor, was fully verified by the results of the investigations made in Norfolk on drift soils. In one district a curious mingling of "acid" and "chalk" plants was found, possibly owing to the super-position of a thin layer of non-calcareous sand on a chalk subsoil, the difference in the root-systems of the plants enabling each to tap the particular soil most suited to its needs.

WIND AND TREE-GROWTH.—Even the most casual observer, who has been at the sea-coast or on mountain heights, must have noticed that full exposure to strong winds coming from one direction has a marked influence on the appearance of trees. In such exposed situations the entire tree may lean with the prevailing wind, or the trunk may grow erect while all the branches are on the leeward side, the branches which come out on the windward side being apparently bent round in the opposite direction by the force of the wind, and kept bent in this way so continuously that the growth and hardening of the wood has finally fixed the branch in this position. At any rate, this appears to be the simplest explanation, and a good example of the power of habit—the young branch finds it easier to bend with the wind than to resist it, and when it becomes old this habit is fixed and the bent and gnarled branches could not then straighten even if the wind abated. Hence, it has usually been supposed that the permanent bending of trees and of their branches in the direction of the wind is due to the mechanical action of the wind, and also to the pruning action of sharp salt or cold winds, which shrivel up the buds on the windward side as soon as they appear on the tree—this would account for the absence of branches on this side of the tree, which is often observed.

However, Jaccard (*Journ. forest. suisse*, 1912) has called this explanation in question, and has put forward a very different one. He takes into account not only the general form of the tree, but also the effect of growth in exposed places upon the thickening of the trunk; emphasizes the fact that there is a close relationship between growth of the leafy crown, the activity of the cambium or growing layer between wood and bark, and the extension of the root system in the soil; and points out that variations in the rate of water transport up the stem play an important part in the progress and localisation of growth in thickness of the wood. He gives the results of extensive comparisons of sections of the wood, showing the anatomical correlation between roots, trunk, and branches, in support of his contention that the modifications in direction of growth, and in the secondary thickening of the woody trunk and twigs, are due to various factors concerned in the nutrition of the plant rather than to the mere mechanical action of the wind, which he does not consider affords a complete explanation of this familiar phenomenon.

Jaccard's observations and interpretations are of great interest, but further work on the subject appears to be required before one can feel convinced that his main conclusion is correct; for it is somewhat difficult to see how the characteristic ꓶ-shaped form of trees exposed to strong winds can be fully explained without reference to the mechanical action of the prevailing wind.

THE GRAFT-HYBRID *CYTISUS ADAMI*.—The remarkable experiments of Winkler and Baur on the production of "graft-hybrids" and "chimaeras" were described in these columns some time ago ("Knowledge," 1911, page 186). At the meeting of the Royal Society on June 20th, 1912, Professor Keeble and Dr. E. F. Armstrong read a paper on "The Oxydases of *Cytisus Adami*." The investigation described in this paper was undertaken with a two-fold object: (1) to test Baur's hypothesis that this graft-hybrid is a periclinal chimaera composed of an epidermis derived from *Cytisus purpureus* and a body derived from *Cytisus Laburnum*, and (2) to ascertain whether migration of oxydases (oxidising ferments) may occur in plants. The results confirmed Baur's conclusions, and indicated that oxydases may pass from one tissue to another. Tests applied to the flowers of the three forms showed that *C. Adami* and *C. purpureus* contain a direct epidermal oxydase and that *C. Laburnum* does not; also that a direct oxydase is contained in the veins of *C. purpureus*, while the veins of *C. Adami* and *C. Laburnum* contain peroxydase and not a direct oxydase. In other words, *C. Adami* is identical with *C. purpureus* with respect to its epidermal oxydase, and with *C. Laburnum* with respect to its bundle (vein) oxydase.

The evidence pointing to oxydase migration is as follows: The buff standards of *C. Adami*, like the yellow standards *C. Laburnum* are marked by lines of chocolate colour, due to anthocyan pigment contained in sub-epidermal cells. Sections across these pigmented areas of *C. Adami* show that they coincide with deeply pigmented epidermal cells. Over the other parts of the standard the pigmentation of the epidermis is faint; over the sub-epidermal pigmented areas it is well-marked. Inasmuch as the fainter pigmentation is due to inhibition of pigment-formation it is concluded that the deeper pigmentation is to be attributed to the passage of oxydase from sub-epidermal pigmented cells to contiguous epidermal cells.

The failure of the buff flowers of *C. Adami* to develop their purple pigment as fully as that pigment is developed in the purple flowers becomes intelligible on the hypothesis of oxydase-migration; for, whereas the purple-flowered branches contain a bundle oxydase which may reinforce that of the epidermis in affecting pigment-formation, the vascular tissues of *C. Adami* contain no direct oxydase and hence cannot aid the epidermal cells in their work of pigment-production.

In connection with this interesting "chimaera," mention may be made of a paper by Janssonius and Moll (*Rec. trav. bot. Néerlandais*, 1911, page 333–368) on the minute structure of the wood of *Cytisus Adami* and its components. These writers find that, as might be expected, the wood of this form closely resembles that of the laburnum and differs from that of *C. purpureus*. The wood of *C. Adami* cannot be said to be on the whole intermediate in structure between that of the two "parents," but shows certain peculiarities which may be due to the influence of *C. purpureus*.

Buder (*Ber. deutsch. bot. Ges.*, Band 28; *Zeit. f. indukt. Abst.-u. Vererebs.-Lehre*, Band 5) has made a very thorough study of the minute structure of *Cytisus Adami*, and has added various details to the descriptions of previous writers. He also confirms the view, established by the work of Macfarlane, Baur, and Winkler, that this form is a periclinal chimaera. He finds that the protoplasm of the epidermal cells is joined to that in the cells below by fine threads passing through the cell-walls, just as is the case with the various cells making up the living tissues of plants in general. The nuclei of *C. Laburnum* are smaller than those of *C. purpureus*; those of the epidermis in *C. Adami* are of the *purpureus* size, those of the underlying cells are of the *Laburnum* size. In *C. purpureus* nearly all the cells contain tannin; in *C. Adami* it is present only in the epidermis. In *C. purpureus* the cork-producing cambium arises in the sub-epidermal layer, in *C. Laburnum* in the epidermis itself; in *C. Adami* the cork may be formed from the hypodermis, or from the epidermis or from both layers—all three cases may be seen in the same twig. In such details as effect the epidermal layer of cells (form of hairs, cuticle, stomata, and so on), *C. Adami* agrees exactly with *C. purpureus*. A curious detail is the fact that in *C. Adami* the nucellus of the ovule projects beyond the micropyle: this is easily explained as owing to the rapid growth of the inner (*Laburnum*) tissue of the ovule as compared with the outer (*purpureus*) integument.

CHEMISTRY.

By C. Ainsworth Mitchell, B.A. (Oxon), F.I.C.

HYDRIDES OF BORON.—Many attempts have been made to prepare definite hydrides of boron, but the instability of these compounds has hitherto prevented their isolation in a pure state. These difficulties have been overcome by Messrs. Stock and Massenez (*Ber. d. deut. Chem. Ges.*, 1912, XLV, 3539), who have succeeded in preparing definite compounds of hydrogen and boron by causing magnesium boride to fall little by little into slightly heated dilute hydrochloric acid. The gases evolved in the reäction were condensed in a series of tubes chilled by means of liquid air, and the condensed portions were then fractionated by replacing the liquid air, first by a mixture of acetone and solid carbon dioxide (−82°C. to −75°C.), then by liquid ammonia (−45°C. to −35°C.), and finally by ice.

By these means two hydrides of boron were isolated, with compositions corresponding to the formulae B_4H_{10} and B_6H_{12}. The first of these melted at about −112°C., and easily decomposed into a series of other boron hydrides. In the gaseous form it ignited spontaneously in the presence of air or oxygen, and produced dangerous explosions in vessels with narrow openings.

The other hydride, B_6H_{12}, was a colourless liquid, which had a repulsive odour, and, like its companion, took fire spontaneously on contact with air. At the ordinary pressure it boiled at about 100°C. It was readily decomposed by water, and, when treated with alkali solutions, yielded hydrogen. A trace of this hydride left in a vessel may give rise to a dangerous explosion on admission of air, and it is recommended as a precaution that the flasks should be rinsed with a solution of sodium hydroxide before allowing any air to enter.

THE BIRTH OF AN ATOM.—Two papers were recently read before the Chemical Society, the importance of which to physics and chemistry it is hardly possible to over-estimate. At the time of writing, the official account has not been published, but an excellent outline, taken from a report to *The*

Morning Post. will be found in *The Chemical News*, 1913, CVII, 78.

As has happened on several previous occasions in science, the same discovery has been independently made by more than one worker, approaching the subject from different points of view.

The first of these papers, "On the Presence of Helium in the Gases from the Interior of X-ray Tubes," was read by Sir William Ramsay, and was the outcome of his attempts to obtain evidence of chemical transformations effected through the agency of the β-rays given off in the decomposition of radium emanation. With this idea several old X-ray tubes were examined, and in each case helium, neon and argon were found in the gases within them. Possibly this helium was produced by the impact of the rays upon the glass walls of the tubes. As to the neon, its origin was suggested by the fact that on decomposing water by means of radium emanation, neon is produced in proportions indicated by the equation:—

$$\underset{4}{\text{Helium}} + \underset{16}{\text{Oxygen}} = \underset{20}{\text{Neon.}}$$

These experiments of Sir William Ramsay were supplemented by the second paper on "The Presence of Neon in Hydrogen after passage of an Electric Discharge through Hydrogen at Low Pressures," which embodied results independently obtained by Professor Collie and Mr. H. Patterson.

In this paper it was shown that when an electric discharge was passed through a vacuum tube containing hydrogen, helium and neon (which could be identified by their spectra), were invariably produced.

All precautions were taken to exclude the possibility of the introduction of any helium during the experiments, so that the conclusion was justified that there were only two explanations of the phenomenon:—(1) That the hydrogen or elements in the glass or electrodes had been transmuted into helium and neon; or (2) That the energy of the discharge had created helium and neon from the immaterial ether.

Mr. Patterson suggested that a possible hypothesis from the purely physical standpoint was that by doubling the electric charge upon the atom of hydrogen it might conceivably be converted into α-particles and so into helium.

When the experiments were repeated, with the tube containing hydrogen surrounded by an outer vacuum tube, helium was found in the latter, apparently owing to its diffusion through the glass of the inner tube. On then introducing pure oxygen into the outer tube, neon was obtained, the equation suggesting the same proportions as observed by Sir William Ramsay:—

$$\underset{4}{\text{Helium}} + \underset{16}{\text{Oxygen}} = \underset{20}{\text{Neon.}}$$

Hence the conclusion was drawn that if the helium produced in the inner tube had sufficient velocity to diffuse into the outer tube, it was quite possible for a new element, neon, to be formed.

It is now accepted as a proved fact that the element radium decomposes with the formation of other elements, the simplest of which is apparently helium, and the experiments of Sir William Ramsay have indicated that the energy liberated by radium can effect the transmutation of other elements into one another; but in such cases man can only watch the changes that go on, and cannot control or vary them. But in the building-up process that has apparently now been discovered, the energy for the change is artificially supplied and controlled, and the changes are thus of a different order from the radioactive decompositions of a decaying element.

To quote the words of Professor Collie—"We are possibly dealing with the primordial form of matter, the primordial atom, which when produced had all the energy necessary for forming the world. By combination of these 'atoms' the atoms of elements could be formed. Possibly the electric current directed the flow of these atoms with the full force of its energy, and with the phenomena of heat and light the elements came into existence."

GEOLOGY.

By G. W. Tyrrell, A.R.C.Sc., F.G.S.

Recent American Memoirs.—Geologists in the United States are fortunate in having a large number of periodicals and transactions in which to publish their work; and, judging from the elaborate and expensively-illustrated memoirs which are constantly being turned out, these societies must have plenty of money to spend. The United States Geological Survey also publishes on a lavish scale. Some recently-issued memoirs are noticed below.

A "Bibliography of the Geology and Mineralogy of Tin," by F. L. Hess and Eva Hess (Smithsonian Miscellaneous Collections, Vol. LVIII, No. 2) is a very elaborate and exhaustive work, containing one thousand seven hundred and one entries. These are principally listed under countries, but subordinate headings are General Bibliography, Mining and Milling, History, Metallurgy, Chemistry, Mineralogy and Statistics. Of the more important papers useful digests have been prepared. An index covering one hundred and sixty-nine pages completes the usefulness of this work.

"The Early Palaeozoic Bryozoa of the Baltic Provinces," by R. S. Bassler (United States National Museum, Bulletin 77) is a memoir of three hundred and eighty-two pages, with thirteen plates and two hundred and twenty-six text-figures. The fossils of the Russian Baltic area, found in almost unconsolidated Lower Palaeozoic strata, are renowned all over the world for their abundance and exquisite state of preservation. This work is as complete a study of the Russian Ordovician Bryozoa as the available collections would allow. A single Cambrian form, the oldest known Bryozoan, is described. A digest of the Lower Palaeozoic geology of Baltic Russia is given, and the Russian beds are correlated with their stratigraphical equivalents in North America.

For stratigraphers a work of inestimable value is that just issued by the United States Geological Survey under the title "Index to the Stratigraphy of North America" (Professional Paper No. 71). This important publication has been compiled by Bailey Willis and G. W. Stose, and runs to eight hundred and ninety-four pages. The aim is to summarize North American stratigraphy as fully as the data available and the scope of the work permit. The material includes some discussion of stratigraphy, some citations of fossils, and views on correlation. The work is accompanied by a geological map of North America in four sheets, making a wall-map 60×77 inches, whereon the geology is set out in forty-two colours. In addition the text contains eighteen sketch maps, giving the areal distribution of the combined formations of each system. This is a magnificent piece of work, for which geologists all over the world will be grateful.

Palaeontologists, likewise, will be grateful to the United States Geological Survey for the publication of Dr. Walcott's monumental monograph on the Cambrian Brachiopoda of the world. This is the crowning achievement of Dr. Walcott's lifelong work on Cambrian rocks and fossils, on which he is the foremost authority. Five hundred and thirty-six species and varieties, grouped in forty-four genera and fifteen sub-genera, are described, along with forty-three Ordovician forms. The great bulk of Cambrian brachiopods are inarticulate, phosphatic-shelled forms, and they attained their maximum of specific differentiation in the Middle Cambrian, where there are thirty-one genera and three hundred and fifty-five species. Even in the Lower Cambrian there are thirty-two genera and one hundred and sixteen species, showing that the Brachiopoda must have originated much farther back in time than the earliest fossiliferous rocks. Dr. Walcott concludes that each species is, in general, confined to one type of sediment, and out of five hundred forms only one hundred and fifty have been found in more than one kind of sediment. The "facies" of the rock, therefore, becomes very important in palaeontology, and especially in zonal stratigraphy.

A Riebeckite Rock from Arran.—Igneous rocks containing the rare soda-amphibole riebeckite are now known to occur in several British localities. The best known is that of Ailsa Craig, the "ocean pyramid" rising in the middle of the Firth of Clyde, but other types occur at Mynydd Mawr in Wales, in the island of Skye, and in the Lower Carboniferous eruptives of the Eildon Hills, near Melrose. A further example, recently discovered by the writer, is important, since it occurs with much the same geological relations, and only a few miles from Ailsa Craig. The rock referred to forms the great so-called "felsite" boss of the Holy Isle, near Lamlash, Arran. This intrusion rises from the sea to over a thousand feet in a steep pyramidal hill, strikingly similar to Ailsa Craig. The rock weathers deeply to a soft, crumbling, yellowish "felsite"; but on breaking a large block, the interior is found to be composed of a fresh dark-grey rock, which, on sectioning, proves to contain riebeckite. The rest of the rock is built mainly of short stumpy prisms of sanidine, with a few irregular interstitial grains of quartz. The riebeckite forms typical spongy masses, with a characteristic pleochroism from indigo-blue to yellowish-green. The rock is a riebeckite-orthophyre, and differs from that of Ailsa Craig only in its comparative freedom from quartz.

MICROSCOPY.

By F.R.M.S.

QUEKETT MICROSCOPICAL CLUB.—February 25th, 47th annual general meeting. The presidential address on "The By-Products of Organic Evolution," was given by Professor A. Dendy, F.R.S. After referring to well-known cases of by-products in industry, the President thought that nowhere in the animal kingdom is there a more exact analogy than in the familiar rotifer *Melicerta* which builds for itself a dwelling-place out of its own waste-products. The main part of the address was devoted to a consideration of the evolution of the very many forms of sponge spicules from the primitive ancestral form consisting, in the case of the Tetraxonida, of four rays diverging at equal angles from a common centre. The development of the orthotriaene, dichotriaene, protriaene, anatriaene, and discotriaene forms was then traced. An altogether different line of evolution from the primitive tetract archetype appears to have given rise to the typical oxeote spicules of the monaxonellid division of the Tetraxonida. In the course of evolution the distinction between skeleton spicules (megascleres) and flesh spicules (microscleres) becomes very marked. Both had, doubtless, a common origin, but whereas the megascleres are obviously adapted as the principal skeletal elements and are arranged accordingly in the sponge, the microscleres are scattered at random through the soft ground substance and in the majority of cases it is impossible to assign any value at all to their presence. They are, however, so constant and characteristic that they afford by far the most convenient and reliable data for the classification of the tetraxonid sponges. The President had previously suggested that the various forms were determined by differences in the hereditary constitution of the mother-cell, and in our ignorance we may assume that such differences arise spontaneously in the germ-plasm, and that it is a mere chance whether or not they may prove to be of any value to the organism. Or, again, the differences may be due to the permutations and combinations of ancestral characters which take place in the maturation and fertilisation of the germ-cells, or to the influence of some change of environment upon the germ-plasm. If the characters of sponge-spicules are really of the nature of mutations it should be possible in the future to obtain Mendelian results by hybridisation, but we should require to know a great deal more than we do now about the breeding habits and life-history of sponges before we could hope to bring such experiments to a successful issue.

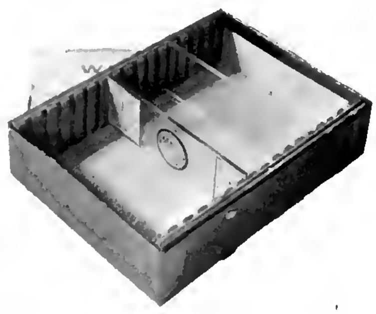


Figure 142.

Figure 143.

A USEFUL POCKET CASE FOR MICRO-SLIDES.—The microscopist often wants to carry in his pocket a dozen or so slides. It is true that small boxes for holding a dozen or a score of slides are on the market. But one may not be able to obtain these at short notice. Again, it is a convenience to have several of these boxes and those with a limited pocket may be glad to spend a hour or two's time rather than so many shillings.

The two contrivances hereinafter described merely require some pieces of card or straw board, a fairly sharp knife, some fish glue or strong gum solution, and a little patience, for their making, which is a very simple matter.

If the reader is not a photographer he is pretty sure to have the acquaintance of one, from whom he can, for the asking, obtain an empty quarter-plate card-box with lid, and very probably also some fairly stout pieces of yellow straw board, such as is often sent out as packing along with packets of bromide and similar printing papers. The quarter-plate measures four and a quarter by three and a quarter inches, and the boxes are about four and a half by three and a half inches inside, and one inch or so deep.

In Figure 142 we see such a box fitted to carry three-inch micro-slips. First we cut a number of cards one inch long and one-tenth to one-eighth of an inch wide. Next cut two strips one inch wide and four and a half inches in length, *i.e.*, just to fit the inside of the longer side of the box. The short bits are fixed to the two longer pieces with an interspace just large enough to take the thickness of a glass slip easily. This, I find, provides for sixteen slips in a quarter-plate box. As the box is three and a half inches wide, and the slips only three inches long, we have to pack up with extra strips of card four and a half inches by one inch behind each side piece. In my case two pieces of packing behind each stepped piece gave an easy fit. A glance at Figure 142 will make all clear. The triangular object behind the open box containing one mount and one clear glass is the box lid on which the box is resting to tilt it up for the purpose of being photographed.

We microscopists frequently want to lay aside a number of freshly-made mounts in a *horizontal* position to set, or dry. If such a box be set up to rest on its smaller end, we have such a contrivance. Half-a-dozen of these drying boxes (*i.e.*, containing ninety-six slips), tied back to back in pairs with a bit of thread, take up very little room, and can be left on the top shelf of a book-case, thus drying off slides in a few hours.

The second contrivance is, perhaps, a little more trouble to make, but has the advantage of holding the mounts horizontal when the box is laid flat on the table in the usual way. Here, again, we utilise a quarter-plate box. The complete article is shown in Figure 143; the box is shown containing four card trays, each tray carrying four mounts (Figure 144). A semi-circular piece of card is cut away from the centre of one side of the box (Figure 143), to enable one to lift out the trays. To the inside of the lid are fixed by fish-glue two folded-up strips of thick cloth. These form a kind of soft spring pad, which keeps the contents of the box from shifting about when the box is being carried about in the pocket.

A glance at Figure 144 shows that either of the two central slips can be got at directly, but if either of those at the ends (right and left) is wanted we have to remove one of those in the centre.

Figure 145 shows one of the empty trays, made thus. First cut the base piece to fit *easily* inside the box. Now lay four plain three-inch by one-inch glass slips, centrally, side by side, on the base piece, and run a pencil line round the lot. Then cut four strips of card (of thickness a trifle more than the thickness of the glasses) of such size as to fit the card just outside the pencil line. These strips will probably be between one-eighth and three-sixteenths of an inch wide, but their actual size will depend on the size of box in use. (Boxes for quarter-plates vary a trifle in inside measurement.) These four edging strips are fixed to the base piece. Then across each of the four corners is fixed on a triangular piece, so that the bottom or underside of the base piece may be safely clear of the cover glasses on the slips.

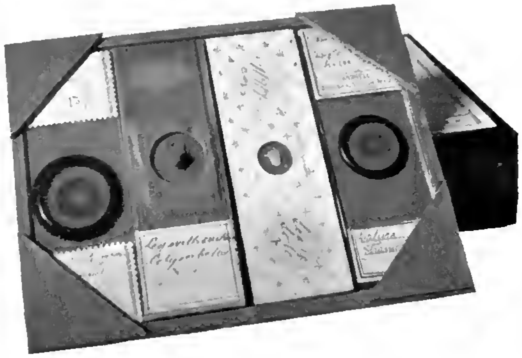


FIGURE 144.

Practical points: (1) Use a sharp knife, preferably one with fixed blade like an office knife. (2) Use a flat metal straight edge for guiding the knife. (3) For cutting on, a piece of card is good—perhaps the best of all things, as it does not blunt the cutting knife point like metal or glass, and the card which is being cut does not slip about. (4) For a fixing agent I vastly prefer fish glue or seccotine. In the bottom of a small wine glass put, say, half a salt spoonful of seccotine, add about one third as much water and work up the mixture with a cheap (penny) paint brush. This is also a good tool for applying the adhesive. (5) When one piece of card has been stuck on to another lay the two together in an old book for a few minutes, to keep all flat until all is fairly dry. (6) Do not use too much adhesive. If any is squeezed out between two pieces of card it is a sign that too much is used. This does not give such a good joint as only just enough to cover the two touching surfaces.

F. C. LAMBERT, M.A., F.R.P.S.

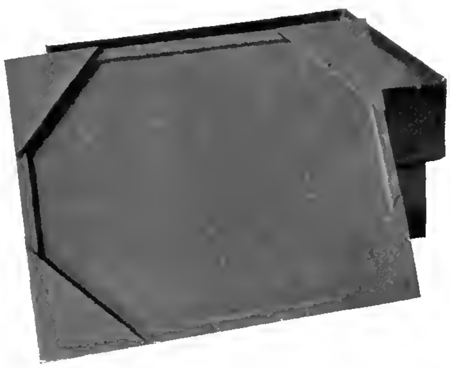


FIGURE 145.

DARK GROUND ILLUMINATION.—It may be of interest to your readers to know that a dark ground illuminator, for use with high power objectives, can be made without grinding away the underside of the top lens, as shown in the piece of apparatus computed by Mr. Nelson in your March issue. All that is necessary, is to place between the top and next lens of the Abbe Illuminator, an opaque disc of such a diameter as will cut off all the rays that directly enter the objective. The simplest way is to take some tin foil and begin by making a disc within a fraction of the diameter of the upper side of the second lens—that is, the lens immediately behind the front lens—of the condenser. This disc is then rested on the upper side of the second lens and made to stay in position by means of a little immersion oil or similar material. The top lens is then screwed on and must be in immersion contact with the underside of the object slide. Now, if a one-sixth inch or one-eighth inch objective be used on the object, which must be mounted in a medium other than air, it will soon be seen whether the object or particles are lit up with a black background. If no light passes, reduce the size of the tin foil disc very slightly and repeat the experiment until the desired effect is obtained. Each individual disc can then be kept for the different objectives and a result equal to that obtainable with the expensive immersion dark-ground illuminators can be secured without expenditure other than that of a small amount of time.

QUEKETTER.

ON THE RELATIONSHIP OF APERTURE TO POWER IN MICROSCOPE OBJECTIVES. — One would have thought that the late Dr. Dallinger had settled the question of the value of aperture once and for all by means of the photomicrographs, Nos. 7 and 8, on the frontispiece to the last edition of Carpenter; but it seems an obsession with some minds to deny the obvious on this subject.

We can pass over Mr. Hutton's references to dilettanti and ignoramuses as opposed to workers and savants and to opticians playing to the gallery, as having no place in a scientific discussion; but he should at least have stated the facts correctly before indulging in such expressions.

He gives the limit of keenness of vision as one hundred and twenty-five lines to the inch because few eyes can measure closer than this unaided. The question is not what the eye can measure or count, but what it can perceive, and most eyes can easily separate lines as close as a tenth of a millimetre. If anyone doubts this, let him observe the scale on an eyepiece micrometer, with this ruling, in ordinary daylight.

He also assumes that no objective will bear more than a ten eyepiece. However true this may be for the highest powers, it increases up to at least twenty, or even twenty-seven, with the lower powers of the same series.

His fundamental error, however, is with regard to the total magnification. The initial power of an objective is always taken for an image distance of two hundred and fifty millimetres, and the image is formed at approximately this distance with the English tube, so that the eyepieces being marked with their actual amplifying power, the total magnification is obtained by simple multiplication. With the continental tube the actual size of the image is only about two-thirds of this diameter, and, to make the result uniform, the eyepieces are marked with only about two-thirds their actual amplifying power—a ten eyepiece being really fifteen—so that simple multiplication still gives the correct total.

Mr. Hutton has given the actual objective magnifications for the short tube; but has taken the nominal figures of the eyepieces as real and has, therefore, worked out his table of apertures at two-thirds of the required figures.

A glance at Professor Abbe's table quoted by him on page 64 of KNOWLEDGE for February will show that the magnifications are given for an image distance of two hundred and fifty millimetres and the list of eyepiece powers given on page 63 are certainly only nominal.

This extra eyepiece amplification with the short tube makes no difference to the quality of the final picture, as the objective image is obviously correspondingly concentrated; but the objective must, of course, be corrected for the tube length with which it is used.

Stated properly, the table becomes as follows with an uniform eyepiece amplification of ten. I have given the necessary apertures for a keenness of perception of both one hundred and twenty-five and two hundred and fifty lines to the inch.

It will be seen that even with an eye of half the usual keenness and a ten eyepiece, the necessary N.A. for a one-

Table 31.

Focal length of Objective.		Initial magnification.	Total magnification.	N.A. for 125 lines keenness.	N.A. for 250 lines keenness.
24 mm. or 1 inch.	...	10	100	·13	·26
16 " " 2/3 "	...	15	150	·195	·39
12 " " 1/2 "	...	20	200	·26	·52
8 " " 1/3 "	...	30	300	·39	·78
6 " " 1/4 "	...	40	400	·52	1·04
4 " " 1/6 "	...	60	600	·78	1·56
3 " " 1/8 "	...	80	800	1·04	2·08
2 " " 1/12 "	...	120	1200	1·56	3·12

sixth inch is well towards what the best makers give, and for a one-eighth inch and one-twelfth inch it is beyond the limit of construction for dry and immersion lenses respectively, whilst for a keen eye we already want an immersion for the one-fourth inch, and with a one-twelfth inch could perceive more than double the structure which it is possible for any cedar oil immersion lens to resolve. For the lower powers a fifteen eyepiece would enable us to use more aperture than any maker has ever offered or could construct in a mount with the society thread. Mr. Hutton's argument that high aperture is futile because the eye cannot use it, therefore, fails completely.

His ideas as to the limit of useful magnification are equally faulty. His formulae with the various denominators ·26, ·13 and ·10 simply mean that eyes with the respective keennesses of 250, 125 and 96 lines to the inch will require magnifications of 577, 1154 and 1500 diameters respectively to define structure as minute as N.A. 1·50 can resolve. There is no need, however, to strain the eyes always up to the limit of perception, and a sensible man will gain relief by using a higher eyepiece whenever the objective will bear it. Thus, a keen eye would require a five eyepiece to see what a one-twelfth inch of N.A. 1·50 can resolve ($120 \times 5 = 600$); but would certainly use an 8, 10 or 12 for comfort. The point as to empty magnification is that the limit aperture of N.A. 1·50 can as easily be given to a one-twelfth inch as to a one-fiftieth inch, and as the eyepiece amplification required for a one-twelfth-inch is only moderate, objectives of higher power are quite unnecessary, besides being more difficult to make and use, and far more costly.

The showing of the beads on *Amphipleura pellucida* has nothing to do with the magnification further than is sufficient to make them large enough to see. The lines usually seen are from 92,000 to 95,000 to the inch, and require only N.A. ·96 to ·99 to resolve them, although they are usually shown with an oil immersion of N.A. 1·3 and oblique light as an exaggerated diffraction effect. I have frequently seen them on what must be a very coarse specimen, mounted in realgar, with the Zeiss apochromats six millimetres for the long, and four millimetres and three millimetres for the short tube, all of N.A.·95, with a fourteen (actual) eyepiece for the first two and a ten for the last. The images are absolutely identical, thereby proving that the resolution is due only to the aperture; but this specimen cannot exceed 90,000 lines to the inch. The resolution of the beads is a far different matter. The cross lines forming them are, according to the late Dr. Van Heurck, 127,500 to 130,050 to the inch and require in theory N.A. 1·33 to 1·35 to resolve them, so that they cannot possibly be seen with N.A. 1·32 and any magnification. Visibility too, is quite a different thing from resolution with such minute transparent structures, and I believe they have never been demonstrated with less than 1·40 N.A. aided by green light. Dr. Spitta's plate is quite as good an example of fine manipulation as it is of photography.

Mr. Hutton makes another mistake with regard to the resolution given by photography in excess of white light. The thirty per cent. is for the extreme violet and would require a specially constructed objective. Blue light gives only eight and a half per cent. over white, and the eye could perceive the extra resolution as well as the photographic plate if it could bear the intense illumination, or had the cumulative power.

The statement, amongst others, that Messrs. Leitz's photograph at 1150 would give as much as the naked eye at 1400 is due to a misconception. The fact that N.A. 1·32 should give as much resolution with blue light as N.A. 1·43 with white, or rather yellow-green, is probably the statement sought for. The magnification does not affect it.

The fact that some medical students prefer low aperture objectives for their greater working distance and depth of focus is no excuse for decrying so vital a property as aperture on false premises. Those students who take their microscope work seriously and desire to see all the structure there is in their specimens will certainly obtain the highest apertures they can afford in their objectives as soon as they realise that resolution absolutely depends upon it, and will quickly learn to substitute depth of focus by the use of the fine adjustment and the natural accommodation of their eyes.

Nor need either cost or working distance deter them. It is true they cannot as a rule afford apochromatics or even semi-apochromatics, and it is not necessary. First class lenses of high aperture can be bought at ridiculously low prices, and are so near perfection in both performance and workmanship that they are used for everyday work by eminent workers.

A two-third inch of a N.A. ·30 for fifteen shillings and a one-sixth in of N.A. ·82 or an one-eighth inch of N.A. ·85 for thirty shillings each can surely not be called expensive. The first and either of the second will fill the battery for dry lenses as they will each bear high eyepieces, whilst the working distance of the one-eighth inch is fully two-fifths of a millimetre over a No. 3 cover (quarter millimetre) and that of the one-sixth inch a little greater. The student who is clumsy enough for this to be a bar has a lot to learn before he becomes a useful member of his profession, and if forty-five shillings is considered too much to spend on them I should like to know where he can get anything fit to work with for less money. These are by a famous continental firm and he cannot even get the lower apertures better than playthings anywhere for less; but if he prefers English make, any of the first class houses supply objectives of similar aperture and equal performance for a few shillings more.

It is the one-twelfth inch of N.A. 1·30 which is the expensive item; but there is no substitute, and in view of the obvious fact that the corrections and workmanship must be better in proportion to both power and aperture to give a relatively as good performance and the smallness of the work makes it difficult to get them even as good, there does not seem much prospect of cheapening this item.

G. E. Garrard.

ORNITHOLOGY.

By Wilfred Mark Webb, F.L.S.

OVEN BIRDS IN THE ARGENTINE. — There is, perhaps, no greater privilege for the naturalist than to wander in foreign parts and observe at first hand the various

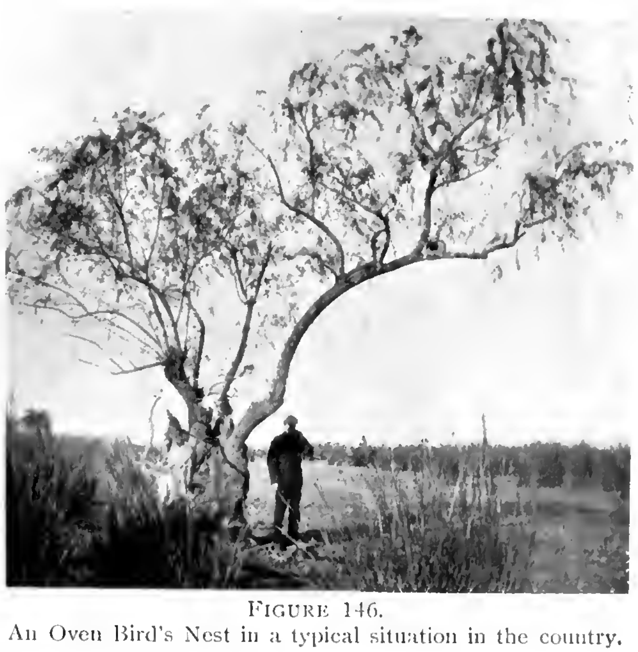


Figure 146.
An Oven Bird's Nest in a typical situation in the country.

creatures he has read of at home. It was recently my luck to explore some of the little-frequented parts of the Parana, four hundred miles up the river. Among the many interesting objects were the famous Oven Birds, of which there are various species. The commonest (*Furnarius rufus*) is a bird somewhat smaller than a Thrush, of dingy plumage and with a continuous cry. The nests (see Figures 146-148) are placed in the most conspicuous positions—on the cross bars of telegraph poles, window ledges, on monuments in cemeteries, and on posts by the roadside, and I have seen one built in a small back yard on a post to which a clothes line was attached. The clothes fluttering, the woman passing to and fro, the children and dogs playing around caused no uneasiness on the part of the birds. No one ever seemed to resent the intrusion of the birds in apparently inconvenient spots—perhaps the characteristic "slackness" of the people accounts for the fact that the abandoned nests are allowed to remain until totally disintegrated by the weather.

The name Oven Bird is singularly appropriate, the clay nests bearing a striking resemblance to the Spanish ovens in common use throughout the Argentine. The natives call the bird *hornero* (baker), or sometimes *casera*, which seems to mean housekeeper. There are two types of these nests; one kind having a large circular entrance (see Figure 148), the other with the entrance obstructed by a sort of half-opened partition (see Figure 147). The nests are about a foot high and an inch in thickness, and weigh nine or ten pounds.

Lionel E. Adams.

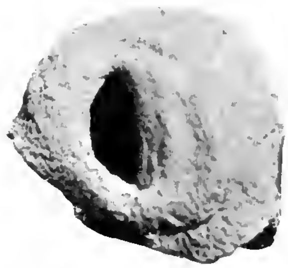


Figure 147.

A Nest of the Oven Bird with a valve-door.

Figure 148.

A boy holding the Nest seen in Figure 146; note the open circular entrance.

PHOTOGRAPHY.

By Edgar Senior.

FADING OF SILVER PRINTS.—Having had occasion recently to look over a number of prints made by various processes some sixteen years ago, and in which every care was taken at the time to make as lasting as possible, such was the condition in which nearly all of those in which silver or its compounds formed the image was found, that we were forcibly reminded of the fact that carbon and platinum are the only really reliable processes for permanency that can be depended upon. It is only fair, however, to mention that those of the prints which were made upon collodio-chloride of silver paper had withstood the test of time and atmospheric influences in a most perfect manner, exhibiting no change whatever that was perceptible. As this want of permanency in prints may be, and often is, a serious matter, one is necessarily led to the consideration as to what are the conditions under which silver prints are liable to fade. It has been stated, and no doubt with a good amount of truth, that the combined bath method is responsible for a considerable amount of the trouble, as these baths usually contain lead salts, added for the purpose of making the toning more regular, and as no amount of washing appears to entirely remove them, the ultimate result is, that the whites of the print become discoloured from the formation of lead sulphide. Without in any way wishing to uphold this method with the combined bath, we must say that prints made upon Lumière's citrate of silver paper, and toned in such a bath, remain unaltered after the lapse of some years, not that this can be taken as a proof of permanency. The question is: are prints made by any particular method liable to fade, and to what extent are they likely to do so? As a test of permanency it has been recommended to photographers to expose a print "in a moist atmosphere" to sunlight for several days when absence of change in colour was to be considered as proof of permanency. This test, at most, is very crude and incomplete, as prints which have withstood it have changed under other conditions. Then, again, many papers will change in colour if exposed to sunlight for a few days, some assuming a yellow, others a greenish tint, and this alteration in the colour must not be mistaken for fading of the print. This latter is brought about by a change in the silver image as the result of chemical action upon it, and must be studied from the nature of the silver print itself. It is well known that although gold, and especially platinum, remains untarnished by any atmospheric conditions, silver, on the other hand, readily becomes coated with a yellowish film of sulphide, due to the presence of sulphuretted hydrogen or more complex compounds of sulphur in the atmosphere, from the products of combustion of gas, the burning of coal, and the decomposition or decaying of organic matter in the presence of sulphates, the action of the hydrogen sulphide upon silver prints in all probability being accelerated by the presence of moisture. Other conditions which would also favour chemical action are increase in temperature, and the state of division of the bodies reäcting. And when the photographic image is made up of silver in a fine state of division, we can understand why it is less able to resist the action of such bodies as sulphuretted hydrogen. Then, again, there are many substances which, though having the same composition chemically, exist under several modifications having entirely different properties. Silver is one of these, and this may account for a certain kind of silver image being more permanent than another. In the case of a silver print upon albumen, gelatine, or collodio-chloride paper, the image is probably little more than a darkened organic silver compound, while that on bromide paper consists of metallic silver. This may be seen by examination under a microscope, when the particles of silver will be readily observable, whereas under the same power a printed-out

Figure 149.

A Spanish Mud Oven at Colastine.

image upon silver paper would only appear as a continuous stain. There is, therefore, a great difference between a printed-out image and one produced by development. Then, again, the former is much more readily affected by external agencies, even prolonged soaking in water being sufficient to very considerably weaken them. Then, if the cause of fading be due to sulphurisation, the product formed may be an organic sulphur compound of silver, as pure silver sulphide itself stands the action of reägents very well indeed, and bromide prints toned by means of "Hypo" and alum, "which is a sulphurisation process," are remarkably permanent. It may be remarked also that some bromide prints tone much more rapidly than others, and examination under the microscope shows that those which tone quickly have smaller-sized particles of silver than the others, and this appears to bear out the statement with regard to the state of division of the silver and its influence upon the permanence of the image. If the presence of hydrogen sulphide in the atmosphere is the most destructive agent upon silver prints, then perfect toning with separate baths of either gold or platinum is to be recommended, as a good deposit of these should go far to ensure greater resistance to atmospheric influences. As a test of permanency prints may be subjected to the action of sulphuretted hydrogen for a short time and the action noted by comparison with part of a print not so treated. It will be found that any prints toned with the combined bath will bleach first, then albumen prints, after which gelatino-chloride and collodio-chloride, and, lastly, bromide. There is still one point, however, which has not been touched upon, and that is the influence of the mountant upon the permanence of silver prints. If prints are kept in a damp atmosphere, the mountant may, from decomposition, liberate hydrogen in its nascent state, when, if any "hypo" remained in the print, sulphuretted hydrogen would be formed, with the result that the prints would be affected. This, no doubt, accounts for many prints which have not been mounted lasting longer than those which have, and is an argument in favour of employing a method of mounting in which a material that is not affected by moisture is used. In conclusion we may say, that whatever may be the exact nature of fading in silver prints, sulphur in some form appears to be the prime cause. That collodio-chloride appears less liable to change than some other forms, is the conclusion arrived at from experience, although there appears no theoretical reason why this should be, as the medium itself cannot be considered as making much difference.

PHYSICS.

By Alfred C. G. Egerton, B.Sc.

RECENT LECTURES.—The results of physical investigations have been expounded recently by their chief pioneers. It seems the time of year is fitted not only to the planning of new investigations, but the clearing up of past work. Among the most interesting summaries of work accomplished which have lately been given, the lecture by Professor Strutt, at the Royal Institution, on February 28th, finds place. He showed numerous experiments illustrating the phenomena caused by active nitrogen. Active nitrogen is almost certainly nitrogen in the atomic instead of the molecular condition; when the atoms re-combine to form molecules, then ordinary nitrogen is again formed. The transformation of active into ordinary nitrogen takes place with evolution of light of a yellow colour. Such a transformation, contrary to usual chemical action, takes place more rapidly at low temperatures, as was shown in the lecture, by plunging a tube containing active nitrogen into liquid air.

The nitrogen is made active by being submitted to an electric discharge from Leyden jars or similar condensers: ordinary pure nitrogen, freed from oxygen by passage over phosphorus, is sucked through a discharge tube at a pressure of about one millimetre of mercury; the nitrogen, as it leaves the discharge tube, passes into a wider tube, where it can be viewed undergoing its transformation into ordinary form by the yellow light emitted. When other gases, such as chloroform or carbon bisulphide, are passed in together with the active nitrogen, cyanogen is formed and gives out the characteristic pinkish light of the cyanogen flame. The nitrogen, unlike ordinary nitrogen, combines readily with most substances. If the metals are heated gently in the active gas, they give out their characteristic line spectra and form nitrides. Thus mercury was shown to give a brilliant mercury arc effect and form a very unstable mercury nitride, which decomposes explosively on heating.

Now ozone and nitric oxide, when they combine under similar conditions, also give out light, but of a much greener hue, and repetition of experiments on active nitrogen in Germany by certain investigators have been ascribed to the production of ozone or nitric oxide from minute quantities of oxygen contained in the nitrogen. But it must be allowed Professor Strutt has freed his nitrogen from oxygen quite satisfactorily. The active modification of nitrogen can be destroyed by the catalytic action of a surface coated with oxide of copper. A copper wire, coated with oxide, dropped into a tube containing active nitrogen immediately extinguishes the glow. It is necessary for the nitrogen atoms to collide up to seven hundred and eighty times before recombination with another atom occurs, in presence of a copper oxide surface; whereas only one collision of a molecule of ozone against a silver surface is necessary to cause it to transform to an ordinary oxygen molecule. Ordinary nitrogen can be converted into active nitrogen by means of the ring discharge. If the inner coatings of Leyden jars are connected to an induction coil, and the outer to a coil of thirty or forty turns of wire, electrical oscillations will be set up in the coil of wire, which will ionise and induce currents in gases enclosed in tubes at low pressure placed within the coil. Therefore, all that is necessary is to fill a tube with pure nitrogen, at about one or two millimetres pressure, and place it within such a coil, in order to obtain it in the active condition and view the glow given by it.

Another lecturer has gathered together Mr. C. T. R. Wilson's work, which has rendered visible the paths of ionising radiations. When Röntgen rays or the rays from radioactive substances pass through air, they cause ionisation of the air in their path: that is to say, air particles carrying positive and negative charges are formed. Moisture will deposit from air overcharged or supersaturated with water vapour on either dust particles or electrified ions, such as these charged particles are called. Thus, if the air through which rays are passed is supersaturated with moisture, the paths of those rays will be marked by the condensation of moisture on the ions produced in those paths. That is the principle of Mr. Wilson's method of making visible the paths of such rays. However, it is not easy to record such effects photographically: much ingenuity has been displayed in doing this satisfactorily. Mr. Wilson allows the base of the ionisation chamber, containing the moist air through which the rays from radium or the X-rays pass, to drop slightly whereby sufficient expansion occurs to cool the air to the necessary point to cause the moisture to be capable of condensing out on any ions present; at the same time as the expansion chamber base drops a ball is released, which passes between a spark gap, and the spark through a mercury arc gives sufficient light to illuminate the condensed particles, and allow them to be recorded on a photographic plate which has previously been focused on the expansion chamber. The photographs obtained are very remarkable; the paths of the α-rays of radium are very distinct and perfectly straight to within a millimetre or so of their termination, when they often branch off for a short distance at another angle. Presumably, the α-rays have been so reduced in velocity by their collisions with air molecules, that they get deflected out of their path. The results with β-rays—the negatively-charged rays from radioactive substances and the rays produced when X-rays strike against substances—have much more irregular and meandering paths, and the streaks on the photographic plates are much less dense than those due to the α-rays, because the number of ions produced are much fewer. It is indeed wonderful that the actual paths of single particles, of which there are more than a million million million in one cubic centimetre, can be made visible and recorded on a photographic plate; and it is a very great feat to have accomplished the actual making visible of phenomena which have only been investigated and understood by process of reasoning; things are understood clearest when they are made to appeal to the visual sense.

Among other lectures of great interest may be mentioned Professor Sir Joseph Thomson's lectures on the Constitution of the Atom, which have just been terminated at the Royal Institution. He expounded in these lectures simply and clearly his view of the atom composed, as all now admit, partly of negative electrons and partly of positively charged matter. The atom possesses a central core of electrons and an outer ring, and the maximum number of electrons in this ring is eight. The number in the ring determine the valency of the atom, and the vibrations (as of a conical pendulum) determine the type of spectra emitted. It would be too much to go into the subject in detail in these notes, and the same also applies to the interesting account of the researches of Professor Nernst, which he expounded on four evenings following the 6th March, to a large audience, at University College, London.

ZOÖLOGY.

By Professor J. Arthur Thomson, M.A.

A MOUTHLESS CARP.—It seems strange that a fish can live and thrive without a mouth. J. W. Fehlmann describes this apparent simplification of life on the part of a carp four years of age. Its mouth was absolutely shut and the same was true of the anus. Yet there were numerous mayfly larvae, crustaceans, pieces of plants and the like in the food-canal. The animal must have not only breathed but fed through its gill-clefts. We are not surprised to learn that the carp showed no trace of fat, but to live for four years without a mouth was certainly an achievement.

MOVEMENTS OF THE SEA-HORSE.—R. Anthony and L. Chevroton have studied the attitudes and movements of the fascinating *Hippocampus*, which is at once a fish of the floor of the sea (benthos) and "arboricolous" among the sea-weed. It fixes itself upright with its prehensile tail, and is helped by its swim-bladder to keep the vertical position. It swims vertically, or obliquely, using its pectoral fins, and the dorsal fin usually helps. The dorsal fin is also used to steady the animal when it is fixed by its tail. In moving towards an object the sea-horse bends forwards a little and mounts upwards. When it descends it stops the action of its fins. There are many remarkable specialisations about this attractive little creature. Thus there are numerous individualised muscles. The head is not in a line with the backbone, but at an angle of 90°—100° to it.

NATURAL HISTORY NOTES FROM BOLIVIA AND PERU.—Mr. James Murray, who was naturalist on Sir Ernest Shackleton's Antarctic Expedition, now sends some very interesting notes from a very different part of the world—from Bolivia and Peru. The rapidly-dwindling Echoja Indians have great skill in wood-craft. The chief Wahshee could bring the animals to him by uttering certain sounds, which did not seem to be imitations. "On one occasion a deer was sighted. Wahshee began a very loud and wild cry, and the deer came slowly nearer and nearer, till it was only two or three yards from us." "On another occasion it was a black monkey. This time he used a quite different sound, a very plaintive, weird kind of whimpering. The monkey began to climb down the tree towards us, and came quite near before something disturbed it."

MAGGOTS IN MAN.—Mr. Murray gives a grim account of one of the common scourges of the forest, the Sututu (*Dermatobia cyaniventris*), a two-winged fly, whose larvae —about an inch long—occur in the skin of men and beasts. They are like Indian clubs in shape and bear rows of prickles. The presence of the parasite is usually first noticed on account of the sharp pain caused by the prickles as it moves. The chief Wahshee already alluded to seemed to be able to summon the larvae out of the skin by making a curious chirping noise with his mouth, but there is need for sceptical criticism here. Worse than Sututu is the Screw-Worm (*Chrysomyia macellaria*) also the larvae of a horse-fly. Large numbers occur together in the skin about a wound. They burrow restlessly and cause great pain. They kill many mules and a few men, and are themselves singularly difficult to kill. The great specific seems to be a medicament called Cebadilla.

THE SCALLOP'S EYES.—Numerous well-developed eyes occur along the margin of the scallop's mantle, and it is well known that the bivalve is exquisitely sensitive to differences of light and shade. Victor Bauer has made a series of careful observations on *Pecten jacobaeus*, and finds that one great use of the many eyes is to direct the animal to the illumined surface areas, where there is special abundance of the phyto-plankton on which it mainly feeds. The scallop does not steer when it swims, it gets its bearings by means of its eyes before it starts. The eyes also help it to detect the movements of an approaching enemy, and the stimulus leads to a shutting of the shell-valves. The skin secretion of a starfish sets the scallop a-swimming, and here tactile and chemical stimuli operate. But the eyes are auxiliary.

COLOUR-SENSE IN BEES.—Very interesting experiments by L. von Dobkiewicz throw a clear light on a much discussed question and on a number of well-established but discrepant facts. It seems certain that bees distinguish different colours. But different colours acquire significance for bees when the insects have learned that certain colours are associated with certain nutritive advantages. The bees are not "reflex-machines," they are not compelled by any organic chromotropism to prefer certain colours to others. They accumulate experience, and remember that certain colours are associated with certain nutritive benefits. They learn to save time by following certain colour-hints, but it is not inconsistent with this that they are eager visitors of flowers without any colour at all, but rich in nectar none the less.

SENSE OF DIRECTION.—Edmond Bordage made a study of digger-wasps and other insects at Réunion and reached some interesting conclusions. He maintains, for instance, that the wasps find their home again by taking particular notice beforehand of the immediate surroundings. As the Peckhams noticed, there is a preliminary scouting and observation of surroundings before the insect quits the vicinity of the nest. Bordage is unwilling to invoke a special sense of direction in such cases.

OXYGEN-STARVATION.—Anna Drzewina and Georges Bohn have made interesting experiments showing the indifference of many marine animals to scarcity of oxygen. A small shore-crab (*Carcinus maenas*) lived for twenty-two hours in water with only a trace of oxygen, and soon recovered. A pea-crab (*Pinnotheres*) survived for three days. A small sea-anemone (*Metridium dianthus*) lived for four days, and others (*Anthea cereus*) seemed to be quite normal after four and a half. The little periwinkle (*Littorina rudis*) was none the worse for four days of the oxygen-starvation and a Polychaet (*Phyllodoce laminosa*) was living after thirty-nine hours. The little starfish, *Asterina gibbosa*, recovered itself after thirty-four hours. In most of these cases, the animal was inert at the end of the experiment, but recovered in the course of a few hours.

VESTIGES OF SCALES IN SIREN.—It is well known that amphibians are almost always quite naked, thus standing in great contrast to the scaly reptiles. The limbless Caecilians which burrow underground are exceptions, for they have numerous scales embedded in the skin; and there are some other exceptions, such as Ceratophrys, which has bony plates on its back. The extinct Labyrinthodonts were also armoured. In studying the mud eel, *Siren lacertina*, Margarethe Kressmann has made a very interesting discovery. There are numerous papillae in the deeper, firmer layer of the underskin or dermis. They occur over the whole body, and although they are hidden by the more superficial layers of the skin, their structure is such that they are very reasonably interpreted as dwindling vestiges of the scales which ancestral amphibians possessed.

ON THE FLORAL BLUE.

By P. Q. KEEGAN, LL.D.

THE origin of a colouring matter is technically termed chromogen, *i.e.*, the precursor thereof, or the special chemical constituent, whose presence in the corolla is necessary for its production. Most vegetable colorations are derivatives of what is called the aromatic series of organic bodies, and it is known that as certain members of this series produce the magnificent aniline dyes, whose spectacular effects are familiar in theatres, and so on, so also other members of the same series form the origin of the beautiful tints and hues which clothe the flowers of the field and garden. The floral structures (corolla, sepal, and so on), are built up out of a number of chemical constituents, *e.g.*, cellulose, wax, oil, tannin, mucilage, salts, and so on, which may be withdrawn therefrom and separated by chemical methods. The question arises—a most interesting one to the inquiring mind—what is the particular component of this structure to which is due the outcome of that most enchanting adornment, the blue, red, or yellow floral coloration? We must, by diligent analysis and with inexhaustible patience, turn over every clue; we must test and examine all the constituents, until we find some particular one which unquestionably betrays its relationship to the aromatic series of hydrocarbons aforesaid; for we are assured that therein will lie the true spring and fountain of all this floral glory.

We commence the research naturally by studying specimens of plants which bear really true blue flowers, taking care, of course, that we do not mistake a violet or purple corolla for a really blue one. An astute chemist, who is well versed in the analysis of tannic materials, can foretell where such a subject is sure to be found. He knows that such and such orders of plants—for instance, the Rosaceae or the Leguminosae—do not produce blue flowers, and he can assign a reason therefor. On the other hand, he is quite convinced that certain other orders, such as the Campanulaceae or the Gentianaceae, can assuredly do so, inasmuch as that particular constituent called tannin is of a similar kind in each of the latter two orders, but is widely different from that in either of the two former orders. Which is as much as to say, that a kind of chromogen exists in roses and sweet peas which does not exist in gentians or bell flowers, and *vice versâ*. True blues exist in veronicas, salvias, verbenas, basil, solanum, penstemon, nemophila, convolvulus, borage, hound's tongue, and in all the orders allied to Gentianaceae and Compositae; but not in lupins, vetches, peas, vetchlings, geraniums, hollyhocks, primulas, balsams, flax, and so on. In the blue flowers just mentioned there is a chromogen, *i.e.*, a tannin common to all as detected by chemical analysis, whereas in the non-blues this special substance does not occur. A noteworthy fact or peculiarity is that while one series or order of plants containing this special colour-producing body may exhibit red or blue flowers only in certain species or even in one and the same plant, another series or species with the same chromogen evolves nothing but red or yellow adornments. In fact, in some cases—as, for instance, in begonias—a genus may be quite capable of displaying an azure appanage, but its powers are confined to that of red.

However, to come to details, it may be mentioned that the parent substance of the blue flower is called caffetannin and is imbibed in every cup of coffee we drink, whereas when we drink tea we merely absorb something concerned in the production of red camellias, for example. The chemist will inform you that caffetannin exists in somewhat different forms, and has a different composition, perhaps, in different plants. Some say it is a glucoside; others deny that; and some others again assert that it is a mere mixture of organic acids and other substances. What is beyond question is that it contains in its composition (molecule) more of what are called hydroxyl groups than perhaps any other tannic compound known; that is to say, that where an atom of hydrogen might be found, an atom of oxygen takes its place. Oxygen is an element essential to the support of animal life, but it is also a supporter of coloration, yellow for less of it and blue for more of it. Moreover, we can artificially produce a blue compound from caffetannin; but from any other kind of tannin save one, this cannot be done. We have only to leave a solution of caffetannin freely exposed to the air with a little chalk added, when we see the latter gradually turn green, and then on pouring off the liquid and adding some acid, a red solution is obtained very like the tint of the foxglove corolla, and so on, and which, like it also, may by a certain treatment be changed into a brilliant blue. By a careful application of dilute solutions of an iron and a sodium salt the dilute colourless solution of the same tannin can also be induced to yield a most beautiful and persistent azure liquid.

In fact, the complete analysis of any plant that contains this tannin reveals in many ways that we are dealing with a powerful colour-evolving substance. Then again, we observe similar phenomena repeated when other plants, perhaps belonging to widely different classes or orders, are taken in hand. But however wide these taxonomic differences, we find invariably one common feature, *viz.*, the capacity to produce a true blue flower. Moreover, this most remarkable feature is absolutely independent of the status of the organism, of the organic perfection or degradation of the species. The gentians, for instance, with their feeble powers of assimilation and their mycorrhiza infestation; the Compositae deprived of one at least of the chief factors of organic perfection; the Labiates more perfectioned than the borages or the solanums; the Ranunculaceae, Liliaceae, and so on, with types representative of a special kind of organic debasement—all these and more rise to the same high level of floral glory when they unfold and hang out to sun and shower the "soft eye-music" of the flaunting blue.

In fact, the blue corolla is caused by the comparative strength and completeness of the process of de-assimilation occurring there, and this, no doubt, is also the cause why in some plants a certain kind of tannic chromogen is produced, and not so in others. The protoplasm, in order to eliminate from its molecule a tannin containing six HO groups, would de-assimilate or oxygenise more completely than if it produced a tannin with only four or five HO groups. Also, in Gentianaceae with very numerous ovules, blue flowers of the most brilliant description are frequently exhibited; in Compositae with only one ovule they are comparatively rare and never so effective. In the latter case, the de-assimilation is not complete, various volatile oils, resins, and tannoids being a common outcome of the process. It may occur, of course, that the plant itself may produce in its green organs a large quantity of caffetannin—for example, the common yarrow—while the flowers are white or pale pink; but this apparently does not occur in plants with vigorous powers of reproduction (*e.g.*, gentians) wherein tannoids only appear in stem, leaf, and root, the more complete and final products being found exclusively in the floral parts. Therefore, in accordance with this report herein set forth for the first time in this journal, let gardeners cease from troubling to "evolute" a pure blue flower on a plant incapable of constructing a tannic chromogen containing less than a certain number of hydroxyl groups.

THE NEGLECT OF METAPHYSICS.

By J. E. CAIRNS, B.Sc.

THE latter half of the nineteenth century beheld a startlingly sudden advance of science unparalleled in the history of the world before; a true Scientific Renaissance. It was the publication of "The Origin of Species" which probably pulled the trigger and released the vast stores of energy which threatened to change completely the face of the world; but the mines had been laid long before, and the time had at last grown ripe for their discharging. The world called for men and the men came. In biology, chemistry, physics, psychology, giant intellects sprang to the fore; discovery followed discovery, theories were conceived only to be supplanted before their birth, and the array of new facts grew so amazingly that the mind was stunned and bewildered before the dazzling display of treasures that were heaped before it. Though confounded at first by its "sudden joy," the mind soon took on a somewhat calmer mood in which it could appreciate its new riches, and it conned them over and over again with ever-widening and ever-deepening delight, till at last the wild excitement of attainment gave place to the wilder excitement of possession. Then ensued a period of what to us now appears like intellectual debauchery: a time of rash assertion, of bitter controversy between those who were conceited with their knowledge and those who were conceited with their ignorance; a pitifully hysterical display of *nouveaux riches*, a cruelly uncompromising attitude of oracularism.

In those days—they seem so long ago, though in truth so recent!—one heard on every hand the stupendous promises of science; that it alone was capable of explaining away all the problems of the Universe, and that it would make for mankind a bed on which to lay his perplexed head in peace,—a hard bed perhaps, but surely preferable to the soft "pillow of obscure ideas" on which he had dreamed so restlessly so long! Science was rapidly assuming the rôle of the fairy-godmother, that unworthy rôle which Huxley so bitterly deprecated.

So it was then; and now, at the beginning of the second decade of the twentieth century, what has it all come to? the sweat of the conflict, the paeans of the victors, the woe of the vanquished—what has come of them all? For now the struggle is over, save for some inconsequential skirmishes that still go on among those who have not yet realised that the whole war was but the striving of phantoms over a shadow; it is over and forces have been reviewed, losses told and trophies counted. And here both sides have found that their losses proved to be their gains, and their trophies were so stained with the marks of meaner passions that they were ashamed to vaunt them. But what of the grandiloquent promises that science made to its partisans? Have these been redeemed, and are the great world-riddles all answered?

We know now the promises were vain; the boasted omniscience but the empty wisdom of intoxication. The phase has passed, and now we know that science has not answered, and cannot answer the clamouring questions regarding human destiny. Soul, mind, consciousness—death, immortality, God,—of these, the physical science that has spoken so loudly for itself knows nothing. Indeed, it has not even a satisfactory criterion of reality to apply to the subject-matter of its own studies; it assumes reality where it knows only appearance. These other vitally important questions it cannot in the very nature of things hope to answer, and they are left to a few enthusiasts whose feeble voices have been almost drowned in the swelling triumph hymn of their brothers in the physical camp. There are aspects of the universe which are not amenable to investigation by retort, microscope or galvanometer, and this the physicist must remember and thereby calm his too-arrogant enthusiasm.

Let us enquire for a moment into the grounds for this enthusiasm of the scientific man—always meaning by that term the student of the physical or material aspect of the universe. At first sight these seem very solid, and the enthusiastic assertions quite justifiable. We think of the theory of natural selection; of the discovery of radio-activity; of the hypothesis of the electro-etherial constitution of matter; and the thrill of intellectual satisfaction we experience shows us that these things are good for man to know. We remember wireless telegraphy, X-rays, the transmutation of the elements, the possibility of utilising the almost infinite stores of energy that is within the atom, and science becomes the fairy-godmother again.

We cannot praise too highly the genius and the patience of those who have learned these things from nature and given them to man. The splendour of the results achieved by modern science is fully appreciated by us all, and to the modern scientific man all pay their homage. It is when he is raised to be a brother of the gods, with his fingers on all the springs that direct the cosmos, that justifiable enthusiasm degenerates into rank hysteria.

For in these results, which as records of human ingenuity are so splendid, no really vital interests are touched. True, the idea of unity and of beautiful inter-dependence which they give reflects back on our moral life and influences our conduct; but it is only a reflexion, not a direct effect. They have made the great mysteries of the whence? the why? the whither? no clearer; and these are for mankind the real vital questions, to which the nature of Nature is only an embellishment.

The value of the work that has been done in science none can gainsay, but it sinks into comparative insignificance before the value of the work that has not been done. For mankind, the study of the physical universe is of great importance, but still its importance is only secondary to the knowledge of the things that are not seen but are eternal. Not that we want a Comte of the spiritual, obstructing all knowledge save such as seems useful. It is a conceited presumption that pretends to be able to demarcate useful from useless knowledge. Our insight—especially of us physicists of the West—is not sufficiently clear to justify such a position. Yet at the same time, while not absolutely decrying any knowledge, we may easily see that some things are of more importance to mankind than others are. And here is the parting of the ways; this is the question that splits the company, the question that Herbert Spencer asked explicitly, and every other philosopher asked implicitly—What knowledge is of most worth?

Spencer answered this question to his own satisfaction by the single word—Science! This was, without doubt, the true answer for the time. Science was then the knowledge of most worth, it was the knowledge the world needed most. But it is not the true answer now. The world has had its science, and has thriven upon it; but now, after a gorgeous feast, repletion is approaching.

Science is growing stultified and engendering stultification. Having neglected things of the spirit and concentrated its attention on matter and force, it has become "of the earth, earthy." Man is growing dissatisfied with the description of himself in terms of chemical equations and mathematical formulae, and nothing more. He *knows* there is something more, and consequently is annoyed when his darling science persistently ignores it, and sometimes denies it. And, as well, there is a rankling vindictiveness against this science, which cut the wings of his airy fancies thirty or forty years ago, and left him to crawl along the ground since.

There is a feeling of unrest, of incipient rebellion; a stirring of resentment against the salt that has lost its savour. The very men of science themselves are casting about after wider things.

If we look plainly at the fact then we must admit that science has failed. It has given us a world without a God, a body without a soul, a life without an objective. But at the same time we must also plainly see that this failure is not due to science in itself, but to the extravagant claims that were made in its behalf. It was thrust into the giant's robe, and could not help but trip over it. It is rather remarkable to think that the necessarily restricted range of physical science was lost sight of by its most gifted exponents. The rule of the game (so to speak) which arbitrarily assigned matter and energy alone to scientific activity, neglecting any other forces or entities that might exist beyond these—this rule was forgotten by the very players who imposed it. After thus consciously and willingly setting limits for themselves, they went on to declare—some openly, some tacitly—that these limits included the whole contents of humanity's intellectual aspirations! All that science could teach was all there was to know!

The enormous success that resulted in this limited field is the only extenuation—and a very poor one it is—for such conduct. The scientific men in their sparkling progress hustled a wondering world along with them, and for a time all forgot that science represented only one aspect of this scheme of things, and that the less important aspect.

But only for a time. The pace is now slackening and cooler judgment is returning. The problems that science *cannot* solve are coming forward once more, as they always must do, to the front. Science must vindicate itself for solving the world-riddles in terms of a godless universe, a soulless body, an aimless life! And science is dumb and helpless.

It is not difficult to see, however, that had physical science been supplemented by metaphysics, as it should be, this *impasse* would not have been reached, but all the unanswerable questions which are now clamouring for answers would have been taken to the metaphysists whose business it is to answer them. For science has solved its own legitimate problems, and solved them brilliantly; it is only with the problems of metaphysics that it has failed.

It would seem, then, that for us the knowledge of most worth, the knowledge that we need most to study, is metaphysics. The laws of the inter-relations of matter and energy we know fairly thoroughly; but what constitutes reality; the nature of the Soul and God; the influence of Mind on Matter—we understand hardly at all, when we need so much to understand them. These latter should be—must be, now!—the subjects of human investigation; and the results when combined with our existing and ever-growing knowledge of things physical will give us a conception of the Universe far more likely to satisfy both the emotional and the intellectual cravings of man than any extension whatever of our science of to-day could do.

And in this investigation it would be well to remember that there are in India and China peoples who have been studying these matters for at least twenty thousand years. Their science was hoary before ours was born. It is for the twentieth century to witness the meeting of East and West in scientific brotherhood, on terms of mutual instruction.

Let us then turn to the East whence cometh the light!

CORRESPONDENCE.

AN IDEAL MUSEUM AND ITS GUIDE.

To the Editors of "Knowledge."

Sirs,—I feel somewhat relieved to learn from the letter signed by Mr. Francis Guy Laking, M.V.O., F.S.A., the Keeper and Secretary to the London Museum, Kensington Palace, which appears on page 93 of your March issue, that he is in no way responsible for the guide. As you, Sirs, rightly pointed out in your note, I had already made this clear in my contribution. I must, however, express surprise at the fact that the guide was never submitted to the authorities, and, in the circumstances, still greater surprise that these authorities yet permit the out-of-date, inaccurate, and misleading guide to be sold at the museum to the public, especially as these authorities are not enveloped in the "entangling meshes of departmental red tape." I know of no provincial curator who would permit this, and I am sorry to learn that the Keeper and Secretary of this important London Museum is not able to prevent it.

I thought I had also made it clear that I was not misled by the so-called guide, but my remarks were based upon an actual examination of the cases and their contents. I feel flattered and gratified at being asked to give any suggestion for the improvement and the arrangement of the specimens in this important museum, and will certainly accept the kind invitation to call upon the curator the next time I am in town.

A PROVINCIAL CURATOR.

THE FOURTH DIMENSION.

To the Editors of "Knowledge."

Sirs,—Mr. H. Stanley Redgrove, in a letter in your February issue, expressed surprise that I did not go into more detail in my reply to his statement that the existence of one dimension implies that of a second, a second that of a third, a third that of a fourth, and so on. I mentioned what experience tells us in reference to dimensions, and pointed out that there is nothing in this experience to support his statement. In his letter in your March issue—in reply to the letter of Mr. Henkel—he gives his argument in more detail, so it is possible for more criticism to be made. He asks what can be the criterion of real existence which denies reality to that which exists in mind. A single dimension has no real existence in mind; only the idea of it exists in mind. Our knowledge of the real existence of anything must be based on experience, and we have no experience of one dimension except in conjunction with the other two. When the mind thinks about one dimension it singles out one thing from its experience and directs its attention exclusively to it, but this action of the mind—or the idea in the mind—does not give the one dimension any independent reality, or give any support to an argument that the one dimension has independent reality. In reference to his statement that nobody has ever seen a three-dimensional body, it may be said that though any single perception cannot give the knowledge of three dimensions, there are very many perceptions—of various kinds—and the accumulated result is experience. Certain kinds of inductive reasoning—as exemplified in his letter in your February issue—may be of use when finding out algebraical laws, but it is a very different thing when it is a case of finding out what is, or is not, in real existence. His statement—in the letter mentioned—that the existence of n dimensions implies the existence of $n + 1$ is of the same nature as a statement that if there are 50 sheep in a meadow there must be $50 + 1$. There is no evidence in favour of the real existence of the fourth dimension and no evidence against this.

Hendon, N.W. JOHN JOHNSTON.

FOURTH DIMENSION.

To the Editors of "Knowledge."

Sirs,—I do not wish to enter on a controversy with Mr. Redgrove as to the nature of reality, for I am inclined to sympathise largely with much of what has been said and written, and the matter is one about which philosophers have always differed, and I suppose will always differ, from the days of Plato to those of Bergson (who by the way owes much to the former, though he does not acknowledge his debt to any great extent). As a "working definition" perhaps one might tentatively define reality as that which exists independently of any human mind perceiving it, as we conceive the "material universe" to do.

With regard to our *seeing only* flat surfaces apart from the stereoscopic effect arising from our two eyes, I would assert that without *some depth* (*i.e.*, third dimension) no surface whatever would be visible. The nearest approximation, optical images and excessively thin sheets of metal, to be seen by me or even distinctly conceived in my mind must have some thickness as well as length and breadth, though the third dimension *may be as small as we please* by comparison with the others. Moreover, it is a matter of convention *which* we call x, y, or z, but a fourth dimension cannot be interchanged with any one of the others, any more than can the time element (one-dimensional) be exchanged for it or them.

"The phenomena whose study is the object of Natural Philosophy take place each at a definite location at a definite moment, the whole constituting a four-dimensional world of space and time" (Whittaker's "Aether and Electricity," pages 447–8) and a method of *analysis* may be (and has been) devised, dealing with the theory of the aether and other matters.

But the essential nature of the one-dimensional element, time, is in thought at least so different from that of the others that nothing can be inferred from this as to the existence of a fourth dimension of *space*.

Bodies move in *space* and require *time* to do so; perhaps, after all, our *knowledge* is confined to *moving objects*, time and space being more or less necessary mental concepts. Then the number of dimensions we adopt for each is a matter of convenience, the *fewest* necessary and sufficient to adequately *describe* phenomena.

F. W. HENKEL.

THE JOURNAL OF ECOLOGY.

Within the next few days the first number of a new natural history journal will be published—*The Journal of Ecology*—which will be primarily the organ of the British Ecological Society. The proposed formation of this Society was mentioned in an editorial note in "Knowledge" for February, 1913 (page 56), and has met with such a hearty response—not only from botanists but from others, both in this country and abroad, interested in Natural History in general, including Zoölogy, Geology, Geography—that it has been found possible to extend considerably the originally proposed scope of the Journal, and at the same time to issue it at a moderate price.

The Journal of Ecology will be published quarterly (March, June, September, and December), at an annual subscription of 12s. 6d., post free to any part of the world. This subscription carries with it the privileges of Associateship of the British Ecological Society, including the use of a library of ecological works which is being formed, the answering of enquiries addressed to the Secretary of the Society, the right to attend the indoor and outdoor meetings, which it is proposed shall be held at different centres in Great Britain, and participation in other advantages which are offered. The membership subscription is one guinea, entitling the subscriber to receive the Journal and to other associateship privileges, and in addition to vote for, and serve upon, the Executive of the Society, and to assist in shaping its policy and directing its activities.

The first number of *The Journal of Ecology* contains eighty pages, and includes many and varied interesting articles.

The Editor has taken a wide and generous view of the scope of Ecology—briefly stated, this embraces everything connected with the relation of plants and animals to their surroundings. So far as the animal kingdom is concerned it is proposed at first to confine Animal Ecology to such topics as the inter-relationships between plants and animals—in itself a large field—but it is recognised that, logically, it is not possible, nor is it desirable, to confine the concept of Ecology to *plant* ecology as is usually done. In the present, as in the past, the distribution and migrations of plants and of animals over the earth are in many respects closely bound up with each other, to say nothing of the many special cases of mutually beneficial partnership (symbiosis in the wide sense) and of other forms of interaction between the two kingdoms of Organic Nature.

Following an introductory article stating the aims of the new Journal, Professor F. W. Oliver, F.R.S., contributes an interesting account of the vegetation of the new Nature Reserve at Blakeney Point—the remarkable shingle beach (see "Knowledge," January, 1913, page 1) and other habitats in this locality now secured as a refuge for an unusually rich flora and fauna—with remarks on the influence of the animals upon the vegetation, Mr. Wilfred Mark Webb, F.L.S., F.R.M.S., gives a useful and encouraging summary of the progress which has been made, and the organisations which are now in existence, towards the making of Nature Reserves in this country—while the Editor reviews a number of recent foreign publications regarding Nature Reserves in various parts of the world. Dr. W. G. Smith writes concerning the work of Raunkiaer on "biological types" or "life-forms" of flowering-plants and their distribution—thus bringing to the notice of English readers, for the first time, some of the most fertile and interesting new ideas and points of view that have been introduced into the study of plant-life during recent years; this article will be of special value to field botanists, and will indicate a fascinating line of work which they can well take up with pleasure and profit to themselves and with every probability of contributing usefully to the general knowledge of plant distribution and adaptation. Mr. A. G. Tansley, M.A., F.L.S., reviews the recent attempt of Drs. Brockmann - Jerosch and Rübel, two distinguished Swiss botanists, to draw up a general classification of plant communities, criticising certain aspects of the scheme proposed by them and giving details of the various communities. Mr. Clement Reid, F.R.S., and Mr. W. B. Crump, M.A., contribute articles originally read by them before the British Association, the former dealing with the relation of the present plant population of the British Isles to the Glacial Period, the latter with the ecology of moorland plants and the phenomena of wilting in plants generally.

In addition to these articles, occupying the first half of the number, there are numerous other articles based upon recent work published in this country and abroad, dealing with Ecology in the wide sense and including plant distribution, the study of individual plants and of plant communities, the anatomy and physiology of plants where the facts discovered bear directly upon the relation of plants to their environment, nitrification and other aspects of soil-study, experimental morphology, and so on. The Editor has succeeded in making these review-articles thoroughly readable and easily intelligible to general readers with little or no special knowledge of botanical science—this is perhaps especially the case with those dealing with coast, woodland, marsh and desert vegetation, and the biology of cushion-plants, of insectivorous plants, of heather, and so on—while at the same time these summaries of recent work will prove useful to botanists and even to those themselves engaged in research work in plant ecology and biology. Teachers, for instance, will find such articles as those on desert vegetation, the glacial floras of Europe, as well as those dealing with British vegetation, of the greatest interest in connection with the teaching of geography as well as nature study.

The editor of *The Journal of Ecology* (Dr. Cavers, Goldsmiths' College, London, S.E.) is also secretary of the British Ecological Society, and information regarding the Society may be obtained from him. Subscriptions for the Journal with Associateship (12s. 6d.) or with membership (one guinea) of the Society should be sent to the Cambridge University Press, Fetter Lane, London, E.C.

The number concludes with extensive lists of recent literature on Ecology and cognate branches of study, and in a list of "forthcoming attractions," inserted in this number, we find promise of some interesting contributions which will appear in subsequent numbers of the Journal. A special feature will be a series of articles dealing with methods of ecological study, which should prove of great value to those wishing to take up this interesting line of study, since the articles will be written by well-known botanists who have specialised in the subjects with which they will deal.

REVIEWS.

AERONAUTICS.

Aeroplanes in Gusts—Soaring Flight—and the Stability of Aeroplanes.—By S. L. WALKDEN. 184 pages. 4 folding plates. $8\frac{1}{2}$-in. × 6-in.

(E. & F. N. SPON. Price 7/6.)

We have heard and read much about the stability of aeroplanes, some that is good and much that is bad; but in almost all cases the stability considered is that of the aeroplane in *calm* air, a condition in which it does not much matter whether the aeroplane is stable or not, so long as the control is easy.

Furthermore, the cases considered are those of machines in which the surfaces bear definite inclinations to one another, and retain definite shapes: that is, the whole machine is rigid; but Mr. Walkden opens up a far wider field with countless possibilities, by considering the case of the non-rigid machine which has a certain amount of elasticity introduced into its construction.

The author breaks fresh ground in the very first page and continues to do so throughout the book. To start with, a gust is defined and it is shewn that the proper and scientific measure of a gust is "the acceleration of headway" impressed upon the flying machine, the word "headway" being used in place of the cumbersome but more general expression "velocity relative to the air." The use of this as the measure gives us a well-ordered explanation of all the questions connected with stability, stresses, and soaring flight in disturbed air.

Throughout the book, pretty graphical methods are adopted for displaying the author's arguments and results. Following on a very complete analysis of gust effects, comes a fascinating treatment of the problem of Soaring Flight. Many a reader will look upon "ascending currents" as the only possible explanation of soaring flight, but Mr. Walkden clearly demonstrates that there are many other and commoner conditions of the atmosphere capable of being utilised by a bird, if not at some future date by a machine. For this purpose, for example, what the author terms "Wheeling Soaring" can be effected by making use of horizontal gusts, or even of large horizontal whirls. That such gusts do always exist and that Mr. Walkden's figures are quite ordinary, will be recognised by anyone who has watched the motions of an up-to-date wind-velocity recorder, which will shew that in any wind there is, say, twenty or thirty times a minute, a variation of perhaps from twenty per cent. to fifty per cent. on either side of the mean.

This may serve to shew the new and instructive matter that is to be found in Mr. Walkden's book. The whole arrangement of the book is of the same high quality as the contents; it is well printed, with a very complete index, and the plates are arranged so that they can be studied while reading without turning back the pages. We congratulate Mr. Walkden on this addition to science.

T. W. K. C.

ASTRONOMY.

Astronomy.—By G. F. CHAMBERS, F.R.A.S. 335 pages. 350 illustrations. 8 coloured plates. $6\frac{1}{2} \times 4\frac{1}{2}$-in.

(Hutchinson & Co. Price 5/-.)

Mr. Chambers is very well known as a writer of astronomical handbooks. The present work is intended for "the man in the street" who desires a speaking acquaintance with the subject, without going into any abstruse questions. In one respect the book may be unreservedly commended, *viz.*, its illustrations, which are excellent; they include some recent photographs of comets and nebulae, and planetary drawings by Antoniadi, Phillips, Bolton, and so on. It is a little disappointing in the text to find the very important astronomical progress of the last twenty years passed over so briefly; most of the book might have been equally well written thirty years ago. There are also not a few inaccuracies. Thus on page 56 we have the old suggestion that the numerous satellites of the remote planets compensate for the diminished sunlight, though it has often been shown that the combined light of Jupiter's or Saturn's moons falls far short of the light of our Moon. On page 59 the axial poses of Venus and Neptune are almost certainly erroneous. The latter is the pose of the satellite's orbit, which is inclined some twenty degrees to the primary's equator. Page 62, line 17, for axis-minor read major. Page 64, the daily distances travelled by the planets ought all to be doubled. Page 73, the light of Venus at maximum is said to equal that of Sirius; it is really some fifteen times greater. Page 83, Deimos, Phobos are generally taken to be the attendants of Mars, not his steeds. The original (Iliad XV, 119, 120), perhaps admits either interpretation:

> Ὣς φατο, και ῤ ἵππους κελετο δειμον τε φοβον τε
> Ζευγνυμεν, αὐτος δ' ἐντε ἐδυσετο παμφανοωντα.

Which Pope translates—

> With that he gives command to Fear and Flight
> To join his rapid coursers for the fight.

Page 84, line 5, for Venus read Mercury; line 12, for five thousand read four thousand three hundred. Page 90, line 26, for one hundred and ninety-four thousand read one hundred and eighty-six thousand three hundred and twenty-six; line 32, for 60″ read 46″. Page 106, the words about the suspected ring of Neptune and the guarded language about the existence of the satellite might have been written about 1850; they are ludicrous now. Page 118: it is misleading to say that the Saros brings back solar eclipses to the same regions after eighteen years. The region is shifted 120° westward, but in the case of eclipses near the poles the two tracks may overlap. The tracks are said to move southward after a saros; this is only true for ascending-node eclipses; in descending-node eclipses, of which 1914 is one, they move northwards. Page 128, the shadow in 1914 travels from Norway to Russia, not *vice versa*. Same page, the map in Oppolzer's "Canon of Eclipse" is quoted as evidence that the eclipse of 1999 will not be total in Cornwall. But the maps in the Canon only represent tracks of eclipses as circular arcs, which do not claim to be accurate. Calculation shows that the eclipse will be total in Cornwall.

Page 195 footnote, Sigma Octantis is stated to be some distance from the south pole; it is really only three-quarters of a degree distant, much nearer than our Pole Star. Page 200, no mention is made of the very important double-star work done at Greenwich. Page 214, the eclipse theory of Algol is no longer merely a suggestion, it is demonstrated fact; the secondary minimum, when the fainter star goes behind the brighter, has been detected by Stebbins. Page 232, the phrases "White" and "Green" nebulae, objected to by the author, are used to denote a very real difference of spectrum. Page 323, axial rotation, for days, hours, minutes read hours, minutes, seconds. It seems rash to give the short rotation periods of Mercury and Venus without query, considering how many astronomers support the long periods. Curiously enough, the Canadian Handbook noticed below gives the long rotation periods without question. The safest attitude seems one of suspended judgment, the evidence being conflicting. Page 324, the period of Jupiter VII should be 260 days, of Jupiter VIII 738·9 days, not twenty-six months.

In conclusion, we may state that the chapter on the construction of a small observatory is written with practical experience, and is likely to be very useful.

A. C. D. C.

The Observer's Handbook for 1913.—72 pages. $7\frac{1}{4}$-in. × 5-in.

(Toronto: The Royal Astronomical Society of Canada. Price 25 cents. (1s.)

A very convenient handbook, containing the same information as our monthly "Face of Sky"; also sunrise and sunset tables for latitudes forty-four degrees to fifty-two degrees, and an article on the Comets of 1912. In the table of elements, page 53, there is a bad misprint. The mass of Mercury is given as 0·476 of the Earth's; this, presumably, should read 0·0476. On the same page, see the remarks in the previous notice *re* rotation periods of Mercury and Venus. Page 54, the periods of Jupiter VII and VIII should be two hundred and sixty days and seven hundred and thirty-nine days, not two hundred and sixty-five, and seven hundred and eighty-nine days. It is curious how often early approximate values of constants continue to be printed, when later ones are readily accessible. Same page, the satellite of Neptune is stated to be nameless; many authorities now use the name Triton, the adoption of which seems worthy of encouragement. The work also contains star maps, with notes on the objects of interest in each constellation; also an article on "Recent Progress in Astronomy," by W. E. Harper. This deals more particularly with stellar parallaxes and proper motions and star-drift. Some recent conclusions in these fields have an important bearing on the structure of the stellar system.

A. C. D. C.

BOTANY.

Hutchinson's Popular Botany.—By A. E. KNIGHT and EDWARD STEP, F.L.S. Volumes I and II. 588 pages. 721 illustrations, 18 coloured plates. $9\frac{3}{4}$-in. × $7\frac{1}{4}$-in.

(Hutchinson & Co. Price 7/6 per volume.)

These two volumes should do much to encourage the study of plants. They contain a great number of attractive photographs, many of which have been taken by Mr. Step, but it is obvious that there are many details which can much more easily and effectively be brought to the notice of the student by means of a drawing or diagram; and it must be said that those by Mr. A. E. Knight which have been introduced serve their purpose extremely well and are most clear. Mr. Step's books are well known and appreciated, and it goes without saying that he has brought forward in a most pleasing way a multitude of points of interest with regard to flowering and other plants. At the same time, the book is a serious one and contains much valuable information. The structure of the plant, the way it does its work, and the relation of the leaf to its environment, make up the first part; while floral forms and their connection with the visits of insects, fruits, and some account of the reproduction of ferns and mosses, go to make up the second, which also contains a glossary of botanical terms and an index. It appears that at the present day the British public demands coloured plates, and nine very effective ones have been introduced into each of the volumes. We sincerely wish Mr. Step's work the success which it deserves.

W. M. W.

CHEMISTRY.

Elements and Electrons. — By SIR WILLIAM RAMSAY, K.C.B., F.R.S. 173 pages. 7-in. × $4\frac{1}{2}$-in.

(Harper & Brothers. Price 2/6 net.)

This little volume gains an added interest from the recent discoveries of Sir William Ramsay, Professor Collie and Mr. Patterson, which indicate the possibility of building up elements from the immaterial ether and transmuting them into one another. These discoveries, in fact, add a further chapter to the history of the atomic theory.

The outline of this history is here given so clearly that even a reader without any previous knowledge of chemistry could follow it. Starting with a brief description of the notions of the ancients about matter, the author soon brings his story to the atomic theory of Dalton, which during the last century was practically unchallenged. It is true that speculations upon the possible existence of a primordial form of matter inevitably followed the discovery of the remarkable periodic relationships among the elements, but it was not until the disintegration of radium into other elementary bodies was discovered that any definite proof was obtained of the existence of something more elementary than the "elements" as defined by the chemist.

Sir William Ramsay keeps modestly in the background while sketching the wonderful discoveries of the last few years, but the story gains much in interest from being told by one who has helped to shape its course.

C. A. M.

Second Stage Inorganic Chemistry (Theoretical).—By G. H. BAILEY, D.Sc. Revised by H. W. BAUSOR, M.A. Sixth Impression. Fourth Edition. 544 pages. 109 illustrations. 7-in. × 5-in.

(The University Tutorial Press. Price 4/6.)

The fact that there has been a demand for yet another edition of this book is a proof that it supplies a want. In fact, as a skeleton outline of all the principal facts of which a knowledge is required by candidates for the lower examination in "Inorganic Chemistry," conducted by the Board of Education, it could hardly be surpassed. Moreover, the information is conveyed in such a clear-cut form that it impresses itself upon the memory. The book should prove useful not only to those studying for particular examinations, but also to all students who need a general summary of the principles of chemistry upon which they can base their furtber reading. Hence, in a way, it may take the place of a course of lectures, provided that it is regarded, like the lecture, as a means of clarifying acquired knowledge. Unfortunately, this type of book also shares with the lecture the danger of being regarded as a thing sufficient in itself.

C. A. M.

Second Stage Practical Inorganic Chemistry. — By WILLIAM BRIGGS, LL.D., M.A., and R. W. STEWART, D.Sc. Revised and enlarged by H. W. BAUSOR, M.A. Sixth Impression (3rd Edition). 206 pages. 13 illustrations. 7-in. × 5-in.

(The University Tutorial Press. Price 2/6.)

This book is the practical portion of the theoretical volume in the same series. Like its companion, it deals with its subject in a thoroughly utilitarian manner, and it should find a welcome from all who are working for the examination in question. The exercises are well-chosen and the directions clearly described, and the student who works conscientiously through the book will gain a good grasp of the general principles of chemical analysis.

One cannot help feeling, however, that it is a mistake to divorce so completely the theoretical and practical sides of a science, and that, apart from examination purposes, it would be more satisfactory to have the two portions incorporated in one book.

The table of atomic weights in the appendix also calls for criticism, for the numbers are rounded off and are prefixed by a note to the effect that they are "sufficiently accurate for the purpose of ordinary chemical analysis." Surely it is a mistake to encourage a beginner to aim at a limited degree of accuracy; and, apart from this, the use of such numbers at the outset will be liable to give the impression that the atomic weights stand in closer numerical relationship than appears to be the case from the recorded determinations.

C. A. M.

GEOGRAPHY.

Turkey and the Eastern Question.—By JOHN MACDONALD, M.A. 92 pages. $6\frac{1}{2}$-in. × $4\frac{1}{2}$-in.

(T. C. & E. C. Jack. Price 6d. net.)

This fascinating little book is, if anything, topical; at first it seems merely so. But consideration shows it is the book for the student of the political movements of the age, whose opportunities for study are limited to morning half-hours with his newspaper, for "the man in the street." It would be a valuable text-book in schools, particularly in Scotland for those reading for the Leaving Certificate in History. It will long remain the concise analysis of the problems of the Near East; of making larger books there will be no end, few will be more useful. It is Anti-Turk, but not partisan, and carries conviction because its argument is built on sound foundations of geography, ethnology and moral and economic evolution.

The first few chapters, the most impersonal, are thrilling. They deal with the evolution of the Balkan Problem, and raise a host of interesting questions. Next, the present situation and its prophase are treated. The last three chapters, the most interesting, discuss the future, and give an instructive comparison between Turkish rule in Europe and in Asia, and British rule in India.

To this volume one would wish a few words of preface. The credentials the author now and then presents in the work would be welcomed in a foreword, setting out his purpose: one resents their intrusion into the text. A few dates given prominently would help the reader to keep his bearings and maintain his grasp. Phraseology requires amendment here and there, as on pages 72 and 78.

A. S.

Atlas of the World.—By J. Bartholomew, F.R.G.S. 56 pages. 39 maps. $6\frac{1}{2}$-in. × $4\frac{1}{2}$-in.

(T. C. & E. C. Jack. Price 6d. net.)

It is questionable whether an atlas is within the scope of such a series as "The People's Books," or can attain its general standard of usefulness. The plates are small, and now atlases with larger maps are available at a price equally low, while larger and more detailed pocket atlases may be had for a shilling. Still, these maps are clear, well-chosen, and quite up to modern standards. They may be of use, for example, in reading other books of the series. The route-chart of Europe is good, and in these days, when history is a-making, a race-chart would also have been valuable. It is a pity that the scale and the projection of each map are not given; particularly on account of the first plate, a note on projection might have been included. Having issued an atlas, it is to be hoped that Messrs. Jack will publish a gazetteer as a companion volume or volumes.

A. S.

Dent's Practical Notebooks of Regional Geography. Book 1. The Americas.—By Horace Piggott, M.A., Ph.D. and Robert J. Finch, F.R.G.S. 64 pages. 25 maps. $9\frac{3}{4}$-in. × $7\frac{3}{4}$-in.

(J. M. Dent & Sons. Price 6d. net.)

These notebooks seem to be intended for progressive use in secondary schools and particularly in connection with the geographies by the same authors. They are interleaved atlases of outline maps, some with no detail, others with contours at large intervals and rivers, in order that the relief of the land may be brought out by shading, the drainage worked out, and the whole correlated with climate and political and economic development. Instructions are given on each sheet for the use of the maps and the writing of notes. Some of these appear to supersede the teacher as a thinking being, and teachers who do think will ignore many of them. There is, nevertheless, much useful suggestion and some freshness in these notes. An interesting feature is the inclusion of squared-paper and data for the construction of economic graphs—data, of course, which should not be used exclusively. Unfortunately, the projection is only mentioned in some cases, but for advanced classes its determination in each map would be a useful exercise. Each completed notebook will at once form the best record of the pupil's work on a Continent throughout his school course and his best work of reference for many a day.

A. S.

Memorials of David Livingstone.—16 pages, 6 illustrations. $7\frac{1}{4}$-in. × 5-in.

(Marshall Brothers. Price 6d. net.)

At present the name of David Livingstone is on every tongue, and people are consulting how best they can pay a tribute to his memory. It is fortunate there are those whose imaginations go beyond tombs and columns as memorials of the illustrious dead. Scotsmen are proposing to establish a Livingstone Chair of Geography in one of their Universities; Churchmen a Livingstone Medical Mission in the sphere of his labours. But already a valuable memorial exists in Livingstone College, Leyton, London, founded in 1893, "to give instruction to foreign missionaries in the elements of medicine and surgery," and so to add very materially to their usefulness. This booklet, issued by the authorities of the College, contains two portraits in colour of Livingstone, the memorial poem printed in *Punch* after his death, and pictures of the inscriptions on his tomb in the Abbey and on the tree, at the foot of which rests the heart of the traveller. The portraits will be valued by many interested in Livingstone, and the purpose of the booklet is to bring before such the aim of the College, and gain their help in an endeavour to raise £10,000 with which to clear off a mortgage, make improvements in the institution, and form the nucleus of an endowment.

A. S.

Cambridge County Geographies. — *Forfarshire.* — By Easton S. Valentine, M.A. 160 pages. 148 illustrations. 4 maps.

Herefordshire.—By A. G. Bradley. 149 pages. 54 illustrations. 4 maps.

Middlesex.—By G. F. Bosworth, F.R.G.S. 165 pages. 58 illustrations. 3 maps.

North Lancashire.—By J. E. Marr, Sc.D., F.R.S. 180 pages. 74 illustrations. 4 maps.

Linlithgowshire.—By T. S. Muir, M.A., F.R.S.G.S. 142 pages. 33 illustrations. 4 maps.

Rutland.—By G. Phillips. 171 pages. 46 illustrations. 4 maps. Each volume being $7\frac{1}{2}$-in. × 5-in.

(The Cambridge University Press. Price 1/6 per volume.)

We have on several occasions testified to the excellence of the County Geographies which are being published by the Cambridge University Press. They are books which everyone should read, for many matters of the greatest interest are touched upon, and the word geography is taken to include not merely the physical conformation and political administration of the district, but also the geology, the ethnology, history, and many other details. We are reminded that at Burley, in Oakham, Geoffrey Hudson, the celebrated dwarf, made his appearance before King Charles I, served up in a cold pie, and we also learn that, although he did not reach more than eighteen inches in height until he was thirty, and when he began to grow again never exceeded three feet six inches, he had a most eventful history. On the roll of honour for Middlesex we find the names of Francis Bacon, and Thomas Henry Huxley, while in the volume for this county there is a very interesting account of the natural history of the immediate neighbourhood of the metropolis. Sir Richard Owen is claimed by Lancashire, as well as Sir Richard Arkwright, and among the illustrations which embellish the book on Linlithgowshire are pictures of Linlithgow Palace (where Mary Queen of Scots was born) and the Forth Bridge.

W. M. W.

ZOÖLOGY.

The Teratology of Fishes.—By J. F. Gemmill. 73 pages. 6 illustrations. 26 plates. $12\frac{3}{4}$-in. × $10\frac{1}{4}$-in.

(Glasgow: Maclehose & Sons. Price 15s. net.)

Till a few years ago structural abnormalities in animals, with the exception of those occurring in certain parts of the skeleton, were regarded by the systematic naturalist as of little or no importance from his standpoint. Nowadays a complete change of view has taken place, and in the present work Dr. Gemmill points how such abnormalities in fishes may indicate in a remarkable manner relationships to the higher vertebrates which are not apparent in normal examples. It is, however, to be regretted that he does not appear to have pointed out as clearly as he might have done the nature of such relationships. Trout and salmon, of which the young states are to be procured in any quantity at the hatcheries, afford the great bulk of the material upon which the author has worked. How great has been the labour involved, may be inferred from a study of the beautiful series of photomicrographs with which the volume is illustrated. Facts of the greatest value have, it is stated, been ascertained by this detailed study with regard to the mode of origin and development of the bony fishes; and much interesting information is likewise recorded with regard to the origin and nature of the different types of monstrosity most commonly met with. It should, however, be distinctly understood that the book is essentially one for the professional morphological and systematic student, to whom it will doubtless prove of the highest value.

R. L.

The Vertebrate Skeleton. Second edition.—By Sidney H. Reynolds, M.A. 535 pages. 144 illustrations. 5¾-in. × 9¾-in.

(The Cambridge University Press. Price 15/- net.)

Professor Reynolds' book on the Vertebrate Skeleton has proved of such value that a second edition has been called for, and in it an attempt has been made to bring it up to date. Professor S. W. Williston has revised the section devoted to reptiles, practically re-writing Chapters XIII and XVI, and making other contributions. A number of new illustrations have been introduced, and those students who want a succinct account of the skeleton, whether external or internal, of vertebrates, will have it ready to their hands. The beginner is advised to start with the skeleton of the dog-fish, and then pass to those of the newt and frog, and after to that of the dog. Other skeletons which are described in detail are those of the codfish, green turtle, crocodile and wild duck; the remaining parts of the volume being devoted to the various classes and general accounts of their skeletons.

W. M. W.

NOTICES.

PHOTO-MICROGRAPHY. — We have pleasure in announcing that Mr. Edgar Senior will give a course of six practical demonstrations on photo-micrography at the South-Western Polytechnic, on Monday evenings from 7.30 to 9.30 p.m., beginning on May 5th. Special attention will be given to the photographing of etched surfaces of metals and alloys, but the course will also be arranged to suit the requirements of students of geology and botany, and those wishing to use their own microscopes to obtain photographic records.

PHYSIOLOGICAL HISTOLOGY.—Messrs. Carl Zeiss are issuing in ten parts an illustrated book on Physiological Histology of Man and Mammalian animals, each of which is accompanied by ten microscopical preparations. The first of these, which is before us, deals with the skin and cutaneous organs and is exceedingly well got up, while the slides, which we have examined, are excellent. We may add that the work has been undertaken by Professor Doctor Sigmund, and the English edition has been prepared by Mr. C. Lovatt Evans, of University College, London.

THE LIGHTING OF OPERATING THEATRES.—Of special interest to surgeons is the system of concentrating light in operating theatres introduced by Mr. E. Leitz. In the past, to get over the difficulties of lack of daylight, arc lamps have been used, but these cause the hands and instruments to cast deep shadows which may obscure the field of operation and even the use of more than one lamp does not do away with this entirely, while only a small fraction of the light from them reaches the operating table. In the system already alluded to the rays from one arc lamp are concentrated upon the operating table by six separate reflectors and so much light can be made available that an iris diaphragm has been fitted to the apparatus for cutting it down.

THE NATURALIST'S DIRECTORY.—A new edition of "The Naturalist's Directory" is now being compiled by Mr. S. E. Cassino, Salem, Mass., U.S.A., and will be published in the fall of this year. This valuable work has been published every few years since 1880, and comprises the names and addresses of all English-speaking Naturalists, as well as full particulars of the subjects in which each is interested. Every Naturalist who has not received blanks should send his name and address and full particulars, as well as the names of any friends and acquaintances. To those who are actively working at any branch of Natural History, the importance of having their name in this directory is obvious, for announcements of new literature in connection with their subject will reach them, and they will be brought into touch with fellow-workers in all parts of the world.

MESSRS. J. H. DALLMEYER, LIMITED, having removed from 25, Newman Street to 19, 21 and 23, Oxford Street, close to the Tottenham Court Road stations of the Central London and Hampstead Railways, and near the junction of Charing Cross Road with Tottenham Court Road and Oxford Street, all communications for the show-rooms and London Offices should be addressed to 19, 21 and 23, Oxford Street, W.

In their new home this famous firm of Dallmeyer, established for over fifty years, are showing a large and varied stock of photographic lenses, cameras and shutters, kinematograph lenses, telescopes, telephoto lenses, and so on, all of which are of the high standard of quality which has made the name of Dallmeyer famous throughout the world. As the firm extends a cordial invitation to inspect its new premises, we would advise all those who are able to do so to take an early opportunity of paying them a visit.

THE ALCHEMICAL SOCIETY.—The third general meeting of the Alchemical Society was held on Friday, March 14th, at 8 p.m., at the International Club, Regent Street, S.W. The chair was occupied by the acting President, Mr. H. Stanley Redgrove, B.Sc. (Lond.), F.C.S., and a paper dealing with the interpretation of Alchemy in relation to modern scientific thought was read by Mr. Sijil Abdul-Ali. The lecturer pointed out that the alchemists in general appeared to have adopted the Hermetic method of reasoning from universal to particular judgments, although there were sporadic indications in the literature of a quite scientific and rational empiricism. The fundamental concepts of their philosophy were, he said—(i) A "First Matter" or "Hyle," containing implicitly the four elements which were subsequently to issue in manifestation; (ii) Four elements (viz., earth, water, air and fire), which, by mutual combination, produced the three principles (viz., sulphur, mercury and salt), whose varying combinations gave rise to the different properties of bodies; (iii) A certain divine spirit or essence, called "The Soul of the World," which was immanent in all created things; and (iv) A mediate spirit, called "The Spirit of the World," by which the soul acted upon and was bound to its body (*i.e.*, matter). The lecturer compared and contrasted these concepts, in a most interesting manner, with modern scientific theories concerning—(i) A possible dual Protyle, or first matter; (ii) The solid, liquid, gaseous, and incandescent gaseous states of matter; (iii) Energy; and (iv) The ether of space. The full text of the lecture and an abstract of the discussion which followed appears in the March number of *The Journal of the Alchemical Society.*

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

MAY, 1913.

THE RED-TAILED HUMBLE BEE.

A STUDY IN MIMICRY.

By G. W. BULMAN, M.A., B.Sc.

AMONG our seventeen native species there is none more easily recognised than the Red-Tailed Humble Bee, the *Bombus lapidarius* of science. Its large size, black body and red tail, are sufficient to enable even those who take little notice of such things to know it when they meet it in the fields. Even in Shakespeare's time it would appear to have been differentiated from the other species. For when Bottom, in "A Midsummer Night's Dream," wished for a sip of honey, his command to Cobweb was. "Kill me a red-hipped humble bee on the top of a thistle."

And yet there is another bee so like it that it requires some practice in diagnosis to detect the difference. It is of the same size, and has also a black body with a red tail. Yet there are points of difference which enable the expert to detect the mimic at once. It does not, for example, go busily from flower to flower gathering honey to take home to the nest. It only wants an occasional sip for its own sustenance, and its idleness is quite apparent. The wings are darker than in the Bombus, there are no little baskets on the hind legs for collecting pollen, and there is a curious shining, almost bald patch on the upper surface of the abdomen. Had Monsieur Cobweb killed it in mistake for the red-hipped humble bee, he would have found no bag of honey. This bee belongs to a group very near the true humble bees, and sometimes known as parasitic humble bees. They have been placed in a different group and named Apathus, or Psithyrus. Noting the striking résemblance we say, in the language of modern zoölogy, here is a remarkable case of mimicry. And when we learn that the mimic is a parasite on the red-tailed humble bee, then, if we are believers in the theory, we say, "This resemblance enables the parasite to enter the nest of the host more readily. It has been acquired because those which possessed it in the highest degree succeeded best in deceiving the host, and so getting their young reared at its expense." Shuckard, in his work on "British Bees," writes of these parasites thus:—

"Both sexes appear to have free in- and egress to, the nests of those Bombi which they infest, without any let or hindrance on the part of the latter, with whom they seem to dwell in perfect amity."

The resemblance of the parasite in the case of the Red-tailed Humble Bee is certainly striking, and according to the above, perfectly succeeds in its purpose of deception. Yet one asks, Why should such a perfect resemblance fail in more than one important point? Why should this bald patch, and these dusky wings, betray it even to a somewhat casual observer? A little difference in the way of greater hairiness, or lighter colour in the wings, would have been so easy, and likely to occur as chance variations! And then it has, as Mr. Sladen says, "a distinctly lower-pitched and softer hum."

It gets its name Psithyrus, that is, "whispering," from this. If, then, it cannot quite deceive us, how can it deceive the owner of the nest in which it wishes to lay its eggs? And in the darkness of the nest where it probably first meets the owner, a resemblance depending largely on colour would be of little avail! Moreover, are we not told that bees recognise each other and strangers rather by *smell* than by sight?

Recent studies of the parasite and its host, however, compel us to change our point of view somewhat. For it does not appear to be the object of Psithyrus to slip unnoticed into the Bombus nest, and lay its eggs unobserved. According to the account given by Mr. Sladen in his recently published work, "The Humble Bee," it invades the nest rather to fight with and kill the lawful queen. The parasites, in fact, rely more on their "exceedingly thick and strong skin, covering them like a coat of mail and protecting them from the stings of the Bombi." Moreover, being idle, they are further protected by having no soft wax-yielding membrane between the dorsal segments, as have the humble-bees. The sting is also stouter, and more curved. It does not appear, then, that the resemblance can be of any advantage to the parasite, or that it can deceive the humble-bee. Psithyrus, in fact, neither requires nor makes use of its remarkable resemblance.

Let us suppose, however, for a moment that the resemblance were perfect, and that the Bombus queen took the invader for another queen of her own kind. What would happen? We turn to Mr. Sladen's book, "The Humble-bee," for an answer. Some of the later-appearing individual queens of the Red-tailed Humble-bee do not take the trouble to start nests of their own, but enter those of others to lay their eggs. At first the stranger is ignored, but soon jealousy arises, and there is a mortal duel. One of the queens is killed, generally, says Mr. Sladen, the intruder. Thus the advantage to the parasite of being like the host is more than doubtful.

Again, the Humble-bee shows by its different behaviour that it recognises the parasite. "The Bombus queen," writes Mr. Sladen, "on first meeting the Psithyrus in her nest, shows a certain amount of agitation and may advance to attack her, but her courage failing she draws back." Evidently the resemblance does not deceive her. And if it be true that bees usually recognise each other by scent, and that they can in this way detect one of their own species from a different nest, we need not be surprised at this, however perfect the outward resemblance. The first alarm of the Bombus queen at the presence of Psithyrus is followed by a "kind of despondency," and her interest and pleasure in her brood seem less. In the course of time there is a fight, and the parasite generally wins, sometimes killing several workers which have come to the assistance of their mother, as well as the Bombus queen.

In the face of all these facts what becomes of the theory that the mimicry of Psithyrus is protective, and has been acquired as a useful character by natural selection? The resemblance does *not* deceive the host, and it would apparently be *no advantage* to Psithyrus if it did.

The resemblance, as Mr. Sladen tells us, is not merely superficial, as in the case of bee-like flies. Psithyrus is almost a Bombus in general structure. And this suggests a close relationship, as if the Psithyrus had been a Bombus which took to parasitism—as individuals of certain species do to-day. Thus, individual queens of the Red-tailed Humble-bee, will, as we have seen, enter the nests of others to lay their eggs. And, if this is so, then it is the points of *difference* that have to be evolved, and not the points of *resemblance*.

Having disposed of the Bombus queen, Psithyrus reigns in her stead. She lays her eggs, utilising the wax she finds in the nest, since she cannot make any of her own. Her young are tended and fed by the Bombus workers. Apparently, as a sort of protest against the usurper, the latter begin to lay eggs, though these would only produce males. The usurping queen, in her turn, eats them! It is obviously her interest to do so, for thus the workers will devote all their time to the rearing of the young parasites.

And a very curious problem is suggested by the fact that the young of the Psithyrus queen are reared by the Bombus workers. For there are no workers among the parasites as there are among the Bombi. And the difference between these workers or neuters and the queens among the Humble-bees is believed to be the result of diet. The workers must settle which are to be queens and which neuter. If a given grub is to become a queen, it must from a very early age be fed with a richer diet. Yet the Psithyrus female grubs all turn out queens! Are they all fed on the royal diet, or are they all fed on the more meagre diet which some superiority of constitution enables them to turn to better account than would the grubs of Bombus? In either case it is curious that the Bombus workers should not make a difference, feeding some for queens and some for workers, as they would in the case of their own kind. And it would obviously be to the interests of the Red-tailed Humble-bee as a species if the Psithyrus grubs were all fed on so meagre a diet that they all turned out neuters. On the other hand, the feeding of *all* on royal diet might be a last effort at self-preservation—a vaulting ambition which overleaps itself and falls, on the part of Bombus. For might not *one* of the grubs fed royally turn out a Bombus queen? But the only result would be the full complement of Psithyrus queens. If, however, they thought to destroy the parasite race by rearing neuters instead of queens then the superior constitution of Psithyrus, thriving on the more meagre worker diet, developed the queenly character in spite of their efforts.

THE POWER OF CONTACT.

By CHARLES E. BENHAM.

Over a hundred years ago a memorable discovery was announced by Volta, who claimed to have proved that by the mere contact of a disc of copper with a similar disc of zinc the two metals became electrified, the copper negatively, the zinc positively. Much dispute arose over the experiment; for though Volta repeated it hundreds of times, always with just the same result, many men of science would not believe in it. It seemed to oppose the fundamental doctrine of the conservation of energy and to suggest the heresy of perpetual motion; and so the "contact theory" of electricity was rejected on the principle that "it can't be; therefore it isn't." It seems strange that instead of arguing as to whether it was possible or not, the scientific world did not try the experiment for itself. It was an exceedingly simple one, one that anybody can try with a condensing electroscope, and one that never fails to verify exactly what Volta announced. But instead of putting the matter to a practical test, the learned world, feeling quite convinced that there must be a mistake somewhere, contented itself with abandoning the contact theory as impossible, and for a long time it remained universally discredited in spite of the fact that anybody could have easily demonstrated its truth at any time. At last came Lord Kelvin, who took the wiser course of repeating Volta's experiment. He did it in a new and ingenious way, which avoided all possibility of any other cause than mere contact coming into action, and to his own astonishment, and that of the whole scientific world, he found that Volta was perfectly right. The discovery led him on to make other tests, all of which completely confirmed the mysterious and inexplicable fact that when one metal touches another, a separation of electricities occurs, one becoming positively charged, the other negatively. Copper filings passing through a zinc funnel are each in turn brought into contact with the zinc, and the falling stream gives up to the vessel that receives it a constantly accumulating charge of electricity. This is but one special case of a widely extending law, and it seems probable that any two dissimilar substances when brought into contact and separated, are charged with opposite electricities. What is called frictional electricity is another particular case of the same law. When a piece of sealing wax is electrified by rubbing it with flannel it is not the force of friction that is converted into electrical energy. The rubbing is only the means by which two such non-conducting bodies are brought sufficiently into contact to produce the effect. It is for this reason that frictional electric machines involve such a wasteful expenditure of force. An overwhelming proportion of the energy used is merely wasted so far as the direct production of electricity is concerned. The electrical output is only equivalent in energy to the amount of force required to bring glass and rubber into contact and to separate them again. All the rest of the rubbing is labour spent in overcoming resistance to such intimate contact. The modern static machines, such as the Wimshurst, require no friction, but depend upon a different principle, the principle of multiplying an infinitesimal original charge by the process of induction. That original charge is derived from contact, either contact between a small metal brush and the tin sector on the glass disc, or it may be by the mere contact of that sector with air.

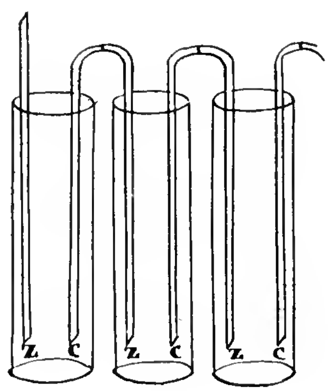


FIGURE 150.

According to Volta's principle the electricity of a battery of zinc and copper plates in acid water is due not to the chemical action of the acid on the plates but to their contact with each other, the acid water merely acting as a conductor to enable the current to pass. The chemical action is to be looked upon rather as the effect than as the cause of the electricity—an unfortunate effect, indeed, from one point of view, because the acid

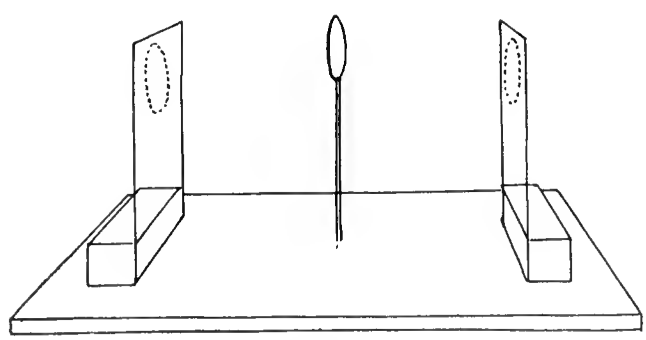


FIGURE 151.

necessarily acts upon the metals and so limits the life of the battery. Yet acid is necessary because without it water is not a good enough conductor for the current.

Whether Volta was strictly accurate in looking upon chemical action as the result rather than the cause of the electricity in a voltaic cell may be an open question, but certainly his explanation may be as good as the other, and it is noteworthy that it is sometimes instinctively adopted even by those who believe in the chemical theory; for it is usual to speak of the corrosion that takes place when zinc and copper are rivetted together as being due to electric action.

But what naturally will occur to anyone hearing of the suggestion that zinc and copper give electricity by mere contact and that the acid solution is a mere conductor which is only incidentally destructive of the plates, is the question, why should not the metals be used without the acid and a conducting way for the current be found by uniting the pairs of metals direct? In this way it would appear at first sight as though we could get a series of cells without any liquid conductor, and one, therefore, practically permanent.

A moment's consideration will, however, show that this is not practicable. If when zinc is joined to copper a current flows from the zinc to the copper, it is evident that by joining another pair a current will be established in the opposite direction. The following diagram, in which the arrows show the direction of flow of the current from contact electricity, will make this clear:—

$$Z\ \overset{\longleftarrow}{C\ Z}\ \overset{\longleftarrow}{C\ Z}\ \overset{\longleftarrow}{C\ Z}\ C\text{, and so on.}$$
$$\underset{\longrightarrow}{Z\ C}\quad \underset{\longrightarrow}{Z\ C}\quad \underset{\longrightarrow}{Z\ C}\quad \underset{\longrightarrow}{Z\ C}$$

The contacts obviously involve currents in the opposite direction which will neutralise the others.

Nor is any better result obtained if a wire of some other metal, say iron, is used to connect the pairs. In this case the effect is shown by the arrows in the following diagram (the numbers representing current intensity between the various metals):—

$$Z\ \overset{\overset{1}{\longleftarrow}}{C\ I}\ \overset{\overset{1}{\longleftarrow}}{I\ Z}\ \overset{\overset{1}{\longleftarrow}}{C\ I}\ \overset{\overset{1}{\longleftarrow}}{I\ Z}\ \overset{\overset{1}{\longleftarrow}}{C\ I}\ \overset{\overset{1}{\longleftarrow}}{I\ Z}\ C.$$
$$\underset{\underset{2}{\longrightarrow}}{Z\ C}\quad \underset{\underset{2}{\longrightarrow}}{Z\ C}\quad \underset{\underset{2}{\longrightarrow}}{Z\ C}\quad \underset{\underset{2}{\longrightarrow}}{Z\ C}$$

In fact the following law has been abundantly established:—When any number of metals are placed in contact in a series that returns to the metal it started with, there is always an equal development of contact electricity in each direction and consequently no flow of current either way.

However, it is said that Nature never locks a door without also providing a key. The key or clue to this problem consists in finding a uniting medium for the pairs of metals which is non-metallic, and at the same time free from chemical action, while sufficiently conductive to allow electricity to pass. Such a conductor is found in water. Its resistance without acid is high, but still it has some conducting power, while its contact electricity with the metals does not appear to be sufficiently appreciable to neutralise the flow. Reverting to our former diagram the series will now be

$$\underset{\longrightarrow}{Z\ C}\ W\ \underset{\longrightarrow}{Z\ C}\ W\ \underset{\longrightarrow}{Z\ C}\text{, and so on.}$$

It is evident that in an extended series, there being a minute difference of electric potential between each pair, there will be a considerable potential difference between the extremities of the series.

The experiment may be made with a hundred test tubes in which copper and zinc soldered strips are placed in order. (See Figure 150).

If these are filled with pure distilled water practically no chemical action will occur, but the ends of the series will be in so high a degree charged with opposite electricities that the gold leaves of an electroscope will diverge widely when connected with either terminal. One end of the series will show a positive charge, the other a negative charge.

So far from this being due to any chemical action, it will be actually found that the potential difference is greater when distilled water is used than when acidulated water is placed in the tubes.

With a water battery of this form made of some thousands of tubes, Leyden jars may be charged and sparks of considerable intensity may be obtained.

The difficulties attending the construction of such a series and of insulating each tube perfectly are, however, very great, and when an extended series numbering thousands is required it is more convenient to resort to what is called the dry pile, though it is not strictly speaking quite dry; if it were it would not work.

The dry pile substitutes a connecting medium of ordinary paper for the distilled water, and so slight is the amount of moisture required for conduction that the small quantity of water always present in the pores of ordinary paper will suffice. For the metal plates it is unnecessary to cut out metal strips. Paper with a metal surface can be obtained ready made, either bronzed or tinned. Cut into squares or punch into circles a series of bronzed and tinned papers, keeping them in uniform order so as to have the arrangement—tin, paper, paper, bronze, tin, paper, paper, bronze, and so on, and the dry pile is made. The heap is firmly pressed together between two pieces of well-varnished glass for insulation, and close contact is maintained either by binding the whole round with tape or by gluing a strong band of brown paper round it. The terminals are strips of thin metal to which wires have been soldered. A series made up of twenty or thirty sections and well insulated will show undiminished electric activity for years. The energy will not be sufficient to give a spark, but the attractive power of the terminals will keep a small brass ball (suspended by a hair or fine silk) oscillating between two bell gongs without cessation year after year with no signs of exhaustion or enfeeblement.

A valuable practical application of the dry pile is found in an instrument for detecting minute quantities of electricity. An insulated strip of gold leaf is suspended between plates connected with the terminals of a dry pile. The plates attract it equally, and, therefore, it remains at rest, but the most infinitesimal charge of electricity suffices to upset this equilibrium and to make the gold leaf sway to right or left according to the positive or negative nature of the charge applied. This form of electroscope is of extreme sensitiveness, and has the advantage of indicating the sign, positive or negative, of the electricity present.

While contact is the source of electrification the intensity of effect from a single contact is so infinitesimal that for practical purposes it is absolutely necessary to increase it. It has just been shown how this can be done by connecting in series a large number of contact-making plates, but this is not the only way in which an increased difference of potential can be brought about.

A second means is by applying the principle of nduction. When a charged body is brought near an insulated conductor without touching it, and the insulated conductor is momentarily earthed, it will be found to have acquired an induced charge nearly equal in amount to that of the inductor, though of opposite sign. And this happens without robbing the inductor of any of its electricity. In fact, by repeating the process any number of induced charges can be obtained without diminishing the electricity of the source. This obviously affords the clue to a way in which by a succession of induction processes an accumulated charge of appreciable magnitude can be obtained from even such an infinitesimal source as that of a pair of metal plates in contact. Adding together the induced charges they mount up to an unlimited extent.

But this process of repeated additions is necessarily slow. Much more rapid is the increase if instead of merely adding them they can be multiplied. Two induced charges, when combined, are practically double the inductor's charge. Two induced charges derived from this double charge will, of course, give a fourfold charge. Two from this will give an eightfold charge, and so on. The rapidity of accumulation on this doubling principle is astounding. Double a charge and its products in this compound interest way twenty-four times, and it increases more than eight million-fold.

A very simple and pretty experiment will illustrate this. Fix upright from the centre of a board a disc of metal supported by a narrow insulating strip of varnished glass. Provide two strips of similar varnished glass a little wider than the disc's diameter and in height not quite as tall as the top of the disc, and let them have discs of tinfoil attached near the upper part. The lower end of each is glued to a block of wood, so that they can be pushed along the board up to the inductor, one on each side, the tinfoil being on the outer side of the glass, *i.e.*, away from the inductor. The arrangement is shown in Figure 151.

The inductor, presumably by its mere contact with the air, has an infinitesimal charge of electricity, and this, solely by multiplied induced charges, can be made to give out in a few minutes sparks half an inch long. The effect is almost miraculous to the uninitiated, as the electricity seems to come from nothing. It really comes, not from nothing, but from an imperceptible and infinitesimal beginning.

The *modus operandi* is as follows:—Push one of the mounted strips close up to the inductor. Earth its sector by touching it with the finger. It has received an infinitesimal charge by induction, equivalent to that of the inductor. Slide it away and do the same with the second glass strip. Now bring both up to the inductor and touch the top of its disc. It will, of course, receive by induction from the combined influence of the two strips a double charge. Repeat the cycle and it will gain a fourfold charge. Repeat the process twenty-four times and the original charge will have increased some eight million times, and by this time at each earthing a growing spark will be heard and seen, and its intensity will go on accumulating until it is limited by the capacity of the three conducting discs.

This simple experiment illustrates very graphically the underlying principle of practically every form of electric influence machine, such as the Voss, the Wimshurst, and Clarke's gas lighter. All these machines merely provide for the rapid performance of a cycle of inductions so arranged as to produce an accumulation on the compound interest principle. The original source of the electricity is always the infinitesimal contact charge, generally that derived from the mere contact of air with the tinfoil sectors of the machine.

Lord Kelvin applied the same principle to a water-dropping apparatus in which two streams of water drops pass through the middle of cylindrical metal inductors, each drop carrying an induced charge as it breaks away from the stream under the influence of the cylinder. The drops give up their charges to metal cups which by means of cross wires communicate the growing charges to the inductors. Starting with no appreciable trace of electricity the accumulation rapidly multiplies and causes the startling phenomenon of flashing sparks between contiguous parts of the apparatus, and the accumulation is only limited by the fact that the streams of drops become so highly charged that they soon repel each other with such force that they scatter instead of falling into their respective receivers.

The same effect may be produced with two falling streams of sand or metal filings. In every such case the initial charge is derived from contact, and its manifestation is due to the doubling principle already explained.

In a very rough and general way it is possible to estimate the voltage of the original infinitesimal charge of a doubler. Reverting, for example, to our preliminary experiment with the strips of glass, it will generally be found that about twenty-four doublings yield a half-inch spark. It may be taken that every tenth of an inch represents roughly a potential difference of ten thousand volts, so that half an inch means fifty thousand volts. Now, the twenty-four doublings represent an increase of eight million times, so that the original charge may be put at about one eight-millionth of this, or the one hundred and sixtieth part of a volt. At the same time the amperage, it must be remembered, is, even in the case of the fifty thousand volts, practically unappreciable, so that the high voltage obtained does not mean practical efficiency, say for lighting or power purposes.

These few experimental illustrations all demonstrate the mysterious principle of the origin of electricity from contact. They do not, however, demonstrate how or why electricity originates from contact. Here we come to the boundary line between the known and the unknowable as far as physical science is concerned. The rest eludes our senses. We come, as it were, to the horizon line of the phenomenal, beyond which lies the noumenal that is not attainable by the material senses.

All that can be said is that it seems as if the law of contact was in the case of electricity merely a particular case of the operation phenomenally of some very vast law that also makes itself manifest in many other ways. The mystery that peeps out in contact electricity may in the noumenal world be one with the mystery that eludes us when we seek for the cause of many potent influences arising from contact in quite other departments of human observation, not only in chemistry and other material sciences but in purely human energies. The power of "the touch of a vanished hand" may be as truly due to polar sympathies as the force that arises from the contact of dead zinc and copper. And in the great unity of things which it is beyond us to grasp the hidden cause of each may be one and the same. It may be that there was no mere playful conceit, but a hint of profound truth, in those pretty impromptu lines with which Dr. Herbert Mayo celebrated the epoch-making discovery by Faraday of electro-magnetism:—

"Around the magnet Faraday
Was sure that Volta's lightnings play,
But how to draw them from the wire?
He took a lesson from the heart:
'Tis when we meet, 'tis when we part
Breaks forth the electric fire."

THE HORNET AS A PET.

By G. HURLSTONE HARDY.

I BEGAN to be interested in *Vespa crabo*, with the appearance of which I was much impressed, in my early youth. It then happened that I acquired a large triple observation hive, but no honey bees. I had to be content with placing therein the nests of several kinds of wild bees, of course, separately, and studied their habits and those of their parasitic enemies.

One summer, when I had in hand two colonies of the large common bumble bee, and was hopeless of acquiring hornets, I determined to add wasps. With the assistance of two schoolfellows I smoked and dug out a nest of three horizontal combs. These we placed in the central hive, with a few young wasps and the queen wasp. These young wasps had very recently emerged, and could hardly yet fly; however, they cleaned and fed the young in the combs. We fed them with jam, house flies, and other insects. In about one week a sufficient brood of newly-hatched working wasps were able to forage abroad and rear all the brood. Unfortunately, the queen disappeared, and the community did not increase to the normal size of a full autumnal brood. The most curious fact observed was that certain lazy wasps made a habit of awaiting at the alighting boards of their bumble bee neighbours, and there beg to be fed. They never threatened the bumble bees, who seemed willingly to feed them without realising that they were fatally neglecting their own broods.

My wasps never entered the nests of the bumble bees, and they did not resent being closely observed as long so the hive was not shaken and was only approached from behind.

Many years later I observed hornets flying very late in the summer evening about trees in Chiswick, but it was some time afterwards, whilst I was casually walking down Chiswick Lane, that I discovered hornets busy around four straw hives in the front garden of a cottage. I entered and asked the proprietor to let me observe them. I found that he kept these hornets for pets, and that he had no bees. We had a long conversation on hornets and again on another occasion, but I regret that circumstances prevented my visiting the locality for several years. When I did eventually go there, my acquaintance was not to be found. I hoped to establish colonies like his in my own garden at Twickenham, but have never been able to do so.

I learned from my acquaintance much of great interest, and I was confirmed in all my somewhat conjectural ideas about the habits of hornets which vary much from those of their cousins, the commoner wasps. Friends are apt to accuse me of joking when I aver that the hornet is a gentle, inoffensive creature very suitable for a pet; but it really is so, and the reason is easily explained. Accustomed to hunt high in the tree tops she remains ignorant of the savagery of the average school-boy and she seldom experiences the malice of man or becomes aware of the trepidation of woman at the mere sight of a wasp. Her services must be overwhelmingly beneficial in woods and orchards. At midsummer she forages much in the night. The honey bee gathers from sunrise to sunset but works hardest in the forenoon and slackens towards evening. The wasp begins an hour earlier and ends an hour later. Now hornets work throughout most of the twenty-four hours if the weather permits. When I visited my acquaintance in Chiswick Lane he bad two hives occupied by numerous inhabitants and one other by a very young colony; he lifted up the latter hive and let me observe the queen at work. He said he felt no danger whatever, although she was at that date being assisted by her first brood of workers. I greatly desired to know how he managed to have inhabitants for his hives year after year, inasmuch as hornet colonies were reputed to be not like those of honey bees, but like those of wasps, started anew each year singly in a new spot by a surviving queen after hibernation. He said that every year, since he had started with a transplanted colony, queens had voluntarily chosen hives in his garden.

Having lost such a unique opportunity of learning more, I regret that now I can only surmise that queen hornets either hibernate in the old nest or inherit an inclination to frequent the locality of their birth, habits which are both contrary to those of the common wasps and bumble bees, though the upholsterer bees and their nearest relatives do exhibit an excessive attachment to the spot from which they emerge.

If ever I succeed in getting a colony of hornets, I shall install them near the top of my house rather than near the front door steps on the ground, as did my acquaintance. I have no fear whatever of these innocent and useful creatures, who seem quite willing to share our dwellings with us if encouraged to do so, but a high elevation would suit their habit of high flight.

EARTHQUAKES FROM A JAPANESE POINT OF VIEW.

By BLACKFORD LAWSON.

Member of the Japan Society.

No other country in the world probably affords such facilities for the study of earthquakes as Japan, nor is there anywhere else such necessity for their scientific investigation.

Nearly one thousand four hundred of these phenomena are recorded annually in the whole of the Empire, and in Tokyo alone there are, on an average, fifty earthquakes that can be felt during the year, or about one a week. Earthquakes, as every one knows, occur in all regions adjacent to active volcanoes, as in the neighbourhood of Teneriffe, Vesuvius, Etna, and Stromboli, which are simply the safety-valves of a single earthquake district. So also Japan, Sumatra, Java, and the islands of the East Indian Archipelago are liable to fearful earthquakes; and geologists say that much of Japan would never have existed but for the seismic and volcanic agency which has elevated whole tracts above the ocean by means of repeated eruptions.

FIGURE 152. Earthquake Crack three feet wide, made during the great earthquake in the Yamogata prefecture (North Japan).

It is, therefore, only to be expected that it occupies an unique position in the world as regards seismology. Consequently, there is a special Chair of Seismology and an Institute attached to it in the University of Tokyo, and also a special committee for the investigation of earthquakes, under the direct control of the Minister of Education. Besides this, all the provincial meteorological stations throughout Japan are equipped with instruments for recording and measuring earthquakes, and seismic phenomena are systematically studied.

In the interior, the writer frequently met, in an out-of-the-way cave or on the mountain-side, members of the Seismological Society of Japan, originally organised by Professor Milne, who, with their delicate instruments set up, were mapping down every quiver of the earth's crust.

A study of a map of the world will show that the configuration of earthquake centres, as seen in India, Japan, Java and Sumatra, is that of an arc, and that in each case the earthquake region lies on the outer or convex side of the arc, where the deformation of the earth's crust seen in the curvilinear form of the arc shows that the strain is greatest. Thus, in the Himalayas, severe earthquakes take place on the outer or steep side, rather than on the concave or Tibetan side; and in the case of the Japan arc, great seismic disturbances occur almost always on the outer or Pacific side, where the Pacific Ocean forms the greatest area of depression in the world, and only small local shocks originate on the inner or Japan Sea side of the arc.

After the great catastrophe in North-West India on April 4th, 1905, the Japanese Government, ever eager to study earthquake phenomena at first hand, sent their leading seismic expert, Dr. F. Omori, Professor of Seismology at the Imperial University, Tokyo (see Figure 157) to investigate and report on the nature of the disaster. During several months' stay in Tokyo, the writer was honoured by the friendship of this eminent man, and spent many delightful hours in his lecture-rooms at the University, and also with his charming family in their picturesque home. From Professor Omori, she learnt that the appalling loss of life in Dharmsala and the Kangra Valley was due to faulty construction, the houses being built of stones roughly piled together without any good cementing material, and surmounted by a heavy roof.

In construction the first point is to make the foundation solid and as large as possible, because, if weak, cracks will be produced. In two-storyed buildings, the upper storey suffers more than the lower ones, the vibration being greater at a height than at the base. Again, a structure may be very heavy, but if built of bad material it can have no

FIGURE 153. The Earthquake-proof Building erected in the grounds of the Imperial University, Tokyo.

resisting power, and it will simply "smash down," for good material and good construction are more important than thickness of walls. Now, in the Punjab the houses were built solidly enough, the walls being two feet thick, but they were filled up with rubble and small stones, and were, therefore, bad from an earthquake point of view.

Professor Omori speaks very decidedly with regard to the responsibility of Government in the erection of jails and barracks, and he used a stronger expression than the writer ever heard before on the lips of a Japanese in criticising Occidental methods, when he said, in conclusion: "It is *almost criminal* on the part of the Government to build bad structures for public purposes, such as schools, jails and barracks, and my advice to the Indian Government would be to build more substantially, always on a sure foundation, with good binding either of wood or iron, and to use good material, especially in the case of public buildings."

In Calcutta, Professor Omori found that the theory of the engineers was, that the soft soil of Calcutta acted as an elastic cushion, and, by absorbing the earthquake motion, prevented it from being communicated to structures standing upon it. Now this was quite an erroneous idea, earthquake motion being invariably felt more in soft than hard ground; and even within the confines of the city of Tokyo a shock varies considerably, one in the upper part being one-half less in intensity than it is in the lower and softer parts. The same fact was also made evident in San Francisco, where at the time of the earthquake "made ground" and soft land suffered more than the hard.

Speaking generally, the most important principle in construction is to make the structure *a single body*, simple and compact, avoiding the possibility of different parts assuming different movements or vibrations. For example, chimneys are dangerous, because a chimney vibrates differently from the main building, and in the event of earthquake it will be found that a chimney is always broken at its junction with the roof; so that, as the fracture of a brick column occurs at a joint, its seismic stability ought to be increased by using good mortar, until the strength of the joint becomes equal to that of the bricks themselves. In 1894 a curious earthquake occurred in Tokyo, during which several chimneys were knocked down in barracks, factories, and schools, killing many soldiers and others. To obviate this danger the Japanese now make the part above the roof of light material, such as sheet-iron, or better still, of earthenware (*dokwan*). As a matter of fact, Tokyo is rendered generally hideous by these iron chimneys—perfect abominations, which tower above the roof-line, and are, indeed, made so long that, when they fall, they do not crash through the roof, but topple over into the street or garden beyond.

In Japan, it is interesting to note that ancient castle walls, built several hundreds of years ago, have forms approximately equal to the curve theoretically giving the greatest stability against earthquake, known geometrically as the parabolic curve. We find that the walls of all old castles are made of parabolic section, thicker at the base, in the form which mathematically gives uniform strength throughout the height and prevents the formation of cracks; and, as a matter of fact, all these castles have withstood terrific shocks of earthquake.

There is no better example in the whole country than the walls of Nagoya Castle (see Figure 154), which are built of polygonal blocks, ten, twenty or

FIGURE 154. Nagoya Castle, one of the "sights of Japan." The walls are of parabolic sections, to give stability against earthquakes.

thirty feet long, uncemented, and fitted into the bank at an even slope; and yet, after hundreds of years of storm and earthquake, there is scarcely a crack to be seen. They withstood the great earthquake in 1892, when thousands of houses fell in Nagoya and Gifu, and in the smaller places round about, and when all the new brick telegraph and post-offices and other European buildings came crashing down like ninepins. On that occasion, Japanese houses did not fall, unless they were old and frail, when in many cases the supports gave way and the roof came down, imprisoning the inmates until they were rescued, sometimes from a house in flames. The walls of the Castle of Tokyo show the same remarkable state of preservation, the blocks of cyclopean masonry, there also uncemented, being neither cracked nor displaced in the least degree.

Figure 153 represents an earthquake-proof structure erected in the grounds of the Imperial University, Tokyo, which has been built according to mathematical calculation on a solid concrete foundation, and is intended for use as a Seismological Observatory, and as a standard with which to compare the effects of a shock on ordinary brick buildings. In it most interesting investigations into the stability of various structures against earthquake shocks are carried on, artificial earthquake motion being produced by means of a "shaking table," which can be made to move with independent horizontal and vertical motions by the use of steam engines. (See Figure 158).

Another remarkable fact in Japan is that pagodas (see Figure 155), built hundreds of years ago embody the principle of the modern seismograph, which is

Figure 155. A typical Japanese Pagoda. It is a remarkable fact that these pagodas, built hundreds of years ago, embody the principle of the modern seismograph.

to minimise the effect of earthquake motion by the combination of an inverted pendulum with an ordinary pendulum; or, in other words, by the union of a stable and an unstable structure, to produce a neutral stability which renders the whole building least sensible to earthquake shock. In the

Figure 156. A Japanese bell-tower, wherein the suspended bell acts as a safeguard against earthquakes.

hollow well of every five-storeyed pagoda a heavy mass of timber is suspended freely, like an exaggerated tongue, from the top right to the ground, but not in contact with it, and at the shock of an earthquake this large pendulum slowly swings, the structure sways, and then settles back safely to its base. This is also the principle followed in the construction of all bell-towers throughout Japan, where the bell acts as pendulum, and the roof, supported by posts, forms an inverted pendulum, as in the seismograph. When an earthquake occurs, a pagoda or a bell-tower may be rotated or displaced, but it cannot be overturned as a whole.

Although seismologists have not yet succeeded in finding out any means of definitely predicting the occurrence of an earthquake, they are very hopeful of finally arriving at this desired goal; and already Professor Omori, with his deflectograph and vibration measurer, can discern danger by careful observation of the pulsations which are always gently agitating the surface of the earth, and can usually give ten or twelve hours' notice of a shock. A sudden cessation of the regular heart-beats or pulsations of the earth's crust is a danger signal, extreme stillness invariably preceding an earthquake, whereas constant tremors are a good sign.

A great earthquake is almost always followed by weaker ones, and when it is violent and destructive the number of minor shocks following it may amount to hundreds, or even thousands, and continue for several months or years. The occurrence of after-shocks is quite natural and necessary for the settling down into stable equilibrium of the disturbed tract at the origin of disturbances, each of these shocks removing an unstable or weak point underneath. Further, as a very great shock would remove a correspondingly great underground instability, it is probable that such a shock would not, for a long time, be followed by another of a magnitude comparable to its own, in the same or a neighbouring district. When, however, the initial shock is not very great, it may be followed by another like it; but even in this case the position of the origin of the second shock would usually be quite distinct from that of the first.

It is a matter of common knowledge that a large part of the soil of Holland, with its villages and cities, is many feet below the level of the sea, and is slowly sinking, while the Scandinavian Peninsula is in process of elevation. It is in this way that the great changes in the earth's surface take place in the course of ages: and the theory that mountain ranges, like the Himalayas, were suddenly thrust up by some world-shaking upheaval, has long since been dissolved by the light of experience and investigation. But while these mighty changes have come about unseen and unheard, the petty shakings of the seismic regions force themselves in a terrible way upon our attention, as in the appalling disaster of 1909 in Calabria and Sicily, one of the most awful of the recorded earthquakes of the world.

Earthquakes are of such common occurrence in Japan that they are hardly noticed unless some damage is done, and the writer was often awakened in the night by the bed rocking from side to side, which sometimes caused a slight feeling of giddiness, like being at sea. She was also unpleasantly reminded of the forces at work at this seismic junction of the universe, when staying in the Yamogata Prefecture, in the north of the main island, where an unusually strong shock of earthquake was experienced. It lasted fully three and a half minutes, and although the house in which the writer was staying was not seriously damaged, there were cracks three feet wide in the ground near the windows (see Figure 152). The building rattled and swayed as though Samson were beneath shaking it as a terrier does a rat, the surprised dogs outside began to bark and the cocks to crow, and the feeling of mysterious tremor or palpitation was distinctly uncanny. At the first indication all the Japanese rushed frantically into the street shouting, "*Jishin! Jishin!*" (earthquake) and stood huddled together in the utmost terror until the danger seemed over. The writer's own instinct was to sit tight and cling to the writing-table, but presently she found herself sliding on the floor with pictures off the walls and bric-a-brac—ancient and modern—strewn around. In Tokyo people mention earthquakes as we in England do the weather, when other conversation fails, and thrilling tales of personal experiences during the most appalling of all the operations of nature, are often told round a dinner-table in the metropolis.

FIGURE 157. Professor Omori with Vibrating Recorder at the Seismological Institute, Tokyo. By means of this instrument vibrations of railway bridges and steamers are measured.

FIGURE 158. "Shaking Table" in the Seismological Institute, Tokyo University. The bricks are made specially for testing purposes from brick columns previously destroyed by earthquake. They are pulled asunder in order to find out the strength of the brick and mortar joint.

THE EXISTENCE OF AN ULTRA-NEPTUNIAN PLANET.

By PHILIP H. LING, M.Sc.

The discoveries of the planets Uranus and Neptune were the first two steps in the outward extension of our knowledge of the solar system. The third step—the discovery of a planet still more distant—is yet to be made. There is, however, a considerable amount of evidence for the existence of such a planet, and in the present article it is proposed to give a short discussion of the arguments which have been brought forward.

It should be remarked at the outset, that visual observation will play no part in the argument; for it is almost certain that no planet exists of sufficiently large dimensions. We, therefore, have recourse to indirect methods by studying the effects which the hypothetical planet may be supposed to produce in bodies which are themselves capable of being observed.

(1) The most obvious way of doing this is by examining the perturbations of Neptune. Now the latter has a period of one hundred and sixty-five years and has only been under continuous observation since 1846—that is, for less than one half of its orbit. It is obvious that no certain conclusions can as yet be drawn from so small a portion of Neptune's path; and while the method may be useful centuries hence, it is at present too precarious.

(2) A more hopeful plan is to study the perturbations of Uranus. These are not completely explained by the attraction of Neptune, and have recently been examined almost simultaneously by Pickering* and by Gaillot,† working independently. They agree in the mean distance of the unknown planet, which is given as about fifty-two astronomical units: but Pickering finds the mass to be twice the mass of the earth, while Gaillot makes it five times: the latter also suggests a still more distant planet to be required. The smallness of the mass militates heavily against the correctness of the arguments since the effects produced must be infinitesimal.

(3) The best method of all is that derived from the orbits of comets. If we compile as complete a list as possible of the periodic comets, arranged in ascending order of period, a very striking fact becomes apparent. They are seen to fall into groups, the first of which contains those with periods ranging from 3·3 to nine years, the second those of period about thirteen, the third about thirty-three, the fourth about seventy-three, while there seems to be a fifth with period about one hundred and twenty-one years. Now each of these groups contains comets whose aphelia are approximately at the same distance as one of the planets Jupiter, Saturn, Uranus, and Neptune, while the fifth group seems to correspond to a hitherto unknown planet. There is, therefore, apparently some connection between these groups of comets and the corresponding planet, and before basing any argument on it, it is necessary to inquire more closely into the nature of the relation.

Now the most obvious explanation of the relation between comets and planets, is that known as the "capture" theory. According to this, at some previous era the comet approached so closely to the planet, that the gravitational attraction of the latter was sufficient to overpower that of the sun, but not large enough to transform the comet into a satellite. The orbit thus became a long ellipse, with one focus in the sun and the other in the position temporarily occupied by the planet; and this orbit would remain permanent in the absence of commensurability between the periods.

This appears to afford an explanation; but two difficulties, mentioned by Newcomb‡, arise. In the first place, Encke's comet has its orbit completely within that of Jupiter, and no close approach occurs; but we know that this comet probably passes through a resisting medium, which is altering the major axis, and it has been shown by Backlund§ that "capture" within the last five thousand seven hundred years is not by any means impossible.

The second difficulty is extremely serious. The planets all move nearly in the same plane; the orbits of comets, however, are inclined to this plane at all angles, and, as a result, though the statement

* See *Nature*, June 17th and August 26th, 1909.

† *Comptes Rendus*, March, 1909. See *Nature*, July 8th, 1909.

‡ "Encyclopaedia Britannica," 11th edition, Art. "Comet."

§ *Royal Astronomical Society, Monthly Notices*, LXX. 5. (March, 1910).

as to the aphelion distance above is still true, there is, in point of fact, no close approach at all. This is exemplified by Halley's comet, which, having its orbit inclined to the ecliptic at about 18°, never passes near the path of Neptune, to whose group it belongs.

In discussing the difficulty, we must remark that for "capture" to take place, it is only necessary that the aphelion focus should be in the plane of the ecliptic. Since this is not the case, there must have been a secular rotation of the major axis, which had moved the aphelion from its original position. If this rotation does not exist, then the "capture" theory must be abandoned. This applies to the more distant comets, for Jupiter's group is generally acknowledged to have been "captured," and in its case the inclination is usually small.

It is interesting to notice in the orbit of Halley's comet (the only distant comet which has been very thoroughly investigated) there was a divergence of two days in 1910 between the actual and calculated times of perihelion passage, so that an unexplained rotation of the major axis certainly exists. This is not to be referred to any known mass in the solar system, while an unknown mass must necessarily be very considerably out of the plane of the ecliptic to produce the observed results.

At this point, much light is thrown on the subject by a remarkable paper by Pickering*, which has just appeared. If the translational motion of the solar system through space experiences any resistance from the ether, or from scattered matter, the effect will be most visible in the case of comets, owing to their small mass and large superficial area. The result will be, that the aphelia will fall behind and will tend to group themselves in a direction opposite to that of the sun's motion. Pickering shows that this actually takes place, and supposes that the divergences which are visible are to be attributed either to a motion of the absorbing medium, or to a curvature in the sun's path. Here, then, is the explanation of that secular motion of the major axis, which we have shown to be required by the "capture" theory; and the latter is, therefore, not inconsistent with the facts.

The assumption of a resisting medium naturally raises some suspicion, for there is a danger of using it as a *deus ex machina*, in the way of solving astronomical difficulties. But it certainly exists in the shape of meteoritic swarms, even if the ether be itself non-resisting, and it is now fairly certain that the cause of the anomalous motion of Encke's comet is to be found in this direction. We may, therefore, conclude that if a group of comets exists outside that of Neptune, it is *a priori* evidence for the existence of a more distant planet.

Now, unfortunately, the evidence is rather meagre. Grignell† examined twenty comets, and deduced a planet at a mean distance of 50·61; but the periods of the comets are very far from certain. Comet 1862 III (related to the Perseid meteors) is supposed to have a period of one hundred and twenty-one years; while there has been stated an identity between the comets of 1532 and 1661. In 1911 it was pointed out that there was a distinct similarity between the Kiess and Quénisset comets of that year and comets 1790 I and III respectively. If this could have been established, there would have been much stronger evidence for the hypothetical planet; but in each case the differences were such as to lead to the conclusion that the similarity was merely fortuitous. It is necessary, therefore, to search for comets whose periods can be irrefragably shown to be in the neighbourhood of one hundred and twenty-one years, *i.e.*, they must be seen at two apparitions at least.

There have been one or two other investigations concerning unknown planets. Pickering‡ stated in 1910 that the orbits of comets and a certain perturbation of Neptune could be explained by the existence of a large and very distant dark body in a direction perpendicular to the ecliptic. Another interesting suggestion is that of Professor Forbes§, who gives some evidence for supposing that the comet of 1556 was split into three in aphelion, about the year 1702, by an ultra-Neptunian planet at the the great distance of eighty-seven units.

The conclusion reached in this paper is, therefore, that the orbits of comets present the most hopeful method of arriving at the unknown planet, their results agreeing roughly, as to the mean distance, with those derived from the perturbations of Uranus. The "capture" theory is, however, only rough; and for a proper treatment it will be necessary to discuss in general the motion of a comet under the combined attraction of the sun and a planet. These "parabolic orbits," as they may be called (since, for a small disturbing mass, they are approximately parabolas), present enormous mathematical difficulties, even compared with the case of orbits nearly circular. In the lunar theory, a revolution was effected by the suggestion of G. W. Hill, to treat the question as a particular case of the problem of three bodies and to solve by series. The parabolic case is complicated by the non-convergence of any proposed series, and practically nothing has been done in the way of mathematical analysis. Nevertheless, it seems to be a necessary step in the establishment of the existence of the unknown planet.

* "The Motion of the Solar System relatively to the Interstellar Absorbing Medium," *Monthly Notices, Roy. Astr. Soc.* LXXII. (1912, Suppl. No.)

† See *Nature*, October, 1902.

‡ See *Science Abstracts*, February 25th, 1911.

§ *Monthly Notices, Roy. Astr. Soc.*, December, 1908.

BIRD-CALLING.

By W. A. NICHOLSON.

THE art of attracting wild birds is one little known or understood except by those whose special interest lies in this direction. The bird-catchers, and those who trade in live birds, understand little, if anything, about this subject, and even the bird-catchers themselves seldom practise it, relying almost solely upon the live decoys shut up in small cages wherewith to attract their wild companions to the deadly limed twigs. One must be well versed and possess a thorough knowledge of the notes emitted by birds, besides being acquainted with their habits, before he can employ the aid of calls with success, and the professional bird-catcher is an individual of too indolent a character for this work, which, doubtless, is the principal reason he leaves it severely alone. Those who use bird-calls regularly are the bird-photographer, the field naturalist and the wild-fowler, and all with the one object and main purpose of decoying the species and making them come nearer, the first, to enable him to secure a good negative and larger picture; the second, to extend his knowledge of the habits of a species; and the third to secure the specimen. The wild-fowler, however, makes use of few calls, often not more than six, these usually being those imitating the cry of the wild duck (mallard) (see Figure 167), curlew (see Figure 164), golden plover (see Figure 163), green plover, (see Figure 165), wigeon and teal (see Figures 161, 162 and 171), and often two only are regularly carried, these being the calls of the golden plover and curlew. As will be observed from the illustrations which have been reproduced from photographs of various patterns in my possession, that I make use of regularly, there is quite a collection of different kinds, a total of eighteen being here represented. They are all of Continental manufacture, but may be purchased in England from Messrs. Spratt's Patents, Ltd., 24, Fenchurch Street, London, E.C.; they are by no means expensive in comparison to the pleasure to be enjoyed by their use, and cost from ninepence to three shillings and sixpence each according to make and finish. It is at all times advisable to procure the very best that are made, for the simple reason that with care they give the finest results and will last for many years. As remarked above, the successful use of these calls chiefly depends upon the operator and his practical knowledge of the proper notes emitted by the birds

FIGURE 159. Pheasant.

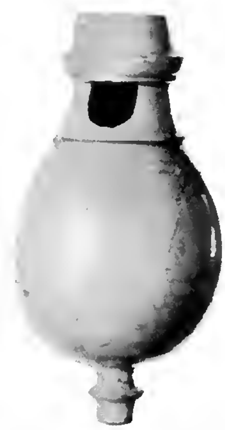


FIGURE 160. Woodpigeon.

FIGURE 161. Wigeon.

FIGURE 162. Wigeon (improved pattern).

FIGURE 163. Golden Plover.

FIGURE 164. Curlew.

FIGURE 165. Green Plover (Lapwing).

FIGURE 166. Owl.

FIGURE 167. Wild Duck.

FIGURE 168. Hare.

FIGURE 169. Hare. (another pattern).

in a wild state, and without experience of the latter it will be only time wasted to endeavour to manipulate them, except, perhaps, with the exception of two of the instruments, namely, that of the woodpigeon (see Figure 160) and the golden plover (see Figure 163). These two are the simplest to operate and little practice is necessary to enable one to make successful use of them. The woodpigeon call may also be substituted for that of the cuckoo, and a little practice with it soon enables one to acquire the correct pitch and modulation of sound necessary. It is very interesting to visit a breeding haunt of the woodpigeon with one of these calls. My method is to conceal myself (I use a hiding tent for this purpose, which is furnished with tapes, to which I attach twigs, grass, and so on, and make use of the surrounding undergrowth to screen it) under the nesting trees, having previously arranged my camera in position, and send out a few notes. As generally happens, the cushats in the immediate neighbourhood are cooing all around, and, at first, little or no notice is taken by the birds of one's efforts, but the secret is to continue to call, not, however, uninterruptedly, but with pauses of about four minutes, making a fairly high pitch in the tone, when the birds will be observed to crane their necks downwards and stop cooing. Some bolder than others fly closer to the hidden caller, often approaching to within a few yards, and altogether the call, always assuming the proper sounds are given, has a most alluring effect on woodpigeons during the commencement of one of their breeding periods. During incubation, however, the birds pay little heed to artificial calls, and at such times it is useless trying to attract them. Another easily duped species is the cuckoo, which may be enticed to within a few feet of the manipulator, and the same may be mentioned of the golden plover (see Figure 163), partridge (see Figure 170), pheasant (see Figure 159), and little grebe (dabchick). Species somewhat more difficult to deal with are the wild duck (mallard) (see Figure 167), curlew (see Figure 164), snipe (see Figure 173), owl (see Figure 166), wigeon (see Figure 161), magpie (see Figure 174), oyster-catcher, and red-throated diver. All the calls illustrated should be worked with the left hand, so as to leave the right hand free for manipulating the shutter of the camera and other necessary items. The art of bird-calling is a most interesting study, possessing a peculiar charm, a charm impossible to describe, and one having a fondness for ornithological pursuits, and with plenty of time to spare, could hardly do better than take up so absorbing a hobby, the acquisition of which would repay him a thousandfold. But such a one must be possessed of great patience and perseverance, otherwise failure is certain.

FIGURE 170.
Partridge.

FIGURE 171.
Teal.

FIGURE 172.
Blackbird.

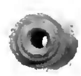


FIGURE 173.
Snipe.

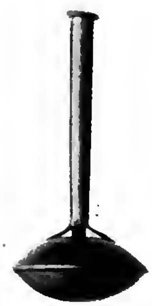


FIGURE 174.
Magpie.

FIGURE 175.
Rabbit.

FIGURE 176.
Jay.

THE ANNUAL CONFERENCE OF THE PARENTS' NATIONAL EDUCATIONAL UNION.

THE seventeenth Annual Conference of the Parents' National Educational Union will be held at Caxton Hall, Westminster, from May 5th to May 8th. The programme is now before us and bears at the top the motto "Knowledge the basis of National Strength." On the afternoon of the first day, Earl Beauchamp will preside and Mr. J. St. G. Heath will give an address on "Education and Social Sympathy." In the evening, a paper on "Self Education," by Miss C. M. Mason, will be read, and one on "How we teach Citizenship" by Miss L. Faunce, an ex-student of the House of Education, Ambleside.

Tuesday morning will be devoted to the consideration of the subjects taught in one of the Parents' Union Schools, and among the other papers of the day will be one on "Knowledge and Learning" by Mr. Stanley Leathes, C.B. The topics chosen for the third day include The Montessori System and some of the ideals of the Union. In the afternoon, with Dr. Parkin, C.M.G., as Chairman, Mr. J. L. Paton, High Master of Manchester Grammar School, will consider "Knowledge and its relation to National Efficiency," while the Earl of Aberdeen will preside in the evening, when the Bishop of Southwark will speak on "The School of Life."

Papers dealing with the administration of the Union will occupy the afternoon of Thursday, and in the evening there will be a meeting for children's nurses, when Dr. Flora Murray will talk about "Things that matter in the Nursery," and Miss Helen Webb, M.B., will consider "The Child as a Person."

There will be receptions on Monday afternoon and Tuesday evening. All particulars can be obtained from Miss E. A. Parish, 26, Victoria Street, S.W., but we may mention that season tickets, which admit to all proceedings, can be obtained at a cost of 3s. 6d. each (invitations to the receptions will be sent to holders of season tickets only), and day tickets for 1s. 6d. each.

WITHYWINDS AND WITHERSHINS.

By HARWOOD BRIERLEY.

An exact definition of the two strange terms, withywinds and withershins, is not easily given. A withe, or withy, may be a flexible willow twig or osier, it may be a band of twisted rings, or the spiral coil of some plant-stem in the tangled hedgerow. The poet's woodbine itself, better known as the honeysuckle, is a typical winding withy, and, therefore, a withywind. We call to mind the fact that there are districts in which our great white convolvulus (*C. sepium*) is variously known as the hedgebell, bellbine, ropewind, and withywind. The latter vernacular name is as appropriate as any, for this plant's twisting stems are in some districts known as "devil's garters," which, like the stem of the woodbine, or honeysuckle, have been known to strangle a fox in the brake after dragging at its noose-like coils in a desperate attempt to extricate himself. The "withershins" or "widdershins" of Scottish literature is a compound of two Scandinavian or Gaelic words which have to do with coiling stems and the sun. Originally a provincialism, the term is now politely applied to some natural object which elects to turn round in a direction opposite to the sun.

Why do our weak-stemmed hedgerow plants turn spirally in totally different directions? The rule commonly obeyed has, of course, very few exceptions: and there is little doubt that every indigenous climbing-plant with corkscrew tendency travels like the hands of a watch, or follows the sun as closely as it can from east to west. Yet some long acclimatised species go the opposite way, while some species included in the same genus are quite antithetical in their feelings on the matter. This general habit of following the sun must surely depend on which hemisphere a plant's progenitors first acquired the instinct essential to its welfare, and it may have been governed by that same plant's desire to find either light or shade. Overnight our convolvuli, bindweeds, bryonies, tamuses, hopbines, and honeysuckles become partially rigid in sleep, and more supple again at sunrise, when they attempt again to follow the source of light around his orbit from the east to the far west of summer. It is reasonable to assume that a sun-loving plant which originated in the southern hemisphere would travel in an opposite direction, from right to left of the observer. Unsusceptible to the solar influence is the tender French bean, and the contrariwise spirals it makes proclaim it to be a withershin. If you unwind it from its stick or post and attempt to direct it aright, the snake-like growing-tip casts itself free to hang stupidly downward, and if the sap and cuticle have given this bine a fixed "set" it declines to resume its skyward journey, unless you place it in some of its former contortions. Although you wrap it round the stake in the direction it disdains, and tie it there at intervals, it will not cease to make erratic twists with new growth, until it can resume that eccentricity of climbing which was established fast in its nature, probably ages ago.

FIGURE 177.

Stem of *Convolvulus arvensis* twining to the left.

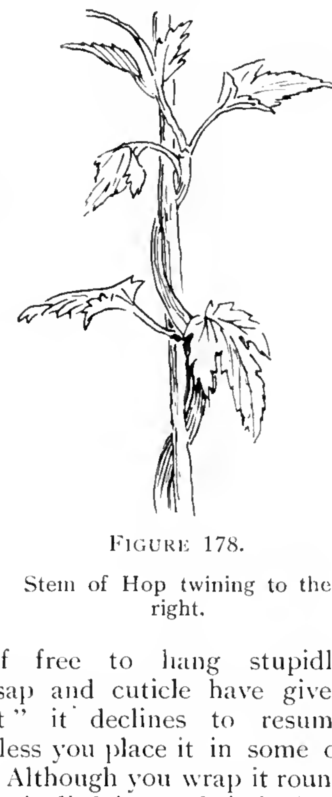


FIGURE 178.

Stem of Hop twining to the right.

Convolvulus sepium, the great white bindweed, may be called the typical withywind (see Figure 177), because of the fact that that name for it belongs to the vernacular of one or more southern counties. Although doubtless bearing the largest and handsomest of our white wild-flowers, which are bell-shaped and as pure white as foam, it is yet unfortunately an emblem of idleness in a garden lying waste, or it is at home on a high hedge which rarely suffers from the slasher. Like the cuscutas or leafless dodders worming their network of delicate pink stems among furze, thistles, and nettles, the numerous white bells hanging amid masses of lovely sagittate or arrow-shaped leaves which half smother the hedge afford some idea of the lianas which form such a striking feature of tropical scenery. On a smaller scale we have the field-convolvulus (*C. arvensis*) with stem trailing along wayside banks and field-borders, embellished at intervals with pink and white-striped shallow almond-scented cups, or often clinging to wheat and barley stalks too tenaciously for any wind to unloose. It is remarkable to find that so many spiral climbing plants conform to the convolvulus type of leaf, all of them being withywinds if not withershins. The climbing polygonum or buckwheat—a common and detested garden weed—and the tamus or black bryony, with its glossy deep-green leaves, have little in common beyond their foliage, which features the convolvulus. This same black-rooted bryony (*Tamus communis*) and the red-berried bryony (*Bryonia dioica*) stand apart in other respects than foliage, but, even more than the vetches, they are both steadied by tendrils. The climbing buckwheat certainly makes good use of its small leaves to fasten it to a supporting plant. Its fine, traily, stringy stem, branching out in all directions, catches round stalks of corn, flowering plants, and foliage, twisting them all together in such a tangle that nobody could release them who had not more than human patience, all being finally borne down with the strain or weight. The convolvulus-like leaves are set singly at intervals, becoming very small towards the top, till they look like pygmean assegais. The growing tips are insinuated through narrow spaces before the topmost leaves open wide, whereupon the two broad lobes prevent any slipping back when wind-shaken or dragged at from beneath. From which it would appear that some species of plants make their leaves answer the purpose of tendrils.

Transgressing its own law and the usages of climbing plants in this hemisphere, we have known the bryony —both the black-rooted and the red-berried—commence its course aright, then halt, turn right round, and proceed from west to east in withershins fashion. We cannot conceive how such a plant comes to infringe the rule of the indigenes, but there may have been an obstacle in its path or some other equally good reason for its "striking out a new line." In fact, the bryonies are, even more than the bindweeds, now recognised to possess some of that inexplicable knowingness or sentience which brings them several stages nearer to the animal kingdom. Your fancy may be mesmeristic or your volition void, but your fingers can hardly cheat the bryony trailer out of its own perceptions exactly where a suitable support lies. Its sensitive leading tip squirms about here and there till it secures a suitable grip, and if, later, it comes to hesitate a moment, one may be sure that the unforeseen has happened, or recent conditions have changed, causing danger to lurk ahead. One wonders what particular sense enables the hopbine to repeatedly cross a three-feet space to its nearest support after as many forcible dissuasions by human fingers.

When the red-berried bryony gets enmeshed on a hedge one has some difficulty in determining which way its individual tendency is to travel. It may be hurtful to the hedge, which was planted originally to keep grazing cattle within bounds, but nature-lovers forgive its faults because of those wonderfully beautiful vine-like leaves which have been so sedulously copied by decorative wood-carvers from the earliest times of Art. The convolvulus type of foliage is wholly departed from, here being five fantastically cut, broad, vine-like lobes instead of the usual couple which terminate with tool-like point. Instead of a leafhold as with the climbing weed-like polygonum there are tendrils, some of which will stretch out for half a foot. When once they catch hold they become a corkscrew-like coil or spring which allows of sufficient "play" to escape damage.

I cannot say that I have ever seen any lonicera or honeysuckle play withershins. But a man once showed me a hazel walking-stick grooved out spirally when still young and tender by Lonicera's clinching hoop-like withywinds, which indicated this plant's indebtedness to the sun as an agreeable compelling-power. Here an individual plant had studiously distinguished itself by an eccentricity, or been compelled to fight for its own living in a novel manner, by taking a wrong or retrograde turn in life which led actually to fortune! The hazel, its host, is at first a sufferer, but, becoming a curiosity of value by reason of the startling spiral impression, gains immortality in the keeping of a collector of walking-sticks, not the least of whom was our late King Edward. Every conchologist knows the value of a very rare variety of shell whose whorls are termed sinister because they go the wrong way round, and long ages ago a shell of this pattern was supposed to bring luck to the finder or wearer, being in this respect not inferior to the swastika symbol or any other amulet. The sinister whorl of a shell and a withywind's withershins, grooved in a stick from the brake or copse, are corresponding freaks of Nature.

The wild and cultivated hopbine (see Figure 178) stands botanically apart from the honeysuckle, the two bryonies, and other climbing plants: but it is nevertheless a true withywind, capable of extending its growth by five inches a day. Although its scientific name, *Humulus lupulus*, appears to be based on a tradition of its being the "willow-wolf which lives in a rich damp soil," and although it is maligned as being able to strangle willows twenty feet or thirty feet high, we really venture to believe that the specific name "lupulus," is derived from lupulin, the active principle in hops. If it were a withershins to any great extent, we should certainly have some records from Kent.

THE FACE OF THE SKY FOR JUNE.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 31.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Jupiter. R.A.	Jupiter. Dec.	Uranus. R.A.	Uranus. Dec.	Ceres. R.A.	Ceres. Dec.	Pallas. R.A.	Pallas. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
June 5	4 51·4	N.22·5	5 26·9	N.28·2	5 9·7	N. 24·1	2 5·2	N.10·5	19 11·2	S.22·5	20 39·6	S.19·1	15 18·9	S.12·0	14 25·2	N25·4
,, 10	5 12·0	23·0	10 24·0	N.12·4	5 56·4	25·2	2 18·2	11·1	19 9·2	22·5	20 39·2	19·1	15 15·4	12·2	14 23·7	25·1
,, 15	5 32·8	23·3	14 38·6	S. 10·1	6 40·2	25·1	2 32·7	12·0	19 6·9	22·6	20 38·7	19·1	15 12·4	12·4	14 22·8	24·7
,, 20	5 53·6	23·4	19 27·0	S. 26·7	7 19·4	24·2	2 48·6	13·0	19 4·4	22·7	20 38·1	19·1	15 9·9	12·7	14 22·4	24·2
,, 25	6 14·3	23·4	23 23·8	S. 4·7	7 53·5	22·5	3 5·6	14·1	19 1·8	22·8	20 37·5	19·2	15 8·0	13·0	14 22·6	23·7
,, 30	6 35·1	N.23·2	3 9·1	N.21·9	8 22·2	N. 20·5	3 23·7	N.15·2	18 59·1	S.22·8	20 36·9	S.19·2	15 6·9	S.13·2	14 23·3	N23·1

TABLE 32.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
Greenwich Noon.	°	°	°	°	°	°	°	°	h. m.	h. m.
June 5	−14·0	−0·0	121·5	− 2·8	−8·4	−1·6	180·0	224·4	7 5 *m*	3 44 *e*
,, 10	12·0	+0·6	55·3	+20·0	8·2	1·0	250·2	250·4	3 0 *e*	4 55 *m*
,, 15	9·9	1·2	349·1	+16·7	7·9	1·6	320·4	288·5	3 15 *m*	11 54 *e*
,, 20	7·7	1·8	282·9	− 8·0	7·7	1·6	30·0	320·5	9 0 *e*	1 5 *e*
,, 25	5·4	2·3	216·7	−21·7	7·4	1·6	100·8	352·6	9 15 *m*	2 16 *m*
,, 30	− 3·2	+2·9	150·6	−14·8	−7·1	−1·6	171·0	24·6	7 0 *m*	9 15 *e*

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Jupiter, L_1 refers to the equatorial zone; L_2 to the temperate zone; T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

THE SUN continues his Northward march till $1^h m$ on 22nd, when the Summer Solstice occurs. Sunrise during June changes from 3–51 to 3–49; sunset from 8–3 to 8–18. Its semi-diameter diminishes from 15′ 48″ to 15′ 45″. Outbreaks of spots in high latitudes should be watched for.

MERCURY is in superior conjunction with Sun at beginning of month, then an evening star, reaching East Elongation on July 7th. Illumination full on 1st, one-half on 30th. Semi-diameter increases from $2\frac{1}{2}$″ to $3\frac{1}{2}$″.

VENUS is a morning star, at greatest brilliancy at beginning of month, reaches West Elongation July 4th. $4\frac{1}{2}$° South of Moon on 1st. Semi-diameter diminishes from 19″ to 12″. At beginning of month 0·3 of disc is illuminated, at end of month one-half. Being south of Sun, it is less well placed for Northern observers than it was as an evening star.

THE MOON.—New $4^d\ 7^h\ 57^m e$; First Quarter $11^d\ 4^h\ 37^m e$; Full $18^d\ 5^h\ 54^m e$; Last Quarter $26^d\ 5^h\ 41^m e$. Perigee $10^d\ 4^h m$, semi-diameter 16′ 12″. Apogee $25^d\ 3^h m$, semi-diameter 14′ 48″. Maximum Librations, 3^d 5° E, 6^d 7° S., 18^d 5° W., 18^d 7° N. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

TABLE 33. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.		h. m.	
June 12 ...	BAC 4200 ...	6·2	8 55 *e*	109°	10 0 *e*	320°
,, 12 ..	BAC 4225	6 3	11 16 *e*	66	11 52 *e*	352
,, 13 ...	62 Virginis	6·7	10 7 *e*	73	—	—
,, 17 ...	BAC 5347	5·5	0 12 *m*	50	0 57 *m*	334
,, 17 ...	BAC 5737	6·7	10 16 *e*	80	—	—
,, 18 ...	γ^1 Sagittarii	var.	10 51 *e*	148	11 36 *e*	216
,, 20 ...	A Sagittarii	4·9	—		11 30 *e*	240

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

MARS is a morning Star, but not yet well placed for observation.

CERES and PALLAS are well placed for observation. They are of magnitude 7 and 8 respectively.

JUPITER is a morning star. Polar semi-diameter, 21½″.

TABLE 34.

Day.	West.		East.		Day.	West.		East.	
June 1		○	3124		June 16	3	⊙	24	
,, 2	31	○	42		,, 17	32	○	14	
,, 3	324	○	1		,, 18	312	○	4	
,, 4	431	○		2●	,, 19	4	○	12	3●
,, 5	4	○	312		,, 20	412	○	3	
,, 6	4½	○	3		,, 21	42	○	13	
,, 7	42	○	13		,, 22	41	○	23	
,, 8	4	○	32	1●	,, 23	43	⊙	2	
,, 9	431	○	2		,, 24	432	○	1	
,, 10	324	○	1		,, 25	4312	○		
,, 11	31	○	4	2⊙	,, 26	43	○	12	
,, 12		○	3124		,, 27	1	⊙	3	4●
,, 13	12	○	34		,, 28	2	○	143	
,, 14	2	○	134		,, 29	1	○	234	
,, 15	1	○	324		,, 30	3	○	124	

Satellite phenomena visible at Greenwich, 1^d 0^h 36^m*m* I. Oc. R.; 2^h 24^m*m* III. Tr. I., 2^h 27^m*m* III. Sh. E.; 2^d 2^h 32^m*m* IV. Tr. I., 2^h 39*m*^{m} II. Sh. I., 4^d 1^h 8^m*m* II. Oc. R.; 7^d 2^h 5^m*m* I. Sh. I., 2^h 45^m*m* I. Tr. I.; 7^d 11^h 27^m 11^s*e* I. Ec. D., 8^d 2^h 22^m*m* I. Oc. R., 3^h 15^m*m* III. Sh. I.; 8^d 10^h 51^m*e* I. Sh. E., 11^h 29^m*e* I. Tr. E.; 10^d 11^h 28^m 6^s*e* II. Ec. D.; 11^d 3^h 25^m*m* II. Oc. R.; 11^d 11^h 0^m*e* III. Oc. R.; 12^d 10^h 28^m*e* II. Tr. E., 15^d 1^h 21^m 14^s*m* I. Ec. D.; 15^d 10^h 27^m*e* I. Sh. I., 10^h 56^m*e* I. Tr. I.; 16^d 0^h 45^m*m* I. Sh. E. 1^h 14^m*m* I. Tr. E.; 16^d 10^h 33^m*e* I. Oc. R.; 18^d 2^h 2^m 57^s*m* II. Ec. D.; 18^d 9^h 30^m 48^s*e* III. Ec. D.; 19^d 2^h 20^m*m* III. Oc. R.; 19^d 9^h 54^m*e* II. Tr. I., 11^h 57^m*e* II. Sh. E.; 20^d 0^h 44^m*m* II. Tr. E.; 22^d 3^h 15^m 22^s*m* I. Ec. D.; 23^d 0^h 21^m*m* I. Sh. I., 0^h 40^m*m* I. Tr. I., 2^h 39^m*m* I. Sh. E., 2^h 58^m*m* I. Tr. E.; 23^d 9^h 43^m 59^s*e* I. Ec. D.; 24^d 0^h 17^m*m* I. Oc. R.; 24^d 9^h 7^m*e* I. Sh. E., 9^h 24^m*e* I. Tr. E.; 26^d 1^h 29^m 21^s*m* III. Ec. D.; 26^d 10^h 46^m 39^s*e* IV. Ec. D., 11^h 43^m*e* II. Sh. I.; 27^d 0^h 9^m*m* II. Tr. I., 2^h 33^m*m* II. Sh. E., 2^h 59^m*m* II. Tr. E., 3^h 30^m*m* IV. Oc. R.; 28^d 9^h 3^m*e* II. Oc. R.; 30^d 2^h 15^m*m* I. Sh. I.. 2^h 23^m*m* I. Tr. I.; 30^d 11^h 38^m 13^s*e* I. Ec. D.

SATURN is invisible, having been in conjunction with the Sun on May 29th.

URANUS is a morning star, coming into a better position for observation.

NEPTUNE is too near the Sun for convenient observation.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant.			Remarks.
	R.A.	Dec.		
	°		°	
May 30 to Aug.	333	+	28	Swift, streaks.
,, June	280	+	32	Swift.
,, to July	252	−	21	Slow, trains.
June to Aug.	310	+	61	Swift, streaks.
,, to Sep.	335	+	57	Swift.
,, to July	245	+	64	Swift.
,, to Aug.	303	+	24	Swift.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 14^h to 18^h, next month 16^h to 20^h, and so on.

TABLE 35. NON-ALGOL STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m.			d.	
U Urs. Min.	14 16	+67 ·1	7·6 to 12	327	May 29.
S Bootis	14 18	+54 ·3	7·7 to 13	273	July 9.
R Camelop	14 24	+84 ·2	7·2 to 13	269·5	June 3.
R Bootis	14 33	+27 ·1	5·9 to 12	223·3	June 19.
RR Bootis	14 44	+39 ·7	8·0 to 13	196·5	May 18.
V Librae	15 7	− 5 ·7	8·0 to 11·3	365	June 12.
RS Librae	15 19	−22 ·6	6·6 to 12	217	May 20.
RU Librae	15 28	−15 ·0	8 4 to 11	314	June 24.
X Coronae	15 46	+:6 ·5	8·4 to 13	246	May 13.
R Serpentis	15 47	+15 ·4	5·6 to 13	357	May 16.
RR Librae	15 51	−18 ·0	8·2 to 12·6	276·7	June 22.
Z Coronae	15 53	+29 ·5	8·9 to 14	245	May 20.
T Coronae	15 56	+26 ·2	Now 9·5		Nova Coronae
R Herculis	16 2	+18 ·6	8·0 to 14	317·7	June 23.
RR Herculis	16 2	+50 ·7	7·8 to 9·5	241	May 9.
U Serpentis	16 3	+10 ·2	8·3 to 14	237·2	July 15.
SX Herculis	16 4	+25 ·1	7·9 to 9·2	100·55	May 12.
W Coronae	16 13	+38 ·0	7·8 to 12	244	July 14.
V Ophiuchi	16 22	−12 ·2	6·9 to 10·8	302·5	Apr. 20.
R Draconis	16 33	+66 ·9	6·4 to 13	245·6	July 29.
Z Ophiuchi	17 15	+ 1 ·6	7·5 to 13	348	May 10.
T Draconis	17 55	+58 ·2	7·5 to 12	426	Aug. 9.
RY Herculis	17 56	+19 ·5	8·2 to 13	222·3	July 22.

NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

THE SIZES AND DISTANCES OF THE STARS.—There was an interesting paper on this subject, by the Astronomer Royal, at the March meeting of the Royal Astronomical Society. He dealt with the faint stars within 10° of the North Pole, as these were observed by Carrington, at Redhill, sixty years ago, and have been recently re-observed at Greenwich, so that their Proper Motions are well determined. While the Proper Motion of an individual star does not give us its distance, it is possible to obtain formulae giving the relation between proper motion and distance for groups of stars. The Astronomer Royal obtains a formula for star distribution that fits the data from observation very well. Extending his figures to the entire sky, he finds that there would be three hundred and twenty stars with parallaxes greater than a tenth of a second. The number with a parallax greater than a fifth of a second would be one eighth of this, or forty. It will be remembered that Mr. Eddington recently gave a list of seventeen stars with a parallax greater than one-fifth of a second; a few more have since been found, and it is likely that there are several stars with an equal parallax that have not yet been studied for the purpose, so that the two methods are in fair accordance. The Astronomer Royal finds that a large proportion of the stars discussed lie between parallax 0″·005 and 0″·0025, and that ninety-five per cent. of them are intrinsically brighter than the Sun. Mr. Eddington finds that in another region only one per cent. of the stars in the catalogue he used are fainter than the Sun. He points out that this does not mean that the Sun really occupies so insignificant a place in the stellar host, for if we consider the stars of large parallax, the Sun comes quite high up on the list as regards intrinsic lustre. But when we go out to great distances, the intrinsically faint stars become too faint to come into our catalogues at all, and only those of high lustre survive. At a distance whose parallax is one-hundredth of a second, the Sun would be of magnitude 10·3, which is about the faintest included by the Astronomer-Royal in his discussion; at greater distances only stars of great lustre are included, so that the catalogue is not a fair sample of all the stars really existing in remote space. Incidentally, the paper made a suggestion that a short name should be given to the distance corresponding to a parallax of one second; the term "Astron" was tentatively put forward, but Professor Turner expressed some apprehension that this might be taken to mean the astronomical unit of length, viz., the mean distance from the Earth to the Sun. It is certainly desirable to have a name both for this unit and for the other, but it will be well to have a little discussion before they are adopted. The Astronomer Royal urged that the "Astron" should be generally used for stellar distances instead of the Light-Year. In view of the large use of the Light-Year that is made in many treatises on Astronomy, it is fortunate that there is a simple relation between the two; one "Astron" is almost exactly three and a quarter Light-Years. The beginner may like to see how this number is found. Light takes 498·2 seconds to travel from Sun to Earth. The number of seconds in a year is $365\frac{1}{4} \times 24 \times 3{,}600$ or 31,557,600. Divide this by 498·2 we get 63,346 astronomical units in a Light-Year.* But there are 206,265 astronomical units in an "Astron," this being the number of seconds of arc in the unit of Circular Measure. The "Astron" comes out as 3·2561 Light-Years, but three and a quarter is near enough for all purposes. I think the question of suitable names for these two units might be a good subject for discussion in our correspondence columns. Apropos of the Sun's distance, I was recently examining Delambre's Solar Tables, which appeared in 1806, and was astonished to find that they used the very same value of the Sun's parallax (8″·80) that is now used in the *Nautical Almanack*. Encke's famous value, 8″·5776, announced some years later, was thus a change for the worse.

THE MEROPE NEBULA IN THE PLEIADES.—Lowell Observatory Bulletin No. 55 contains an account of the photography of the spectrum of the nebula; an exposure of twenty-one hours was given with the twenty-four inch refractor, with the surprising result that the spectrum is continuous, with five distinct hydrogen lines and three fainter helium ones, the spectrum being quite like that of Merope itself. This was a great surprise, as the nebula resembles that of Orion, and little doubt was felt that its spectrum would be gaseous. Tests were made to see if diffused light from Merope could have caused the continuous spectrum; the results appear to negative this idea. It is concluded that the nebula shines by reflected light from Merope. It is calculated that Merope would appear nearly as bright as our Full Moon from the region of nebula photographed, and as we can photograph a landscape by moonlight, the assumption of reflected light seems reasonable. Mr. Slipher, the author of the Bulletin, also suggests that the Andromeda nebula (for which a similar spectrum has been found) may also shine by reflected light, but this would only be possible if there were a very bright central star, which is veiled from us by a dense screen of dust or other opaque material. This seems a somewhat strained hypothesis. We have, however, evidence of the existence of such opaque screens in the numerous dark lanes that are shown in photographs of the Milky Way. It would, however, require an artificial and improbable arrangement that the opaque veil should hide the central star from us, while leaving it free to illuminate the nebula.

DISCOVERY OF A COMET IN SOUTH AUSTRALIA.—Mr. Dodwell, the Director of the Adelaide Observatory, has communicated the discovery of a faint comet by Mr. Lowe, at Laura, South Australia, at the end of December. Owing to some delay in the announcement, and the vagueness of the description, the comet was not seen elsewhere, and only a very rough determination of the orbit is possible. I take the opportunity of pointing out that should any readers of this column pick up a comet, they can make observations of sufficient accuracy to be of real value by carefully drawing the small stars visible in the field of the telescope, and fixing the position of the comet as accurately as possible by alignment among the stars, also noting the time when the position of the comet was noted. A rough clue to the position must also be given, which may be obtained by looking along the outside of the telescope tube, and inserting the position on a star map. Tracings of the sketches should be sent to some Observatory, when the region can be identified with the aid of a good star map or a photograph, and a very fair position of the comet deduced. Had Mr. Lowe done this, we should have known the orbit of his comet, and it would have been possible to recover it at other observatories. I have myself tested the possibilities of the method, and find that with care it is not difficult to fix the place of a comet within 30″ or 40″.

OBITUARY.—The Council of the British Astronomical Association has had another loss by death, that of Dr. David Smart. He was an indefatigable cometary computer, and gave invaluable assistance in the laborious work of carrying back the motion of Halley's Comet for two thousand years, and in discussing the extensive series of observations of its recent return that were sent in from all parts of the world.

* Since there are 63,360 inches in a mile we have the curious relation exactly satisfied that on a scale of 1 inch for the distance Earth-Sun a Light-Year is 1 mile.

BOTANY.

By Professor F. Cavers, D.Sc., F.L.S.

VEGETATION OF JAPAN.—Mr. H. Takeda gives, in the February number of *The New Phytologist*, an extremely interesting and readable account of the geography, climate, and vegetation of Japan, which has well been termed the "Britain of the East"—in fact, the author begins with the almost inevitable comparison between the geographical positions of Japan on the Asiatic coast and of Britain on that of Europe. Apart from the geographical resemblance and the existence of a warm current comparable with the Gulf Stream, however, the climate and the vegetation show striking differences, as might, indeed, be expected.

The Japanese Empire consists, from north to south, of the Kurile islands, the southern half of the Saghalien, Yezo, the main island known to the Japanese as Honto, though by others often called Nippon, Shikoku, Kyushu, the Loochoos, Formosa, and the Pescadores; these islands stretch diagonally from 52° to 21° N. Lat., and lie between 120° and 156° E. Long. This area was in 1910 increased by the annexation of Corea, hence the Empire has now about the same area (over two hundred and fifty-six thousand square miles) as Austria-Hungary, and the population (over sixty-three millions) is nearly equal to that of Germany.

A warm current, the "Kuroshio," similar to the Gulf Stream, arises between Luzon and Formosa, and flows along the southern Loochoos to the southern end of Kyushu where it divides into two; the main stream bends northward and flows along the south-east coast of Kyushu, Shikoku, and Honto, while the smaller branch washes the west of Kyushu and the Goto group and runs up to the Sea of Japan through the strait of Tsushima or Krusenstern. The cold currents in the North Pacific which affect the climate of Japan arise in the Sea of Okhotsk and in the Behring Sea; the most important of these, the Kurile Stream, flows southwards along Kamtschatka, turns towards the Kuriles and washes the whole length of the island chain, and then runs chiefly along the east coast of Yezo to 39° N. Lat., where the above-mentioned main stream of the warm current bends away into the Pacific Ocean; the water of this Kurile Stream is very cold, and even in summer its temperature does not rise above 5° C.

These warm and cold currents exert great influence on the distribution of seaweeds; this is clearly seen on the east coast of Japan, the thirty-ninth degree being the separating point of two different alga floras. On the west coast, however, the course of the currents is more complicated, hence the elements of different floras appear somewhat intermixed. The strand flora is similarly affected, the northern elements being distributed in the localities touched by the cold currents. For instance, *Mertensia maritima* (with stouter stem and larger flowers than the type in Europe and America) has a wide distribution from the Behring Sea to 38° N. Lat. in Okhotsk, Manchuria, North Corea, and Honto; *Glaux maritima*, another arctic plant, is distributed mainly from Yezo northward, but also occurs in a locality on the west coast of Honto, whither it was probably carried by the cold currents; *Plantago camtschatica* is another plant found in localities visited by these currents. As the warm current comes into direct contact with the southern parts of Kyushu, Shikoku, and Kii, various sub-tropical plants are found in these places—*Rhizophora mucronata*, *Senecio scandens*, *Ipomaea pescaprae*, *Pteris Wallichiana*, *Asplenium Nidus*, and so on; *Statice japonica*, mainly distributed in south-west Japan, also occurs on the east coast as far north as 38° N. Lat.

The islands of Japan are all mountainous, some of the smaller islands consisting simply of one or more volcanoes, and most of the high mountains are densely clad with luxuriant vegetation from foot to summit, often so densely that the mountain forests are almost impenetrable. The great chains in Central Japan, forming the backbone of Honto, rise in places to three thousand five hundred metres; there are no glaciers, though traces of earlier glaciation have been noted, but considerable névé is present on some of the mountains. As the mountainous nature of the country would suggest, Japan is naturally very rich in water; a dense network of rivers, torrents, and lakes is seen almost everywhere. The rivers are usually short and their gradient steep, causing frequent floods; in late spring, when the snow begins to melt, or when in summer the continuous rain carried by the south-west monsoon falls in torrents, the mountain streams are converted into raging floods.

Owing to the extension over thirty degrees of latitude and the great variety in physiography, the climate is very varied; it is much influenced by that of the neighbouring countries and modified by the warm and cold currents above mentioned. The climate of the region from Formosa northward to the mouth of the Amur River is controlled by the monsoons, formed by the warm damp south wind in summer and the cold north winds in winter; the Loochoos, down to Formosa, are sub-tropical and have practically no winter; while the Kuriles, south Saghalien, and parts of Yezo have the climate of Nova Scotia or Iceland. In the winter drifting ice is carried by currents and wind in the Kuriles and blocks up harbours from November to April; on the northernmost islands, not until June does the snow disappear and vegetation awaken. The rainfall is high (about one hundred and fifty centimetres a year in Tokyo), especially in summer, when the air is very damp, except in Yezo and the Kuriles which are not affected by the monsoon; the winter is dry and fine; the annual temperature range is considerable—in Tokyo the mean temperature is 13°·8 C., maximum 36°·6, minimum 9°·2.

The vegetation is, naturally, well developed, varied and abundant, with about four thousand five hundred cryptogamic and six thousand phanerogamic species—apart from the floras of South Saghalien (three hundred species of vascular plants described) and Corea (two thousand two hundred species, of which about two hundred are endemic). Though Japan is surrounded by seas, in the west it is closely connected with Manchuria through Corea, in the north it reaches Kamtschatka by the Kurile islands, and Alaska through the Aleutian islands, and it also has a connection with Amurland through Saghalien; on the other hand, the Loochoos and Formosa join it to South China, the Philippines and the East Indian islands. Hence, except on the eastern side, it is closely connected with other countries, the floras of which show many signs of close relationship with that of Japan, which was probably connected with the mainland of Asia until a comparatively recent period. Plants indigenous in Eastern Asia are also found in Japan, and teeth and bones of the mammoth have been found in various parts of the country.

The main characters of the Japanese flora are (1) the abundance of species and varieties, (2) the presence of numerous endemic species, (3) the remarkably high proportion of woody plants, (4) the presence of tropical and sub-tropical plants throughout the country. Even in Yezo, the large island of North Japan, are found many representatives of southern floras (*Picrasma*, *Vitex*, *Rhus*, *Hydrangea*, *Aralia*, *Magnolia*, and so on) growing together with representatives of the cold flora; in the northern parts of Honto *Aesculus*, *Zanthoxylon*, *Ardisia*, *Elaeagnus*, *Smilax*, and *Camellia* are often seen. The same or closely allied species have been found in the Tertiary strata of the north of Eastern Asia. Probably in the middle of the Tertiary period, even Saghalien had a much warmer climate, for at that time *Ginkgo*, *Biota*, and *Sequoia* grew there. When, towards the close of the Tertiary, the greater part of the northern Hemisphere was covered with ice, the main island of Japan seems to have suffered very little. Probably since the end of the glacial period and the change of climate in the middle diluvial age, Japan has maintained a fairly warm temperature enabling many plants of warmer climates to survive, while in Saghalien the temperature has been very low so that this island is unfavourable to plants of the warm temperate region. The arctic plants once compelled by the cold climate of the glacial period to come southward were consequently left behind when the climate became warmer, but only persist on the summits of the high mountains.

Starting with the flora established in the Tertiary period, the migration of arctic plants towards the south and of tropical plants towards the north has caused the present flora to be very complex. The connection of the country with the northern, north-eastern, south-eastern, and southern parts of the Asiatic continent made paths for arctic and tropical plants into Japan; the interruptions between the various islands are bridged over to some extent by currents and wind. Evergreen trees and shrubs and many other tropical plants found their way northwards and became acclimatised to the colder winter night and contented with comparatively high temperature during the day, and above all the warm and moist atmosphere during the summer; while those coming from the north or north-west, where they were accustomed to a severe winter, migrated up the mountains until they obtained the necessary climatic conditions. Investigations of the Tertiary fossil plants of Japan, Amurland, and North America, show that the present flora originated in the large common flora of the northern region of the Far East. One striking feature is that the flora of the north-east part of Japan bears a striking relationship to that of the Atlantic coast of North America. This was noticed by Asa Gray, who compared the two floras and showed that more than sixty per cent. of Japanese plants grew on the eastern coast of North America, or were represented by closely-related species, while only thirty-seven per cent. grow on the western coast. His suggestion that the close affinity between these floras originated in the Tertiary period has been borne out by further geological evidence, and Engler and other phytogeographers have concluded that the two regions were actually connected, and had a similar climate and flora. After the glacial period many plants which migrated towards the south returned northwards and formed the foundation of the present flora of Japan, while in North America a change in climate had taken place between that of east and west—in the west the climate became dry and mild, and caused great alteration in the flora, in the east little change has taken place and many old species have been preserved.

Apart from the northern islands, however, the vegetation of Japan shows little actual resemblance to that of North America. Although the same or closely allied plants occur in both regions, they are not found in the same proportion. For instance, in Japan, *Tsuga* forms continuous and almost unbroken forests of great extent on the mountain slopes, above one thousand six hundred metres from sea level, while in North America this tree is rarely found except scattered in small groves, or as individuals in the deciduous forests; on the other hand, *Picea* and *Abies*, which, in America, form immense forests almost to the exclusion of other species, in Central Japan grow singly or in small groves on the lower border of *Tsuga* forests, or mingled with broad-leaved trees. In northern Japan and on the high mountains of Honto, birches are more abundant than they are in the northern forests of America, and the river banks in the north, like those of North Europe and Siberia, are lined with arborescent willows and alders, which are rare in eastern North America, where these genera are usually represented by trees. Moreover, the numbers given in Gray's estimate should be reduced slightly, since he included as natives some Chinese and Corean plants cultivated in Japan. Besides these and some endemic species, the flora of Japan includes many plants of the boreal region of the old world. For instance, *Asperula odorata*, which occurs in Europe but not in America, is abundant in North Japan. In South Japan, many tropical and sub-tropical elements may be seen; certain plants growing in the central and southern parts of the country have also a close affinity to those of South China, as well as to those of the Himalayas.

The vegetation of Japan may conveniently be arranged in three divisions mainly based on the climatic conditions—(1) Northern Region, extending from 38° N. Lat. northwards to the Kuriles and Saghalien; with the northern part of Corea; (2) Middle Region, including the greater part of Honto and Shikoku, part of the north of Kyushu, and South Corea; (3) Southern Region, including the southern parts of Kii and Shikoku, the greater part of Kyushu, the Bonin islands, the Loochoos, Formosa, and the Pescadores. Within each of these regions the northern and southern portions show certain differences in the vegetation. The northern part of the Northern Region is represented by the arctic, and the southern part by the sub-arctic, with a few elements of the cold temperate flora; in the northern part of the Middle Region the plants of the cold temperate flora are found, in its southern part those of the warm temperate; the Southern Region has warm temperate and sub-tropical plants in its northern part, and tropical plants in the southern.

(1) Northern Region.—The sea coasts are lined partly with sand-dunes and partly with cliffs; salt marshes are but poorly developed. Lists are given for these formations; the exposed parts of the cliffs show many interesting arctic species of *Androsace*, *Artemisia*, *Draba*, *Empetrum*, *Erigeron*, *Salix*, *Saxifraga*, *Sedum*, and so on. Lists are also given for the dry hillsides, humid places in the mountain valleys, the *Sphagnum* bogs (not much in evidence in the other regions, but here fairly well developed), the ponds and lakes, and the forests. The characteristic forest trees are deciduous oaks, birches, cherries, elm, hornbeam, maples, poplars, *Cercidiphyllum* (a peculiar tree, the sole representative of the family Cercidiphyllaceae, and closely resembling Ginkgo in general appearance), and various willows in damp places; conifers are represented by a few species of *Abies*. *Juniperus*, *Larix*, *Picea*. *Taxus* and *Thujopsis*, pines being rare—the only wild species is the small *P. pumila*, usually on mountain summits. Even in Saghalien and the Kuriles there are various woody climbers (species of *Celastrus*, *Hydrangea*, *Rhus*, *Vitis*, and so on), growing in tropical luxuriance—the abundance of these plants in Japan has been attributed to the undergrowth of bamboos which cuts off the light and makes the plants climb up the trunks of other trees. On the high peaks, not much over two thousand three hundred metres, there are interesting arctic plants like *Bryanthus* and *Phyllodoce*, generally on exposed rocks.

(2) Middle Region.—This region is very extensive and mountainous, hence the vegetation is varied. The coasts are lined by pines (*Pinus thunbergii* and so on) and many dune plants: rocky cliffs are infrequent, and show a poorer vegetation than in the Northern Region. The forest trees show great variety; evergreens occur largely, and broad-leaved species are especially numerous; there are many conspicuous spring-flowering species of *Azalea*, *Prunus*, *Pyrus*, and so on. More species of Pinus appear in this region, and *Cryptomeria* flourishes here, while the tall bamboos (mostly species of *Phyllostachys*) form a special feature of the vegetation, being mostly under cultivation and forming dense groves. This region contains the great mountain ranges with perpetual snow in the gulleys, and their flora shows ascending zones of vegetation—illustrated by reference to Fujiyama, the highest volcano in Japan. The gently sloping basal zone, up to three thousand feet, consists of lava and cinders, and is largely covered with grasses, brambles, roses, and bracken, with numerous herbaceous phanerogams, and in places various trees; this passes into the tree zone, divided into a lower belt with deciduous trees (maples, alders, birches, hornbeam, oak, and so on) and many shade-loving plants in the undergrowth, and a higher conifer belt in which *Abies firma* appears first, and is followed by *Larix*, *Picea*, *Tsuga*, and so on. Above two thousand metres, the gradient becomes steeper, and trees are less abundant, the approach to the shrub zone being marked by rowan, rhododendron, alders, stunted birches, shrubby *Spiraea*, dwarf willows, and various Ericaceous shrubs, with herbaceous species of mostly alpine character. The zone from seven thousand five hundred to ten thousand feet belongs to the alpine region, with typically alpine and arctic plants; above this to the summit (about thirteen thousand five hundred feet) is the lichen zone with *Cetraria islandica*, *Cladonia rangiferina*, *Rhizocarpon geographicum*, and so on. The alpine zone of Fujiyama does not contain many plants, though a few are known only from this mountain, but on the other mountains of Central Japan, which form the backbone of the main island, and are often called the Japanese Alps, alpine vegetation is well developed. On these mountains a creeping pine (*P. pumila*), also found in Siberia, appears in the shrub zone and extends to the alpine zone; many interesting plants are found in the shade of the thickets of this pine. Many arctic plants found

on the rocky cliffs of the Kuriles occur also in the alpine zone of these mountains.

The aquatic vegetation of the Middle Region shows great diversity; the genera, and many of the species are cosmopolitan; *Isoëtes japonica*, one of the largest species of this genus, frequently grows in running water instead of still lakes.

(3) Southern Region.—Even at the northern limit of this region, in Kyushu, the vegetation is quite sub-tropical. On the coasts, washed by the warm current, various Indo-Malayan strand plants are found; in the Loochoos, *Bruguiera gymnoverhiza* forms the mangrove forest in the tidal estuaries; well-developed mangroves are seen in Formosa, consisting of *Avicennia officinalis*, *Kandelia*, *Rhizophora*, and so on. Various palms belonging to the genera *Arenga*, *Livingstonia*, *Trachycarpus*, and so on, flourish in this region, which may be characterised as a region of *Ficus*, with which broad-leaved evergreen trees and shrubs, such as various Lauraceae, *Quercus*, *Hibiscus*, *Myrica*, and so on, are found. On their branches are many epiphytic lycopods and ferns, and sometimes parasites (*Loranthus* and *Viscum*) are found, while in the dense, moist forests there flourish many tropical ferns.

In Formosa also the vegetation is typically tropical, with abundance of huge trees, thick bushes, dense forests with numerous woody climbers, and so on. In the mountain valleys the camphor tree (*Cinnamomum camphora*) reaches great dimensions; *Macuna gigantea* and *Pusaetha scandens* (leguminous trees with enormous pods), other climbers, and gigantic bamboos, tall tree-ferns, palms and *Musa* grow in the forests and on mountain slopes; while higher up on the mountains which occupy the greater part of the island, conifers are seen at an elevation of two thousand metres. *Chamaecyparis formosensis*. *Cunninghamia*. *Konishii*, *Picea morrisonicola*, and *Pinus formosana* are some of the interesting trees, and are only known from this island, while a few years ago a new conifer discovered here was placed in a new genus (*Taiwania cryptomerioides*); and higher up we get first the shrub zone, and then, at four thousand metres and upwards, various alpine and arctic species of *Arabis*, *Artemisia*, *Cerastium*. *Deschampsia*, *Festuca*, *Fragaria*, *Gentiana*, *Luzula*, *Potentilla*, *Sibbaldia*, and so on. The flora of Formosa has some two thousand five hundred species of vascular plants, seventeen per cent. of which are endemic, and doubtless many more remain to be discovered.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

UTILISATION OF MILK WEED.—The current issue of the *Journal of the Society of Chemical Industry* (1913, XXXII, 72) contains a paper by Dr. A. C. Neish, describing experiments that have been made to discover uses for the enormous quantities of this wild plant which are annually wasted. The common milk weed (*Asclepias syriaca*) grows abundantly on sandy or clay soil in the United States and Canada. It produces a milky juice or latex, which yields from two to three per cent. of rubber, but the amount is so small and its quality so poor that its extraction would not be commercially profitable.

On the other hand the bast fibres of the plant are likely to prove a more profitable product, for they can be readily separated, and when bleached yield a white silky textile material, which is stronger than flax, which in other respects it closely resembles. The seeds also contain about twenty-one per cent. of a drying oil which may be easily extracted with a suitable solvent, while the down attached to the seeds is white, very soft and springy and contains 0·9 per cent. of ash. It could be utilised as an upholstering material, as has already been done with the seed hairs of other species of *Asclepias*. The woody tissue. about eighty per cent. of the plant material, yielded, on treatment with soda solution under pressure, a pulp from which paper of good quality could be made. From the results of his experiments in general Dr. Neish considers that it may prove practicable to start a new industry to utilise the product of the common milk weed and similar plants of the same species, but some system of cultivation would probably be required to supplement the supply of the wild plants already available. Such a crop might be grown upon dry or wet soils with which little else could be done.

USE OF ALCOHOL AS A MOTOR FUEL.—The "*Times Engineering Supplement*" for January 15th, 1913, deals with the question of the substitution of alcohol for petrol as a motor fuel. A comparison of the relative calorific values of the two liquids showed that petrol of specific gravity 0·684 produced eleven thousand six hundred and twenty-four calories per kilometre, while methylated spirit gave only six thousand two hundred calories. In practice, however, this superiority of petrol disappears. For example, in comparative tests with the two fuels in specially constructed eight horse power engines, it was found that 340 grammes of petrol were consumed per horse power hour as against 373·5 grammes of methylated spirit, showing that the relative efficiences were as 16·5 per cent. for the petrol and 28 per cent. for the alcohol. The better results given by the alcohol are to be attributed to the greater ease with which it is possible to obtain complete combustion, and to the smaller proportion of air required. In addition to these factors, it is possible with the use of alcohol to obtain greater compression and a cooler cycle, both of which conditions tend to economize fuel.

Although denatured alcohol can be obtained free of duty, its price is still as high as that of petrol at the present time, and the reason for this is not the manufacturing cost, but the charges made by the Government for supervision to ensure that the spirit is not drinkable when it leaves the distillery. A spirit containing about ten per cent. of crude benzene would be undrinkable, and could be manufactured at a cost of about sixpence per gallon, while only slight modifications of the carburettor would be required to enable it to be used in ordinary petrol motors. Hitherto efforts have been directed to the perfection of the petrol engine, and it is possible that when an equal amount of research has been given to discover the best methods of using alcohol, the latter will be recognised as the more suitable fuel.

UTILISATION OF HORSE-CHESTNUTS.—Although several attempts have been made during the last two centuries to utilise the horse-chestnut in the preparation of detergent preparations, none of them have been adopted as commercial processes. As far back as the year 1757 it was discovered by a Frenchman named Marcandier that the juices of this nut had strong frothing and cleansing properties, and that they could be used instead of soap for removing dirt and grease from textile materials. . A similar use of horse-chestnuts was known in Germany, as is shown by the account given in 1824 in a technical paper.

After the lapse of years, the idea of using horse-chestnuts for washing preparations has again come to the fore, and since the year 1888 there have been several processes patented for extracting the saponine or frothing substance from the nut. An outline of the methods suggested, and a discussion on profitably utilising the other constituents of the horse-chestnut, is given by M. Rousset in the current issue of *Les Matières Grasses*, 1913, VI, p. 2980.

The kernel, after removal of the shell (which is rich in tannin, and is utilised in the preparation of a tanning extract for leather), contains the following proportion of extractive substances:—Oil, 6·6: aesculic acid, 3·2; carbohydrates, 10·8; reducing sugars, 5·2; gums. 1·2; and proteins, 1·0 per cent.

The oil, which can be extracted with petroleum spirit, is a pale yellow liquid with characteristics similar to those of almond oil. After removal of the oil, the residue, when extracted with dilute alcohol, yields an extract containing about fifteen per cent. of aesculic acid, a substance of a saponine character which has strong lathering and cleansing properties.

Finally, the mass left from the two extractions could be used in the preparation of a white starch, which, after treatment with cold water to remove a bitter principle, would be quite suitable for use as a food,

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

LONDON WELLS.—The water-supply of London is of such tremendous importance that contributions to its fuller study are extremely desirable. Hence the Geological Survey has accomplished a valuable piece of work in compiling an exhaustive record of London wells. The information as to this mode of water-supply is scattered, and in the older records incomplete. So far as is possible this incompleteness has been remedied, and a very large number of borings made during the last few years have been included in the Memoir, which has been compiled by G. Barrow and L. J. Wills. The introduction by Mr. Barrow is a valuable account of London water-supply, and describes the strata penetrated by the wells, methods of well-sinking, relation of water-supply to geological structure, and many other kindred subjects of interest. Part II consists of a catalogue of published London wells, and Part III of a descriptive list of new London wells with some old ones.

Special attention is drawn in the introduction to the continued fall in the water-level under London. The fall is greater than was anticipated, and has recently been taking place at an increased rate. The fall is illustrated by contour-maps of the water-level at different dates in the London area. These show very clearly the setting up of specially low water-levels, and the gradual outward spread of the low contours from these areas. The fall may be illustrated by the three wells sunk in 1847 to supply the fountains at Trafalgar Square. These once produced five hundred and eighty thousand gallons a day, and supplied several government offices beside the fountains. Only one is now in use, and supplies only eight thousand gallons an hour, and in this well the water-level has fallen one hundred and fifteen feet in sixty-four years. A similar instance is offered by the deep well sunk in 1864 to supply the fountains at the head of the Serpentine in Kensington Gardens. There is a general coincidence of the areas of low water-level with those areas where there is a considerable thickness of Tertiary beds, or where the top of the Chalk is a considerable depth below the surface. A great thickness of cover tends to check the rate of inflow of the water from the chalk outcrops, and this, added to the lowering of the water-level by pumping, has produced especially heavy falls in certain areas. Moreover, the Chalk, so often thought extremely permeable, is only so under pressure; and if the head of water in the formations above the Chalk be reduced, as, for example, by the fall in the water level, the passage of water through the Chalk becomes increasingly difficult. The low water-level extends much farther to the north of the Thames than the south. This appears to be due to three main causes. There is a much thicker and more extensive cover of impermeable strata (London Clay) in the north than in the south. This not only prevents rain-water from entering the Chalk, but also tends, by reason of its weight, to hinder the flow of water from the north towards the central areas. Then, again, the intake areas of Chalk are more distant on the north than on the south. Furthermore, the existence of the deep valleys of the Lea and Colne transverse to the general direction of underground water flow towards London, still further depletes the supply on the north as compared with the south. In the latter, not only are the intake areas nearer, but they are not traversed by valleys in which part of the flow towards London might be abstracted by springs.

IGNEOUS QUARTZ.—The theory of the probable direct igneous origin of some quartz veins and masses receives support from observations made by Dr. J. Ball in South-Eastern Egypt. According to the memoir, "Geography and Geology of South-Eastern Egypt" (1912), this area, covering twenty-two thousand square miles, consists principally of ancient metamorphic and igneous rocks, with a few patches of Nubian sandstone (Cretaceous), and gypseous limestone (Miocene ?). The igneous rocks include great masses of granite and serpentine, with subordinate syenite, diorite, and gabbro. In addition several masses of quartz-rock of igneous origin have been found. The most conspicuous of these occurs as a group of three hills known as Marwot Elemikan (Marwa = Arabic for quartz). They consist almost entirely of white quartz, and from their dazzling white colour form landmarks visible at a great distance. The only other mineral present is white mica, of which a few spangles occur in the outer portion of the mass. These three bosses, together with another on the south side of the Wadi Khoda, penetrate granite.

Of quartz veins and dykes the best-known example in south-eastern Egypt is a great dyke forming the backbone of a ridge known as Erf el Fahid. This dyke is intrusive in schists, is at least ten metres wide, and can be traced for two kilometres. A similar dyke occurs in the ridges to the south-west of Erf el Fahid.

Dr. Ball considers that the shape of these masses of quartz, their close association with aplites and pegmatites in at least one locality, the absence of ores and of minerals due to deposition from solution and the occasional presence of mica, all point to igneous origin. He considers them as the final ultra-acid products of the differentiation of a granitic magma.

MICROSCOPY.

By F.R.M.S.

QUEKETT MICROSCOPICAL CLUB.—March 25th, Mr. G. T. Harris presented a type collection, numbering seventy-two preparations, of British Hydrozoa.

Messrs. Heron-Allen and Earland read a paper "On some Foraminifera from the southern area of the North Sea, dredged by the Fisheries cruiser 'Huxley'." The work was undertaken with the view of determining the distribution of *Saccammina sphaerica* Sars. and *Psammosphaera fusca* Schulze, in the area mentioned. Material was examined from three stations far to the north-east of the Dogger Bank near the Great Fisher Bank, and from three stations in the belt of deep water lying to the west of the Dogger, close in to the Northumberland coast. The first-named species was found to occur only at two of the inshore stations, but the second species was found in all the dredgings except that from one of the inshore stations. The authors' first intention was to examine the material solely with regard to the presence or absence of these two species, but so many other species were noticed that an exhaustive list was prepared containing one hundred and thirty-seven species, many of which are first records for this area, and were given in detail in a table appended to the paper. A number of excellent lantern slides from photomicrographs of some of the more interesting forms was shown.

Mr. D. Bryce read a paper on "Five new species of Bdelloid Rotifers." Four belonged to the genus *Habrotrocha* and the fifth to *Callidina*. They are fully described and figured in the current (April) issue of the Club's *Journal*.

THE MECHANICAL CONSTRUCTION OF THE MICROSCOPE.—Although the optical parts of the microscope have been greatly improved in recent years, the mechanical construction of the instrument has not advanced in proportion.

The books written on the subject, which have come under the writer's notice, have little to say on general construction, but confine themselves to descriptions of the models by various makers.

The principal faults, in the writer's opinion, are that most microscope stands are built on too small a scale and that there is an unnecessary amount of patchwork in the assembling of the various parts. For some purposes a portable instrument is no doubt desirable, but for general work ample room for manipulation, for the use of low power objectives, and various accessories, is a most important feature.

The optical equipment of the microscope need not here be described in detail; it is sufficient to point out that it consists of two divisions, namely, the upper or magnifying portion, consisting of the ocular and objective, and the lower or illuminating portion, consisting of the condenser, and mirror, or source of light; between these must be fixed the stage for carrying the object under examination.

The Stand of the microscope consists generally of two parts, the foot or base which supports the instrument, and the limb which is connected to the upper part of the foot through an inclining joint permitting any angle of inclination from the vertical to horizontal.

Much discussion has taken place concerning the relative merits of the two styles of base generally in use, namely, the tripod or so-called English style, and the horseshoe or so-called Continental style; the former, no doubt, gives greater stability to the instrument in various positions, and the latter provides more room for the manipulation of the substage fittings, especially if these are required to be swung out from the optical axis. A little consideration will shew how these advantages can be combined in a suitable design.

The Limb should be one continuous piece to which all other parts can be attached either rigidly or through slides which allow for the requisite vertical movement. The limb should provide ample room between the top slides carrying the body tube and the stage, so that a low power objective (with a working distance of, say, three inches) can be used when a nosepiece, or objective changer, has been added to the tube.

At the present time other appliances are supplied for attachment to the body, such as a slot for quartz wedge, a vertical illuminator, and so on, for which the space provided is generally quite inadequate; some modern objectives also are of much greater length than those formerly constructed.

In my opinion the construction should allow sufficient room for the use of any accessories necessary with a low power objective when a mechanical stage has been added to the stage proper; if these accessories are not used, and an exceptionally short objective with small working distance could not be racked down far enough for focusing, a matching piece could be used on the body tube.

The space between the limb and the optical centre could be made with advantage greater than usual; it should be such as to allow for a large-sized stage, say five inches in diameter, to be completely rotated with a mechanical stage attached, and to allow the limb to be used as a handle for lifting the instrument without any strain or derangement of the various adjustments.

The stage is preferably carried on a stage bracket; this construction allows for a wide choice of the style of stage and also provides for a slight adjustment to insure the stage being exactly at right angles to the optical axis.

Another point which has been much discussed is the construction of the fine adjustment; in the first place, the coarse adjustment should be made and finished so that it works as smoothly as possible without any sign of backlash in the

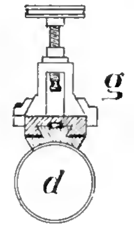


FIGURE 179.
Section through body.

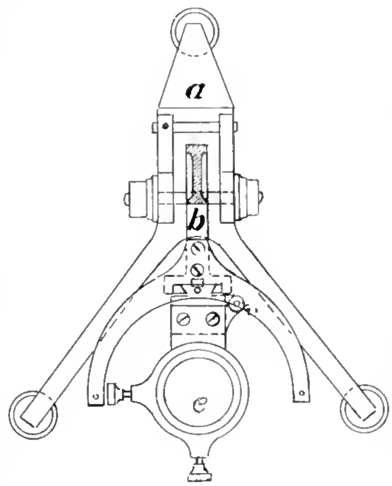


FIGURE 180.
Plan with stage removed.

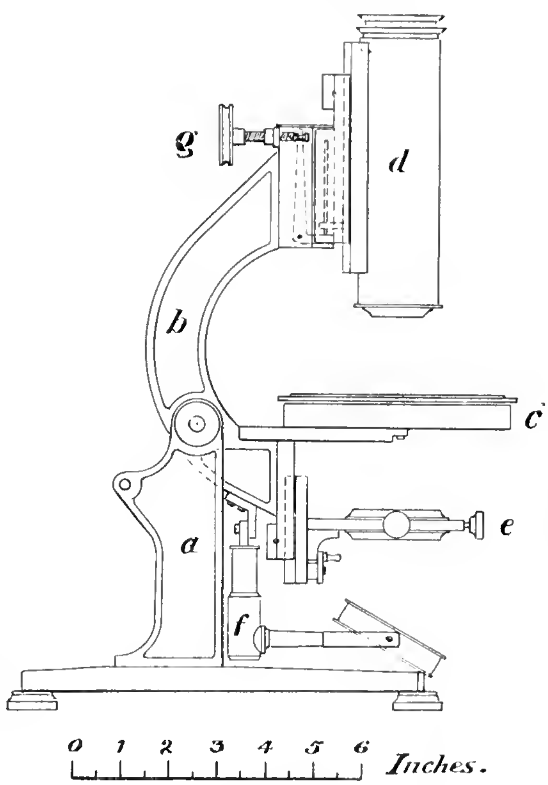


FIGURE 181.
Side elevation. Key to Figures 179, 180 and 181.
A. Stand; B. Limb; C. Stage; D. Body; E. Substage; F. Tail-piece; G. Fine adjustment.

movement or looseness in the slide; if this is done the fine adjustment need only be used for high powers and need only have a small amount of vertical movement (say one-sixteenth inch).

The fine adjustment mechanism should be as compact as possible and should act directly upon the slide carrying the coarse adjustment; there is no doubt that mechanically the method involving leverage, by which a greater movement is provided and less weight comes upon the fine adjustment screw, is preferable and more sensitive than that in which the whole weight of the body is borne directly on this screw, and it is difficult to see why the latter method should have ever been adopted.

In most models the under-stage fittings consist of a general patchwork attached indiscriminately to the stage or limb. They should be connected directly to the same limb which carries the stage and the body tube which then forms a continuous support for the optical parts above and below the stage.

Sufficient room should be provided below the stage for a modern condenser, with a stop carrier and iris diaphragm, below which can be placed a large sized polarising prism, sufficient room also for the requisite vertical movement for focusing and dismounting of the various parts conveniently without interfering with the mirror which is also attached to the rim through the tailpiece. It is also advisable that the substage fittings can be swung out from the optical centre.

The line drawings (see Figures 179–181) shew a simple design which complies with the requirements noted above.

The photograph (see Figure 182) illustrates a more complete model which was entirely designed and constructed by the writer. The chief differences from the design shewn in Figure 181 are that the stand is somewhat higher, the stage has a vertical movement of one inch and that a separate holder is provided for a polariser below the condenser. A short description of this instrument is as follows:—

The stand consists of two parts—the base and the upright. The base is supported on three feet shod with cork, and having a spread of seven inches by eight inches. The upright part has two sides one inch apart, between which the limb is suspended on a pin at the top, and can be inclined at any angle from the vertical to the horizontal, a second pin at the back supporting the limb in the latter position. The upright and horizontal parts of the stand are connected by screws, and can be taken apart when desired to pack the instrument into a small bulk. The limb is cast in one piece, provided at the top with a dovetail slide to carry the body, and at the bottom with a slide to carry the stage bracket and substage fittings. The central portion of the limb is of I section, to secure rigidity without undue weight. The fine adjustment is located at the top end of the limb in a hollow recess; it is actuated by a divided screw head projecting backwards, which works on the long arm of a "bell crank" lever, on the bottom or horizontal arm of which rests the fine adjustment slide. The reaction is taken up by a vertical spiral spring. The pitch of the screw thread is forty to the inch. The vertical arm of the lever is four times the horizontal. A complete revolution of the fine adjustment screw gives, therefore, a movement to the body of ·00625 inches.

The bearing surface of the fine adjustment slide is two and a half inches in length, and the possible movement about one eighth of an inch.

The body is carried on a slide having a bearing surface of three and a half inches in length, actuated by the coarse adjustment pinion, with a movement of three inches. The main tube is one and five-eighths inches in diameter, and contains two draw tubes giving a latitude of extension of from one hundred and sixty to two hundred and sixty millimetres.

In the body tube, as close to the back of the objective as possible, are—first: an iris diaphragm; second: a slot which can be uncovered or closed by a circular ring, and third: a slide carrying an analyser prism, which can be moved in and out of the optic axis as desired. The two latter accessories, in conjunction with a polarising prism below the stage, are indispensable for petrological work. The advantage of placing the analyser near the objective instead of over the eyepiece—as is sometimes done—is that a much larger field of view is obtained with a small prism. The bottom of the inner draw tube is screwed to receive a "Bertrand Lens." Very perfect interference figures in crystals have been obtained with this instrument.

At the bottom of the body is an objective changer, which is preferred to the usual nosepiece; this is considered as a fixture and is taken into account when measuring the tube length.

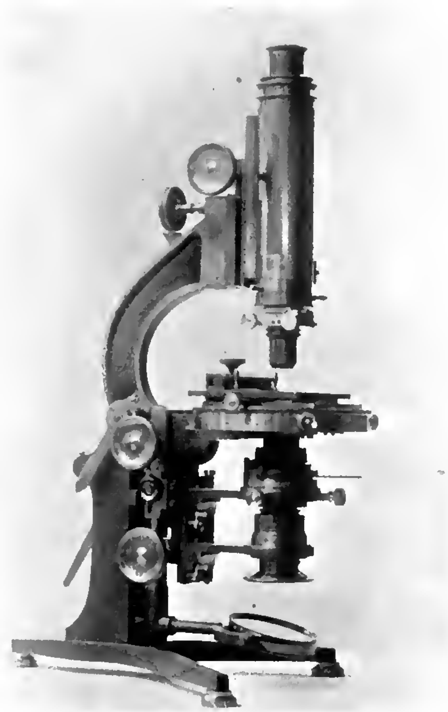


Figure 182.
Complete microscope. Designed and constructed by the writer.

A circular stage—five inches in diameter—rests upon a stage bracket. It is provided with centreing screws and divided in degrees reading from a fixed index. Upon the circular stage are two slides in which a mechanical portion is held, having a rectangular movement of two and a quarter inches from left to right and one and a quarter inches at right angles. The stage can be completely revolved with the mechanical portion in any position. The stage bracket is connected to the bottom of the limb through a slide actuated by rack and pinion, by which the stage can be moved in a vertical direction with regard to the limb a distance of one inch. The bearing surface of this slide is two and a half inches in length and can be fixed by a binding screw in any position. This movement of the stage adapts the instrument to metallurgical work, and also allows for a variation of the gap between the stage and body.

The substage fitting is carried on a slide, actuated by rack and pinion, having a vertical movement of two inches with regard to the stage. It is provided with two carriers: the upper provided with centreing screws to hold the condenser; and the lower to hold a polarising prism. These carriers are supported on a vertical pin, upon which they can be separately swung clear of the optic axis without dismounting—they are provided with clamps to hold them in the central position.

The tail-piece to carry the mirror is attached to the limb, and is of the ordinary tubular type, which allows a mirror two and a quarter inches in diameter to be placed in any necessary position or to be swung out of the centre when using the instrument in an horizontal position.

General: All the sliding parts of the instrument were designed to give ample bearing surface for the weight supported, and are all provided with means of adjustment and for taking up any slackness due to wear.

The principal parts were cast in phosphor bronze and the smaller parts, bearing strips, and so on, were made of good quality brass.

The optical parts and some accessories were supplied by Messrs. Watson & Son, as follows:—Objectives and oculars, "Holoscopic" series; substage condenser, "The Universal"; polarising and analysing prisms; objective changer, "Facility."

The total height of the instrument, racked down, without eyepiece, is fifteen inches. The weight, in working order, =17 lbs.

The instrument can be easily disconnected into three parts. The limb with all attachments can be lifted from the stand by the withdrawal of connecting pin in the inclining joint. To prevent accident, the stand at this joint is provided with semi-circular cheek pieces, which support the limb when the pin is withdrawn. The stand can then be taken into two parts—the vertical and horizontal—which are connected by quarter inch screws. When thus disconnected, the instrument can be packed into a case twelve and a quarter inches by nine inches by five and a quarter inches inside measurements.

George G. Holmes, A.R.S.M

PHOTOGRAPHY.

By Edgar Senior.

CRYSTALS AND X-RAYS.—Of the endless number of instances in which photography has come to the aid of the original investigator, none perhaps are of greater interest and value than the one which has recently led to the discovery of the interference effects obtained with X-rays, by means of crystals. Ever since Röntgen rays were first discovered in 1895, attempts have been made to obtain results analogous to interference, diffraction and reflection of ordinary light waves, but always until recently with negative results. The wave lengths of light visible to our eyes are those which are comprised between 7594 (red) and 3930 (violet), and beyond the violet are those of shorter length, known as ultra-violet, to which photographic plates are particularly sensitive. Now, it has always been supposed that X-rays were of the nature of ultra-violet light of extremely short wave length, quite beyond the limits of the spectrum known to us. The experiments, however, carried out by Messrs. Friedrich and Knipping at the instance of Professor Laue, opens up a new range of the spectrum which was unexplored before. In conducting any experiments by means of the spectrum of visible light, a diffraction grating is very commonly used in order to decompose the light into its constituents, from which the wave lengths can be measured. A diffraction grating is usually a plate of glass having a number of fine lines ruled upon it at regular intervals, the lines being practically opaque, acting as so many diffracting objects, while the clear spaces between allow of free transmission of the light. The spectra produced by means of gratings are known as interference spectra. Now, as it was supposed that X-rays consisted of waves of very short length, Professor Laue formed the conclusion that it might be possible to obtain interference effects with them, by using a crystal as a diffraction grating. As the atoms of a crystal are arranged regularly, and the spaces between them have about the same relation to the supposed wave length of the rays as the "constant" of a diffraction grating has to that of visible light, a crystal would thus form a most perfectly ruled grating for them. In order to test this practically the aid of photography was called in. In the first place, however, it was necessary to obtain as far as possible a parallel beam of X-rays, so that the conditions should be the same as when a parallel beam of light is allowed to fall upon the grating of a spectroscope. This was accomplished 'as well as could be," by means of holes pierced in sheets of lead, the X-rays being finally transmitted by an aperture of one millimetre in diameter, and thus a very narrow pencil was obtained. This was allowed to fall upon the crystal, and behind it, at a distance of about three centimetres, a photographic dry plate was placed perpendicular to the beam of rays. The rays, after traversing the crystal, fell upon the plate, and this, after the necessary exposure (which amounted in some instances to several hours), was developed. The effect produced was shown as a dark, circular spot, surrounded by a series of much weaker ones, arranged in regular order. By altering the distance of the photographic plate from the crystal, the spots could be made to approach, or recede from, the central one, so that it appeared clear that they were due to narrow rectilinear pencils spreading outwards from the crystal. It was found that the angles some of these made with the undeviated rays were as much as forty degrees. It was also noticed that the spots scarcely altered in size as the distance between the plate and the crystal was increased, but remained of the size of the smallest aperture employed for the transmission of the rays. And whatever the final result of the experiments may lead to, whether they solve the problem of crystal structure as well as that of the true nature of X-rays, there is no doubt but that photography has again rendered great service in showing that which otherwise might have remained of theoretical interest alone.

FIXED FOCUS CAMERAS.—Fixed focus is the term applied to hand cameras in which the plate is placed at a fixed distance from the lens, so that no focusing of the image can be accomplished. In many cases the plate is at a distance greater than the focal length of the lens; in other cases it is at the focal length itself. Now, in order for an image to appear sharp, it is generally considered that any point in the image of an object must not exceed one hundredth of an inch in diameter. Therefore, the distance of the object must be such that these points, "termed discs of confusion," do not exceed this value in the image. When the plate is at a distance from the lens greater than its focus, then a slight amount of confusion exists for objects at infinity. If, however, the plate is placed at a distance from the lens equal to its focal length, then all objects from a certain near point to infinity are in sharp focus. In order to find this point the following formula is employed:—$\frac{(f)^2 \times 100}{a}$ where f = the the focal length of the lens, and a the value of the stop. Thus, suppose with a lens of five inches focus and stop F/6 it is desired to find the nearest point beyond which everything else would be in focus, then $\frac{5^2 \times 100}{12 \times 6} = 34 \cdot 7$ feet.

Therefore, all objects from this distance to infinity would be sharply focused: that is, the circles or discs of confusion forming the points in the image of the objects would not be greater than one hundredth of an inch in diameter with the stop employed. When the object is nearer than this, then the image will be at a greater distance, and will agree with the case first stated, and although there may be certain advantages attending it, the method given for calculating that of the object would no longer be correct, as the formula only holds good when the plate occupies the position of the principal focal plane of the lens. There are, doubtless, many cases in which strict attention to theoretical details need not be paid, this, of course, depending largely upon individual ideas; but it should always be remembered that when images are intended for enlargement either by means of lantern slides or otherwise, the results are likely to suffer in a serious manner if too little attention be given to obtain a sufficiently sharp image in the first place.

PHYSICS.

By ALFRED C. G. EGERTON, B.Sc.

RÖNTGEN RADIATION.—When the cathode rays—the rays emitted in a vacuum tube normally to the cathode—were originally discovered, some considered them to consist of small discrete particles, and others considered them to be waves in the ether. Professor Sir J. Thomson's researches eventually proved without doubt that the rays consisted of negative charges emitted with great velocity carried by corpuscles of mass, one seventeen-hundredth of the mass of the atom of hydrogen. The cathode rays, when they impinge on a substance, are stopped, provided the thickness of the substance is sufficient, and they give rise to another penetrating type of radiation called the Röntgen rays, after their discoverer. The rays evolved are rays of mixed penetrating power, but for every metal there is also a definite radiation, characteristic of that metal and of definite penetrating power; the higher the atomic weight of the element, the greater the penetrating power of the characteristic radiation. Now, the Röntgen or X-rays give rise to secondary rays on being allowed to impinge on a metal, and these rays, too, are found to be characteristic of the metal, their velocity varying with the atomic weight of the metal. Thus, a cathode ray gives rise to an X-ray, and an X-ray to a secondary ray of the same type as the cathode rays. The γ-radiation from the radio-active substances is also in all its properties similar to a very penetrating Röntgen radiation.

Now, discrete electrically-charged particles, be they positive or negative, are affected and bent out of their path by magnetic or electric fields, but the X-rays or γ-rays are not affected by such fields. Consequently, the rays must be either neutral and consist of a pair of equal and opposite electrical charges, or consist of a pulse (a kind of single wave) in the ether. It cannot be said that complete proof has been adduced in favour of either view. But the latter theory explains most easily the majority of the facts, while the former has for support the ready convertibility of the X-rays and "secondary" β radiation, though with the pulse theory there is no great difficulty in considering that since an electron possesses around it an electro-magnetic field, and when stopped it is the inertia of this field which continues in motion and gives rise to a pulse in the ether. The energy of the pulse may be absorbed by obstructing matter, but addition of energy to an atom in that way is almost similar to adding an electron, and so an electron is released from the atom and forms a secondary ray. Recently, Professor Barkla has been able to demonstrate the reflection of X-rays from the cleavage planes of a crystal of rock salt. The narrow pencil of X-rays was allowed to fall at grazing incidence, and the principal secondary pencil of rays formed was one obeying the laws of reflection from the cleavage planes. It has also been possible to demonstrate the formation of Interference Fringe systems: a diverging beam of radiation was so directed on to a crystal that various portions of the beam were directed at different angles on the crystal cleavage planes; it was found that the intensity of the reflected pencil varied periodically with varying angle of incidence, and that such maxima of intensity that were obtained could be explained by the interference of the various reflected radiations from different equal spaced parallel planes within the crystal. The wavelength works out to be $\cdot 6 \times 10^{-9}$ centimetres which agrees with the probable wavelength of the X-radiations from other considerations.

These experiments have added to many others carried out by Professor Barkla and his collabrators in favour of the Ether pulse theory of the Röntgen rays.

"THE DYNAMICS OF PIANOFORTE TOUCH."—This is the title of a paper by Professor Bryan read before the Physical Society on February 14th; the automatic piano player, unlike the gramophone, has not been given great prominence in scientific literature. Professor Bryan has now introduced the subject and has, moreover, invented a device which improves the mechanical player in connection with its "touch." The theories of Helmholtz and Kaufmann on the action of the pianoforte are very incomplete and do not take into account either the sounding board or the time and nature of the impact of the striking keys. It is this last factor which controls the quality of the tone given by the vibrating wire, and the quality of the tone is regulated by the "touch" of the pianist; the problem is whether a mechanical player can be devised which will be capable of adjustment so that its touch can be modified. Professor Bryan, by means of a lever which regulates the air pressure, has succeeded in imitating mechanically to some degree the touch of the human hand. Still, the touch and emphasis which can be given by the hand to a single note amongst many others within a number of chords is still a problem which it would seem to be somewhat difficult to solve in a mechanical player.

UNDAMPED OSCILLATIONS.—Electrical waves can be produced either in a continuous train or as a succession of damped vibrations, as with the oscillations produced for the purpose of wireless telegraphy by means of the spark discharge. The production of a continuous train of waves is the type of oscillation which is employed by Poulsen in his systems of wireless telegraphy and telephony. An oscillation circuit of this type can be conveniently set up for laboratory purposes in the following way, and it may be pointed out that it is a very convenient method of obtaining discharges through gases at low pressures, when it is not possible to use metallic electrodes.

An arc is constructed of copper and carbon, the carbon is fitted in a brass tube, which passes air-tight through another brass tube fitted through an indiarubber cork; the carbon can be rotated or moved in and out by rotating the brass tube. The copper is screwed to the end of a brass tube passing through a rubber cork, and down which passes an iron tube through which water passes into the brass tube; the copper electrode can thus be cooled. The corks fit into the ends of a silica tube, which is cooled by an outer tube, through which water passes. The arc is connected through suitable resistance, giving about two or three ampères, to the two hundred volt mains. The arc is also connected to a variable inductance—a coil of insulated wire wound on a wooden frame, and so bared that a slider brings in more or less inductance, and a variable condenser connected in series. If a large inductance and capacity, consisting of a long coil of fine wire wound on a tall glass cylinder, is connected to one end of the first inductance, electrical oscillations are set up and are of sufficient intensity to illuminate vacuum tubes situated several feet away.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

UTILITY OF SENSITIVENESS TO LIGHT.—It is well known that many animals are very sensitive to different degrees of illumination—some seeking more light and others less. Dr. V. Franz gives some good illustrations of the utility of this sensitiveness. Many larvae hatched on the floor of the sea make for the light, which is the best thing they can do for nutritive and other reasons. Still more frequent is the case of animals which show marked light-sensitiveness only when some unusual conditions have intervened, such as perturbations in the water or foulness of water. They retreat in the direction of the light conditions they are accustomed to. They make for stronger or weaker light, as the case may be, and the degree of illumination has a directing influence in a sense. But it is not the degree of illumination in itself that is significant; it is the avoidance of concomitant unpropitious conditions.

MANGANESE IN ANIMALS.—It has been usually supposed that traces of manganese detected in various animals were accidental and without physiological significance. But that is not the view taken by Messrs. Bertrand and Medigreceann, who have found manganese in dog, boar, pig, ox, sheep, horse, rabbit, guinea-pig, seal, dolphin, fowl, duck, angler, herring, and dogfish. It occurs everywhere in these animals except in white of egg. There is great diversity in amount, the maximum occurring in the oviduct of birds. Liver and kidneys contain more than muscle or nerve. There is a relatively large amount in hair, feathers, and nails. The authors maintain that manganese must have some physiological significance, probably as a catalytic agent.

PERCHING IN BIRDS.—From the time of Borelli it has been stated that the tendon of the ambiens muscle in many birds is continued over the knee, and enters into connection with the tendons of the perforati muscles which bend the toes. When the knee is bent, the story runs, the ambiens tendor is stretched, and through the mediation of the others, clinches the toes on the branch. Professor Brauer points out that the ambiens (which starts from the spina pubica) is connected by its tendon with the tendon of the flexor of the second or third toe, or with the third and fourth (which are closely wrapped up together), but that it has nothing to do with the bending of the first toe. In fact, its importance has been greatly exaggerated. It has little effect in bending the toes, and it is absent in many birds which ought theoretically to have it. The bending of the toes is due to the perforati muscles and the tightening of their tendons when the intertarsal ankle joint is bent.

REPRODUCTIVE DISHARMONY IN WILD DUCK.—Julian S. Huxley calls attention to a remarkable "disharmony," to use Metschnikoff's term, in the reproductive habits of the wild duck (*Anas boschas*). The sexual appetite is extended through the period of incubation. When the female is actually on the nest this cannot be gratified; hence, when a female leaves her nest, she is often pursued by a number of unsatisfied males. This may readily end in the drowning of the overtaxed female. At Tring Reservoirs a considerable number (probably seven to ten per cent.) of the females are killed in this way every year. This is a noteworthy loss to the species, due to a disharmony within itself.

EXTRAORDINARY REGENERATIVE CAPACITY.—E. Uhlenhuth removed the eyes and the surrounding skin from the larvae of salamander and newt (*Salamandra maculosa* and *Triton alpestris*), and implanted them in the back of other larvae of the same species. The implanted eye first underwent degeneration, and the visual cells disappeared. But after some weeks there was regeneration, and the retina showed the typical structure. The optic nerve grew, and with the co-operation of the adjacent tissue, it formed a long strand, which in certain conditions may grow into connection with a spinal ganglion.

A KING-CRAB ON THE SURFACE.—R. B. Seymour Sewell reports from the "Investigator" the capture of an adult king-crab (*Limulus moluccanus*) in a large surface tow-net, allowed to drift with the tide from an anchored vessel, and kept on the surface by means of a bamboo float. How an animal, so obviously a dweller on the floor of the sea, had been carried or made its own way to the surface remains a mystery.

HABITS OF TRILOBITES.—Hans V. Staff and Hans Reck have made an interesting and ingenious attempt to work back to the habits of these ancient extinct types. They argue from structural peculiarities to the mode of life. The primitive Trilobites were creeping animals, and some retained this habit. The *Olenellus* type illustrates adaptation to creeping. But some, such as *Phillipsia* and *Illaenus*, became swimmers; and some went further, like the laterally-expanded *Deiphon-Acidaspis* types, becoming adapted to plankton-drifting. Some, like *Dalmanites*, got long terminal spines suited for creeping in the King-crab fashion. Some, which had progressed on the swimming line of evolution, relapsed and became creeping types again. There is a fascination in this attempt to put life into fossils, making them move about again each after its kind.

SOLAR DISTURBANCES DURING MARCH, 1913.

BY FRANK C. DENNETT.

ONLY one day has been quite missed during the month, namely, March 4th. The spot disturbances have been both few and insignificant in appearance, yet one at least was of importance. The disc appeared to be quite free from disturbance on twelve days (3rd, 7th. 9th, 10th, 15th to 17th, 22nd, 23rd, 26th, 27th, and 31st). The central meridian at noon on March 1st was 309° 17′.

On March 8th, at 1.30 p.m., there was an evanescent group of minute pores in high southern latitude, but clouds prevented the exact determination of their position. Observations earlier in the day failed to reveal them.

No. 5.—A small pore close to a faculic patch seen on the 13th and 14th only. It was specially noticeable owing to its high latitude, 34° South.

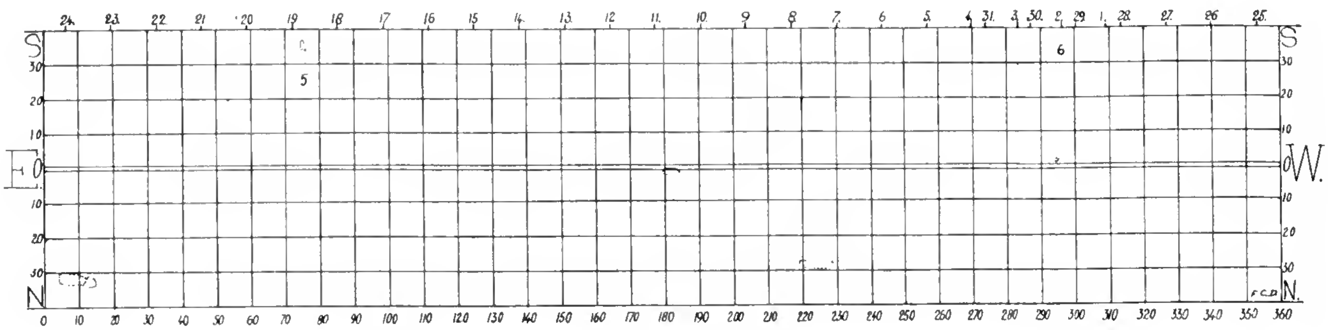
No. 6.—A group of pores only seen on the 28th, very near to the equator.

The photosphere appeared to be in an active state on the 27th, dull spotlets appearing and disappearing in the north-western quadrant.

Faculic patches were visible in the south polar regions on the 5th, 6th and 8th, also on the first two dates close to the equator, near longitude 180°. On the 1st and 2nd the faculic remains of No. 4 were visible near the north-western limb, and from the 18th to the 21st were advancing from the north-eastern limb, re-appearing on the 29th as they approached the north-western limb. On the 29th and 30th another patch around longitude 225° was visible near the north-eastern limb.

Our chart is constructed from the observations of Messrs. John McHarg, E. E. Peacock, W. H. Izzard, A. A. Buss, and the writer.

DAY OF MARCH.



CORRESPONDENCE.

PHYLLOTAXIS AND THE DISCAL FLORETS OF COMPOSITE FLOWERS.

To the Editors of "KNOWLEDGE."

SIRS,—A few months ago I published a paper in "KNOWLEDGE" on the ray and discal florets of *Senecio Jacobaea*. The following note is a supplement to it. The plant, of which a specimen is appended, so that you may have it identified, is fairly common about Cordoba. In appearance, it is something between our blue cornflower and a rampion, with the colouring of the latter. It is well-suited for the purpose, the sterile ray- and fertile discal-florets being neither of them very numerous, but there was not enough of the plants to repeat, on anything the least like the same scale, the elaborate observations on the small wild calendula, nor for that matter was there any reason for attempting it. At the same time the present observations seem to put beyond any reasonable doubt the fact that the coincidence shewn in the number of the florets with numbers indicating a system of concentric rings is far more than chance would give. The reasoning is simple enough, and I do not think there is any serious flaw in it. The number of circular ring systems was found for the digit series from the lowest discal number to the highest discal number + the ray florets, and the percentage of coincidences was found to be nearly three times what chance would give. Taking, however, what may be considered the normal types of flower head with 17, 18 and 19 rays, the percentage was much higher. In fact, for the 18-rayed type it was 90·9 instead of 20%. For the sake of brevity (3), (4), (5), and so on, are put for "a system of concentric rings beginning with 3, 4, 5, and so on." When a number has one dot over it, that means that it belongs to a ring system, either with or without the ray florets being counted in; when two, that it belongs to both.

TABLE 36.

Giving all the ring systems in the tract of numbers to be dealt with, viz., from 28...to 100 or 72.

Ring System.	No. of Concentric Rings.		
	3	4	5
Beginning with a ring of 3 ...	—	48	75
" " " 4 ...	—	52	80
" " " 5 ...	—	56	85
" " " 6 ...	—	60	90
" " " 7 ...	39	64	95
" " " 8 ...	42	68	100

TABLE 37.

Results of first counting:—

Rays.	Flower Heads.	Discal Florets.
11	1	
12	0	
13	1	
14	1	
15	4	
16	5	39, 41, 54, 56, 61
17	7	50, 50, 51, 52, 54, 56, 63
18	7	42, 48, 49, 64, 64, 69, 56
19	12	46, 48, 49, 50, 53, 56, 56, 62, 63, 66, 68, 71
20	5	53, 58, 59, 62, 69
21	5	49, 72, 74, 78
22	0	.. .. ..
	41	

Nine ring systems in 39 corresponds to 23%.
Thirteen coincidences in 41 counts to 31%.

There are, however, 13 coincidences, one off, so that we have about $1\frac{1}{2}$ what chance should give.

* If we count in the rays we have numbers from 55...99, in which series there are again 9 ring systems or 20%. Excluding the ring systems under 52 we then have just 15 coincidences, or about 34%.

TABLE 38.

First and subsequent countings together:—

No. of Ray Florets	Flower Heads.	Discal Florets.	
13	3	28, 29, 41	(3)
14	4	35, 35, 44, 46	(4)
15	11	35, 38, 40, 42, 43, 45, 47, 53, 53, 62	(10)
16	10	39, 39, 41, 41, 43, 49, 51, 54, 56, 61	(10)
17	18	35, 39, 40, 43, 46, 46, 48, 50, 50, 51, 51, 52, 54, 56, 63, 65, 65	(18)
18	11	34, 39, 42, 48, 49, 50, 60, 61, 64, 64	(11)
19	19	44, 46, 48, 49, 50, 51, 53, 54, 55, 56 (3), 59, 62, 63 (2), 66, 68, 71	(19)
20	9	44, 49, 53, 58, 59, 62, 65, 69, 70	(9)
21	8	49, 54, 72, 74, 75, 78	(6)
22	1	64	(1)
	94		

Thus the total number of coincidences is 48. The range is 28 to 99 or 71 with 13 ring systems.

$\frac{13}{71} = \frac{x}{100} = 18 \cdot 3\%$ ring systems.

$\frac{48}{91} = \frac{x}{100} = 52 \cdot 8\%$ coincidences with ring systems, or nearly three times what chance would give.

If, however, we take the three commonest forms 17, 18, 19, with the most numerous countings we get 17 range 35...82, *i.e.*, in 47 digits there are 10 ring systems or 21·25...% observation gives 55·5%.

18 range 34...82, 48 digits with 10 ring systems or 20·8% observation gives 90·9%.

19 range 44...90, 46 digits with 11 ring systems or 24·0% observation gives 57·8%.

21, 20·0% observation gives 50%.

W. W. STRICKLAND.

HEN BIRDS ASSUMING THE PLUMAGE OF THE MALE BIRD.

To the Editors of "KNOWLEDGE."

SIRS,—The experiments carried out at Graaff Reinet, Cape Colony, in removing the ovaries of the hen bird in Ostriches and thereby causing the plumage to be that of the male bird, are very interesting.

As is well known, hen pheasants and probably hens of poultry, also assume the garb of a male bird if the ovaries become diseased, or are removed, and it would be interesting to carry the experiment still further, and find whether all hen birds would be affected in the same way. I think it is probable that it would be so.

Some years ago an old male Ostrich in these Gardens assumed the plumage of a hen bird, and was evidently badly diseased before the change occurred, as he shortly after died; unfortunately I was absent at the time, so the skin was not preserved.

The effect of the removal of ovaries in animal life is well known.

DUDLEY LE SOUËF, C.M.Z.S., *Director.*

ZOOLOGICAL GARDENS,
MELBOURNE.

ON THE RELATIONSHIP OF APERTURE TO POWER IN MICROSCOPE OBJECTIVES.

To the Editors of "KNOWLEDGE."

SIRS,—After reading Mr. Hutton's interesting article on the craze for aperture, which appeared in "KNOWLEDGE" for February, I looked up some of the points in Wright's "Principles of Microscopy" and came across the following, which raised the question, "How are we amateurs to decide when doctors disagree." On page 225 the following is given:—

"*Example*: In the case where a 100-fold magnification is to be exacted . . . and where our choice lies between . . . N.A.'s of 0·6 and 0·3 respectively, preference ought, other things being equal, to be given to the former. The 0·6 objective would not only gather in more light into the image and give better resolution in depth, but it would give us the required magnification in association with a terminal beam of 0·006 N.A., *i.e.*, a beam which would fill the whole aperture of the pupil. The 0·3 objective would, in association with a hundredfold magnified image, give us a beam of 0·0003 N.A., *i.e.*, a beam whose diameter would be less by one half than the diameter of the pupil."

The differences between the two writers is curious. Mr. Hutton, taking the average power of resolution of eyesight at one hundred and twenty five lines to the inch, gets an N.A. of 0·13, sufficient with a magnification of one hundred. Sir A. E. Wright, taking the diameter of the pupil, recommends an N.A. of 0·6 for the same magnification. Thus, while both are guided by the limits of human eyesight, the results they arrive at are widely different.

Nor is this the only difference between the two writers, for Mr. Hutton says: "Besides, we sacrifice depth of focus" by going in for a larger aperture, whereas, according to Sir A. E. Wright, quoted above, the higher N.A. gives "better resolution in depth."

C. H. DE MELLO.

RIVERSIDE,
CASTLE STREET,
SALISBURY.

REVIEWS.

CHEMISTRY.

Modern Inorganic Chemistry.—By J. W. MELLOR, D.Sc. 871 pages. 316 illustrations. $8\frac{1}{2}$-in. × $5\frac{1}{2}$-in.

(Longmans, Green & Co. Price 7/6.)

No one who has had any experience in teaching chemistry can fail to have been struck with the difficulty of inducing a beginner to get a grasp of the general principles of the science as distinguished from the numberless facts upon which they are based. This is often lost sight of, however, in text books, largely because a knowledge of detail "pays" best in examinations. It is, therefore, a pleasure to meet with a book in which stress is laid upon the point that it is more important to train the reasoning faculty than the memory. In fact, the views of the author on this point may be summarised in the aphorisms that we find in different parts of his book; as, for example, "The best chemist is not necessarily he who is familiar with the greatest number of compounds;" and "Dictionaries of chemistry, not the memory, are the natural storehouse of isolated facts."

At the same time, it must not be inferred that the facts essential to understanding a theory are omitted. On the contrary, throughout the book the evidence for and against particular views is cited, and the student is, to a large extent, encouraged to draw his own conclusions. The only instance where generalisation seems to have been carried too far is in the account of the elements of the rare earths, to which only two pages are given.

The chapter upon radioactivity is particularly clear and full, and is well illustrated by diagrams. Although the author does not expressly say so, he evidently regards the experiments of Sir William Ramsay upon the transmutation of copper into lithium and sodium as "not proven." Prominence is also given in this connection to the view of Professor Armstrong (1912) that "radioactive elements" may not be really elements at all, but compounds of ordinary elements with helium.

The book is quite sufficiently advanced to deserve references to the original authorities, so that any student may be encouraged to follow up a subject further. This would add greatly to the value of the work.

In an epilogue, Dr. Mellor remarks: "The teacher has failed in his work if he has not whetted the student's appetite for more." If we apply this standard to his own book we can say without hesitation that no one with any taste for chemistry can read it without being interested and stimulated both by the matter itself and the way in which it is presented, with appropriate quotations from great chemists and natural philosophers as introductions to the different sections.

C. A. M.

Questioned Documents.—By ALBERT S. OSBORN. 501 pages. 200 illustrations. 10-in. × 7-in.

(London Agents for American Publishers: Sweet & Maxwell. Price 30/- net.)

This book belongs to a class of works against which objections are sometimes brought upon the grounds that they may be of use to criminals and so defeat their own end. But we venture to think that no one who studies Mr. Osborn's most valuable book will endorse this view, for it will be seen that the pitfalls are so numerous that in avoiding one a forger must inevitably fall into another.

Every scientific question which has to be answered in deciding whether a document is genuine or not is here fully discussed, and the author rightly lays stress upon the point that a reason ought to underlie every expression of opinion upon a matter of this kind.

The methods used in the examination of the writing, the paper, the ink, and so on, are described at length, and well illustrated with diagrams and photographs of exhibits in actual cases in which Mr. Osborn has been engaged.

Throughout the book the use of scientific appliances is advocated wherever practicable. Special cameras and microscopes are described and directions are given for the most suitable methods of applying them to the examination of documents; micrometer callipers and micrometer eyepieces are to be used for the measurement of lines and spaces; and the tintometer for recording differences in colour.

In dealing with the judgment of handwriting the author gives an excellent survey of the more modern and scientific methods of solving a very difficult problem, while a separate chapter is devoted to the effect of the position of the pen, and the pressure applied to it, upon the character of the writing.

There is only one important direction in which we can suggest an improvement for a future edition. A short outline of each of the illustrative cases so frequently cited in the text might with advantage be added in the form of an appendix, as is done in Mr. Justice Wills' "Circumstantial Evidence." This would add greatly to the interest of the work without in any way detracting from its scientific value.

But even in its present form the general reader will find much to entertain him in this book, while to the lawyer it should prove invaluable. It has already met with a warm welcome in America, and it only requires to become known to be equally in demand in this country.

C. A. M.

The Problem of the Gas-Works Pitch Industries and Cancer.—By H. C. ROSS, M.R.C.S., L.R.C.P., J. W. CROPPER, M.B., M.Sc., and W. J. A. BUTTERFIELD, M.A., F.I.C. 48 pages. 2 illustrations. $8\frac{1}{2}$-in. × $5\frac{1}{2}$-in.

(John Murray. Price 6d. net.)

For some years past the prevalence of warts, ulcers, and epitheliomatous cancer among persons engaged in the distillation of gas-works tar and and the manufacture of briquettes from gas-works pitch has been recognised, but hitherto no explanation has been given of the remarkable fact that the similar pitch from blast-furnace tar does not produce these effects.

In this little book we have the interesting results of a research made by two physiologists and a chemist in an attempt to discover the causes of this phenomenon. Starting from the hypothesis that cancer is the result of certain factors which include (1) rapid proliferation of cells upon a chronically injured site; and (2) an abnormal tendency of these cells to migrate into neighbouring tissue, experiments were made to discover what chemical agents were capable of stimulating these tendencies to rapid growth and abnormal migration.

The method employed was based upon the fact discovered in 1909 by Drs. Ross and Cropper that human white blood cells could be made to reproduce by cellular division, in response to the action of certain chemical substances such as creatinine, methylamine, and other compounds (extracted, *e.g.*, from dead animal matter). Some thirty-one different substances were discovered, capable of causing such cell proliferation, and to these the name of *auxetics* was given. The action of these compounds was also proved physiologically; for, when applied to the surface of ulcers, they produced granulation tissue and accelerated the healing process.

A second class of bodies, working in association with auxetic agents, caused unsymmetrical division of the blood cells and excited amoeboid movements which would give rise to infiltration of the cells into neighbouring tissue. These bodies were termed *kinetics*. Now, in experiments with aqueous extracts of the two kinds of pitch, it was found that that derived from the gas-works contained both auxetics and kinetics, but that the extract from blast-furnace pitch, while containing a small amount of auxetics, showed no signs of kinetics, and did not produce amoeboid movements in the white blood cells.

From this the conclusion was drawn that the pathological effects of gas-works pitch was the result of chemical injury and not of mechanical injury caused by irritation produced by the coal dust, as had previously been supposed. Attempts to remove these chemical substances by washing the pitch were successful on a small scale, but washing would not be practicable in the works, since it would interfere with the binding properties of the pitch.

The results of fractional distillation of the tar showed that it was not possible to eliminate the dangerous products at a lower temperature than 360°C, and that pitch which had been heated to that extent was useless for practical purposes. Washing the tar with hot water before distillation completely eliminated the auxetics and kinetics, and the pitch from such tar would be as valuable as that now used in making briquettes. There would certainly be difficulties in the manipulation of the tar, but these should not be insuperable.

Such, in brief, is an outline of the main results and conclusions of a most striking investigation attacking the cancer problem from the chemical side. Further researches are now being made to isolate the definite chemical compounds from the gas-works tar and pitch, and since the publication of the present work it has been discovered that there is a pronounced difference in the proportion of auxetics and kinetics in different kinds of coal. This is one of the reasons why blast-furnace pitch (largely derived from hard coal) does not produce the effects of gas-works pitch (from bituminous coal). Another factor is the difference of temperature at which the two kinds of tar distil.

The details of this investigation have been communicated to the Home Office, and they appear so convincing as to the causes of the evil, that it ought to be possible to devise precautions that will entirely prevent it.

C. A. M.

GEOGRAPHY.

Papua or British New Guinea.—By J. H. P. Murray. With an introduction by Sir William MacGregor, G.C.M.G., C.B., D.Sc. 388 pages. 38 illustrations. 9-in. × 6-in.

(T. Fisher Unwin. Price 15/- net.)

Of all the British possessions few are less well known than Papua. There is a great deal of pioneer work to be done in all directions. The geology and the natural resources, the geography and ethnology have been only superficially investigated, though at present investigations on all of them are being pursued. Most people seem to associate New Guinea with rain and perpetual mists, and a book which helps to dispel these mists and others that cloud general knowledge of this most interesting land is decidedly welcome, and does not need the apology with which the modest author prefaces it.

Some peculiarities of the people of Papua are very striking. For instance, on Rossel Island, to the south-east, traces of separate languages for men and women are found. The disabilities of women are curious. On Rossel they must not speak in a canoe, and the native, on being asked what would happen to one who transgressed, suggests that she might probably be eaten, but refuses to contemplate such an unheard-of occurrence. Even the men of Rossel speak a different language when they are on the neighbouring island of Roa, for some mysterious reason. On the Gulf of Papua, again, we find a South Sea snobbery. The possession of tails is imputed to the despised tribes. One native relates of a race of tailed men that they sit with their tails hanging through holes in the floors of their pile-dwellings. While among them, he used, for a joke, "to creep under the house, take hold of each tail very gently and tie a knot in it"; then raise an alarm, with the result that the caudate warriors, springing up to meet the foe, were jerked on their backs by their own tails. Another has conclusive evidence of the existence of one tailed man at least, "Because I eat him!"—all fairly strong evidence, remarks Mr. Murray, if not of the existence of men with tails, at least of lively imaginations. And so we are taken through interesting chapters on the People, History, Exploration and Development. One is struck with the sympathetic and far-sighted policy of the Australian Government which guides the destinies of the Possession, and recognises in Mr. Murray, who is the Lieutenant-Governor, a wise and thoughtful exponent of it.

We do not think the introduction very fortunate, and the two first chapters, on the geography, are certainly the least interesting. The numerous photographs are excellent, but the map is not very satisfactory, and there are a few misprints. The index is good.

A. S.

The Earth, its Shape, Size, Weight and Spin.—By J. H. Poynting, Sc.D., F.R.S. 141 pages. 49 figures. $6\frac{1}{2}$-in. × 5-in.

(The Cambridge University Press. Price 1/- net.)

In three chapters, on "The Shape and Size of the Earth," "Weighing the Earth," "The Earth as a Clock," Dr. Poynting has collected for the student and the general reader a great deal of useful information on certain branches of earth-knowledge for which one has usually to search large and difficult treatises, and the information is presented in such a way that it is acquired really as scientific knowledge, not merely as positive fact is got from the usual popular book. The student must have a preparation in Mathematics and Physics, but the general reader will read with profit though his equipment be less.

Very fresh and stimulating is the treatment of Relative Motion, Precession and Nutation, and most of the part on the Tides. Frequently the expression is striking and illuminating. It is characteristic of many of the Cambridge Manuals that exactly as the reader knows more he learns more, and this is even more than usually true of the present volume. One complains of some things that might be easier to follow, as at pages 11–12, 58, 115. These are but slight faults in a book elsewhere remarkably excellent, which is well got up, and has a good index.

A. S.

GEOLOGY.

The Geology of Soils and Substrata.—By H. B. Woodward, F.R.S., F.G.S. 366 pages. 44 text-figures. 4 plates. $7\frac{1}{2}$-in. × 5-in.

(Edward Arnold. Price 7/6 net.)

The aim of this book is to provide the necessary geological information for agriculturists, and those engaged in the management of estates, in sanitary or engineering work—in short, any business which involves some knowledge of the soil and subsoil. The practical importance of geological knowledge is nowhere brought out more fully than in connection with agriculture, sites for houses and cemeteries, sewage disposal, and kindred applications of the science. In our opinion, Mr. Woodward has fully achieved the object with which he set out. In the book is brought together an immense amount of geological information on subjects that are rarely even mentioned in the text-books, and it is a special convenience to have it set out so clearly in this book.

The first six chapters provide such general geological knowledge as is necessary for the study of the soil and subsoil that follows. The next eight chapters deal with every conceivable phase of agricultural work in which geological knowledge is a desideratum. For instance, besides the method of formation of soils, we are shown how climatic and other conditions affect its fertility or cause its barrenness. This leads to a discussion of the drainage necessary to increase the fertility and workability of the soil, and of the geological principles involved.

Next are described the mineral manures which it may be necessary to apply in order to make up some natural deficiency in the soil. Then come chapters on the geological features to be studied in connection with forests, woodlands, orchards and gardens; and the practical geological considerations in respect to estate management, and economic materials (such as road-metals) derived from the soil or subsoil. The chapter dealing with the geology of sites for houses, cemeteries, sewage farms, water supply and ponds, is of special value. The remaining chapters describe the soils and subsoils derived from each of the various geological formations in Great Britain, and in this part of the book a large amount of practical information has been brought together. At frequent intervals there are appended good lists of references, and the book is illustrated by excellent plates and text-figures.

G. W. T.

ZOÖLOGY.

Comparative Anatomy of Vertebrates.—By J. S. KINGSLEY. 401 pages. 346 illustrations. 9-in. × 6-in.

(John Murray. Price 12/- net.)

With such a multitude of works on the anatomy and anatomical evolution of the vertebrata already before the public, it might well have been thought that there was scarcely even standing room for a new one. Such, however, is evidently not the opinion of Professor Kingsley, who occupies the chair of Biology in Tuft's College. Apparently, as a reason for the new venture, it is stated in the preface that the modern method of teaching biology in the laboratory, by means of dissection, does not constitute a science, and that it is consequently essential that the facts so collected "should be properly compared and correlated with each other, and with the condition in other animals. It is the purpose of the author to present a volume of moderate size which may serve as a framework around which these factors may be grouped, so that their bearings may be recognised, and a broad conception of vertebrate structure obtained. In order that this may be realized, embryology is made the basis, the various structures being traced from the undifferentiated egg into the adult condition."

That Professor Kingsley has done his work thoroughly and in first-rate style every student who has cause to make use of the book can scarcely fail to admit: the amount of information which has been crammed into such a small space being little short of marvellous, especially when the number and, in some instances, the relatively large size of the illustrations are taken into consideration. For excellence of execution, cleanness of detail, and suitability to their respective purposes these illustrations can scarcely be surpassed. In the legend to Figure 92, we notice, however, that the American fashion of applying the term "turtle" to a fresh-water "tortoise" is retained; and we cannot approve of the practice, as exemplified in the same illustration, of referring the reader to a figure twenty pages earlier for an explanation of most of the lettering. Neither do we like the Americanism of spelling the name of the European pond-tortoise *Emys europea*. Save for trivial criticisms of this nature, we have nothing but unqualified praise to bestow upon Professor Kingsley's book, which ought to have a wide circulation among university and other students.

R. L.

Heredity.—By Professor J. ARTHUR THOMSON, M.A. 627 pages. 47 illustrations. $8\frac{1}{2}$-in. × 6-in.

(John Murray. Price 9/- net.)

Professor Thomson is to be heartily congratulated on the issue of a second edition of this volume, which forms the best semi-popular text-book on this interesting and important subject, and is long likely to maintain this enviable position. Apparently, the new edition has not required much alteration, with the exception of the correction of a few errors; but the author has taken the opportunity of adding references to papers embodying discoveries made since the appearance of the first edition.

Doubtless many of our readers are familiar with the work in its original form, and to these anything like a review would prove wearisome; those who have not yet made its acquaintance are recommended to remedy the omission with the least possible delay. For heredity is a subject in which we are all nowadays more or less practically and directly interested in—or, if we are not, we ought to be; and whether we believe or disbelieve in eugenics as a potential factor in modern life, we ought at all events to be acquainted with the arguments in favour of the new doctrine.

To the general reader, perhaps, the most interesting part of the work is contained in the concluding sections, where the author reviews the effects of heredity on the present population of our country. After referring to the well-ascertained fact that while the children of exceptionally gifted parents are not infrequently worse than commonplace (as if nature had exhausted herself in the special mental development of the former), those of parents of a low type are often very fair examples of the human species, Professor Thomson proceeds to discuss the question whether modern therapeutic and hygienic methods tend to prevent the elimination of weaklings, and thus lead to the deterioration of the race as a whole. Here it is pointed out that insanitary surroundings, and the consequent epidemics, affect the strong as well as the weak, while the latter may in some cases develop mental character not vouchsafed to the former. On the other hand, the question whether bodily weaklings should be permitted to transmit their failings presents a more serious question.

Whether the relatively unfit should be allowed to multiply is another serious question of the same nature, which the author answers unhesitatingly in the negative. The burden of militarism, and the consequent destruction from time to time of the flower of our manhood, is also discussed at some length, with the suggestion that certain kinds of deterioration may be due to this cause. With this we take leave of a fascinating volume, on which the reading and thinking world has already bestowed its imprimatur of appreciation.

R. L.

Problems of Life and Reproduction.—By MARCUS HARTOG. 362 pages. 41 illustrations. $8\frac{1}{2}$-in. × $5\frac{3}{4}$-in.

(John Murray. Price 7/6 net.)

We learn from the preface that the author, when incubating the idea of this volume, had in his mind to write a general treatise on reproduction suited to the needs and capacity of the non-scientific reader. Further consideration indicated the existence of certain reasons against such a mode of procedure, and these reasons—to our thinking, unfortunately—ultimately prevailed. The author found, however, that he had already written certain articles on reproduction—one so long ago as 1892; and these, with others on more or less distinct subjects, have been collected and reproduced, with such alterations as were deemed essential, in the present volume, which is consequently a kind of scientific *olla podrida*, and a very mixed one at that. For it includes such diverse topics as reproduction and fertilisation, the transmission of acquired characters, mechanism and life, the biological writings of Samuel Butler, the teaching of nature study, and—what we venture to suggest will prove a regular stumper to the man in the street—the new force, mitokinetism. But whatever Professor Hartog writes, even if it be a bit unduly technical and in a somewhat involved style, is worth reading; and those readers of "KNOWLEDGE" who wish to have even a bowing acquaintance with some of the up-to-date subjects of modern scientific thought, will do well to at least dip into his pages.

With such a multitude of subjects before him, the unfortunate reviewer who is expected to give something like a comprehensive notice of the book, within the compass of a few short paragraphs, must be completely and hopelessly nonplussed. Personally, we have been most interested in the article on the inheritance of acquired characters; but we are somewhat disheartened by a footnote at the commencement to the effect that another author has collected a number of facts in favour of this theory since the first appearance of the article, which ought surely to have afforded sufficient reasons for rewriting. Among Darwinists who hope to attain the Valhalla of orthodox followers of their doctrine, anything approaching recognition of the possibility of inheritance of acquired characters (for what these are we must refer our readers to the pages of our author) is anathema, but Professor Hartog, being a bold spirit, runs a-tilt at the objectors, and demonstrates to his own satisfaction, at any rate, that such characters can, at least in some instances, be transmitted to the offspring. Whether he will have succeeded in convincing the orthodox Darwinists of the error of their ways is quite another matter.

R. L.

CONSIDERATIONS ON THE PHYSICAL APPEARANCE OF THE PLANET MARS.

By E. M. ANTONIADI, F.R.A.S.

In the year 1877, our knowledge of the markings which variegate the surface of Mars was in a very satisfactory condition. A series of excellent observations by Dawes, Lockyer, Lassell, Kaiser, Burton, Green, and others, had disclosed the true natural structure of the spots on that planet. The question thus appeared definitely settled, when it was troubled by the Italian astronomer Schiaparelli,* who announced that linear objects, to which he gave the name of channels, or canals, were furrowing the so-called continental regions of our neighbour in space. During the apparitions of Mars following the year 1877, the Milan observer continued and extended his discoveries; his later maps seemed practically covered with spider's webs; while the zeal and discernment of his followers could number no less than one thousand different canals on the yellow or grey expanses of the planet.

From a photograph *by the Writer.*

FIGURE 183. View of the Great Dome of the 33-inch Refractor at Meudon.
Height of the ground above sea level, 533 feet.

Gigantic watercourses, mostly running along great circles of the sphere, and, consequently, appearing straight near the centre of the disc, continued to look straight in Italy even when nearing the limb of Mars. A geometrical cross of canals in the land called Hellas was seen attended with four symmetrical bright specks of light, recalling somehow to memory the *In hoc signo vinces* of the emperor Constantine. Canals, scores of miles wide, and hundreds of miles long, were observed in a few days, or even hours, to double, either by the formation of a parallel band, or by the disappearance of the original canal, and by the formation of two new parallel streaks separated by hundreds of miles. Nor were hesitations in these doublings neglected to be put on record, since canals were seen to be alternately single and double on the same night.

To account for these wonderful phenomena, the vast powers of Nature were found totally inadequate; and thus it was that Schiaparelli was led to enunciate the idea of the artificial origin of the canals, conceiving the larger of them to be composed of six different watercourses, whose dykes would be opened now and then by the Martian minister of agriculture.

Speculations of such a character were eagerly embraced by M. Flammarion and other popular Continental writers. Yet it is to be regretted that the originator of this artificial theory, and his imitators, have failed to do the utmost with their cherished idea. For, inasmuch as the canals appear straight about the central meridian, and also when carried by rotation near the limb, it is obvious that the Martian engineers would be constantly engaged in rapidly digging and destroying their watercourses, so as to make them look always straight to the observers on the Earth.

It is to the credit of British science that the results of Schiaparelli were, from the very onset, strongly controverted by English astronomers. In 1879 Green boldly questioned the reality of these canals. In 1882 Mr. Maunder and Mr. (now Sir) William H. M. Christie rightly insisted on the error of Schiaparelli in using too high powers. But the honour of first recognising the true nature of the minor detail of the planet is due to Mr. W. F. Denning, who announced, as far back as 1886, that the continents of Mars show here and there some irregular streaks, presenting frequent interruptions and condensations. As is wont

FIGURE 184. The Laestrygon. 1896, June 12.

FIGURE 185. The Jamuna. 1894, August 27.

Single and double Canals of Mars, as glimpsed for a quarter second by the Writer.

*This view of the discovery of the canals was given by Mr. Maunder, in "KNOWLEDGE" for 1894, p. 249.

in such cases, this statement attracted no attention at the time; and it was only several years later that it received full confirmation at the hands of Professors Young, Barnard, Hale, and the writer, all observing with very powerful telescopes. And when we recollect that Mr. Denning used in this enquiry only a ten-inch reflector, and that he made his innumerable other discoveries in an unfavourable climate, and under difficult circumstances, we deem it only just to consider him as the greatest of all modern observers.

The canal problem, thus solved by observation, was next approached from the point of view of theory. In 1894-1895, Mr. Maunder laid stress, in these columns, on the error of believing that our telescopes reveal to us the ultimate structure of the surface of the planet. As a consequence, he expressed his conviction that the canals are only the summation of a complexity of detail, comparing them with the linear appearance to the naked eye of an irregular stream of sunspots. This is the key to the whole question. "I quite agree with you," says so high an authority as Professor Barnard, in a letter to the writer, "in respect to Mr. Maunder's work in trying to clear up the tangle about the canals of Mars. I think he has thrown much light on the subject."

Many able observers believed that Schiaparelli had imagined all his system of spider's webs. But this is quite unfair, as, with the exception of an abuse of magnification, the errors of Schiaparelli were errors of judgment, and not of observation. Although the constant use of high powers made him lose the half-tones of Mars, his outlines of the dusky areas are usually more accurate than anything ever drawn with a telescope of the size he used.


FIGURE 186. Schiaparelli. 1883–1884.


FIGURE 187. The Writer. 1909.

The "Canals" Laestrygon, Antaeus and Tartarus, as seen in an aphelic apparition with an $8\frac{1}{2}$-inch, and in a perihelic apparition with a 33-inch Refractor.

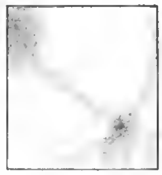


FIGURE 188. Schiaparelli. 1883–1884.

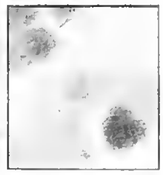


FIGURE 189. The Writer. 1909.

The "Canal" Eosphoros in an aphelic apparition with an $8\frac{1}{2}$-inch, and in a perihelic apparition with a 33-inch Refractor.

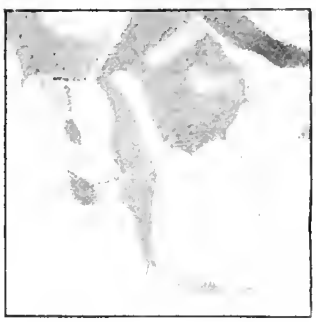


FIGURE 190. September 18. V. Fournier. Jarry Desloges Observatory. $11\frac{1}{2}$-inch Refractor.

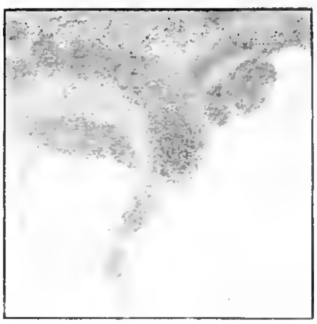


FIGURE 191. September 20. The Writer. Meudon Observatory. 33-inch Refractor.

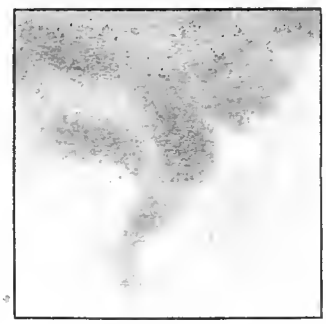


FIGURE 192. October 5. From a photograph by Professor Hale. 60-inch Refractor.

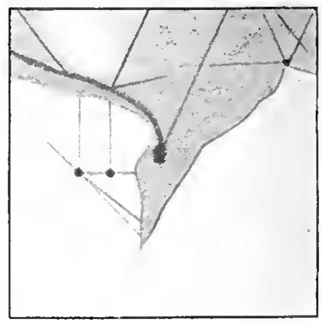


FIGURE 193. November 3. Professor Lowell. 24-inch Refractor, stopped down to some 15 inches.

Views of Syrtis Major and Lacus Moeris in 1909 with various telescopes.

As a patient record of fleeting impressions, his results stand unrivalled; while his splendid triangulation of the Martian surface has victoriously resisted the test of time.

An unsympathetic feature of most planetary drawings is the regularity of their markings. Scientific candour is partly responsible for this, as the truthful observer will avoid the impossibility of sketching complex irregularities which he is only glimpsing, rather than introduce elements of doubt in his delineation. A less excusable reason for geometrical outlines may be sought in a widespread disregard of angular diameters. In fact, areographers too frequently forget that Mars is usually seen as a sixpenny piece held at the distance of two feet from the eye; and that what is sharp on such a small disc, so far off, ought to be represented as exceedingly vague on drawings three inches in diameter, seen at the distance of one foot only.

The student who passes many consecutive hours in the study of Mars with medium-sized instruments, is liable to catch rare glimpses of straight lines, single or double, generally lasting about one quarter of a second (see Figures 184 and 185). Here we have a vindication of Schiaparelli's discoveries. But their deceitful character will obtrude itself on the observer using a large telescope, when, in the place of the lines, he will hold steadily, either a winding, knotted, irregular band, or the jagged edge of a half-tone, or some other complex detail (see Figures 186 to 189).

In their anxiety to prop their views against natural law, believers in the reality of the linear canals have presumed to champion the alleged superiority of small over large telescopes; and this

Figure 194.
1911. October 28^d 22^h 19^m.
Longitude = 58°.

Figure 195.
December 4^d 22^h 0^m.
Longitude = 87°.

Figure 196.
October 20^d 21^h 35^m.
Longitude = 120°.

Figure 197.
October 17^d 21^h 55^m.
Longitude = 152°.

Figure 198.
October 14^d 23^h 0^m.
Longitude = 195°.

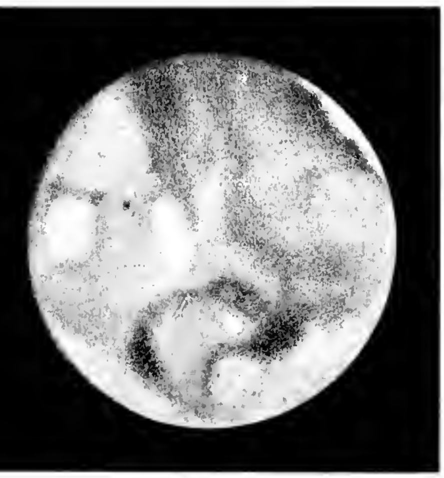


Figure 199.
October 14^d 21^h 30^m.
Longitude = 255°.

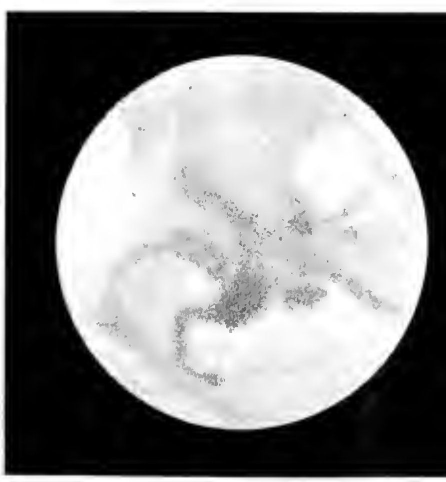


Figure 200.
November 13^d 22^h 45^m.
Longitude = 282°.

Figure 201.
November 6^d 22^h 15^m.
Longitude = 337°.

Figure 202.
November 3^d 21^h 48^m.
Longitude = 357°.

Observations of Mars in 1911, made by E. M. Antoniadi, F.R.A.S., with the 33-inch Refractor of the Meudon Observatory, magnifying 320, 540, and 810 diameters.

(Published by kind permission of Professor Henri Deslandres, A.R.A.S., of the French Academy of Sciences, Director of the Astro-physical Observatory of Paris, situated at Meudon (S.-et-O.), France.)

either in revealing planetary detail, or in separating close double stars. But the attempt has been defeated, both by theory and observation: (*a*) by theory, because of the law of diffraction, which proves that the defining power of a telescope increases with its aperture; and (*b*) by observation, from the evidence of the facts themselves. A comparison of the appearance of Syrtis Major on Mars with various instruments in 1909, when the weaker telescopes revealed inexistent lines while failing to show the coarsest details (see Figures 190 to 193) will establish for ever their hopeless inferiority. Nor was the smaller instrument more fortunate on double stars. A spurious satellite to Sirius was discovered and measured in an impossible position in 1896, with a refractor of moderate power. But when the question of finding the true satellite was seriously raised, the discovery was naturally made with the thirty-six inch equatorial of the Lick Observatory, one of the most powerful instruments in existence.

Thus it is that diffraction fetters the efficiency of small telescopes; and their comparison with large ones is as childish as the attempt to bombard a fortress twenty miles off with guns whose range is only eight.

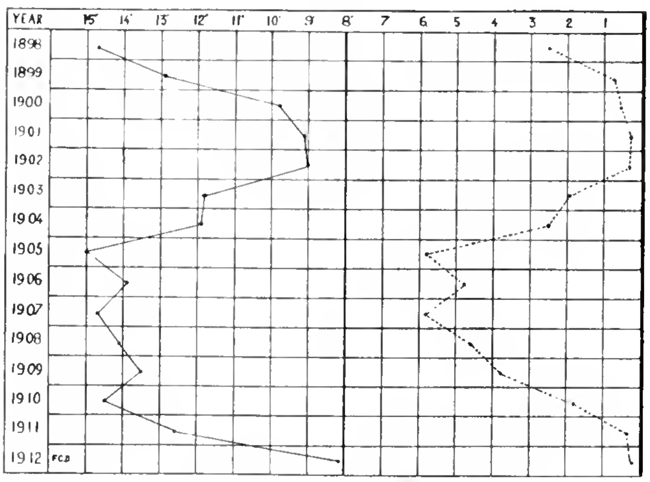
Such the errors foisted on the scientific world, and such the arguments leading to their final refutation. Yet truth will seldom receive acceptance without strenuous opposition. The laws of perspective will again be curbed by the evidence of lines appearing straight in all positions of a rotating globe. Some observers will continue proclaiming the superiority of small telescopes. Ponderous volumes will still be written to record the discovery of new canals. But the astronomer of the future will sneer at these wonders; and the canal fallacy, after retarding progress for a third of a century, is doomed to be relegated into the myths of the past.

STONYHURST COLLEGE OBSERVATORY.

By FRANK C. DENNETT.

The report of this useful observatory for the year 1912 has just been issued by its Director, the Rev. Walter Sidgreaves, S.J., F.R.A.S. The mean barometric pressure for the year was ·054

Table 39.



Magnetic mean declination range. Mean daily spot area.

inch below the average of the previous sixty-five years, and so lower than 1911. Only in the months of April, September, October and November was it above the month's average; September yielding the highest mean, and March the lowest of the year. The rainfall was nearly seven and a quarter inches above the annual average, for which the excessive rains in March, June, August and November were largely responsible. During March the fall was half an inch above double the usual fall, being 7·205 inches, the greatest during the previous sixty-five years. April proved the finest month, the only one with the duration of sunshine above its average, and its rainfall little more than half its average. The total duration of sunshine during the year was only 927·6 hours, or 409·6 hours short of the annual average, the smallest on record for thirty-two years. The dullest months, March, June, August, and December all yield the lowest number of shining hours previously on record. The year, notwithstanding the small amount of sunshine, proved a mild one, for though the summer was below the average, the winter was above. The mean temperature for the year was 47°·5, or 0°·6 above the average. Only on five days the wind attained the velocity of a gale, the strongest being on April 6th and 8th, when the record stood at forty-five and forty-six miles per hour. Magnetic records appear to be missing on three days, September 30th, November 18th and 19th. Of the rest, one hundred and twenty-four days are recorded as calm, two hundred and twenty small disturbance, eighteen moderate, and only one, October 14th, as great, no very great disturbances being recorded. The mean daily range of the Declination magnet in arc minutes was 8'·1, the lowest of the past eighteen years. The lowest monthly mean daily range, 6'·1, was in January. The mean area of sunspots (in units of $\frac{1}{5000}$th of the visible surface) appears at 0·22. Compared with previous years, together with the magnetic declination range in graphical form, it seems to show that 1912 marks the minimum of sunspot activity. The diagram is constructed by the writer from the Stonyhurst records since 1898, and is perhaps more striking than figures. The spectrum of Nova$_2$ Geminorum was photographed on seven occasions, besides being observed visually on other nights. Gale's and Borelli's comets were both photographed and observed, but not under favourable conditions.

One sentence in the report we note: "It has been decided at the Meteorological Office to reduce the number of its observing stations; and our connection with the office ceases at the end of March. But the automatic recorders are to remain here, and will be kept in active service."

TRYPANOSOMES.

By MALCOLM EVAN MACGREGOR, F.R.M.S.

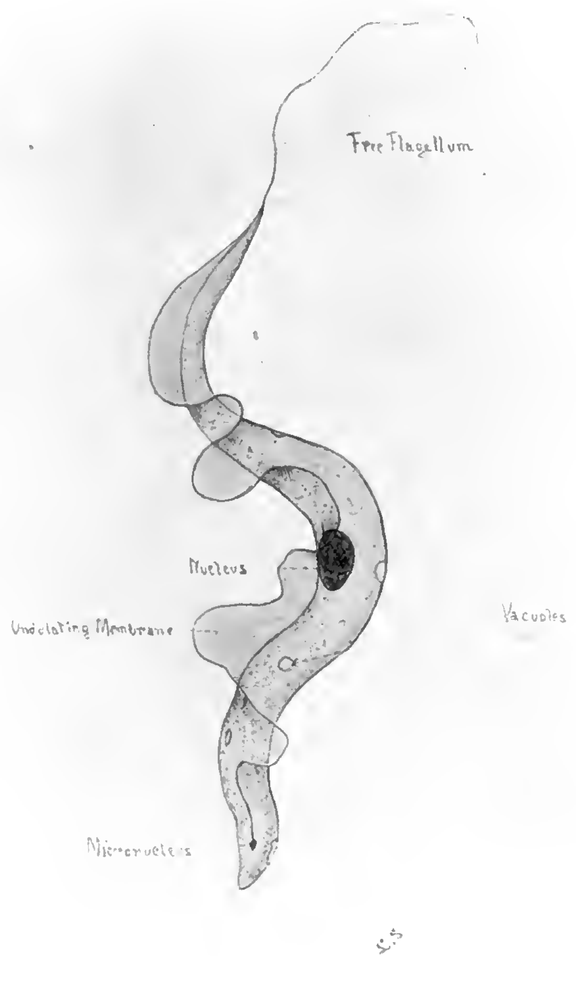
CONSIDERING the great amount of attention trypanosomes have demanded, and are still demanding, in many tropical and semi-tropical countries, it will be the endeavour in this paper not so much to present a scientific or in any way thorough description of the organisms called trypanosomes, but more to give a brief survey of a few of the aspects of general interest that are met with in their study.

Trypanosomes belong, in the animal classification, to the Phylum Protozoa, and are parasites in the blood of vertebrate animals. They are minute unicellular organisms of somewhat eel-like shape, and range in length very widely: from seven to thirty microns being about the commonest variation.

First discovered in the year 1841, by Valentin, in the blood of a fish, they have since been found in the blood of nearly all vertebrates, and while some species of trypanosomes do little, if any, harm to the animal in whose blood they live, and where they may swarm; other species, if present only in the smallest numbers, produce most terrible results.

Such diseases, for instance, as sleeping sickness, Nagana (the fly-sickness of cattle in Africa), Dourine (a horse-sickness in India), Mal de Caderas, of South America, a human disease that occurs in the same country, and many others, are all diseases due to trypanosomes; so that trypanosomes in some parts of the world have to be looked upon as one of man's deadliest enemies: an enemy over which, as we shall see later, he has yet been able to get but the smallest victory.

It was, as already stated, Valentin in 1841 who discovered the first trypanosome, and this he did in the blood of a trout; but it was not until 1880 that Evans, working in India discovered the first pathological trypanosome. This was the trypanosome that produced the disease in horses and camels, called Surra. Fourteen years afterwards, in 1894, came Bruce's discovery of a trypanosome as the cause of Nagana (or fly-sickness) in Africa.



From a Drawing by *Count L. de Sibour.*

FIGURE 203. *Trypanosoma gambiense.*
The most salient structural details of a Trypanosome.

In 1901, Dutton discovered a trypanosome in the blood of a European in the Gambia, which he appears at first not to have quite realised the significance of. In the May of 1903, Castellani, while examining the cerebro-spinal fluid of a native suffering from sleeping sickness, discovered in this fluid a trypanosome, and it was he who first connected the organism with the disease.

MORPHOLOGY.

The Morphology is extremely simple (see Figure 203). The body consists of an elongated mass of protoplasm tapering anteriorly to a fine point, and ending posteriorly rather more bluntly. The body protoplasm is often very granular, and often shows vacuoles in it.

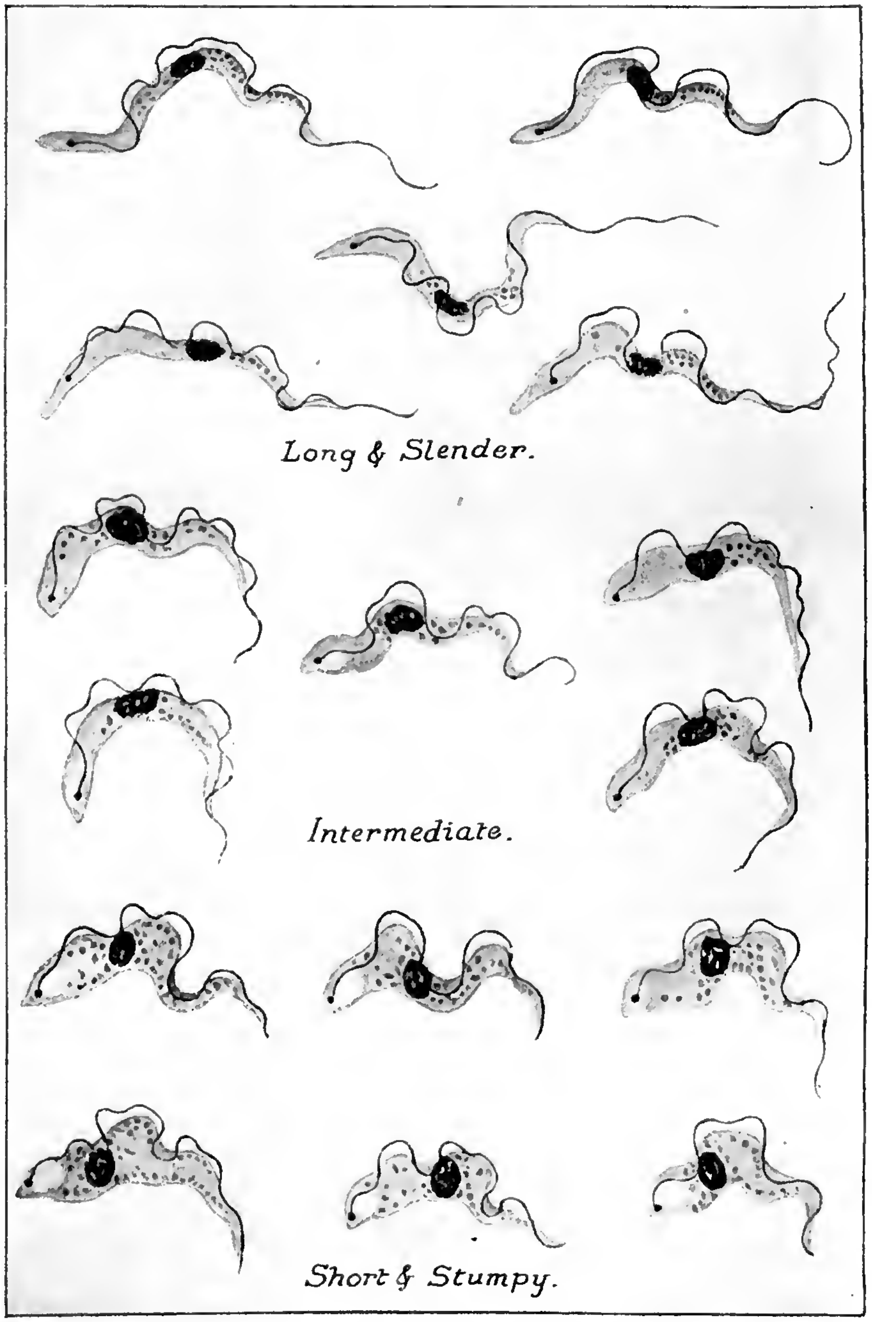
About the centre of the body the structure known as the nucleus is generally situated, but oftentimes it is found more anteriorly placed, and at other times it is in quite a posterior position. In shape the nucleus is usually oval or resembling the shape of a bean, and stains a dense purple-blue colour with the ordinary trypanosome stains. The chief function of the nucleus is thought to be the governing of the functions of the protoplasm (the metabolism and katabolism), and it is hence sometimes called the "tropho-nucleus" to distinguish it from another small mass of nuclear material that occurs in the

* Being the subject-matter of a lecture delivered before the Cambridge Natural History Society, February 20th, 1913.

body of the organism, namely, the Micronucleus. This occurs usually quite posteriorly in the body, and it is thought that its function is to govern the movements and reproduction phases, and hence it is sometimes called the "kinetonucleus."

The "undulating-membrane" is a fin-like ridge or fold of the body protoplasm, and lies to one side of the body. Being longer than the body-length, as will be seen in the illustrations, it is cast into many wave-like folds. It is a very delicate membrane of very variable width, being in some trypanosomes so narrow that it is almost impossible to make out: at other times it is considerably broader even than the body-width. It constitutes an organ for swimming.

From the micronucleus there arises a thread of nuclear material called the "flagellum," which runs forward anteriorly along the body, bordering the extreme edge of the undulating-membrane, as far as that goes, and then proceeding beyond the anterior end as a free thread or lash, called the "free flagellum." This may extend to twice the body-length. Its purpose is also for swimming.



By permission of The Tropical Diseases Bureau.

FIGURE 204.

Trypanosoma gambiense × 2,000, showing types. After a plate by Lady Bruce (Royal Society Proc. B. vol. 84.)

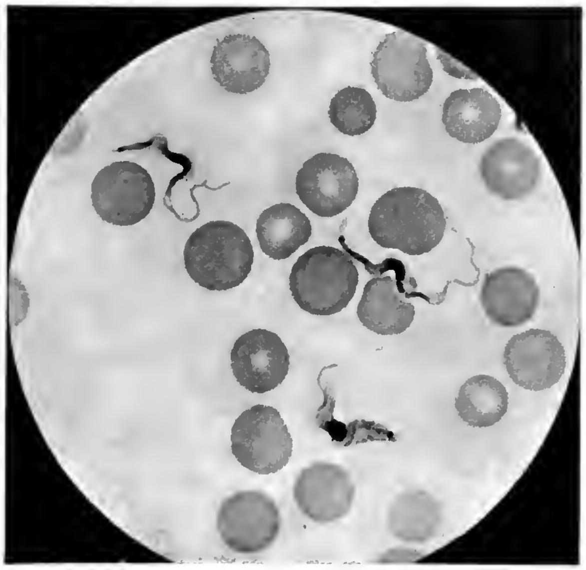
Trypanosomes are essentially very "lively" creatures, and most, while capable of swimming actively in the blood by means of the undulating-membrane, and free flagellum, are also capable of wriggling and twisting movements. All the movements in healthy trypanosomes are generally very violent, and the blood corpuscles are thrown in all directions as the organisms dart here and there.

The movement of the undulating membrane has been very aptly compared to the flapping of a boat's sail that has "lost the wind." It is an exceedingly graceful movement, and travels as a rippling wave over the entire membrane. The direction of the waves vary according as to whether the animal travels backwards or forwards. The movements of the flagellum are almost impossible to make out as only their effects on the surrounding medium give one any indication of what they are; but they must obviously be some systematic series if they are to benefit progression. It is due to the rapidity of the movements of trypanosomes, that trypanosomes, while they are living, are such extremely difficult subjects to study. In the case of *T. vivax*, a particularly lively creature, all that can be seen in the medium in which it exists are rocket-like paths as the trypanosome dashes across the field of the microscope.

Trypanosomes multiply in the blood of their hosts.

by longitudinal fission. The micronucleus is first seen to divide into two, splitting, as it does so, the flagellum into half, so that each of the two new micronuclei has a strand of the flagellum attached to them. The splitting of the flagellum then proceeds through the whole length, the nucleus divides into two, and by fission in the protoplasm, the organism becomes two separate individuals, usually of unequal size. The reproduction phase probably has a far more complicated cycle than this, however, even when reproduction in the blood of the host is only considered, to which the above description refers: but beyond this fission-method of reproduction nothing is yet sufficiently definitely known to need mention here. In the alimentary canal and salivary glands of the tsetse-fly, the reproduction phase of trypanosomes is exceedingly complex.

The remarkable diversity in size and shape that is found in trypanosomes of any one species living in the blood of an animal is striking. They may vary from slender organisms of great length, possessing highly developed undulating membranes, and long free flagella, to quite short, stumpy organisms entirely wanting both these appendages. What the complete significance of this series is we are at present unable to say, but some are probably younger individuals, and it seems likely that the stumpy type are of a more resistant kind than the long type, since it is they that are most numerous in the blood when the host is fighting the disease, or when drugs are given to the animal that render its blood unfavourable to the development of the trypanosome. Figures 204 and 205 show various types of the same organism.



By permission of Professor Minchin and The Cambridge University Press.

FIGURE 205.

Trypanosoma gambiense from blood of rat. × 1,000.

(Smear fixed out with osmic acid vapour, and stained by Giemsen. A slender, a stumpy, and ao intermediate form are seen. From plate illustrating Professor Minchin's paper in Parasitology, I. No. 3.

Natural size.

Magnified 13 diameters.

By permission of The Tropical Diseases Bureau.

FIGURE 206.

Glossina palpalis Rob-Desv. The tsetse fly.

A good representation of the resting fly, but in life the palpi would be appressed and light would not be visible between them From a photograph by Dr. W. M. Graham, Director of the Medical Research Institute, Lagos, S. Nigeria.

DISTRIBUTION.

Trypanosomes occur all over the world, and those found infecting wild animals in nature, are, as a rule, quite specific to a particular host, and so far as can be observed, perfectly harmless to it, but there are some which infect man and animals, and are highly pathogenic. Such, for instance, is *Trypanosoma gambiense*, the parasite that produces Sleeping Sickness. It is pathogenic to all animals as well as man. *T. brucei*, the trypanosome that is so deadly to the cattle and domestic animals in Africa, gives rise to the disease called Nagana or Fly-sickness; but it is *harmless* to man, for it is unable to exist in his blood.* An example of a trypanosome that is harmless to its host is to be found in *T. lewisi*. This trypanosome is quite specific to rats, and though it may swarm in the blood, so far as can be seen, it has no harmful effect on them, and as soon as the infection has reached a certain stage the number of trypanosomes steadily decreases in the blood, finally disappearing altogether, and leaving the rat quite immune to a second infection.

A marked contrast to this state of affairs is found in the case of the trypanosome of sleeping sickness. Here, at no time in the course of the disease in man and many animals, are the trypanosomes ever very numerous, and though their deadly effect may be highly manifest in the infected animal, their presence in the blood may be exceedingly difficult to detect, owing to the extreme scarcity of the parasites.

* Since the above was written it has been stated, positively, that the cases of sleeping sickness in Nyasaland are due, not to a specific trypanosome called *T. rhodesiense*, but that this trypanosome (*T. rhodesiense*) turns out to be none other than *T. brucei*, i.e., the parasite that produces Nagana. (See paper by Sir D. Bruce and others, Royal Society's Proceedings, Biological Section, April 7th, 1913). This shows how indefinite much of our knowledge of these organisms still is. For all there is to the contrary, we may very well find ere long, that one half of what are looked upon as distinct species, are one and the same organism, altered slightly, it may be, by its adaptation to different environments.

Trypanosomes depend for their transmission from one animal to another, with very few exceptions, on the agency of blood-sucking invertebrates, which we may call "the carriers."

Thus the trypanosomes of fishes are transmitted by leeches from one fish to another; the trypanosomes of rats, by the rat-flea; the human trypanosome (*T. cruzi*) of South America, by a hemipterous insect; the trypanosome of sleeping sickness and the cattle disease of Africa, by a blood-sucking fly of the genus *Glossina*; and so on.

The trypanosomes having entered the alimentary tract of the carrier in a meal of blood from an infected animal, there undergo a developmental cycle, and it seems most probable that not until this cycle is complete are they able to infect other animals, when the blood-sucking fly or carrier feeds. They enter the blood stream of the new host in the secretion the fly pours out through its proboscis preparatory to commencing its meal.

Distributing Factors.

Glossina palpalis, (see Figure 206) the carrier of sleeping sickness, is a fly not unlike a common house fly in appearance, though it has a proboscis for piercing the skin of animals in place of the house-fly's suctorial pad, or so-called tongue. There are fifteen different species of *Glossina* already known, but only two or three of these species can be incriminated in spreading disease, as it has been found that only particular species can act as carriers of trypanosomes. All the flies of this genus, except for minor differences in the species, have much the same life-habits, so that a description of one will more or less apply to all. We will deal with *palpalis*.

This fly, like several species of tsetse flies, lives near the banks of rivers or lakes, and is found, fortunately, in only a comparatively small area of Africa's vast extent. The fly is not naturally infected, but has first to partake of a meal of infected blood before it becomes so. It then only is capable of infecting people, when it bites them, after a certain interval has elapsed—a few hours—and the period while it is capable of infecting people lasts only for a certain number of days. To become reinfective the fly must again feed on infected blood. Both sexes suck blood, and it is in the early morning and at sundown that they are most vigorous in this pursuit. Rarely they feed at night-time, when the moon is bright. The fly having settled and pierced the skin of its victim, can become gorged with blood in from twenty to thirty seconds. The bite is hardly more painful than that of a mosquito or gnat, and there is a similar slight swelling at the site of the bite. The name "tsetse" is a Zulu word, and is supposed to describe the peculiar high-pitched buzzing of the insect's wings in flight, as it passes within one's range of hearing.

It has been calculated that the number of flies that are infected at any one time is small, and so a bite from one does not necessarily mean to contract sleeping sickness; but the fearful havoc that even this small percentage can work will be understood when it is said that between 1901–1912 in Uganda alone, a very low estimate of the number of victims is about one hundred and fifty thousand to two hundred thousand people. Whole tribes of natives have in some cases been exterminated.

The flies do not lay eggs, but produce their young, one at a time, in the pupa stage. These they deposit in the dry sand below the undergrowth on the bank of watercourses, and the pupae, burrowing their way a few inches below the surface, there undergo a metamorphosis, and ultimately emerge as fully developed flies. This metamorphosis is completed in about six weeks.

These are quite healthy, and as already said, cannot cause disease by their bites until they have fed on the blood of an infected animal. Therefore, the question naturally arises, "Where is the reservoir of the disease by which these flies become infected?" That question cannot unfortunately be quite satisfactorily answered at present. The big game of those parts have been blamed, and although it has not been definitely shown yet that they are responsible, evidence is every day accumulating against them.

It was at first thought that the crocodile was the reservoir, as *palpalis* was known to feed on them, and in their blood was very commonly found a trypanosome very similar to *T. gambiense*, and which was at first mistaken for it. But it has now been proved to be a different parasite.

(To be continued.)

NOTICES.

"LIQUID AIR OXYGEN NITROGEN."—Messrs. J. and A. Churchill announce that they are about to issue a translation of this book, which is by Mr. Georges Claude. It will be of particular importance to Agriculturists in this country, as considerable attention is devoted to Nitrogen.

CATALOGUES.—We have received Mr. John Wheldon's Entomological Catalogue which contains the titles of about fourteen hundred books and papers dealing with all orders of Insects, together with Spiders and Myriapods.

Mr. Charles Baker's classified list of second-hand instruments for April, 1913, is before us, and should prove as useful as any of its predecessors.

MISS FLORA WINSTONE.—We very much regret to hear that Miss Flora Winstone, for many years assistant editor of *Hardwicke's Science Gossip*, died on the 22nd March at South Norwood.

PHOTO-MICROGRAPHY.—We would remind our readers that the demonstrations on this subject which Mr. Senior is to give begin on Monday, May 5th, at the South Western Polytechnic.

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

JUNE, 1913.

PROBLEMS OF PLANT LIFE.

1. EVOLUTION AMONG LOWLY FORMS (THE ALGAE).

By S. REGINALD PRICE, B.A. (Cantab.).

Ever since the publication of Darwin's great work, one of the chief aims of the biologist, in studying organic nature, has been the establishment of a scheme indicating the real evolutionary relationships of forms, or, to use the more stereotyped expression, a natural system of classification.

In the plant kingdom certain lines and tendencies within the great groups have been established with a high degree of probability, chiefly from evidence of comparative development, of reproductive structure, and of the fossil record. Of the origin of the great groups themselves, theories and speculations have been numerous; but they are nothing more than bare possibilities, and, perhaps, hardly that in some cases. If, as seems rather probable, all plants evolved from a common stock, the divergence took place countless ages ago, but the voice of the rocks is silent on this question.

Assuming, however, such a common group, it is almost certain that its members were aquatic, and so it seems reasonable to expect that the more primitive members of our existing flora will be found in such an environment. All the evidence goes to show that the Algae as a group—comprising plants almost as simple as may be imagined as well as the quite complex bodies of the higher seaweeds—have never lost their aquatic habit, and so, presumably, the group as a whole has not suffered that great change in the course of evolution which must have accompanied the adoption of the terrestrial mode of life. It has, therefore, been interesting to examine this group carefully, with a view to throwing some light on the evolution of plant-forms within it, and thus indirectly obtaining a dim and indistinct reflection of the process of elaboration of the "Proto-plants."

The evidence has been confined to the study of existing species alone, for the few fossil Algae, often of very doubtful identity, are quite useless as indications of the phylogeny of the group. When, therefore, an evolutionary line is spoken of in this connection, it must be remembered that it represents a series of related species, not necessarily and most often probably not directly related in a single line of descent, but nevertheless giving an indication of the tendency which has led to the elaboration of the various forms. Exactly what is meant may be illustrated by considering several obviously related forms, which may be indicated by the letters A to G, the last being presumed to possess the most complex organisation of the series. Without considering the factors at work, there is reason to suppose that the form A has retained more primitive features and undergone less alteration than B, and so for each succeeding form, the climax of the series being represented by G. The diagram (Figure 208) represents this in a crude manner; the lines running from left to right indicate progressive evolutionary tendencies, while those running vertically indicate branches from the stock, which have undergone comparatively little modification, and which terminate in living species. The real direct line is from P, the primitive type, to G, while the so-called evolutionary series is represented by the forms A to G. The conception must usually be understood in this sense, and the *Volvox* line considered below may be cited as a concrete example.

Collective evidence has shown that the main lines of progressive evolution in the Algae have probably diverged from a group represented to-day by the Flagellata, a complex of minute organisms lying on the border line between the animal and vegetable kingdoms. These Flagellates, as their name indicates, are ciliated free-swimming "creatures," often saprophytic in their mode of life, of which some members are colourless, some possess chlorophyll alone as a pigment, while others are coloured yellow, brown or red by substances closely allied to or often, perhaps, identical with those present in the brown and red sea-weeds. There is no need to consider these organisms further here.

Those forms, which are unicellular and motile throughout the greater part of their life-history, seem to illustrate the types of Algae which are nearest to the primitive forms and to their hypothetical progenitors, the Flagellata. Considering for the present the green Algae or Chlorophyceae alone, such forms are found in the order Chlamydomonadaceae (of which the genus *Sphaerella* is a well-known type), and various authors have taken the genus *Chlamydomonas* as a primitive type, and have outlined systems of classification indicating the probable lines of evolution from this.

Chlamydomonas, or the common pool-alga *Sphaerella*, which is very similar, is unicellular, with a

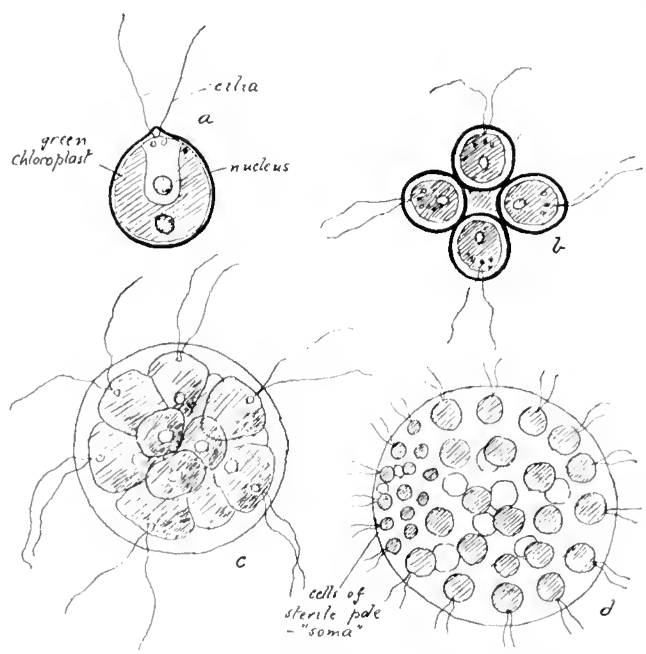


Figure 207. Some forms of *Volvox* Line. Diagrammatic.
a. *Chlamydomonas*. b. *Gonium*.
c. *Pandorina*. d. *Pleodorina*.

single nucleus and chloroplast, and possesses two fine protoplasmic cilia attached to a small beak-like projection at the anterior end of the cell. It is motile by means of these cilia throughout the greater part of its life-history. Reproduction takes place by simple fission of the cell contents, or by conjugation of gametes. Under unfavourable conditions, the cells may go into a non-motile resting condition.

Starting from such *Chlamydomonas* forms, three main series may be recognised among the lowlier Algae leading to the establishment of three distinct

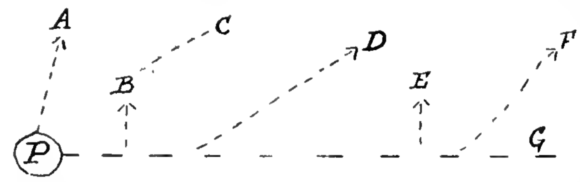


Figure 208. Diagram illustrating the evolution of forms.

types of thallus: one to the formation of colonial bodies, one to the filamentous and plate-like forms, and the third to the so-called siphoneous or coenocytic type of plant body. The organisation of these various types of plant body will be more fully described when we consider the several lines in detail.

The Volvocineae comprises a series of genera and species which have long been recognised as closely related, and they seem to illustrate well the stages which have probably led to the development of a free-swimming colony. In *Gonium* there is an association of four or sixteen cells, each like *Chlamydomonas* provided with two cilia, the whole colony being in the form of a flat square (see Figure 207, b). There is a non-motile resting period when asexual reproduction takes place—simply by the division of each cell to form a new colony. *Pandorina* is slightly more complex; there are sixteen cells arranged in the form of a closely packed sphere. The cells are all alike, each with its two cilia, and any cell of the plant can divide to produce a new colony or coenobium as it is called. *Pleodorina* has the cells at one end wholly vegetative and smaller than the rest—the first real indication of the structural unity of state—and the sterile cells represent an incipient vegetative body or "soma" as opposed to the portion concerned in reproduction alone (see Figure 207, d). *Pandorina* is quite common in freshwater pools and ditches in this country, but *Pleodorina* does not seem to occur. The culminating type of the line is *Volvox*, well known to all microscopists. The colonies here consist of several thousand cells arranged in the form of a hollow sphere, and there is a definite sterile pole. There is a fairly high type of sexual reproduction besides the asexual method by division of the parthenogonidia. The unity of the whole colony is still more pronounced than in the other types, for the cells are in connection with one another by means of fine protoplasmic threads, which connecting threads have not been detected in other colonial forms of this group. These genera may be arranged in a series as shown in the diagram (see Figure 209). The evolutionary

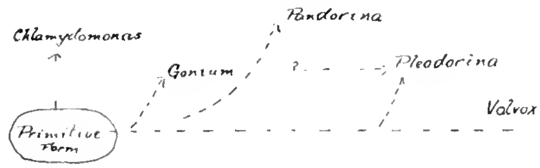


FIGURE 209. Possible scheme of Evolution of *Volvox* Line.

tendency represented by the base line may thus be read as one leading to the association of motile cells to form a free-swimming colony, and to the elaboration and differentiation of the coenobium. It appears that this line has led no further than to *Volvox*, possibly owing to the instability of the large body of loosely connected cells.

The manner of derivation of the filamentous and thalloid types is by no means so clearly indicated by living forms, but still a line can be traced with a fair degree of possibility through the Tetrasporaceae. Essentially, the filament is a segmented tube, each compartment representing a single uni-nucleate cell. Many of the simpler forms, *Ulothrix*, for example,

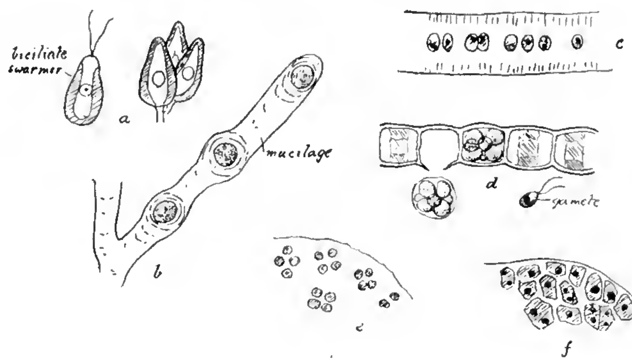


FIGURE 210. Some types of *Ulothrix* and *Ulva* Line.
a. *Chlorangium*. b. *Hormotila*. c. *Radiofilum*.
d. *Ulothrix*. e. *Tetraspora*. f. *Monostroma*.

produce zoöspores which are substantially of the *Chlamydomonas* type, indications of the retention of primitiveness in the reproductive condition. Evidently if these filaments and plates have been so evolved, there took place an increase in the length of the resting periods, and an association of the resting cells to form a chain or flat plate. A few examples from the Tetrasporaceae will show that there is certainly some evidence for such a process.

In *Chlorangium* the swarm-spores attach themselves, develop a short stalk, and divide to form tree-like growths of which any one cell may detach itself and act as a bi-ciliate swarmer. The significance of this genus is rather the marked non-motile stage in the life-history. In *Hormotila* the spherical cells are enclosed in cylinders of mucilage, and the whole association shows some approach to the filamentous condition. Each cell can produce zoöspores by division. *Radiofilum* is still nearer to the filamentous condition (see Figure 210, c). None of these genera is at all common. On the other hand *Tetraspora*, a somewhat common alga, builds gelatinous aggregations of indefinite shape, the spherical cells being arranged in groups of four in the mucilage. *Monostroma* is somewhat similar, but forms a definite plate one cell thick, and on account of its thalloid type of body is generally placed in the Ulvales. These two lead to the genus *Ulva*, a common green seaweed, where the thallus is quite definitely two-layered and more highly differentiated.

A general tentative scheme for the evolution of simple filamentous and plate-like forms is shown diagrammatically in Figure 211.

From the simple *Ulothrix* type a series showing various higher degrees of differentiation may be traced in the plexus of orders called the Ulotrichales, but the consideration of these would lead us into a mass of details rather to be avoided in a purely general outline.

The third main line has probably led to the so-called coenocytic type of thallus, where the plant body is unseptate or nearly so, but each "cell" thus formed is multi-nucleate. The living forms in the Chlorococcineae, none of which is very generally known, however, seem to lie near the root of the siphoneous type. Without going into detail, then, it may be said that *Pediastrum* (a common moorland alga) and *Hydrodictyon* (the beautiful, but rare, "water-net") are really colonies of many multi-nucleate "cells." *Protosiphon* is obviously a fairly primitive member of the Siphonales, possessing a hollow, sac-like coenocytic body. The more highly differentiated members of this group will not be considered, but it may be interesting to note that many of them, like *Caulerpa* or *Acetabularia*, are beautiful forms inhabiting the warmer seas.

It is obvious that our present flora must represent very many lines of descent, which have branched

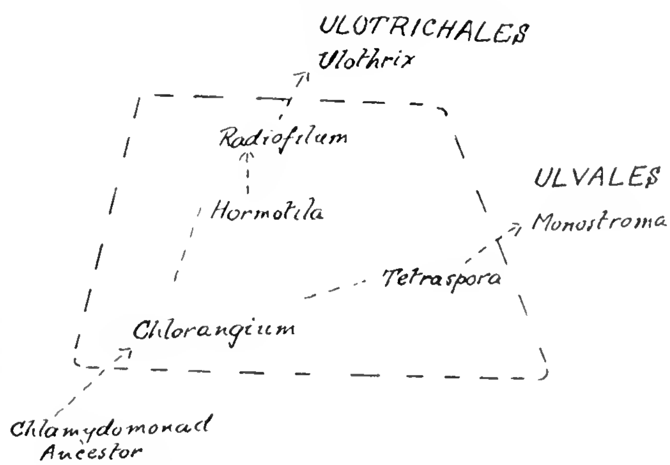


FIGURE 211. Possible scheme for *Ulothrix* and *Ulva* Line.

into new lines over and over again. The well-worn simile of the tree and its branches will once more serve to illustrate this. The "tree of the Green Algae" has its trunk represented by the main line of evolution from the Flagellata, and then it may be supposed to branch into three—the three lines which have been considered. The Volvocine branch is probably short and with little ramification; the others fork repeatedly, producing finer and finer branches and twigs. The leaves of the tree alone represent existing forms, but here the simile rather breaks down; for it must be supposed that the leaves nearer the top of the tree are more highly evolved than those lower down. The trunk and branches are obscured in the mists of the past, and our problem is to indicate these from a knowledge of the leaves alone. The postulated arrangement of the leaves must give considerable help, but the impossibility of complete solution is patent.

It must be remembered that not one of these proposed modifications in evolution has actually been observed to take place, and the position and basis of the scheme are theoretical. It is quite impossible to dogmatise on any problem of evolution, at least in the present state of our knowledge, and different schools of thought may read quite a different interpretation into the facts.

The forms which have been considered here are all characterised by the bi-ciliate type of zoöspore or gamete, with equal cilia, when any are produced, and this has been thought of sufficient importance to mark off the group, which has been called the Isokontae by Blackman and Tansley. Space does not permit of the discussion of the other groups, but there is evidence that the "coloured seaweeds" have been evolved directly from coloured Flagellates, while the *Oedogonium* forms and the Conjugatae, including the Desmids, and so on, may have sprung from the Isokontan stock.

It is impossible to doubt the great fact of progressive evolution when confronted with this and similar series of organic types. Most of the great underlying principles and laws of the process are still to be elucidated, however. The Algae appear to be still plastic, and further study and observation should at least help us to grasp some of the forces and influences which are at work in the production of a new species in the world flora.

ELECTRICAL CONDUCTIVITY IN THE SERVICE OF BACTERIOLOGY.

By DR. ALFRED GRADENWITZ.

INTERESTING experiments have recently been made by Dr. M. Oker-Blom, Professor at Helsingfors University, on the possibility of utilising the electrical conductivity of bacteria cultures for obtaining useful data on the nature of bacteria and the biological phenomena occurring in these cultures.*

The electrical conductivity of an electrolyte is known to be reduced by the presence of non-conductive substances such as sugar, albumen, and so on, the more so as the amount of these substances is greater. This reduction of conductivity has further been shown to depend on the nature both of the electrolyte and the non-electrolyte, being accounted for by some sort of friction between the ions and non-conductive molecules. If, now, a culture solution containing albumen or sugar, or both of these, be submitted to such conditions that these substances will undergo chemical scission, the conductivity of the system is bound to be influenced in some way or other. On one hand, the conductivity of the culture liquid is increased by reducing through chemical scission the amount of non-conductive substance; if, however, the substances newly formed should likewise be non-electrolytes, the total amount of non-conductive substance in the solution will, as a matter of fact, be increased, and variable effects will be observed according to circumstance. Far more marked effects are, however, obtained whenever new electrolytes are produced in the liquid, and as acids and alkalis are the most highly conductive of these, any variation in the acidity or alkalinity of a culture liquid as produced by bacterial influences is bound to manifest itself in the conductivity of the liquid.

Dr. Oker-Blom has made three parallel series of experiments comparing the respective influences of two bacteria (*Bacterium coli* and *Bacterium typhi*) on the electrical conductivity of culture liquids. The glass vessels used in this connection had been specially constructed on his suggestions, and contained strictly equal amounts of liquid. After their inlet and outlet openings had been stopped with small pads of wadding, they were introduced into a water thermostat, maintaining them at any constant temperature desired, where the electrical conductibility of the liquid could be watched at any moment.

The curves reproduced in the original memoir give an excellent idea of the behaviour shown by the conductivity of culture liquids under the influence of the two bacteria. In the first series the conductivity curve of the *coli* bacteria is found to rise considerably already after two days, and even more rapidly on the third and fourth days, in order afterwards only to rise by degrees somewhat further. The conductivity curve of *typhi* bacteria shows a quite different behaviour. After exhibiting, during the first five days, only a slight tendency to rise, it will rise abruptly on the fifth day, and continue rising in a marked degree from the seventh to the tenth day. After a slight further rise, it eventually approaches towards the *coli* curve, though not reaching it entirely during an eighteen days' experiment. The two curves show between the second and the fifth day the greatest mutual departures.

The liquid used in this connection was Fraenkel's culture liquid, with a slight addition of soda. The two other series of experiments, made with the same liquid, containing one per cent. of lactose and glucose respectively, gave quite similar results. During the first two days a very satisfactory agreement between the curves of conductivity and those of acidity or alkalinity was noted.

These experiments go to show that the bacteriological variations in the electrical conductivity of culture liquids are really determined by products of chemical scission (neutral, alkaline or acid). Though, being only the collective expression of bacterial decomposition, the electrical conductivity thus gives a fairly good idea of the actual phenomena, and as the conductivity curves for each kind of bacteria show some specific features, they might prove useful in detecting these bacteria for the purposes of diagnosis.

* *Centralblatt f. Bakt., etc.*, I., Numbers 4–5, 1912.

WHY ARE WE RIGHT-HANDED?

AN UNBIASED BIOLOGICAL ENQUIRY.

By LEOPOLD KATSCHER.

ALL the more important manual actions are accomplished by the right hand rather than the left. It is the right hand that is used to hold the sword, tool or pen, the right that shakes hands with another, that gesticulates, gives the sign of blessing, takes part in various ceremonies, and so on. The place of honour is conceded to the right hand. In German and French an awkward person is termed "linkisch" and "gauche" respectively. In several other languages "clumsiness" is synonymous with "left-handedness." The English word "sinister" comes from the Latin for "left-handed."

Shortly before his death Thomas Carlyle wrote: "What extraordinary preference is given to the right hand by all mankind! It is probably a matter of the very oldest human organisation. I wonder whether a people exists that makes no difference between the two hands. . . . Why just the right hand should be chosen is an unanswerable question not worth asking, unless it is to be treated as a conundrum. Probably the matter originated in fighting habits, for the left hand shields the heart and surrounding parts better, and is the more suited to carry the shield."

What was considered as inexplicable by the sage of Chelsea later investigators have regarded as well worth research. This is particularly the case with Sir Daniel Wilson, who also offers a plausible explanation in his work on left-handedness, in which theoretical investigation is combined with practical observation, for he was himself left-handed.

It is a fact that many people are left-handed—how does this arise? Is the general use of the right hand alone a rooted, inherited consequence of a primeval habit of mankind? Or is it to be attributed to natural and, therefore, more or less immutable causes of a physical and constitutional nature? To become clear on the subject, investigation must first be made as to the degree in which right-handedness prevailed in the past and does prevail in the present, and whether there was a time when both hands were used indifferently, or whether this has never been the case at all. The celebrated novelist, Charles Reade, who was able to use both hands with the same skill, and justly urged the training of children to practical ambidexterity, declared himself for the first hypothesis (that in former times no difference was made) in his "Coming Man" (1882), and asserted that there are still savage tribes among which no preference is shown for any one hand. If such is the case, the preference would be the result of an artificial habit acquired later. A recent investigator, Dr. Ernst Weber, also expresses his conviction that there was a time when men used both arms indifferently. At that time, those who happened to choose the right arm for fighting had the advantage of shielding their hearts as they pushed forward with the right side foremost. "Thus more left-handed than right-handed men perished before begetting progeny, and the right-handed were, therefore, more often able to transmit their habit of fighting with the right, and so their numbers increased," while the left-handed, who became ever fewer, endeavoured to overcome their pernicious habit till right-handedness became all but general. Dr. Manfred Fränkel believes this theory to be in accord with fact, as it may be concluded from the statues that have come down to us, that in the Stone Age there were many more left-handed people than there are now. He adds: "What happened in the fight may soon have been retained in all other manipulations. Practical deliberation caused them to pursue the course of development once begun, and so right-handedness was transmitted by heredity, and superinduced by habit and training to a definite characteristic of humanity."

This hypothesis is not without deficiencies and, therefore, not altogether satisfactory. Sir Daniel Wilson, who devoted many years of study to the subject, has come to quite a different conclusion founded upon archaeological, palaeontological, philosophical, geological and historical researches. As regards the prehistoric cave-dwellers of the Stone Age, Sir Daniel has most carefully examined their flint implements and has come to the conclusion that they were right-handed with rare exceptions. He makes the same inference from the many references in all the known oldest and most primitive languages, as well as ancient writings. The fact that several oriental languages, including Hebrew, are not written from left to right, but in the opposite direction, might at first sight argue for left-handedness, but a closer examination contradicts the supposition. These writings are not continuous, they are separated, so that it is perfectly natural that they should be written with the right hand. A superficial inspection of some of the old Egyptian monuments leads to an inference of left-handedness, but a thorough study reveals this to be wrong. Although in drawing the profile of a face a right-handed artist would depict the left side as a matter of course, and many Egyptian reliefs present faces turned to the right, the reason is not to be found in the possible left-handedness of the sculptors in question, but in deference to architectonic effect. Even when a figure is represented holding a pen or a sword with the left hand, it is only as an exception which is to be traced back to considerations of symmetry and perspective. Where such considerations are not necessary, preference is always given to the right hand. With regard to the monuments of Central America testifying to a long vanished civilisation, it is to be noted that the stone figures mostly face towards the left and will have been chiselled, therefore, by right-handed artists.

Separate designations, in different languages, of the quarters of the heavens also speak for the age and generality of right-handedness. Thus, for instance, the Hebrew word "jamin" signifies both "south" and "right hand." The same is the case with the Sanscrit "dakschina," derivations of which are to be found in most Indo-European languages, and the like is to be met with elsewhere as well. These double meanings originate in the fact that the peoples in question took their bearings from the position of the rising sun, and the south was, of course, on their right. Sir Daniel infers from all this that right-handedness is no chance or mere habit, but is based on our physical and mental constitution. The fact, therefore, that door-hinges and handles, the spirals of a corkscrew, the adjustment of scissors, and hundreds of other objects are all calculated upon right-handedness rests upon valid reasons. This deduction that there must be some physical reason caused Sir D. Wilson to endeavour to discover its nature. There is a great variety of opinion on this point. The celebrated anatomist, Barclay, for instance, a few decades ago, expressed it as his opinion that the flow of blood was less as to quantity and less regular on the left side than on the right; but Professor Buchanan, of Glasgow University, maintained the theory that right-handedness depends upon mechanical laws in connection with the build and position of the intestines; thus the right lung has three lobes and the left only two, and the liver, the heaviest organ of the body, also lies on the right. Dr. Struthers endeavours to strengthen Prof. Buchanan's theory by asserting that the intestines to the right of the median vein weigh twenty-two and three-quarter ounces more than those on the left. But the above-mentioned scholars acknowledge, and acknowledge respectively, that their theory is not able to account for all the phenomena connected therewith. Sir D. Wilson admits that the arrangement of the intestines exercises some influence, but he seeks the chief reason elsewhere—in the relationship between the hands and the brain. As is well known, the two cerebral hemispheres are the centres of the nervous and muscular force in a contrary sense, the left hemisphere governing the right side of the body and the right hemisphere the left side. "Now the left part of the brain *is larger* and *has more convolutions* than the right, and it *also receives a more direct flow of blood*." * In forty brains Broca found the left frontal lobe to be heavier than the right; and Boyd met with the same result in the examination of five hundred brains. It would thus follow that in cases of left-handedness the right side of the brain would, by way of exception, be heavier than the left. Wilson naturally sought an opportunity for a practical test of this conclusion. After several years of expectation, the opportunity was offered by the death of an incorrigibly left-handed soldier in Toronto. In weighing the brain it was then found that the right hemisphere really was heavier than the left.

A rather queer theory has been advanced by Dr. F. Rosenberger. He connects the predominance of the right hand with the apparent movements of the stars, the need of taking orientation bearings in space, and the consequent necessity for an artificial division of the body into two asymmetrical halves, the left one negative and the right positive, as well as with the fact that an inhabitant of the higher latitudes of the Northern Hemisphere, standing with his face to the sun to take his bearings, can follow the sun's course across the sky better with the outstretched right arm than with the left. Leaving other improbabilities out of the question, Dr. Rosenberger's hypothesis must be wrong from the mere fact that the right-handedness of the inhabitants of the Northern Hemisphere would then necessitate the prevalence of left-handedness among the dwellers in the Southern, which, however, is not in the least the case.

An attempt at an explanation made anonymously in the Paris *Nature* is no happier. It maintains that mothers more often present the better-developed right breast to their infants, whose right arm is thus less cramped and more able to make frequent spontaneous movements, so that it strengthens sooner than the left. Text-books on anatomy make no mention of it, and personal information gathered from experts partly denied it and partly maintained the reverse. Nor can the hypothesis be proved that children are more often carried on the right arm than on the left.

Other investigators assign the reason for right-handedness to the asymmetrical position of the heart and point out that owing to the construction of the aorta the right side of the body has a stronger supply of blood than the left, and that the right arm thus has a distinct advantage through the better nourishment of the muscles. The very structure of the heart would, therefore, enforce right-handedness. This, however, is not valid. Apart from the fact that it has been proved practically that it is not difficult fully to develop the left hand, there exist animals, such as the gorilla, chimpanzee, and seal, with a like anatomical structure revealing no trace of a preference for one side or the other. "In fact, it would be absolutely impossible for birds to fly," remarks Dr. Stekel, rightly, "if they were constructed so as to be right-winged."

* This is contradicted by many anatomists of our own day.

According to Bolk, right-handedness is connected with "the better nourishment of the left cerebral hemisphere which is the nerve centre for the right half of the body." According to Biervliet, "the nervous system also participates in asymmetry." Professor Buschan wrote in 1902:—"In a large majority of cases the right side of adult bodies is the more fully developed, with the exception of the left leg. . . . The activity of the nervous system is always greater on the more fully developed side. If the right ear is the stronger it never happens that the left eye sees best. One is born either right-handed or left-handed, and it is impossible to train a left-handed person to be right-handed, or the other way about."

Other investigators deny that it is "inborn" and it is also frequently asserted that left-handedness *can* be overcome. Among the numerous right- and left-handed persons examined by two German doctors, Langstein and Hecht, there was a young soldier who was originally left-handed, and had overcome the habit of chiefly using his left hand, although with difficulty, when learning his trade, and afterwards during his military service, and for years he had worked easily with his right. Yet, whenever he was in need of special dexterity he made use of the left. It seems possible to get rid of left-handedness, not alone by habit, but also by hypnotic suggestion. Such an experiment was made by a doctor on a left-handed child of four. The child's right hand was held when she was in a hypnotic state, and she was told to make more use of it in the future. The effect of the suggestion was surprising, for the girl began to use her right hand more from that time, and after the third treatment given in the course of a few days, she became right-handed, and has remained so. The report in the *Wiener Klinische Wochenschrift* reads:—"Quite apart from its therapeutic success this case is of peculiar interest because the effect of suggestion upon left-handedness seems to establish that even when left-handedness is developed in childhood, already the two cerebral hemispheres may have originally had equal capacities. The case not only argues against the theory that the superiority of the right half of the brain is the cause of left-handedness, but maintains that it must certainly be possible to prevent left-handedness through early training."

The following extracts, published anonymously in the *Frankfurter Zeitung*, are worth noticing. They recall the conjectures of Carlyle and Weber mentioned above. "The preponderance of the right hand is not a primeval gift, but an achievement of civilisation, an outcome of the progressive corporeal and mental differentiation and division of work. When man became man, when the build of his body enabled and compelled him to walk upright, the right and left hands must have been of equal importance to him. While the legs and feet, as organs of locomotion, still preserve equal rights and duties, the activity of the arms and hands, which was destined to a fuller development, was distributed in such a way that the left hand plays a passive, holding and shielding part, and the right hand an active, seizing and attacking one. The preponderance of the right hand must have been a secondary phenomenon in the first instance. Combat was at that time the principal thing — primeval instinct was a surer guide in orientation than the observation of the stars—and the need in combat with man and beast to shield the most vital part of the body, the heart, with the armed or unarmed left necessitated that the club, axe, knife or spear should be held in the right. This habit was carried into peaceful pursuits. Since the day of primeval manhood, even after the original cause had ceased to exist, the preponderance of the right hand was developed and established more and more in civilised nations through heredity and education. This differentiation is even to-day less marked in some primitive races, and there is also to some extent less distinction made between the upper and lower limbs (prehensile foot). Our children are in a similar position, and must, in fact, be educated to the use and conventional higher appreciation of the right hand. Thus the greater skill of the right hand is occasioned by the structure of the human body, the position of the heart, and perhaps the nature of the aorta, together with man's relation to the outer world and the primitive cause for a stronger development of the right arm, to which factors of civilisation have been added."

Dr. Andrew Wilson has set forth an entirely new theory.* With reference to the fact that the centre controlling the movements of the right arm is situated near the centre of speech in the left hemisphere of the brain, he asks: "Is it not probable that the superiority of the right side of our bodies has kept step in growth with the development of language?" He denies right-handedness to be the outcome of continued practice from childhood in the use of the right hand, and considers it the result of evolution from ambidexterity. Dr. Wilson gives no explanation of left-handedness, to which Sir Daniel Wilson has dedicated a whole book.

The explanations given by the late Dr. Fritz Lueddeckens† for left-handedness as well as right-handedness are very detailed. This German doctor's treatment of the subject is anatomical throughout, and is based upon thorough investigation. The keynote to his exposition is his unqualified rejection of the theory that right- or left-handedness can rest upon habit. Among other things, he says that the hypothesis "is absolutely untenable that man should more and more restrict the collaboration of one half of the brain and become accustomed to the consequent use of one hand if it were true that both cerebral hemispheres had originally equal functions." The mere anatomical fact that the centre controlling the muscles for speech is fully developed on one

* "The Light Side of Science." (Chapter on "Right-handedness.")
† "Die Ursachen der Rechts- und Linkshäendigkeit." Leipzig, 1900.

side only of the brain—in the case of the right-handed on the left side—excludes the accuracy of the theory of habit as an explanation of right-handedness.

Dr. Lueddeckens opposes the widespread belief that left-handedness is a phenomenon restricted to the hand. On the contrary, it affects the physiological character of the whole left side, which presents the same characteristics in the left-handed as does the right side in the right-handed. This thesis, which Lueddeckens endeavours to confirm in detail, is the leading feature of his researches, together with the preponderance of the left hemisphere of the brain over the right as the chief explanation of right-handedness, in which, as we have seen, Bolk and Biervliet also agree. In support of this theory he examines not only the hand but the arm, brain and spine, the ear, speech, walk, sleep, psychic processes, the whole muscular system, and so on, giving particular attention, however, to the eye. His manifold observations have enabled him to recognise left-handedness, as a rule, in the dilation of the left pupil. As science, the statements about the eye are the most important and valuable in his book.

He emphasises that James Mark Baldwin also considered "the prevalence of the left half of the brain" the natural cause of the predominance of right-handedness, and he quotes from this celebrated investigator's book on the mental development of the child interesting experiments that Baldwin made with his own infant daughter. In the first place he would not allow the child always to be carried on one arm. From the fourth to the tenth month he placed her daily at a fixed hour in a comfortable sitting posture and let her reach out after the most varied objects. During this time he found that no preference was shown for either hand, but it must be noted that no exertion was exacted. As soon as the distance was increased from ten or twelve inches to fifteen inches the child at once evinced a marked preference for the right hand. In the first period of the experiment she stretched out her right hand five hundred and seventy-seven times, her left five hundred and seventy-eight times, and both hands at once one thousand and forty-two times, and in the second period, at an increased distance of the object, out of eighty tests she used her right seventy-four times, the left only five times and both hands together but once. At a distance of thirteen to fifteen inches she used her right hand alone for seizing. If the object were shifted to the left all the greater exertion was made by the right hand in the domain of the left, while there was a diminution in the use of the left hand. On the other hand, I must mention Dr. Manfred Fränkel's assertion that Baldwin's experiment, put by himself (Dr. Fränkel) "to a test with several children and many trials, in no way verified itself."

The right-handed only sleep well on the right side as a rule, and if they fall into a heavy sleep on the left side they often have unpleasant dreams, and sometimes nightmare or pollution. The left-handed, again, generally only sleep well on the left side. The reason is that the pressure of blood is higher on the right side of the brain with the latter, and on the left side with the former. Similarly also, according to Lueddeckens, the characteristics of the left side of the left-handed correspond in every detail with the characteristics of the right side of the right-handed. As the result of numerous observations, "I was astounded," he writes, "at the degree of conformity manifested by the two states or conditions, resembling an object and its mirrored reflection." He lays great weight on heredity in cases of left-handedness. He gives dates and tables showing the frequent recurrence of left-handedness in one and the same family in many instances. With regard to left-handedness in school children, he says in part:—"Cases of left-handedness are, as a rule, soon noticed at school, especially in writing. Although the scholars, often with great difficulty, learn to write with the right hand the characters that are adapted to right-handedness, very many of them show the inclination to use the left. Later, when they notice that it is unpleasant to write against the point of the nib, they often begin to write from right to left in so-called mirror writing, in which they often attain remarkable facility with a relatively small amount of practice. . . . When requested to write her name with her left hand, a left-handed, mentally deficient schoolgirl of twelve executed it in mirror writing, and when a church with a tower to the left and a house to the right was drawn for her, she copied it with her left hand, beginning at the right side of the paper and drawing the tower first, and then, working towards the left, the house. She had learnt at school to write and also knit in the customary right-handed manner, but at times she fell back to knitting with the left hand. Such cases of mirror knitting are probably rare in Germany, though another case had been noticed before in the same school. In any case, it proves what technical difficulties will be overcome instinctively, even where there is mental deficiency, by left-handedness in order to assert itself."

According to Wilhelm Fliess also, in "Vom Leben und vom Tod," in no case are the two sides of the body in perfect symmetry, the left side being more developed in one person and the right in another. Other investigators as well are of the same opinion, but there is novelty in Fliess' assertion that "the significance of both sides changes with these deviations, so that manly women and womanly men manifest a fuller development of the left side of their bodies. Left-handed men are always more womanly, and left-handed women more manly, than the right-handed of their sex. . . . When there is deviation in the characteristics of the sexes and the man is more effeminate, his female side, the left, has a fuller development; and when the woman is more masculine her male side, also the left, is more developed." The connection between the accentuation of the "left" side principle and the mixed realm of male and female is thus shown. The side corresponding with the opposite sex, *i.e.*, the left, is accentuated more strongly. "Accentuated" does not imply by any means that the person in question is always undoubtedly left-handed. This is as problematic as it is interesting.

Broca's sensational discovery that the centre of speech in the human brain is situated on the left side, which was confirmed and extended by Bastian's painstaking investigations, was all the more a matter for wonder as the examination of animals gifted with a certain power of speech manifested no such one-sidedness. It was established that this one-sidedness in man was connected with his right-handedness. Further research showed that in the case of the left-handed the centre of speech was situated in the right cerebral hemisphere. There was, therefore, no longer any doubt as to the interdependence between the left position of the speech centre and right-handedness. Already in the seventh and eighth centuries scientific men were aware that diseases of the left cerebral hemisphere were very often attended by difficulties in speech, whereas this was extremely rare—only with the left-handed—in cases of disease of the right half of the brain. This, too, confirms Broca's discovery. A right-handed person may suffer loss of speech through a blow on the left side of the head, and a left-handed person by a blow on the right side.

Consequently, people whose two hands are equally skilful should have two speech centres. This seems actually to be the case. Dr. Ernst Weber says that it is easy to detect in children unmistakable traces of two speech centres, but that later one of the centres atrophies owing to the preference given to one hand. But though it atrophies, it can be aroused again and rendered useful by systematic development of the other hand. How very far this resuscitation can be made to go is shown in practice by numerous successful experiments in trying to make people ambidextrous by way of training the left side. Of course, these experiences tend to disprove Dr. Lueddeckens' utter disbelief in gradually acquired habit as a possible cause of the prevalence of right-handedness.

With regard to the number of cases of left-handedness, Hasse and Dehner estimate it at one per cent., many others at from two to four and a half per cent., Flechsig at three per cent., and Biervliet at two and a half per cent. The Bible states that in the tribe of Benjamin, which numbered twenty-six thousand seven hundred men, there were seven hundred left-handed; this would be 2·62 per cent. Up to the present no one has been able to draw up far-reaching statistics referring to thousands of cases—and such alone would be really reliable—as no investigator has examined and compared more than a few hundred.

EFFECT OF SCHOOL WORK ON THE LUNGS.

By DR. ALFRED GRADENWITZ.

Interesting experiments have recently been made by Dr. M. Oker-Blom, of Helsingfors, on the respiratory movements on both sides of the chest of twenty-five school children in the course of different kinds of work, by means of an apparatus recording any variations in these movements.* When reading aloud was practised for three minutes, the upper parts of the left lung were found to breathe more deeply than those of the right lung, irrespective of whether the pupil was seated or standing, the ratio of the respiratory movements on the right and left sides respectively being $r : l = 100 : 118$. This is, of course, an average figure, there being sometimes exceptions, especially in cases where the left lung is somewhat abnormal.

The total number of respirations $(r + l)$ on both sides together during reading aloud is on an average seventy-eight when the pupil is standing, but decreases to seventy-two if he is sitting.

The most important point brought out by these experiments, however, is the influence exerted by a prolonged sitting posture on the respiration of the upper part of the lungs. During a sedentary occupation of some duration (*e.g.*, knitting) the two sides of the chest are found generally to have the same amplitude of respiration, the breathing movements of the left side being impeded more than those of the right. This is accounted for by the frequent changes in the position of the body which are made involuntarily from time to time to alleviate the fatigue in the back. In fact, even in cases where there is no habitual scoliosis, the vertical column is found alternately to lean to one side or the other, the body straightening itself from time to time, while a few deeper respirations ensure a certain amount of compensation. In any case the unfavourable influence of any prolonged sedentary occupation generally is more marked in its effects on respiration in the upper parts of the left side than in those of the right. The total number of respirations is found to decrease during uninterrupted sedentary work lasting up to about forty minutes, from seventy-two to thirty-nine, *i.e.*, to about half its original value. This is accounted for by the fact that during sedentary work certain groups of muscles are extended without interruption, thus impeding the freedom of respiratory movements.

In order to obviate the harmful action of prolonged sedentary work it is recommended that such work should be from time to time interrupted by a few minutes' respiratory gymnastics. Not only would such practice prove beneficial as regards respiration and pulmonary exercise, but it would, in addition, have a certain prophylactic effect against scoliosis.

**Internat. Archiv f. Schulhygiene.*

POLISHED CELTS AND THEIR MANUFACTURE.

By T. H. POWELL.

The polished celt or axe probably represents the highest artistic and manipulative skill of prehistoric and savage peoples; its outline in fine specimens being perfectly symmetrical, its poise and finish perfection, the skill and patience necessary for its flaking and polishing must have been the result of long experience under conditions of life where time was of little value.

Whether used for cutting wood or as a weapon of offence, a polished celt was necessarily subject to great strain; and it was, therefore, of primary importance that a material should be selected which was not only exceedingly hard, but without flaw, otherwise the celt would fly to pieces directly it was used.

If a stone, such as diorite, were chosen, this would be a matter of little difficulty; but in countries where flint was the only material available, great care and knowledge were required in the selection of a suitable block which would prove homogeneous throughout. The first thing, therefore, was the selection of a suitable mass, probably fresh from the quarry, as it was then more easily worked; and this mass, somewhat larger than the implement to be made, was flaked into a rough oblong with broad flat surfaces with thinner sides and ends. The two ends were then flaked longitudinally, the butt only slightly, but at the opposite end the flaking was continued, first on one side and then on the other, till the edges along the plane of flaking met, and a rough, slightly curved outline resulted (see Figure 225). One of the sides was then chipped from end to end at right angles, the flakes struck off being smaller than at the butt and cutting ends, and the four edges were successively dressed in a similar way till two wedge-shaped sides resulted (see Figure 219). The two broad faces were then trimmed all over in such a way that the celt was thicker along the centre than at the edges (see Figure 224). The next process was the production of the cutting edge, and it is at first difficult to understand how this was done, as the edge is often so true and sharp that no amount of face or side grinding could possibly have produced it. But a comparison of examples will show that it was made much as follows. The roughly flaked mass was held upright in the hand, with the narrow side towards the workman, and the curved edge rubbed backwards and forwards on a piece of quartzite or sandstone, with a rotary movement, till perfectly smooth and symmetrical, the outline aimed at being exactly the same as in the finished article. The celt was then held obliquely, and rubbed backwards and forwards until the broad surface on both sides extending for an inch or more from the cutting edge became smooth and the edge was perfectly thin and sharp (see Figure 217). In many cases very little else was done, the butt end being left in a rough state so that the haft would grip it more firmly; but in the finest examples the grinding and polishing were extended over all the surface from one end to the other both on the faces and sides (see Figures 220 and 222). It is a curious fact that although broken cutting ends of celts are comparatively common (see Figure 214) broken butts are rare. The explanation probably is that the sharp cutting end could often be remounted and used again, or if only an inch or two in length it would form a serviceable wedge. In the case of the butt, however, it seems probable that the fragment, being of fine quality and having cost so much time and labour to produce, was regarded by its owner as a treasured possession, and was used up again for a variety of purposes. If the piece were large a smaller celt could easily be made from it; but if not of sufficient size for that purpose it was made into some other tool, and every good collection contains examples of borers, scrapers, knives, and even hammer stones showing old polished surfaces (see Figures 212, 213, 215 and 216).

It must often have happened that the sharp edge became blunted or damaged in use, and resharpening became necessary. This was easily done by striking off small flakes from both sides, then grinding down until the curved edge again became true and sharp, and finally rubbing down till all marks of flaking were obliterated and repolishing was complete (see Figure 223).

The method employed in the case of diorite and similar tough rocks was altogether different; flaking was out of the question, so the stone was struck or pecked into the required shape and the rough surface subsequently rubbed and polished (see Figure 218).

Flint and the many other materials made use of in the manufacture of celts are necessarily of great hardness. It must be evident, therefore, that the grinding process was both slow and laborious, and as in the finest examples all trace of flaking is completely rubbed away, a polished celt may be regarded as evidence, not only of great skill, but also of almost infinite perseverance and patience.

FIGURE 212. FIGURE 213.

Flint implements, formed from broken or damaged polished celts.

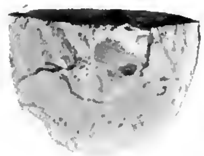


FIGURE 214.

Cutting edge end of a fine flint celt, two and a half inches long, from the Sussex hills, probably broken in use.

FIGURE 215. FIGURE 216.

Flint implements, formed from broken or damaged polished celts.

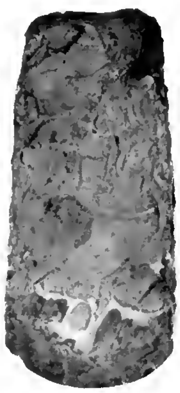


FIGURE 217.

Chert celt, with cutting edge sharpened and nearly finished by rubbing, six and a half inches long (from Denmark).

FIGURE 218.

Celt of hornblende diabase, four and a quarter inches long, from the Oxfordshire hills, of perfect shape and finish.

FIGURE 219.

Side view of flint celt, showing the wedge - shaped form (from Denmark).

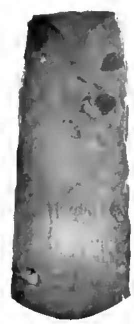


FIGURE 220.

Flint celt from the Beck Collection, said to have been found at Pulborough, Sussex, a beautifully finished Danish implement, five and a half inches long.

FIGURE 221.

Flint celt found near Horsham, Sussex; the rubbing process begun all over the surface, six inches long.

FIGURE 222.

Flint celt, eight and three quarter inches long, polished on all surfaces (from Denmark).

FIGURE 223.

Flint celt undergoing process of re-sharpening; the extreme cutting edge is smooth and somewhat thick, thence for about one inch small flakes have been struck off. This only requires rubbing down to produce a perfectly sharp edge. Eight inches long.

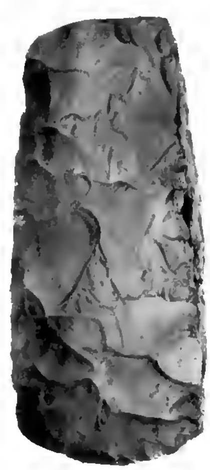


FIGURE 224.

Flint celt, eight inches long, flaked into shape and ready for polishing (from Denmark).

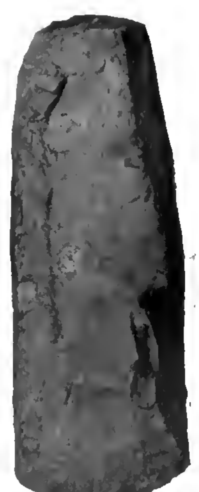


FIGURE 225.

Oblong block of chert, nine inches long, with roughly flaked ends, the cutting edge rounded, the one edge trimmed, the other still in the rough (from Denmark).

SUGGESTIONS TOWARDS A SOLUTION OF THE PROBLEM OF THE IBERIAN PLANTS IN SOUTH-WEST IRELAND.

By G. W. BULMAN, M.A., B.Sc.

We do not propose to give here any review of the subject, or to criticise any of the explanations which have been brought forward. On the assumption that a land connection between Spain and Ireland was necessary, and that such really existed, we offer a suggestion as to why these Irish species do not also occur in England. None of the theories we have come across explain this, or even admit it as a difficulty.

Again, assuming that the land connection was pre-Glacial, and that there has been none since the retreat of the ice, we will enquire what grounds there are for believing that much of our present flora may have survived glaciation.

As regards the first point, it is practically impossible to imagine a land connection between Spain and Ireland which did not also include England. And it is to be remembered that Cornwall also has its own peculiar species of Southern plants, which equally need a land connection. The Spanish plants spreading across the assumed land bridge would have had time to reach England also. Why are they, then, not found in this country? One is inclined to suggest at first—and the suggestion has indeed been made—that they were driven out by the cold of the Glacial epoch everywhere but in the south-west of Ireland. To this, however, it may be replied that if they could survive there they could surely do so also in Cornwall and the Scilly Islands. We propose, then, another explanation, founded on the influence of the geological structure of the land on the spread of plants. Let us suppose a set of plants spreading northwards along a line sufficiently extended to reach along our south coast to some distance west of the extreme south-west corner of Ireland. Normally such a migrating band of plants would reach England and Ireland simultaneously. But let us suppose that the advancing front of the Iberian plants meets with a wedge-like barrier of unsuitable ground, mountains, desert, marsh, on merely a different sort of rock. The advance is thereby turned to the north-west and north-east or the two sides of the barrier. The former branch in due course reaches the south-west of Ireland, and the then existing land to the west of this. The other diverges so far that by the time it reaches our latitudes it is too far east to touch our shores. Or the nature of the barrier may have been such as to stop the species altogether from getting further north. The present continental distribution of the species in question, if known in sufficient detail, might possibly indicate which way it was. But the barriers of unsuitable country which prevented the Irish species reaching England may have favoured the spreads of the southern species now found in Cornwall, and the migrating area of the Cornish species may have tapered northwards, and had its apex in Cornwall, which would account for their absence in the eastern part of southern England.

As regards our second point, a careful consideration of the facts seems to suggest the possibility—if not the strong probability—of the survival of many, at least, of our native plants over the Glacial epoch. That the whole of our flora and fauna was driven out or exterminated by the cold is, perhaps, only held by those who have had the "Glacial nightmare" badly. Yet even those who take more moderate views might be excused for doubting the possibility of a fragment of the Spanish flora surviving glaciation in the south-west of Ireland. Let us ask, then, What evidence can be brought forward indicating the possibilities of survival? The present flora of Greenland seems to furnish a strong argument. In spite of its glaciation this country possesses at the present day a considerable number of species of flowering plants. Some of these are members of our own flora. Even, then, if we suppose the glaciation of our land was as severe as that of Greenland to-day, we have here absolute *proof* that some of our species could survive. But it is not probable, in fact, it seems impossible, that the climate of Glacial Britain was as severe as that of Greenland to-day. Even if the amount of ice and snow was as great, or greater, Britain would still have the advantage of its more southern latitude. The amount of heat received during the summer would be as great as—or, according to some authorities, greater than—at present. The amount of land freed from ice and snow during this season would be greater, and the time it remained free longer. Thus, there would be a greater possibility of survival than in Greenland to-day. But this is not all. It is difficult to understand how Greenland can have received its present flora since the Glacial period. The ordinary means of transport, winds, ocean currents, and so on, are not available for Greenland; nor is there any suitable land connection; and Greenland's migratory birds go to it in the spring when there are no ripe seeds for them to carry. It almost seems as if we would have to grant that Greenland's present flora survived the Glacial epoch there. But if this flora survived, in Glacial Greenland, the necessarily severe conditions, may we not be almost absolutely certain that our flora could survive in milder Glacial England?

And then there arises the interesting botanical question: Does it require a plant to be of a hardier constitution to stand being covered with snow or ice for several months, and then have a warm summer —as it would during glaciation—or to be alternately frozen and thawed—as it is apt to be in our uncertain climate to-day? In other words, would it kill any of our native species to be so treated? A deep covering of snow and ice, in fact, keeps the earth warm. That is why we usually see a stream of water issuing from beneath a glacier. And it is to be remembered that a country covered with ice and snow is not necessarily as cold as Siberia, or the Antarctic. Nor because an ice-sheet or glacier came down to the latitude of London need we suppose that a temperate vegetation could not flourish there. At present alpine glaciers end amid a varied flora, while in New Zealand glaciers come down to the regions of a sub-tropical vegetation. In North America, again, the limits of the forest go up into the ice, and the limits of the ice come down into the forests. Ice and snow require only a temperature of 32° F. for their formation, and unless there are other causes than the presence of these, there need not be intense cold. And it is to be remembered that every pound of water frozen means the setting free of enough heat to raise eighty pounds of water 1° C. Hence the enormous quantities of ice and snow imagined by extreme glacialists do not necessarily imply a proportionately lower temperature. The cold is, so to speak, used up in freezing the water.

The fact that our little group of plants is confined to the south-west corner of Ireland, and that they are Spanish plants, inclines us to view them as tender species. And this makes one of the special difficulties of the case. How could such tender species survive? But may they not in reality be hardier than the facts suggest? The Arbutus stands the winter and ripens its fruit in the southern counties of England, while London Pride is a perfectly hardy plant which does not suffer in our severest winters. Information as to the altitudes attained by the various species in the Pyrenees might help to settle this point. And the fact that some of our species are also natives of Greenland suggests that a group of Spanish plants might be hardy enough to be natives also of a more northern latitude.

But it may be asked, If our plants did survive glaciation, ought there not to be some positive evidence in the form of fossils? The difficulty of obtaining such actual evidence of survival in glacial deposits arises from the fact that many geologists believe that there have been several Glacial periods in Pleistocene times. Thus, if remains of temperate plants are found in such Glacial deposits, the actual beds containing them are classed as inter-Glacial. The plants which had been exterminated by the cold are supposed to have come back during a warm inter-Glacial period. Personally, we have defended the case of one Pleistocene Glacial epoch (*Geological Magazine*, August and September, 1891). And, if this is correct, then there is abundant evidence of the survival of temperate plants during glaciation. But, even on the view of several glaciations, there are not wanting cases where temperate species occur in deposits which are classed as Glacial by reason of the Arctic species which they also contain. Mr. Clement Reid, who advocates the view of several Glacial epochs, and believes that all temperate species were exterminated by the cold, gives detailed lists of species found in various Glacial, and so-called inter-Glacial, deposits. Glancing through these as given in his "Origin of the British Flora," we realise that it must often have been extremely difficult to the author to decide from the plant remains whether the deposit should be classed as Glacial or inter-Glacial. We will take one or two illustrations of this from the above work in support of our contention. Thus, a deposit near Edinburgh is described as follows:—

"In the lower part of the lacustrine deposits filling a silted-up lake are numerous seeds and leaves of Arctic plants. The deposit is probably Late Glacial."

Yet the plant list appended contains such temperate forms as the Creeping Buttercup, the Marsh Violet, the Dandelion, the Bogbean, and so on.

Another deposit, yielding Arctic plants, has in addition to the above temperate forms, Campion, Wood Sorrel, Knot-grass, and so on. Examples of such mingling of Arctic and temperate forms might be multiplied, and even on Mr. Clement Reid's own interpretation of the order of events they seem to indicate the survival of the latter.

Finally, if there is no evidence of a *post*-Glacial land connection, and if we cannot satisfactorily account for the presence of the peculiar flora of south-west Ireland by other means of dispersal, this in itself is a proof of the possibility of survival.

ANNOUNCEMENTS.

EUGENICS as a practical science is now recognised by sociologists as an important factor in race culture; and the Eugenic Club Committee cordially invite the co-operation of ladies and gentlemen who are interested in Eugenics and kindred subjects to communicate with the Secretary, 6, Hand Court, High Holborn, W.C.

MUSEUM EXTENSION AT HULL.—A further valuable gift has just been made to the Hull Municipal Museums Committee by C. Pickering, Esq., J.P., the donor of the new Museum of Fisheries and Shipping at the Pickering Park. It was recently represented to him that the new museum was already crowded with exhibits, and he has kindly presented a strip of land stretching from the Hessle Road to the Pickering Park, and adjoining the present museum, for the purpose of extension.

TRYPANOSOMES.

By MALCOLM EVAN MACGREGOR, F.R.M.S.

(Continued from Page 200.)

THE EFFECT OF TRYPANOSOMES ON MAN AND ANIMALS.

BOTH in man and animals the effect that pathogenic trypanosomes have while living in the blood is very similar. We will first consider a case of sleeping-sickness in man.

Long ago, when Livingstone penetrated into the heart of Africa he noticed that as he got into certain regions of Central Africa the natives spoke of a disease which made people sleepy, and that the invariable result of this sleepiness was death.

Recognising this and the hopelessness of curing people of the disease when once they had contracted it, the natives were wont to banish the poor unfortunate sufferer from his tribe, so that ere long, without anyone to help or look after him, he died of starvation. What brought this disease, or how it was caught, nobody knew; but while in those days it was more or less confined to comparatively small areas, it has now, since Livingstone's day, spread gradually in Central Africa, and by the name of sleeping-sickness has come to be known as one of the most dreaded diseases of mankind. The trypanosome which causes sleeping sickness is not confined, it is thought, to one species. In the Gambia and other parts of tropical Africa the organism is *T. gambiense.* In Nyasaland and Rhodesia it appears to be caused by a trypanosome of slightly different form, to which has been given the name *T. rhodesiense.**

The picture of a man suffering from sleeping sickness is a very terrible one (see Figure 226). At first, after he has been bitten by an infected fly, there may be little to notice the matter with him, and the parasites may be in the blood for several months without causing any marked effect—in fact, so long as they remain only in the blood-stream they seem to do little harm.

But after a time they appear in the cerebro-spinal fluid, and then their deadly work begins.

The man's temperature goes up, and he feels generally tired, and exhausted by the slightest effort. He becomes hyperaesthetic, so the little everyday knocks that he receives from surrounding objects while he goes about his everyday duties, and to which, while he is well he pays no attention, cause him the intensest pain. There may now be tingling, or even pain, in the soles of the feet and palms of the hands, and peculiar reddish patches may occur on the skin. This continues for a varying period in different cases, but finally it gives place to just the reverse condition where the patient loses feeling, and gradually becomes stupid, sinking into a heavy lethargy, from which it becomes impossible to raise him. At first this condition is manifest, when one speaks to the sufferer, by his apparent lack of interest in the subject of conversation: he is constantly failing to follow the drift of things, but by raising the voice he is made to grasp what is being said. This continues, and rapidly becomes worse, until in the end a pistol could be fired a few inches from the person's head without his responding at all. There is a dull, sleepy expression about the face; oedema under the eyes and elsewhere causes the skin to have a puffy look, and the man presents the appearance of a person utterly exhausted from want of sleep. So on it goes, until the patient lies completely comatose, the coma ending in death.

This is, to some extent, the outward picture of the man, but besides these symptoms he presents an extremely emaciated condition, and general anaemia. There are infiltrations of lymph into the body cavities, the spleen is usually enlarged, and there are changes in the grey matter of the brain and spinal cord; but on the whole the visible damage to the body is not great.

Sleeping-sickness in man is a prolonged disease, and may last as long as three years from the time of its onset to the death of the patient.

In animals, sleeping-sickness produces much the same effect, but its course in the smaller animals, such as the rabbit, the guinea-pig, and the rat, is of much shorter duration, terminating, of course, in the death of the animal.

The actual condition of "sleep" is perhaps not so manifest as it is in man, but it is present nevertheless, and very noticeably in the case of the rat, which places its head between the front paws, rests the crown of the head on the ground, and, throwing the body well forward, looks for all the world as if it were endeavouring to "stand on its head."

It was at first thought by many tribes of natives in Central Africa that sleeping-sickness was caused by the eating of the m'lolo root (manioc), a root that is eaten fairly extensively. Then came the idea that it was produced by eating a certain species of mud-fish, or that it was caused by "integarti" (the native name for devils). Finally, it was recognised that tsetse-flies had something to do with it, and the tsetse-fly was credited with having a "powerful poison," which it injected while it bit, and that it was

* See Footnote on Page 199.

By kind permission *of the Royal Society.*

FIGURE 226. A case of Sleeping-sickness in a Native Child. The last stage in the disease, where, as it will be seen, there is complete coma and extreme emaciation.

By kind permission *of the Royal Society.*

FIGURE 227. A group of Natives and their Children, upon whom the ravages of Sleeping-sickness and starvation are prominently in evidence.

this poison which ultimately killed the animal or person—a theory that at basis was almost right.

But all these theories, and many others, have been exploded completely by the discovery of the trypanosome in the blood of sleeping-sickness patients, and which long since has been proved to be the cause of the disease.

An interesting idea was that the European was less prone to sleeping-sickness than the native, but so far as his susceptibility to the disease is concerned the idea is entirely wrong. There is some truth, however, in the statement that a smaller proportion of Europeans than natives are attacked; but this is probably, in part, due to the fact that most Europeans are not subjected to the same risk, living, more or less, indoors during the day, when the tsetse-fly is at the height of its activities. On the other hand the natives are in the open all day and always subject to the fly's attentions.

There is, nevertheless, a curious thing that has often been noticed, and which undoubtedly has a good deal of bearing on this subject, and that is the tsetse-fly's marked aversion to settling on anything white. It is the prevailing fashion, of course, for the Europeans of tropical parts to dress in white duck, and it has been observed that when a European so dressed and natives have gone to a spot where flies are abundant, the natives are attacked most mercilessly, while the European is comparatively unmolested. That this is due to the colour of his clothes has been proved by tacking a square of black cloth over, say, one arm, when instantly, under the same conditions, the flies will settle on the square. It is probably that the fly instinctively will not settle on white owing to its becoming then conspicuous.

Notwithstanding this, all things being equal, the European quite as readily falls a victim to sleeping-sickness, and he possesses no natural immunity.

Nagana, or the African "fly-sickness" of cattle, is produced, as has been mentioned before, by *T. brucei*, a trypanosome very similar in some of its phases to *T. gambiense*, but which at other times is met with as a small trypanosome of tadpole-like shape, having neither undulating membrane of any width nor "free flagellum." Besides cattle it attacks dogs and cats, while it is pathogenic to most small animals as well. It is harmless, however, to man, and it is found in the blood of wild antelopes and other big game, in which it seems to cause no ill-effects, strangely enough.

Nagana constitutes one of the great cattle plagues of Africa, and has done untold harm to the development of the country for stock-raising; for it is impossible to keep even domestic stock where this disease occurs. Its effects on the animals it attacks are essentially similar to the effects produced by *T. gambiense*, with only minor differences. "Nagana" is a Zulu name, and means "breaking, or withering up," and this name describes the course of the disease very well, since the animals present a most lamentable appearance of utter weakness.

The tsetse-fly responsible for the spread of Nagana is *Glossina morsitans*, a tsetse-fly resembling *G. palpalis* in many ways, but its body is of a lighter brown colour, and has characteristic markings on the abdomen. *Morsitans* is the commonest of the tsetse-flies, and is widely spread over Africa; moreover it is not confined in its haunts to water-tracts.

TREATMENT.

Now we come to the last consideration, namely, the cure of trypanosome diseases. A great deal of work has already been done in this direction, but there is a vast amount more needed yet. There is practically no cure whatever, although there have been rare cases of apparent recovery, which, quite as likely, were due to the patient's own bodily strength as to the success of any "treatment" he may have had.

The drugs known as atoxyl and arsacetin* and other arsenic-containing compounds may be said to be the standard drugs used in the treatment, but an enormous number of substances of all kinds have been tried.

All the drugs like atoxyl are violent poisons, and so have to be used with extreme caution, or the "remedy" becomes worse than the disease, and, in the case of atoxyl, blindness is very easily produced in the patient by the slightest overdose.

Although these drugs do not produce permanent good, they seem to have a beneficial effect sometimes, and if cure meant only the ridding of the patient's blood from trypanosomes, they would indeed be admirable cures. Their effect in this way may be quite remarkable, for while the patient's blood may be swarming with trypanosomes, a dose of atoxyl will completely free it from the parasites in the course of an hour or two. Moreover, it may remain free for months actually, but sooner or later the trypanosomes will reappear, and the course of the disease is not interrupted in reality. What happens to the trypanosomes under the influence of atoxyl nobody knows exactly. It has been said that they "hide" in the bone-marrow or form invisible spore forms, but all the same nobody knows perfectly where they go or what they do in the meantime.

Apart from the drug treatment there is another way of fighting the disease which, while it does not aim at curing people who have already contracted sleeping-sickness, does nevertheless aim at a decided check to the spread of the disease. This consists in removing the natives away from watercourses and areas that the tsetse-fly inhabits, in confining all people suffering from the disease to isolation-camps, in destroying the undergrowth of river and lake

* Atoxyl $= C_6H_4 \begin{cases} NH_2 \\ AsO.(OH).ONa \end{cases}$ Arsacetin $= C_6H_4 \begin{cases} NH.CO.CH_3 \\ AsO.(OH).ONa \end{cases}$

banks near roads and villages—for the tsetse-fly needs the undergrowth as a breeding place—and in the control of natives living in infected areas by preventing their migration to other parts until they have been proved free of the disease.

Since trypanosomes do their work of destruction by some poison—toxin—they secrete, or by using up some essential substance in the blood of their host, which the host needs for the continuance of its life; and since the multiplication of the parasite in the host's blood is unchecked except by the ultimate death of the host, it is safe to conclude that, unlike some bacterial diseases, the body in this case is unable to produce an antitoxin by which to rid itself of the infection. Therefore, I do not think that any "vaccine-treatment" will ever be found of any avail, but the cure must come through the discovery of some drug that shall deal death to the trypanosome and yet not poison the patient. It is not, however, that the trypanosome in itself possesses any extraordinary vitality that makes it difficult to kill but it is merely its position in the host's blood which gives it its present unassailable position; for drugs that are harmful to it are equally harmful to the tissue-cells of the host, and effectually to poison the one means, just as effectually, to poison the other. Trypanosomes in fluid media—blood, and so on—when raised outside the body, only a few degrees above the normal animal temperature, quickly succumb. Were it possible to keep the infected animal at such a body-temperature without killing it, that, perhaps, would be the simplest method of cure! Needless to say this is quite an impossibility, and so, notwithstanding all that has been done up to the present, the difficulty in the cure of trypanosome diseases still awaits solution.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

THE MOUNT WILSON ONE HUNDRED-INCH REFLECTOR.—Some good news about this great instrument has arrived from California. It was previously reported that the glass disc for the mirror had proved a failure, but it has now been found that the fault was only in the method of mounting, which caused flexure; an improved method gave satisfactory results, and the disc has been accepted and paid for, which indicates confidence that it is sufficiently good. We may hope for some wonderful results in stellar astronomy when this giant instrument is complete. Even the sixty-inch shows stars of the twenty-first magnitude.

THE SPECTRO-HELIOGRAPH.—The Gold Medal of the Royal Astronomical Society was given this year to M. Deslandres for his work on the Sun. The address of the Astronomer Royal gives an interesting summary of his work, calling attention to the spectro-heliograms of the lower, middle and upper layers of the solar atmosphere, which are obtained by shifting the second slit to the outside, intermediate, or central region of the K line. In the upper-layer photographs the prominences can be seen both inside and outside the disc, and it is possible to say whether a limb prominence has its base on the near or remote hemisphere of the Sun and to localise it exactly in the former case. The ordinary limb observations of prominences do not admit of this. Another interesting feature of the high-level spectro-heliograms is the system of long dark filaments, which play the same important part in this layer that spots do in the lowest one. They form a network over the whole disc and sometimes persist for several rotations. They are intimately connected with prominences, one of these being generally present where they cut the limb. M. Deslandres finds that they are céntres of rotation about a horizontal axis, the spots rotating about a vertical one. It was also found possible to obtain spectro-heliograms of these in the hydrogen light, using the $H\alpha$ line, though its narrowness made the difficulty greater than in the K line of calcium. The upper layer of hydrogen shows the same filaments as the calcium ones, while the middle layer shows the vortices round spots, which Hale was the first to detect. Deslandres also devised the "Velocity Recorder," which is a spectro-heliograph with a wide second slit, enabling the whole width of the line to be photographed. As the slit traverses the solar disc, variations in the position and width of the line give indications of the motion of gases in the atmosphere of the Sun. He concludes that on the whole the bright regions are descending and the dark filaments ascending. He thinks that the circulation of a sun-spot is as follows:—The gases in the surrounding regions are ascending, then they approach the facula and go down in it, a continuous circulation being maintained. If the downward motion prevails, the lowest layer may be pierced and a spot formed, while if the upward current prevails a prominence is formed. He also finds in the varying rotational velocity of different parts of prominences (the base having the more rapid rotation) evidence of the existence of a magnetic field in the higher layers, just as Hale had found it in the vortices surrounding spots.

Another interesting solar paper was read at the April meeting of the Society: it was by Mrs. Evershed (Kodaikanal), and was accompanied by a beautiful series of prominence photographs. A certain type of explosive prominence appeared to be intimately connected with spots, and in several of these prominences there was evidence of outward motion, which was, however, slow, this being a different result from that found by Slocum, who noted inward motion. The photographs will be reproduced in the *Monthly Notices*, and it will then be possible to follow the argument more closely.

SPIRAL THEORY OF THE MILKY WAY.—The idea that the Milky Way may be a spiral has been many times put forward. I think Mr. Proctor was the first to do so. Dr. Easton, who is well known for his studies on the subject, gives in *The Astrophysical Journal* for March a small-scale diagram of the whole Milky Way from a combination of photographs and eye drawings, also a spiral form that he suggests might account for the appearance, though he adds that he does not insist on the accuracy of the details. It is of the Catherine-wheel kind, consisting of several curved streams radiating from a large nucleus, which he places in Cygnus. The form was suggested by several spiral nebulae, notably the one in Canes Venatici. At many places the streamers point straight towards us, this being his explanation of brighter portions; since we see a great depth of galactic matter in such streams. He makes one stream pass through the solar system, which seems improbable, as the evidence of the proper motions is that no part of the Galaxy is very near us. The spiral theory is rendered more probable by the fact that a spiral structure is suspected for the Magellanic clouds.

SPECTROSCOPIC DETERMINATION OF THE SUN'S ROTATION.—Many astronomers have investigated the Sun's rotation in this manner in recent years. The obvious advantage is that it can be extended to all latitudes, while the visual method by the spots is confined to the tropical regions. Moreover the spots are clearly of the nature of great disturbances in the photosphere, and there is some objection in using them to give the motion of the undisturbed regions

The spectroscopic method can be extended to the poles and to undisturbed regions of the surface, and there is the possibility of examining the lines of different elements and seeing whether they indicate the same velocity. The drawback of the method is that the linear velocity of rotation, even at the Equator, is only two kilometres per second; and though this is doubled on comparing opposite limbs it can hardly be determined by the spectroscope within about three per cent., which means an uncertainty of nearly a day in the period. The three most reliable series appear to be those of Adams, Plaskett and De Lury, the last two having been made at Ottawa in 1912, and published in *The Astrophysical Journal* for March.

Table 40 gives the smoothed mean values of the three determinations for each five degrees of solar latitude. They are smoothed by the formula $10°\cdot31 + 4°\cdot03 \cos^2$ latitude. The values from sun-spots (due to Adams) are given for comparison, also the times of sidereal rotation of different zones.

TABLE 40.

Latitude.	Spectroscope. Daily Angular Rotation.	Spectroscope. Period of Sidereal Rotation.	Sun-spots. Daily Angular Rotation.	Sun-spots. Period of Sidereal Rotation.	Sun-spots. Carrington's Value.
°	°	d	°	d	d
0	14·34	25·11	14·40	25·00	24·92
5	14·31	25·16	14·38	25·03	25·00
10	14·22	25·32	14·31	25·16	25·19
15	14·07	25·59	14·20	25·35	25·47
20	13·87	25·95	14·06	25·60	25·73
25	13·63	26·41	13·89	25·92	
30	13·34	26·98	13·69	26·30	26·47
35	13·02	27·65	13·47	26·72	
40	12·68	28·39			28·46 South
45	12·32	29·22			
50	11·98	30·05			27·45 North
55	11·64	30·92			
60	11·32	31·81			
65	11·03	32·64			
70	10·79	33·37			
75	10·58	34·03			
80	10·43	34·51			
85	10·34	34·82			
90	10·31	34·91			

There seems to be no clear evidence of different rates from the lines of different elements, such differences as are found being comparable with the probable errors.

Carrington's adopted period for the sidereal rotation is 25·38 days, which corresponds with latitude 14° 6′. His values for 45° and 50° are from too few spots to be reliable.

ULTRA-NEPTUNIAN PLANETS.—I have read with interest Mr. Ling's paper on this subject in the May number, page 171. There are two little points on which I desire to comment. First, at the end of his paragraph (2) he implies that a planet of mass five times the Earth's, at a distance fifty-two, would not sensibly perturb Uranus. But, as Dr. Cowell pointed out, the perturbations which one planet produces on another depend only on the mass of the first and the ratio of the distances of the two planets from the Sun; consequently a planet of mass five times ours would produce the same perturbations (in heliocentric longitude) on Uranus that our Earth would on Mercury if our mass were increased fivefold; but even the present perturbations of the Earth on Mercury are sensible, so that those of the fivefold Earth would be readily so; in the case of planet O and Uranus the slower motion and the longer time for perturbations to accumulate make up for the increased distance between the planets. Again, on page 172 he says that an unexplained rotation of the major axis of the orbit of Halley's Comet undoubtedly exists. If he compares the predicted elements of the orbit with the observed ones he will see that they accord within a few seconds. The discordance of two days does not arise from a rotation of the orbit, but from an alteration in the comet's mean anomaly.

OBITUARY.—I have heard with regret of the death of Professor F. W. Ristenpart, Director of the Observatory of Santiago, Chili. When in Berlin he commenced and partially carried out a very useful work, the combining of all star catalogues into one great catalogue, with determination of proper motions. He discovered a great many errata in the catalogues in the course of his work, and these have already been circulated. He went to Santiago about four years ago. Some interesting observations of his have been published, notably the organising of the observers who watched the occultation of a small star by Ganymede, also good series of observations of Encke's and other comets. He has lately made an attempt to induce astronomers to adopt 1925 as the epoch for all star places deduced up to 1950; for this purpose he has published tables for reducing places from each year to 1925.

THE ORBIT OF SCHAUMASSE'S NEW COMET.—Messrs. Kiess and Nicholson have found these elements:—Perihelion passage, 1913, May, 17·91 G.M.T.; Omega, 57°28′; Node, 317°0′; Inclination, 153°34′. Perihelion distance, 1·440. Ephemeris for Greenwich—Midnight, May 27th, R.A. $18^h\ 22^m\ 8^s$, N.Dec. 35°41′; May 31st, R.A. $17^h\ 22^m\ 42^s$, N.Dec. 39°51′; June 4th, R.A. $16^h\ 19^m\ 13^s$, N.Dec. 41°40′; June 8th, R.A. $15^h\ 21^m\ 52^s$, N.Dec. 41°11′; June 12th, R.A. $14^h\ 35^m\ 48^s$, N.Dec. 39°17′; June 16th, R.A. $14^h\ 1^m\ 24^s$, N.Dec. 36°47′; June 20th, R.A. $13^h\ 35^m\ 56^s$, N.Dec. 34°16′. Nearest earth May 31st, when the distance is sixty-two million miles; it will probably then be of the eighth magnitude.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

CLIMATE CHANGE AND WOODLAND SUCCESSION.—In an interesting paper the Rev. E. A. Woodruffe-Peacock (*Journ. of Bot.*, 1912) claims that historical records of the former occurrence of vineyards in Southern England are indicative of a warmer climate. Other evidence is seen in the more open texture of oaks and pines found in the older peat deposits as compared with the closer texture of the stems found in the more recent peat. The peat deposits of East Anglia are regarded as having developed in relation to woodlands on adjoining higher lands, and the tree-remains represent phases of migration of woodland on to the peat. It is suggested in a general way that the tree-remains represent *periods*—oak being the oldest; ash, holly and elm the more recent. On historical, floristic and faunistic grounds the Scots pine may have always been indigenous in parts of Lincolnshire, as also the beech, which comes in a later period with a warmer climate.

A BRITISH FOSSIL *SELAGINELLA*.—Professor Seward (*New Phytologist*, March, 1913) describes a fossil *Selaginella* (*Selaginellites Dawsoni*) found in beautiful preservation in the Fairlight Clay at the base of the Wealden series at Ecclesbourne on the Sussex coast. The fact that the genus *Selaginella* is now represented in the British flora by a single species (*S. spinosa*), somewhat rare and chiefly confined to hill regions, adds interest to this discovery of a Wealden species which differs from *S. spinosa*, but shows a close resemblance to the widely distributed recent species *S. rupestris*—not found in Europe, however. The vegetative parts are not sufficiently well preserved to show with certainty whether the fossil species had one or two forms of foliage leaves, but the two kinds of spores are extremely well preserved and show the most minute markings on the spore coat with great clearness.

FAIRY RING FUNGI.—Miss Bayliss (*Journ. Econ. Biol.*, Vol. VI) has found that the well-known "fairy ring" fungi *Marasmius oreades* and *Clitocybe gigantea* are not saprophytes, but are parasitic on the roots of grasses, which they kill by the secretion of some toxic substance. The same or some other secretion is toxic to the fungi themselves, making them unable to grow in the same soil for three years in succession, and hence producing the well-known development of yearly widening rings. As compared with the infected grass, that which lies just outside as well as that inside the ring is stimulated into better growth by the greater abundance of nitrogenous food which is made available by the action of the mycelium of the fungi in secreting protein-digesting ferments (proteolytic enzymes). The yearly increase in the radius of the rings was measured—in the case of *Marasmius oreades* it was found to be from six to fourteen inches.

CAUSE OF LEAF-FALL.—From experiments made with detached twigs of various deciduous trees placed in water in a saturated atmosphere Varga (*Oesterr. bot. Zeitschr.*, Band 61) has sought to establish a relationship between this familiar phenomenon and the processes of transpiration and photosynthesis influenced by various conditions of light and temperature. He concludes from the results of his experiments that (1) any decided checking of photosynthesis, either from light conditions or from a deficiency of carbon dioxide, brings about leaf-fall; (2) any lowering of transpiration also induces defoliation, but less rapidly than diminished photosynthesis; (3) variation in the intensity and quality of the light has no direct specific action upon leaf-fall; (4) lower temperatures are effective in producing leaf-fall through decreased photosynthesis and transpiration only within limits which allow the activities involved in the development of the absciss layer—below these limits the leaves die, but cling rather persistently to the twigs.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

INSTITUTE OF METALS.—At the annual general meeting of the Institute, on March 11th and 12th, 1913, the Report of the Council was presented by the President. From this it appears that there has been a steady increase in the number of members, which has risen from three hundred and fifty-five in 1908, to six hundred and fourteen in 1912.

Six papers were also read on this occasion by Fellows of the Institute. These included a study of the "Corrosion of Aluminium," by Dr. G. S. Bailey, in which it is shown that the results obtained by acting upon the metal with acids or alkalies afforded no definite indication of its behaviour in the presence of water or solutions of salts. In the paper read by Mr. Siemens upon "Metal Filament Lamps," an account is given of the evolution of the processes of preparing the wire for these lamps, descriptions of many of which have been given in these columns. The general conclusion reached, is that it is doubtful whether it will be possible to construct a much more economical glow-lamp than the tungsten lamp, and that further progress must be sought in the directions of the improvement and cheapening of the electric supply. The remaining papers by Mr. Gulliver, Messrs. H. & J. Primrose, Mr. Hudson, and Mr. A. Philip are more purely technical in character.

NEW GERMAN INK REGULATIONS.—An account is given by Dr. Hinrichsen in the *Chemiker Zeitung* (1913, XXXVII, 265) of the Prussian regulations for the official tests of writing ink, which came into force last year. In these regulations inks are classified into "documentary" and "ordinary writing inks," and the methods for their analysis and examination are outlined. For example, a "documentary" ink must contain at least twenty-seven grammes of anhydrous gallotannic and gallic acids, with at least four grammes of iron, per litre, and the ratio of tannin to iron must lie within the limits of 4·5 : 1 and 6·75 : 1. Ordinary iron-gall writing inks may contain less tannin, but must still have the same ratios of tannin and iron.

Both kinds of ink must show no alteration in the ink-pot for at least fourteen days, must flow readily from the pen, and must give writing which after being exposed for eight days to the air, is deep black, and can be washed with water and with dilute alcohol.

In testing the permanency of the writing, pieces of standard paper are stretched in a frame inclined at an angle of 45°, and a definite quantity of the ink is made to flow over this paper from a pipette, which is placed in a rest on the frame, so that it is always at the same angle. Simultaneously, parallel ink bands are made upon the paper with a standard ink of known composition, prepared in a definite manner.

The paper, with the colour bands of the two inks upon it, is exposed for eight days in diffused daylight, and is then cut horizontally into three strips. One of these is immersed in water, the second in fifty per cent. alcohol, and the third in eighty-five per cent. alcohol. In none of the strips should there be any perceptible bleaching of the ink.

HARDNESS OF RAINWATER.—Rainwater is commonly regarded as one of the purest forms of natural water, but this is not always the case with the rain that falls in large towns and especially in industrial centres. For example, some years ago it was found that the rainwater in Paris was decidedly hard, and the cause of this was traced to the dust from macadamised roads, the salts in which had been taken up by the rain during its passage through the air.

Another remarkable instance of hard rainwater has recently been investigated by Dr. S. Wolff (*J. Soc. Chem. Ind.*, 1913, XXXII, 345). The water used in some large works outside Manchester has frequently given trouble on account of its hardness, though consisting largely of rainwater collected from the roofs of the buildings. All the samples of the rainwater examined prior to their entering the reservoir were found to be decidedly hard and to give an alkaline reäction. In some of them the proportion of dissolved calcium salts was so great that a scum could be formed by blowing into the water.

A specimen of rainwater collected directly from the roof contained one hundred and seventy parts of total solids per one hundred thousand, and had a total hardness of 87·2 and temporary hardness of 15·75.

In the discussion upon this paper it was mentioned by Mr. W. H. Coleman that much of the coal used in the neighbourhood of the works came from the Bradford Colliery, and that this coal was rich in crystallised carbonate, and it was suggested that the smoke from this coal might convey calcium compounds into the air. Apart from this, a considerable quantity of flue dust must be blown up the chimneys into the air, and a considerable quantity of this must settle upon the roofs; whence some of its soluble constituents would be dissolved by the falling rain.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

OLD RED SANDSTONE AT SOUTHALL.—The interesting discovery of Palaeozoic rocks made by E. Proctor in a boring at Southall is described in the current volume of *The Quarterly Journal of the Geological Society*. The platform of old rocks was struck at a depth of one thousand one hundred and thirty feet, and continued to one thousand two hundred and sixty-one feet, the total depth of the boring. After two hundred and sixty-two feet of gault, the boring entered red and green mottled clays and sandstones, with occasional bands of fine conglomerate. On breaking up the cores remains of fossil fish were found in a marked type of rock occurring in thin bands and consisting almost entirely of organic remains associated with rounded and subangular grains of quartz. The fossils, as determined by Dr. Smith Woodward, consist of scales and teeth of *Holoptychius* and plates of *Bothriolepis*, both of which are characteristic of the Upper Devonian or Old Red Sandstone. This discovery creates a probability that other but unfossiliferous Red Rocks found in other borings in the London Basin are of the same age.

RAISED BEACHES AND PALAEOLITHIC MAN.—In the April *Geological Magazine* Mr. H. Dewey describes the raised beach of North Devon and discusses its relations to other Pleistocene deposits and to Palaeolithic man. The raised beach forms a shelf and notches the cliffs about ten to fifteen feet above sea-level. Between Croyde Sand and Saunton Down the beach lies on a shelf, and is overlaid by a variable thickness of current-bedded sand, the contained shells of which indicate a warm temperate climate. The raised beach deposit consists of pebbles of slate, sandstone, vein-quartz, quartzite, and chalk-flints. Erratic boulders of a red granite lie on the platform. The granite closely resembles a gneissose granite from Ross-shire; and if this identification be correct, ice is the only conceivable transporting agency. The sand is overlaid by a bed of "head," which in turn is covered by a bed of large rounded stones. A bed corresponding with the latter, occurring at Fremington, contains glaciated stones in a brown loamy clay, and indicates an arctic climate during its formation. A similar bed of glaciated stones overlying "head" was discovered by Mr. Barrow in the Scilly Isles. In the Coombe rock of Southern England and France, which is equivalent and contemporaneous to the "head" of Devon and Cornwall, Palaeolithic implements of Mousterian type have been found.

Mr. Dewey comes to the conclusions that the deposits overlying the raised beaches were formed during a period of variable climate—arctic at first, then warm temperate, finally reverting to arctic—and that early Palaeolithic man lived during the inter-arctic period. He is later than the chalky boulder clay and the raised beach, and earlier than the boulder clay of Glamorgan and South Ireland.

QUANTITATIVE STUDY OF ACTIVE VOLCANOES.—The great quantitative geological investigations which we owe to the Geophysical Laboratory of the Carnegie Institute at Washington are now being supplemented by a study of the physics and chemistry of active volcanoes (Year Book No. 11, 1912). The crater of Kilauea in Hawaii is the one selected for this purpose. During the past summer it was found possible to descend into the crater and collect the volatile ingredients directly from the lava. These gases were collected and sealed in glass tubes without having come into contact with the air at all, and sent to Washington for detailed study. A very important observation is, however, available, and that is that the temperature of the lava in the active basin varies from day to day, and that this variation depends on the quantity of gas emitted. The temperature rises with an increase of gas emission, and falls when the volume of gas diminishes.

The composition of the smoke cloud above the volcano, which contains much non-gaseous matter, was also studied, and samples of the liquid lava were taken directly from the molten lake. It is hoped to determine the character of the chemical reäctions within the gases, between the gases and the liquid lava, and between the gases and the air. Arising out of the recent contention of Brün and others that volcanic eruptions are essentially anhydrous (see "KNOWLEDGE," April, 1911, p. 352), it is mentioned that from one of the gases collected directly from the boiling lava no less than half a pint of water was condensed on cooling.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

DEATHS BY LIGHTNING.—Most people imagine that the number of persons killed by lightning each year is very great. This impression is largely due to the lack of reliable information and to the inherent dread of thunderstorms, and is far from being correct. Dr. A. Jex-Blake, in a recent course of lectures delivered before the Royal College of Physicians on "Death by Electric Currents and by Lightning," gave some statistics on the subject from which he showed that during the ten years 1901–1910, the Registrar-General had reported one hundred and twenty-four fatal instances in lightning stroke in England and Wales—one hundred and eight in men and sixteen in women—a yearly average of only 12·4 deaths, or 0·36 per million living. In the twenty-nine years 1852–1880 there were five hundred and forty-six such deaths, the yearly average for that period being 18·8, or 0·88 per annum per million living. The number of these deaths varied widely in different years; three people were killed by lightning in 1863 and forty-six in 1872. The annual death-rate from lightning also varies widely in different parts of England. In the north Midlands from 1852–1880 it was 1·8 annually per million living, in the Metropolitan district only 0·13 (Lawson)—a figure that should be of comfort to anybody who is in London during a thunderstorm. On the Continent much higher yearly death-rates are found. In Hungary the annual death-rate from lightning is said to be sixteen per million living (Milham); in Styria and Carinthia about ten per million; in Prussia 4·4; in France and in Sweden three; in Belgium two, so far as the imperfect statistics available go (McAdie and Henry). In the United States of America the annual death-rate per million is high—about ten—in consequence of the frequency of thunderstorms on the one hand and of the large percentage of the inhabitants engaged in outdoor labour on the other; about seven hundred or eight hundred deaths from lightning were estimated to occur in the United States every year by Henry in 1900 in a population of seventy-six millions.

Many more people are struck by lightning than are killed. For example, Jack records an instance in which a church was struck: three hundred people were in it, one hundred were injured and mostly made unconscious, thirty had to take to their beds, but only six were killed. Weber gives an account of ninety-two people struck in Schleswig-Holstein: ten were killed, twenty paralysed, fifty-five stupefied, and seven only slightly injured. In 1905, a tent with two hundred and fifty people in it was struck, and sixty were left on the ground in various states of insensibility; one was killed outright, another breathed for some minutes before dying, the rest recovered. As many as eleven and eighteen persons have been killed by a single stroke of lightning. Vincent mentions a stroke that threw down one thousand two hundred and killed five hundred and fifty-six out of a flock of one thousand eight hundred sheep. Dechambre believes that children are perhaps less liable to be struck than adults; but statements such as these are really not capable of proof or disproof.

STORMS ON THE ATLANTIC, JANUARY, 1913.—The month of January, 1913, was probably the stormiest month on record on the North Atlantic Ocean. Mr. R. E. Harris has given an account of the storms of this month, together with some synoptic charts over the North Atlantic at Greenwich mean noon, and also barograms from several vessels.

During the first half of the month several unusually severe storms crossed the North Atlantic, the most severe of which can be traced on the synoptic charts from the 8th to the 11th. This storm was only a moderate depression with two centres at noon of the 8th, the lowest barometer at the primary centre over New York being 29·60 inches. At the same time a severe storm was central near latitude 49° N., longitude 25° W., and was causing winds of force eight to twelve (Beaufort scale) over a wide area north of the Azores between the fifteenth and forty-fifth meridians. By noon of the 9th a rapid development in the western storm had occurred, and it was central near latitude 45° N. and longitude 48° W., with lowest barometer 28·72 inches. Winds of force seven to twelve were prevailing west of the fortieth meridian and north of the thirty-fifth parallel. During the night of the 9th and 10th the storm was at its height, and remarkably low barometer readings were recorded, the lowest, 26·96 inches, being registered on the SS. *Manchester Inventor*, at 1 a.m., on the 10th, at 52° N., 25° 30′ W. This is probably the lowest reading ever made on the North Atlantic. By noon the storm was central near 51° 30′ N., 27° W., with lowest barometer 27·76 inches. Winds of hurricane force were experienced by many vessels north of the fortieth parallel, between the forty-fifth and fourteenth meridians. Within this area ten ships reported winds of force twelve, thirteen force eleven, five force ten, and nine force nine, out of a total of forty-seven. By noon of the 11th the storm was central near 56° N. and 15° W., and winds of force seven to eleven were prevailing over the ocean north of the fortieth parallel and east of the forty-fifth meridian. Severe gales occurred over the British Isles.

LOWEST BAROMETER RECORDS.—In connection with the above remarkably low reading of 26·96 inches it may be of interest to give what is, so far as is known, the next actual lowest barometric pressure which has been observed in any other part of the world, viz., 27·135 inches on September 22nd, 1885, at False Point, on the coast of Orissa, India. In the British Isles the lowest recorded barometric pressures have been:—27·332 inches on January 26th, 1884, at Ochtertyre, Crieff; and 27·380 inches on December 8th, 1886, at Belfast.

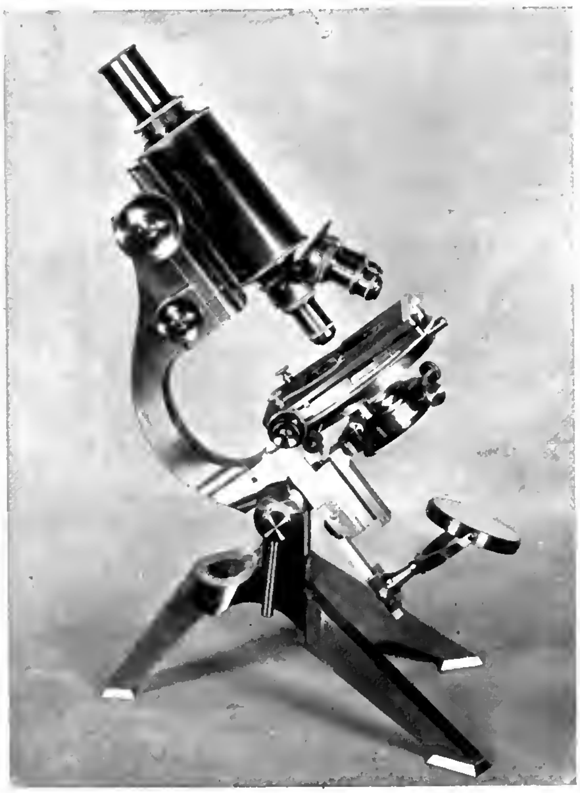


FIGURE 228.
A new model Microscope.

VIOLENT UPRUSHES IN CUMULUS CLOUDS.—Everyone who has carefully watched clouds is familiar with the peculiar boiling and tumbling of large cumulus clouds, their formation of new heads, and the other evidences they often give of violent motions and an explosive-like turbulence. The late Dr. W. von Bezold suggested that these movements indicate that there is a source of power within the cloud itself, and he ascribed this power to the latent heat set free by the more or less sudden condensation of a supersaturated vapour, or the sudden freezing of undercooled waterdrops.

Professor W. J. Humphreys has recently investigated this subject, and he has come to the conclusion that the difference in temperature between the free air and the interior of large cumulus clouds at the same level is the real cause of the violent uprush and turmoil in their centres. He is also of opinion that most of the electrical and other energy of the thunderstorm comes directly or indirectly from the latent heat of condensation set free within the mass of turbulent cumulus clouds.

PHENOLOGICAL OBSERVATIONS, 1912.—At the meeting of the Royal Meteorological Society on April 16th Mr. J. E. Clark and Mr. R. H. Hooker presented their report on the Phenological Observations for the year ending November, 1912. This dealt with the dates of the first flowering of certain plants, the song and migration of birds, the appearance of insects, and the yield of farm and fruit crops. The chief factors affecting the field crops were probably the dry warm April and May, followed by the cold, wet, sunless summer. The spring was perhaps the more important of the two: it affected the corn crops and the hay. All the crops in the United Kingdom were below the average of the preceding ten years, although in Great Britain alone meadow hay was a little better than usual, and hops were also above the mean by fully twenty-three per cent. The harvest of 1912 must be classed as very deficient, and one of the worst experienced for many years.

HARVEST WEATHER FORECAST.—The Meteorological Office will be prepared, from June 1st to September 30th, to supply forecasts of weather by telegraph, to farmers and other persons desirous of receiving them, upon payment of the cost of the telegram. The forecasts are drawn up each week-day, at 2.30 p.m., and refer to the probable weather during the fifteen hours from 6 a.m. to 9 p.m. on the next day. A note as to the further outlook is given when possible. Applications for the forecasts should be sent to the Director, Meteorological Office, South Kensington, London, S.W.

MICROSCOPY.

By F.R.M.S.

A NEW MODEL MICROSCOPE.—Figure 228 represents a new pattern microscope, designed by Mr. E. Leitz, which combines in itself features of both the English and Continental models. There is a tripod base which gives rigidity in the horizontal as well as in the vertical position. A curved limb allows of additional working space on the stage, which is of the square fixed type, though a detachable mechanical arrangement may be added. The sub-stage has centring screws controlling the condenser sleeve which is of the standard gauge of the Royal Microscopical Society, while the fine adjustment is of the type originally introduced into the Leitz Continental Microscopes and consists of a cam and worm screw continuous motion.

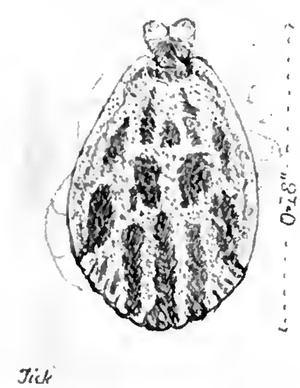


FIGURE 229.
A *Rhipicephalus* from Australia.

AN AUSTRALIAN TICK.—A short time ago two small "insects" were sent to me by a friend in Devonshire, who said they had been found on the dress of a child, whose mother, being unable to recognise them, feared they might be some species of *Cimex*, and was anxious to know if this was so, and where it was likely they came from. On placing them under the microscope I saw at once that they were Ticks, but were so flat and so dry that I concluded they had died of starvation, and had been dead a long time. They measured ·18 inch in extreme length and were lemon-coloured, with purple-brown markings and spots. After careful examination and comparison with the figures and descriptions given by Neumann in his "Revision of the Ixodes," I determined them to belong to the genus *Rhipicephalus*, and therefore certainly not British; but as to species they did not exactly agree with anything figured either by Neumann or by any other authority consulted. Having only two specimens I was unwilling to dissect more than one, and having detached and prepared its capitulum I was successful in this instance in getting a clear view of the chelicerae, though, unfortunately, not also of the hypostome. On looking through the mounted specimens of some fifty species in my cabinet I found that the chelicerae closely resembled those of a Tick sent to me from Brisbane as having been found on a dog in the neighbourhood of the Filbert River in Queensland. How, then, could it have been found in Devonshire? Further enquiries elicited the fact that the child on whose dress these Ticks were found had shortly before been playing on a fur rug made from the skins of Australian Dingoes, and there seemed no doubt that these Arachnids had been imported in this.

R. T. L.

Figure 230.
Chelicerae of the *Rhipicephalus.*

A PORTABLE MICROSCOPE.—It is an axiomatic truth that the Continental form of microscope, with its short tube, lends itself to portability better than the English one, with its long tube and extended base.

Messrs. Leitz, in 1899, introduced a portable model, in which a closing V was substituted for the horseshoe foot; but in 1901 further improvements were made by adopting the well-known plan of pivoting the stage, so that it could be turned round into the plane of the optic axis; thus the whole microscope, although of full size, could be folded up into a compact block, which could be packed in a small box (see Figure 232).

Their later microscope model with a horizontal pinion fine-adjustment (introduced in 1903) has now been adapted to this portable form, and one has just been made in which some alterations have been adopted.

First, the stage has been made on my horseshoe plan, and fitted with a sliding bar (Figure 231). It measures 13×9 cm.; rather a contrast to the 6×4 cm. stage, at one time an extreme size for a Continental microscope!

Attached below the stage is the usual spiral focusing mechanism carrying a sub-stage ring, which has a small amount of play for centring by means of a spring opposing two screws. A tube sliding into this ring carries an achromatic condenser and an iris diaphragm; below this is a turn-out ring, with a rather deep cell, to hold screens, stops, and so on.

Secondly, the pillar which carries the microscope is fitted with a conical pivot, so that the V-foot may be turned round in order that the toes of the V may face backwards instead of forwards (Figure 231). The rotating foot was first made by John Cuff, 1750. Previously, when the microscope was inclined it was found that its stability was seriously impaired, so much so that when a horizontal position was reached the microscope fell over; but now, when the foot is rotated backwards, the microscope is perfectly stable. Figure 233 shows the instrument holding an Abbe camera in a position for drawing at the side, an increase of stability being required on account of the weight of the large mirror on the top of the tube. In this case the V-foot is rotated half-round. The draw tube has been increased in length, so that with eighteen millimetres for the objective slide or rotating nosepiece, a total of two hundred and eleven millimetres has been obtained. There are some objects which require the whole of that length, even with a short tube objective.


Figure 231.
A Portable Microscope.

In Figure 231 the instrument is seen fitted with one of Messrs. Leitz's eyepieces, with rotating eye-lenses (introduced 1899); the same field lens does duty for both. This is a most convenient and time-saving device. One is a No. 2 (×6), the other a No. 5 (×12). The corrections of these eyepieces are very perfect.

The objectives, six in number, *viz.*, Nos. 1, 2, 3a, apo. 8 mm., 6a and apo. $\frac{1}{12}$ 1·4 N.A., are all supplied with slides, and fit, while attached to their slides, in a separate box: this plan saves much time in screwing and unscrewing and packing them away in their own brass boxes. This box is itself packed in the same case as the microscope, as also are the six brass boxes for the objectives, and an oil bottle.

In addition to the rotating eyepiece, there are Nos. 2 and 3 Huyghenian, a micrometer eyepiece, and an 8, a 12 and an 18 compensating eyepieces. A polariser and analyser has also been added, the whole thus forming a fairly complete microscopical outfit.

Edward M. Nelson.


Figure 232.
The Microscope folded.

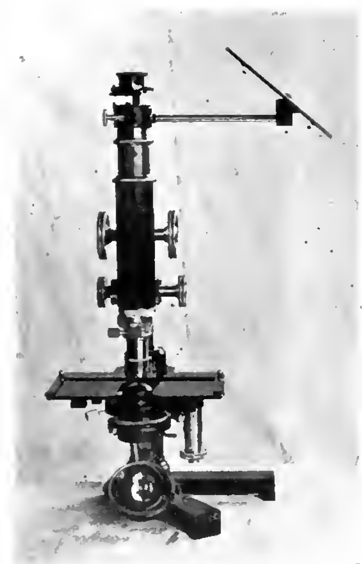


Figure 233. The instrument with draw tube increased in length and fitted with an Abbe camera.

PHOTOGRAPHY.

By Edgar Senior.

IMPERFECT FIXING.—Hypo "Sodium Thiosulphate" is invariably used as the fixing agent for both negatives and prints. Its action depends upon the formation of a double salt with the unaltered silver salt left in the film, and when the hypo is present in sufficient excess the double salt formed is highly soluble in water and diffuses readily out of the film in washing. If, however, the fixing bath is too weak, or the plates or prints are removed too soon, then imperfect fixing results, owing to the formation of a double salt which is almost insoluble in water. This may be shown as a simple test-tube experiment by taking a solution of silver nitrate and one of hypo, when, on adding them together in such a manner that the former is present in excess, a white precipitate, which rapidly turns brown and finally black, is the result, the reäction being expressed by the following equations:—

$$2AgNO_3 + Na_2S_2O_3 = Ag_2S_2O_3 + 2NaNO_3.$$

Then

$$Ag_2S_2O_3 + H_2O = Ag_2S' + H_2SO_4.$$

By the addition of hypo in excess, however, the white precipitate first formed is readily dissolved and a perfectly clear solution results. Therefore care should be taken to have the fixing bath sufficiently strong and to allow the plates or prints to remain in long enough to ensure perfect fixation. In other words, to ensure the formation of the double thiosulphate of silver and sodium, which is highly soluble, a reäction expressed by the equation:—

$$2AgBr + 3Na_2S_2O_3 = Ag_2Na_4(S_2O_3)_3 + 2NaBr.$$

ACID FIXING BATHS.—The use of an acid fixing bath has certain advantages over that of a plain solution of hypo in water, inasmuch as the bath keeps clean for a much longer time and the plates are quite free from any deposit or stain in the film. Their preparation requires care to avoid any precipitate of sulphur taking place due to decomposition of the hypo by the acid. A very good formula for such a bath, "originally given by Mr. Sandell for fixing his double- and triple-coated plates," is the following:—

Hypo	7 ounces
Soda Sulphite	1 ounce
Water	20 ounces
Strong Sulphuric Acid	1 drachm

After the hypo and soda sulphite are dissolved the sulphuric acid is added in drops at a time, stirring all the while. Such a fixing bath keeps quite a long time and may be diluted or not as thought desirable. Another bath, containing meta-bisulphite of potassium, is as follows:—

Hypo	5 ounces
Potassium meta-bisulphite	$2\frac{1}{2}$,,
Water	20 ,,

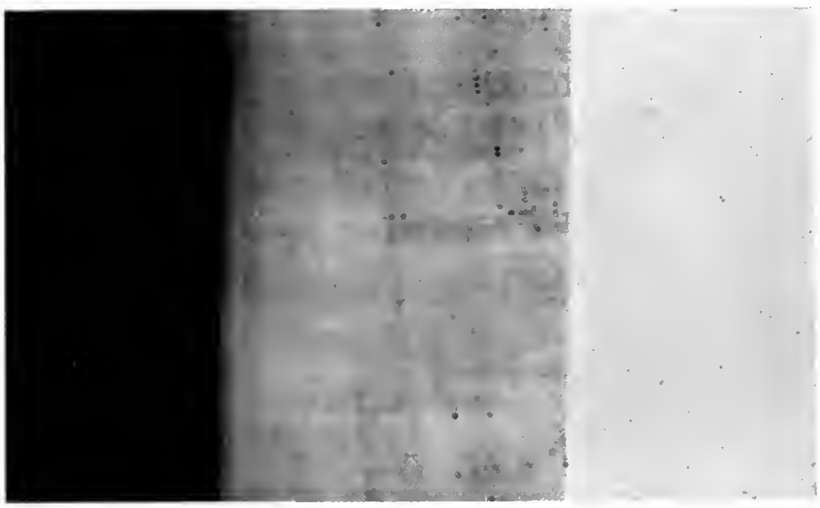
An acid fixing bath, containing common alum, can be prepared by taking certain precautions in mixing. The following will be found a very good formula:—

Hypo	4 ounces
Soda sulphite	1 ounce
Common alum	$\frac{1}{2}$,,
Tartaric acid	60 grains
Water	20 ounces

The ingredients must be dissolved in the order given, as, supposing the soda sulphite were to be added last, it would be found that the alum and tartaric acid would reäct with the hypo and a precipitate of sulphur would result.

A good plan is to dissolve the hypo and sulphite in a part of the water and the alum and tartaric acid in the remainder. The alum is then added to the solution of hypo and soda sulphite and finally the tartaric acid solution is poured slowly into it, stirring all the while. A precipitate which first forms will be found to dissolve up completely, and the acid solution will remain quite clear. This fixing bath possesses considerable hardening properties when freshly made, which, however, decrease rapidly by keeping.

TESTING DARK-ROOM LIGHT FILTERS.—One frequently sees an otherwise good negative completely spoilt through undue exposure of the plate during manipulation to the light from the dark-room lamp. If we remember that there is probably no such thing as an absolutely safe light—it simply being a question of the length of time a plate may be exposed without showing any effect due to this cause—it is evidently advisable that some kind of test should be made to ascertain it. Of course, the spectrum test is valuable in showing the region of the light transmitted by the material used as a filter, but then the general sensitiveness, as well as the spectrum sensitiveness of the emulsion, has to be taken into consideration also. And it is found that a light which is perfectly safe to employ with a plate of low sensitiveness would not be so for one of the opposite nature. In fact, a plate may be orthochromatic, but its general sensitiveness so low that it may be developed in a yellow light, without any bad result following from so doing. The question naturally arises then as to what test should be applied to ascertain the safety or otherwise of the medium in use for the purpose of filtering the light through. The one employed by the writer is due to Sir William Abney, and consists in exposing a plate behind several different kinds of coloured glass, paper, or fabrics to the light used as the source of illumination for periods varying with the nature of the emulsion on the plate. A test of this kind is shown in Figure 234, the material used being (*a*) canary medium, (*b*) cherry fabric, (c) orange paper. These were fastened together and placed upon a piece of clear glass in a printing frame, and a special rapid gelatine plate, 225 H and D, laid upon them. The whole was then exposed to the light from a sixteen-candle power incandescent electric lamp for a period of two minutes at a distance of two feet from the light. The plate was then developed in darkness, the time allowed being five minutes. Examination showed that practically no action had taken place upon that part of the plate under the orange paper, while the cherry fabric had allowed sufficient light to pass to cause considerable action on the surface beneath it, while that part of the film protected by the canary medium was, as might be expected, practically black. Instead of fixing the image, the film was simply washed and then placed in a solution of bichromate of potash, made acid with sulphuric acid. This quickly dissolved out the reduced silver, and after a thorough washing in running water the plate was brought into the light and redeveloped with amidol. By adopting this method the necessity of making a transparency in the usual manner is done away with and we at once get the relative effects produced shown in their correct aspect of light and shade, and the test furnishes the information that one thickness of orange paper employed in front of a sixteen-candle power electric lamp would practically afford such safety that a gelatine plate



A B C

FIGURE 234. Photographic test of the safety of dark room light filters.

of 225 H and D might be exposed at a distance of two feet for two minutes to the light transmitted by it without showing any fog on that account. Tests of this kind are valuable in conjunction with spectroscopic ones from the quantitative estimation of the time required to produce any action. Of course, the time could be still further prolonged by exposing further away, and so taking advantage of the greater distance. But two minutes are ample for all practical purposes, and by keeping the developing dish covered during development no trouble could possibly occur through any fault of the dark-room light. Unfortunately, orange paper varies very much in colour as well as thickness, but that which is fairly stout and of a dark tint should be chosen, and then tested after the manner described. It will be noticed that the cherry fabric is rather uneven in texture and also has a good number of pin-holes in it, so that either two thicknesses would have to be used or a combination made with canary medium, when a fairly safe light would result for plates of average rapidity.

PHYSICS.

By ALFRED C. G. EGERTON, B.Sc.

THE HALL EFFECT.—Metals have the power of conducting electricity and also heat; their conductivity, however, varies with the nature of the metal; some metals, such as tellurium, are feeble conductors, others, such as copper, offer very low resistance indeed. The connection between conductivity of electricity and that of heat is not at once evident, though on the whole the thermal conductivity varies similarly to the electrical with the nature of the metal. Electricity, according to modern views, is conveyed along a conductor by the electrons which pass from atom to atom. Heat is conveyed as an increase in the kinetic energy of the molecules of the substance; but since the agitation of the molecules increases, so does the agitation of the particles contained within them, *viz.*, the electrons, and part of the thermal energy conveyed along the conductor is due to the increased kinetic energy of the electrons. This is especially the case for the metals; substances, such as sulphur, which are bad conductors, conduct heat chiefly by the motion of the molecules. It is possible to calculate approximately from such considerations what the ratio of thermal conductivity to electrical conductivity should be, and the ratio κ/σ at 10° to the ratio κ/σ at 18° should be constant and have the value 1·28. The results of experiments show that such a ratio is approximately constant for many different metals—a remarkable confirmation of the theory.

Now if electricity is conveyed along a wire by the free electrons which carry a negative charge, a magnetic field should deflect such electrons across the breadth of the conductor, and so one side will acquire a negative charge of electricity. At the same time a diffusion of such charged particles will take place from crowded parts to those less crowded, and equilibrium will be attained when the effect due to diffusion counterbalances that due to the deflection of the electrons by the magnetic field, a difference of potential between the upper and lower edges of the conductor being the result. Such a difference of potential was observed by Hall in 1879, and has since been studied by Nernst and others. Experiments have been very difficult, as several effects come into play besides the Hall effect.

Kammerlingh Onnes, of Leyden, whose experiments on liquefaction of gases are well known, has recently investigated the Hall effect at very low temperatures. The effect obtained in the case of bismuth can be divided into two components: the effect due to the magnetic field, which always gives a negative charge, due to the deflection of the electrons; the other effect is a thermal effect inversely proportional to the absolute temperature, which may reverse the sign of the charge due to the magnetic field. Results of considerable importance to the electron theory of metallic conduction may be expected from such experiments.

THE ROYAL SOCIETY'S CONVERSAZIONE.—On May 7th the Royal Society held its conversazione, at which many interesting exhibits were on view. Among such exhibits may be mentioned the new lines which Professor Fowler has found in the spectrum of hydrogen. Lines which have only previously been seen from investigations of the spectrum of the stars have been found when a very strong condenser discharge is passed through a mixture of helium and hydrogen. Another interesting exhibit was the micromanometer of Mr. Fry, who arranges a stretched membrane so that its movement twists a mirror suspended in a special manner: the pressure differences being indicated by the deflection of a spot of light, a difference of pressure of one-millionth of a millimetre of mercury can be detected.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

SPOTTED NEGROES.—Q. I. Simpson and W. E. Castle put on record an interesting peculiarity in human skin colour, "which made its appearance as a mutation or sport in a negro family of the southern United States some sixty years ago, and has shown itself fully hereditary through two generations of offspring." The peculiarity is "piebaldness," the dark skin being spotted with white in a fairly definite pattern. The original "mutant" was born in 1853, and her parents were normally coloured negroes. She married a normal negro, and had fifteen children, all of whom are living. The spottedness behaves like a Mendelian character—as a simple dominant, "the only peculiarity of the case being the excess of spotted grandchildren over the expected one-half." Some of the spotted descendants are now connected with "museums," and the authors note that the piebaldness, being an economic asset, is not likely to interfere with their racial increase.

CLIMBING FISHES.—It is well-known that the tropical fish, *Periophthalmus*, like its relative *Boleophthalmus*, spends hour after hour out of water, squatting on the mud by the sides of the tropical estuaries, or even climbing up on the roots of the mangrove trees. But such climbing powers as *Periophthalmus* possesses are far surpassed by a catfish *Arges marmoratus*, which lives in the torrential rivers of the Andes, where there is a rapid succession of falls, cascades, and pot-holes. Under usual conditions *Arges* is a clumsy and awkward swimmer, but for creeping and climbing in the torrents it is wonderfully adapted. It anchors itself by its suctorial mouth, and works itself upstream with the help of a ventral bony plate bearing the ventral fins and equipped with strong muscles which move it backwards and forwards. The plate is studded with small sharp teeth pointing backwards. The fishes climb up the smooth water-worn surfaces of deep pot-holes, and have been known to ascend eighteen feet without a slip or fall.

NOTICES.

ROYAL INSTITUTION.—The President has nominated the following gentlemen as Vice-Presidents for the ensuing year:—Dr. Henry E. Armstrong, the Right Hon. A. J. Balfour, J. H. Balfour Browne, Esq., Sir William Crookes, Dr. Donald W. C. Hood, the Right Hon. Sir James Stirling, Sir James Crichton-Browne (Treasurer), and Alexander Siemens, Esq. (Secretary).

SECONDHAND BOOKS ON NATURAL HISTORY.—More than nine hundred and fifty books on Natural History are included in Messrs. Henry Sotheran & Co.'s recent catalogue, numbered 736. The prices appear to be most reasonable and the volumes are on view at 43, Piccadilly.

THE FACE OF THE SKY FOR JULY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 41.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Jupiter. R.A.	Jupiter. Dec.	Uranus. R.A.	Uranus. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
July 4	6 51·6	N. 22·9	7 10·7	N. 27·3	8 41·4	N. 18·7	3 38·9	N. 16·1	18 56·9	S. 22·9	20 36·3	S. 19·3
,, 9	7 12·2	22·4	11 53·3	N. 0·6	9 0·2	16·4	3 58·6	17·2	18 54·2	23·0	20 35·6	19·3
,, 14	7 32·6	21·7	16 16·4	S. 26·2	9 12·8	14·4	4 19·2	18·3	18 51·4	23·0	20 34·8	19·4
,, 19	7 52·7	20·9	20 55·3	S. 21·1	9 18·5	12·7	4 40·5	19·2	18 48·8	23·1	20 34·0	19·4
,, 24	8 12·7	20·0	0 34·0	N. 5·0	9 16·5	11·7	5 2·5	20·0	18 46·2	23·2	20 33·2	19·5
,, 29	8 32·4	N. 18·8	4 39·5	N. 27·2	9 7·2	N. 11·6	5 25·1	N. 20·6	18 43·9	S. 23·2	20 32·4	S. 19·5

TABLE 42.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
Greenwich Noon.	°	°	°	°	°	°	°	°	h. m.	h. m.
July 4	− 1·4	+3·3	97·6	+ 6·5	−6·9	−1·6	83·0	256·4	7 34 *e*	2 35 *e*
,, 9	+ 0·9	3·8	31·5	+21·9	6·6	1·6	153·2	298·4	5 39 *e*	11 37 *e*
,, 14	3·2	4·3	325·3	+ 9·5	6·3	1·6	223·3	330·4	3 44 *e*	10 45 *e*
,, 19	5·4	4·8	259·1	−15·0	6·0	1·6	293·3	2·3	11 40 *e*	9 52 *e*
,, 24	7·6	5·2	192·0	−21·7	5·8	1·6	3·3	34·1	9 45 *e*	9 0 *e*
,, 29	+ 9·6	+5·6	126·8	− 7·5	−5·5	−1·6	73·2	65·8	7 51 *e*	8 7 *e*

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Jupiter, L_1 refers to the equatorial zone; L_2 to the temperate zone; T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

THE SUN has now commenced his Southward march. Sunrise during July changes from 3.49 to 4.23; sunset from 8.18 to 7.49. Its semi-diameter increases from 15′ 45″ to 15′ 47″. It is at its greatest distance from the Earth at midnight on July 3rd. Outbreaks of spots in high latitudes should be watched for.

MERCURY is an evening star, reaching East Elongation on July 7th, when it is 16° from the Sun. Illumination one-half on 1st, one twenty-fifth on 30th. Semi-diameter increases from 3½″ to 5½″.

VENUS is a morning star, reaching West Elongation July 4th, when it is 46° from the Sun; 7½° South of Moon on 30th. Semi-diameter diminishes from 12″ to 9″. At beginning of month one-half of disc is illuminated; at end of month five-eighths. Being South of Sun till the 24th, it is less well placed for Northern observers than it was as an evening star; after that its position is favourable.

THE MOON.—New $4^d\ 5^h\ 6^m$ *m*; First Quarter $10^d\ 9^h\ 37^m$ *e*; Full $18^d\ 6^h\ 6^m$ *m*; Last Quarter $26^d\ 9^h\ 59^m$ *m*. Perigee $6^d\ 12^h$ *e*, semi-diameter 16′ 24″. Apogee $22^d\ 7^h$ *e*, semi-diameter 14′ 46″. Maximum Librations, 1^d 6° E, 3^d 7° S., 14^d 5° W., 16^d 7° N., 28^d 7° E., 30^d 7° S. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon. (See Table 43.)

TABLE 43. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.		h. m.	
July 1	BAC 1170	5·5	1 38 *m*	119°	2 12 *m*	201°
,, 1	26 Tauri	6 6	—	—	2 42 *m*	289
,, 1	BD+23°569	6·8	—	—	3 10 *m*	267
,, 6	8 Leonis	5·9	8 38 *e*	111	9 28 *e*	300
,, 8	82 Leonis	6·7	9 31 *e*	126	—	—
,, 8	83 Leonis	6·3	10 16 *e*	149	—	—
,, 13	b Scorpii	4·7	11 27 *e*	108	—	—
,, 21	39 Aquarii	6·2	0 50 *m*	349	1 20 *m*	305
,, 23	BAC 47	7·3	—	—	10 44 *e*	305
,, 23	BAC 57...	6.3	10 20 *e*	72	11 22 *e*	226
,, 25	70 Piscium	7·8	—	—	0 42 *m*	305
,, 25	ε Piscium	4 5	0 18 *m*	38	1 22 *m*	254
,, 26	27 Arietis	6 4	10 43 *e*	67	11 37 *e*	243
,, 28	BAC 1055	6·9	—	—	0 40 *m*	187
,, 28	66 Arietis	6·1	2 5 *m*	37	3 0 *m*	272
,, 29	χ Tauri ...	5·3	1 18 *m*	88	2 12 *m*	235

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

MARS is a morning Star, but not yet well placed for observation.

JUPITER is in opposition on July 5th. Polar semi-diameter, $21\frac{1}{2}''$.

TABLE 44.

Day.	West.		East.		Day.	West.		East.	
July 1	32	⊙	4		July 17	1	○	324	
,, 2	3	○	124		,, 18	2	○	134	
,, 3	1	○	234		,, 19	12	○	34	
,, 4	2	○	413		,, 20		○	3124	
,, 5	14	○	3	2●	,, 21	312	⊙		
,, 6	43	○	12		,, 22	342	○	1	
,, 7	4321	○			,, 23	431	○	2	
,, 8	432	⊙			,, 24	41	○	32	
,, 9	43	○	12		,, 25	42	○	13	
,, 10	41	○	23		,, 26	412	○	3	
,, 11	42	○	13		,, 27	4	○	312	
,, 12	41	○	3	2●	,, 28	431	⊙		
,, 13		⊙	412		,, 29	324	○	1	
,, 14	312	○	4		,, 30	31	○	24	
,, 15	32	○	14		,, 31		⊙	24	3●
,, 16	3	○	24	1●					

Configuration at $11^h e$ for an inverting telescope.

Satellite phenomena visible at Greenwich, $1^d\ 2^h\ 1^m m$ I. Oc. R., $8^h\ 44^m e$ I. Sh. I., $8^h\ 49^m e$ I. Tr. I., $11^h\ 2^m e$ I. Sh. E.. $11^h\ 7^m e$ I. Tr. E.; $2^d\ 8^h\ 27^m e$ I. Oc. R.; $4^d\ 2^h\ 19^m m$ II. Sh. I.. $2^h\ 23^m m$ II. Tr. I.; $5^d\ 8^h\ 29^m e$ II. Oc. D., $11^h\ 15^m\ 38^s$ II. Ec. R.; $6^d\ 10^h\ 19^m$ III. Tr. E.. $10^h\ 27^m$ III. Sh. E.; $8^d\ 1^h\ 26^m m$ I. Oc. D.. $3^h\ 45^m\ 52^s$ I. Ec. R., $10^h\ 33^m e$ I. Tr. I., $10^h\ 38^m e$ I. Sh. I.; $9^d\ 0^h\ 51^m m$ I. Tr. E., $0^h\ 56^m m$ I. Sh. E., $10^h\ 14^m\ 26^s e$ I. Ec. R.; $12^d\ 10^h\ 42^m e$ II. Oc. D.; $13^d\ 1^h\ 51^m\ 47^s$ II. Ec. R., $10^h\ 19^m e$ III. Tr. I., $11^h\ 10^m e$ III. Sh. I.; $14^d\ 1^h\ 36^m m$ III. Tr. E., $2^h\ 27^m m$ III. Sh. E.. $8^h\ 34^m e$ II. Tr. E., $9^h\ 2^m e$ II. Sh. E.; $15^d\ 3^h\ 10^m m$ I. Oc. D.; $16^d\ 0^h\ 17^m m$ I. Tr. I., $0^h\ 33^m m$ I. Sh. I., $2^h\ 35^m m$ I. Tr. E., $2^h\ 51^m m$ I. Sh. E.. $9^h\ 37^m e$ I. Oc. D.; $17^d\ 0^h\ 8^m\ 56^s m$ I. Ec. R., $9^h\ 1^m e$ I. Tr. E., $9^h\ 19^m e$ I. Sh. E.; $20^d\ 0^h\ 58^m m$ II. Oc. D.; $21^d\ 1^h\ 37^m m$ III. Tr. I., $8^h\ 47^m e$ II. Sh. I., $9^h\ 35^m e$ IV. Tr. I., $10^h\ 49^m e$ II. Tr. E., $11^h\ 37^m e$ II. Sh. E. $22^d\ 0^h\ 25^m m$ IV. Tr. E., $1^h\ 22^m m$ IV. Sh. I.; $23^d\ 2^h\ 2^m m$ I. Tr. I., $2^h\ 27^m m$ I. Sh. I., $11^h\ 21^m e$ I. Oc. D., $24^d\ 2^h\ 3^m\ 30^s m$ I. Ec. R., $8^h\ 28^m e$ I. Tr. I., $8^h\ 35^m\ 53^s e$ III. Ec. R., $8^h\ 56^m e$ I. Sh. I., $10^h\ 46^m e$ I. Tr. E., $11^h\ 14^m e$ I. Sh. E.; $25^d\ 8^h\ 32^m\ 10^s e$ I. Ec. R.; $28^d\ 10^h\ 16^m e$ II. Tr. I., $11^h\ 23^m e$ II. Sh. I.; $29^d\ 1^h\ 6^m m$ II. Tr. E., $2^h\ 13^m m$ II. Sh. E.; $30^d\ 8^h\ 23^m\ 43^s e$ II. Ec. R.; $31^d\ 1^h\ 6^m m$ I. Oc. D., $10^h\ 13^m e$ I. Tr. I., $10^h\ 51^m e$ I. Sh. I.

Near the time of opposition, the satellites, when crossing the disc, are very close to their shadows.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant.			Remarks.
	R.A.		Dec.	
	°		°	
May 30 to Aug.	333	+	28	Swift, streaks.
,, to July .	252	—	21	Slow, trains.
June to Aug....	310	+	61	Swift, streaks.
,, to Sep. ..	335	+	57	Swift.
,, to July ..	245	+	64	Swift.
,, to Aug....	303	+	24	Swift.
July 6-22 ..	284	—	13	Very slow.
,, 15-31 ...	23	+	43	Swift, streaks.
,, 19 ...	315	+	48	Swift, short.
,, 22-27 ...	335	+	51	Swift, streaks.
July to Aug...	308	—	12	Slow, long.
July 25 to Sept. 15	48	+	43	Swift, streaks.
July 28 ...	339	—	11	Slow, long. The July Aquarids, a conspicuous shower.
July to Sept...	335	+	73	Swift, short.
July 8-31 .	317	+	31	Swift, white.
July to Aug....	280	+	57	Slow, short.
July to Oct. ..	355	+	72	Swift, short.

The Perseids may be seen from July 19th, radiant $23° + 52°$, advancing 1° per day in R.A.

TABLE 45. NON-ALGOL STARS.

Star.	Right Ascension.		Declination.	Magnitudes.	Period.	Date of Maximum.
	h.	m.	°		d.	
R Herculis	16	2	+18 ·6	8·0 to 14	317·7	June 23.
RR Herculis	16	2	+50 ·7	7·8 to 9·5	241	May 9.
U Serpentis	16	3	+10 ·2	8·3 to 14	237·2	July 15.
SX Herculis	16	4	+25 ·1	7·9 to 9·2	100·55	May 12.
W Coronae	16	13	+38 ·0	7·8 to 12	244	July 14.
V Ophiuchi	16	22	−12 ·2	6·9 to 10·8	302·5	Apr. 20.
R Draconis	16	33	+66 ·9	6·4 to 13	245·6	July 29.
Z Ophiuchi	17	15	+ 1 ·6	7·5 to 13	348	May 10.
T Draconis	17	55	+58 ·2	7·5 to 12	426	Aug. 9.
RY Herculis	17	56	+19 ·5	8·2 to 13	222·3	July 22.
T Herculis	18	6	+31 ·0	6·9 to 13	165	May 2, Oct. 13.
RY Ophiuchi	18	12	+ 3 ·6	8·2 to 13	153·3	July 14.
W Lyrae	18	12	+36 ·6	7·3 to 12	196·5	May 28.
RS Draconis	18	40	+74 ·2	8·4 to 12	281	June 29.
SU Sagittarii	18	59	−22 ·8	8·3 to 9	88	May 18.
R Aquilae	19	2	+ 8 ·1	6·2 to 11	337	May 15.
W Aquilae	19	11	− 7 ·2	8·2 to 13	489	July 24.
R Sagittarii	19	12	−19 ·5	7·0 to 13	269	Aug. 16.
T Sagittae	19	18	+17 ·5	8·3 to 9·5	156·7	June 14.
AF Cygni	19	27	+46 ·0	7·0 to 8·0	94	May 11, Aug. 13
TY Cygni	19	30	+28 ·1	8·7 to 13	354	June 22.
RT Aquilae	19	34	+11 ·5	7·6 to 12	325	Sept. 4.
RT Cygni	19	41	+48 ·5	6·6 to 12	190·5	Mar. 22.
TU Cygni	19	44	+48 ·8	8·5 to 14	225	July 21.
X Aquilae	19	47	+ 4 ·2	8·2 to 10	348	Aug. 18.

SATURN is badly placed, having been in conjunction with the Sun on May 29th.

URANUS is in opposition on 29th. Semi-diameter, $1\frac{3}{4}''$.

NEPTUNE is too near the Sun for observation, being in conjunction on the 19th.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 16^h to 20^h, next month 18^h to 22^h, and so on.

SOLAR DISTURBANCES DURING APRIL, 1913

BY FRANK C. DENNETT.

April has yielded very little by way of disturbance upon the sun. His disc was observed every day, but spots were only recorded on four—5, 6, 7, and 22—and faculae on ten others—1, 3, 8, 9, 12, 16, 17, 20, 23 and 24—whilst he appeared free from disturbance on the remaining sixteen. The longitude of the central meridian at noon on April 1st was 260° 37′.

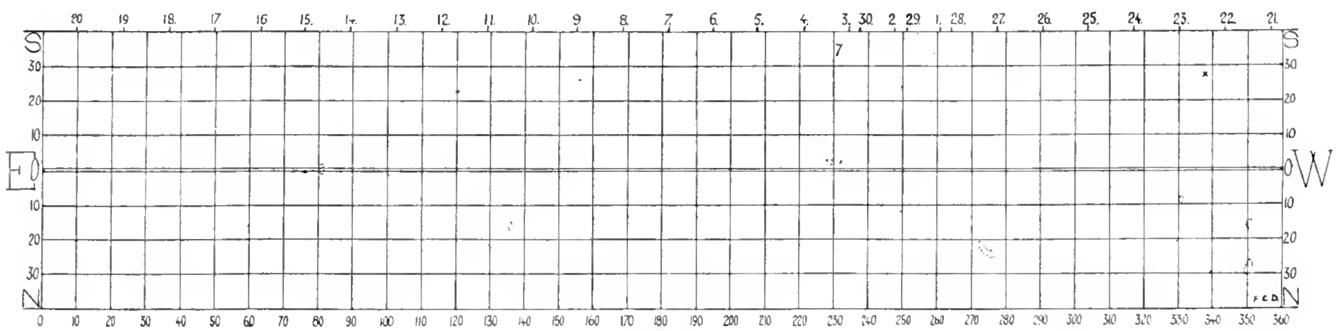
No. 7.—First seen on the morning of the 5th, as two larger and two or three smaller pores outlining the northern half of an ellipse. These smaller pores changed somewhat during the day, and the leader increased somewhat in size and became divided. The spectroscope showed only very moderate activity to the north-east of the leader, but dark hydrogen flocculi were seen, and also the presence of the dark helium line, D_3. On the 6th it had increased somewhat, being 30,000 miles in length. The area between the spots and for some distance northward looked disturbed, and this was confirmed by the spectroscope, which also showed the presence of dark hydrogen flocculi and dark helium. On the 7th only the leader remained amid a faculic display, and died out before the 8th, although the faculae remained visible until the 9th.

On the 22nd, at 3.30 p.m., there was a small but evanescent black pore situated approximately in longitude 338°, latitude 28° S. where the cross is marked on the chart, but it soon became gray, and disappeared.

A facula around 136°, 16° N. was seen on the 16th, when larger paler faculic areas were situated at 351°, 16° N., and 351°, 28° N. The latter being seen also on the 17th. A facula also seen on the 17th at 330°, 9° N. A small facula on the 20th at 81°, on, or close to, the equator. On the 22nd and 23rd a faculic area was situated at 273°, 23° N. On the 24th a pale faculic area, too faint for measurement, was round the eastern limb apparently just south-west of the place of No. 7.

The chart is constructed from the combined observations of Messrs. John McHarg, E. E. Peacock, A. A. Buss, and the writer.

DAY OF APRIL, 1913.



REVIEWS.

ASTRONOMY.

The Solar System.—By G. F. CHAMBERS. Second edition. 202 pages. 28 illustrations. 6½-in. × 4¼-in.

(Hodder & Stoughton. Price 1/- net.)

This is a second edition, partly rewritten to bring it up to date, of a work first published in 1895. The present edition gives no year of publication—a frequent modern fault—but from the date of the preface one can infer that the year was 1912 or later. The book is light and of a convenient size for the pocket, also the paper and printing are both good in quality. It has thirteen chapters, of which Chapters II (Sun) and XIII (Comets) occupy seventy-five pages, or more than one-third of the whole. The chapter on the Sun, pages 21 to 62, is almost entirely devoted to Sun-spots—in fact, all but four pages, and, though very interesting reading, is out of all proportion to the rest of the chapter and book. In the next edition, which we hope to see during the author's life, we should like to have quite twenty of these pages replaced with something upon other parts of solar physics: for instance, a general account of the beautiful phenomenon of the solar corona, which can certainly be best viewed with a small, or without any, telescope, cannot be adequately given in eleven lines (eighty-one words), nor can the situation be saved by giving an antique illustration.

The remarks upon scintillations in Chapter V are very useful, interesting and suggestive; the reference to Tacchini on page 91 we can bear out from personal observations at an altitude of two miles. Likewise the reference, on page 99, to P. Smyth upon the exact similarity of terrestrial and lunar volcanoes, we can substantiate from actual rambles among the former and telescopic views of the latter. A brief reference to the excellent results of lunar photography and Saunder's work would not have been out of place. The remarks at the top of page 107 do not appear to be courteously expressed. We are glad to see the remarks on page 108 about the misuse of a revered name.

Galle does not appear to have sufficient credit given him, on pages 143 and 158, for his pioneer observations. On page 146 we notice an error in the number of satellites for Saturn. The chapters on Uranus and Neptune are concise and full of facts. There is a useful index: we noticed the omission of Aston and Titius, and the references under Satellites might have been extended with advantage. Altogether a book full of interest and facts, not fanciful, not overburdened with numbers, but pleasantly written by that veteran pen and published at such a cost that everyone should possess and read it.

F. A. B.

Annuaire Astronomique et Météorologique pour 1913.—Par C. FLAMMARION. 49ᵉ année. 404 pages. 135 illustrations. 7¼-in. × 4¾-in.

(Paris: Librairie Ernst Flammarion. Price 1fr. 50.)

A book full of useful astronomical and meteorological tables and information, both for reference and for the amateur's daily use. Pages 245–390 contain a *résumé* of observations and progress in 1912, and the last pages record facts upon the scientific jubilee of Flammarion.

F. A. B.

BOTANY.

The Moorlands of North-Eastern Yorkshire. — By F. ELGEE. 356 pages. 3 maps. 71 figures. $8\frac{1}{2}$-in. × $5\frac{1}{2}$-in.

(A. Brown & Sons. Price 15/- net.)

As the author rightly claims in his preface to this work, representing the results of his long-continued observations on the geology and natural history of the eastern moorlands of Yorkshire, we have here for the first time a comprehensive book dealing with a British moorland area from a scientific standpoint. The ecology of moors in various parts of Britain has been dealt with in memoirs by members of the British Vegetation Committee, while among Continental memoirs two stand out prominently—Graebner's *Heide Nord-Deutschlands* and Früh and Schröter's *Moore der Schweiz*—but the present work differs from all these in that it deals not only with the plant life of the moorland but also the geology and zoölogy in their relationship and interdependence.

The author does not claim to have produced a definite monograph, and though every aspect of the moorlands has been touched upon in his work, an exhaustive treatment of each topic has not been attempted; for instance, detailed descriptions of moorland plants and animals have been omitted, as these are found in works dealing with the British flora and fauna. By judicious selection, and owing to his having taken into account the current literature of the topics dealt with, he has produced a striking contribution to ecology, and since he indicates throughout the work the various problems in moorland ecology which are still open to solution, and upon which further search is required, the book is one that should stimulate other workers in various districts to take up some of the many questions raised. For instance, he points out that the investigation of the peat deposits, layer by layer, is a piece of research that is urgently needed, because of the light it would throw upon climatic changes in post-Glacial times and upon the development of the "mosses" (moss-moors, *Hochmoore*).

The greater part of the book is of general rather than merely local interest, since a large amount of space is given to the consideration of subjects which have a general bearing —the peat beds and the evidence they yield as to primitive woodland on the moors, the relationship of the moorland flora and fauna to the glaciation of the district, the origin of various geological features such as outliers and inliers, the general conditions determining the existence of moors, the origin of the moorland flora and fauna, and the relations of the moorland fauna to the flora. "The scope of the work," to quote from the author's statement in the introductory chapter, "is to exhibit the interdependence of all aspects of the moors: their antiquities, plants, rocks, insects, stones, birds, and climate form a coherent whole which cannot be fully understood unless all are considered. We shall regard the moors as a unique assemblage of factors of intense interest, which owe their present status to innumerable causes that have been operating for ages. In other words, we shall follow that sequence of events which has led to the evolution of the moorlands of North-Eastern Yorkshire." In this introduction a general account is given of the general physical features and the geology of the district.

In Chapter I the author discusses the antiquities of the moorland, with some interesting notes on the etymology of the terms "moor," "heath," and so on. On various grounds it is concluded that from early times, perhaps three thousand years ago, the high moors were never clothed with trees. Chapter II deals with the "fat moors"—the typical heather moor, or heath, with a well-developed peat-layer, often of considerable thickness—as contrasted with the "thin moors" considered in Chapter III, where the peat is thin and the different associations are dominated by *Calluna*, *Erica* spp., *Scirpus caespitosus*, *Molinia* and *Nardus* and other heath grasses, *Ulex*, and so on. Chapter IV is concerned with "mosses"—*Sphagnum* bog, cotton grass moor ("Eriophoretum vaginati"), and so on; Chapter V with the moorland slopes, including associations dominated by bracken, birch woods, oak-birch woods, larch and pine-woods, bilberry slope, rush bogs with *Sphagnum*, and so on; Chapter VI with the interesting "slacks" and "gills" (small valleys with broad flat streamless floors and steep slopes) which often present a remarkable congestion of plant associations, so that many of the types of moorland vegetation may be found within a limited area. In connection with the "slacks" the author gives an interesting summary of recent work on the plant remains in peat deposits in Britain, and concludes that for many thousands of years, probably even since the Ice Age itself, the moors were islands and peninsulas of heath vegetation, surrounded by a great sea of forest and woodland, feelers of which penetrated far into the heart of the uplands along the sides of the streams. This subject is developed more fully in Chapter VII, which is devoted to the geological effects of the Ice Age on the moors, with an account of Professor Kendall's investigations on the former glacier lakes of the district.

The origin of the moorland flora is next discussed (Chapter VIII), and the conclusion reached is that the geological history and geographical distribution of the chief moorland plants proves that the moors were formed in pre-Glacial times, probably towards the close of the Pliocene period. This leads to a further discussion in Chapter IX of the Ice Age and the moorland flora, the history of the latter being summed up in the following stages: (1) Evolution of *Vaccinium* spp., *Eriophorum*, *Empetrum*, and so on, in a northern land in Pliocene times, and a gradual dispersal of these species southwards with the approach of the Ice Age; (2) origin of *Calluna* and *Erica* spp. in South-Western Europe and their dispersal north and east during the Pliocene period; (3) advent of the Ice Age with survival of most of the northern species on the driftless area—*Erica cinerea*, *E. Tetralix*, *Myrica Gale*, and *Pteris aquilina*, however, probably driven from the district; (4) post-Glacial re-entrance of these four plants, and development of moors from the Arctic plant communities of the uplands and upon the bare ground; (5) a warmer and drier climate with a decline of wet moors and the growth of trees in the slacks, gills, and dales and on slopes and parts of the higher moors; (6) an increased rainfall with an acceleration of moor formation, and a destruction of the birch and oak woods in the slacks and gills by the development of peat bogs; (7) the present moors, where peat formation and destruction counterbalance each another.

Then follow four chapters of mainly geological interest, and the work concludes with three extremely interesting and suggestive chapters on animal life (in particular insect life) on the moors, containing the results of the author's patient and successful investigations in a field which has been comparatively little worked at, and a finely written general conclusion, in which the author skilfully gathers up the threads of the work and emphasises the importance of his main theme—the interdependence of the various factors which condition the moorland climate, physiography, flora, and fauna. Extensive tables are appended, giving the chief facts regarding the moorland lepidoptera divided into two groups according to whether the food plants are *Calluna* and *Erica* or *Vaccinium*. This portion of the book forms a mine of information concerning the insect fauna of moorlands and its relation to the flora.

There are two large maps coloured to show the geological formations and the distribution of moorland respectively in north-east Yorkshire, and a map of typical geological sections. Of the photographic plates with which the book is lavishly illustrated all are excellent and many are particularly fine. This book will certainly rank as a standard work on British vegetation, and it is to be hoped that the successful publication of a work of this scope will be followed by the production of other books dealing in a similar manner with the vegetation of larger or smaller areas of the British Isles.

By the courtesy of the publishers we reproduce here two of the plates illustrating Mr. Elgee's work (see Figures 235 and 236).

F. C.

From a photograph FIGURE 235. *by Frank Elgee.*

Birch Wood and Juncus Swamp, Eston Hills, Yorkshire.

From a photograph FIGURE 236. *by Frank Elgee.*

Loose Howe, Rosedale Head, Yorkshire.

From "The Moorlands of North Eastern Yorkshire."

Economic Woods of the United States.—By Samuel J. Record, M.A., M.F. 117 pages. 6 plates. 9¼-in.×6-in.

(Chapman & Hall. Price 5/6 net.)

This book is most complete for a somewhat condensed work on the subject, and is offered at a very reasonable price. It refers to U.S.A. timber trees only, but a large number of these are important to us owing to their commercial uses and also in several cases to their value for planting in this country. The book is well arranged; each point is dealt with in a businesslike and concise manner, and with as little repetition as possible. The language is clear, and it is refreshing to find no peculiar American phraseology or spelling.

Part I deals with the structural and physical properties of wood, and contains much of interest to the student in technology, the forester and the commercial user of timber. Although many of the points are of necessity dealt with in a somewhat condensed form the ground is well covered, and after each heading is given a list of textbooks referred to and from which more detailed information can be procured where desired. A complete list of references, including the standard books of each branch, is published at the end.

Part II is a key with photomicrographs of some of the American timbers, and is useful for showing the main characteristics in structure; but it is somewhat limited in its application.

The work, although not intended to be original, brings together a mass of useful information, and, taken altogether, is a welcome and valuable addition to the literature on the subject. It should appeal to those who require a general grasp and have neither the time nor the means to go deeply into every point.

M. C. D.

GEOLOGY.

The Petrology of the Sedimentary Rocks.—By F. H. Hatch and R. H. Rastall. 425 pages. 60 figures. 7½-in.×5-in.

(G. Allen & Co. Price 7/6 net.)

The petrology of the sedimentary rocks has been much cultivated lately, and although it was neglected in the early days of the science compared with the igneous and metamorphic branches, it is now coming into its own. This book represents a culmination of interest in which sedimentary petrology threatens to rival the other branches in its attraction for workers. The literature of the subject is large and scattered, and the authors are to be congratulated on their successful attempt at its collation in the book under review, which is the first of its kind. The title scarcely records the scope of the work, since the majority of rocks usually treated as metamorphic are also described. The term "metamorphism" is used in its widest sense to indicate all sorts of change in rocks, cementation, metasomatism, and weathering, as well as the severer forms due to great heat and pressure which result in the production of rocks included as metamorphic in the narrower sense. There are certainly no sharp boundaries between the various types of change, and logically, therefore, the plan of the book is unassailable. We think, however, that the inclusion of the metamorphic rocks might have been more prominently indicated in the title; or alternatively they might have been relegated to another volume. The use of the term "metamorphic" in such a wide sense involves the incongruity that our typical sedimentary rocks, such as sandstone, shale, and limestone, are treated in the second part of the book under the heading "Metamorphic Derivatives of the Sediments," and the cursory student may be somewhat at a loss on finding their descriptions in this place. It is to be admitted, however, that, given the definition of metamorphism here adopted, the arrangement of the book is perfectly logical.

In the first part of the book the modern sediments are dealt with under the headings of "Deposition in General," "Fragmental Deposits," "Chemical Deposits," and "Organic Deposits." In Part II the older sediments which have undergone various types of change are described under the headings "Metamorphism in General," "Cementation and Metasomatism," "Contact Metamorphism," "Regional Metamorphism," and "Weathering." In these chapters very lucid accounts of the methods of deposition and the modes of change in the sediments are given. In fact the book is really a well-knit and concise account of the petrogenesis of the sedimentary rocks. Because of this fact, and perhaps also because of its limited size, the book is a little disappointing on the petrographical or descriptive side. Its plan also involves some discontinuity of treatment for sediments which are related in various ways. The calcareous rocks, for instance, excluding the metamorphic types, are to be found under three headings. The ordinary sedimentary limestones in general appear to be inadequately described as compared with the sandstones and shales. Referring to the index we find five entries under "limestone," but four of these refer to metamorphic types and the other to cave-limestone. In other parts of the index we find additional references to crinoidal limestone, dune-limestone, and dolomite, but none to oölitic limestone. Then no description of the ways in which the various organisms which build limestones may be recognised is given.

These, however, are but small spots on the sun of the general excellence of the book, and inasmuch as the authors have in our opinion accomplished what they set out to do, and have produced a most interesting and important work, they are entitled to all praise. They have been fortunate enough to secure a most useful appendix, by Mr. T. Crook, on "The Systematic Examination of Loose Detrital Sediments," in which are described the methods of separating and identifying minerals in small fragments.

G. W. T.

A Manual of Petrology.—By F. P. Mennell. 256 pages. 124 figures. 9-in.×5½-in.

(Chapman & Hall. Price 7/6 net.)

This book is based on the author's "Introduction to Petrology," the second edition of which was reviewed in "Knowledge" of August, 1910. It differs from the earlier book in several particulars. The chapters on the origin of igneous rocks and on metamorphism have been remodelled, and the position of some chapters has been altered. Many of the illustrations are new, and, as a whole, are decidedly better than in the former work. We wish we could say the same of the classification of igneous rocks adopted. Mr. Mennell "simplifies" petrological nomenclature by classifying igneous rocks into five groups according to silica percentage, and each of the latter into three divisions of plutonic, intrusive, and effusive types respectively. By this method he gets fifteen classes, for which fourteen names are supplied, the ultrabasic plutonic rocks (*i.e.*, those with less than forty-five per cent. of silica) not being provided with a name. Varieties are indicated by mineralogical prefixes. It is a delusive simplification, however, which reduces the nomenclature of a science, for progress or increasing complexity demands an increasing nomenclature. In particular the silica percentage is an extremely artificial attribute on which to base a classification. Thus, for example, to call all plutonic rocks with a silica percentage between fifty-five and sixty "diorites," and thus to include the majority of nepheline-syenites, is merely to introduce confusion, just as it would introduce confusion to call all marine animals "whales," or all land animals "elephants," on the strength of a community of habitat.

The classification by silica percentage ignores the fact that rocks are composed not of silica percentages, or of percentages of various oxides, but of minerals. Hence the mineralogical variations in rocks are the most significant variations, and should be those expressed in the major divisions of the classification. Not less, but more, nomenclature is needed for the philosophical discussion of petrological principles. What is needed is not a reckless aggregation of, for example, such unlike units as nepheline-syenite and diorite into one group, but a more subtle and closer characterisation of igneous types leading to a more detailed classification.

In this book the classification by silica percentage leads to such anomalies as the inclusion of ditroite in the diorite group (page 144); the treatment of kentallenite and borolanite under that very accommodating term "dolerite" (page 156); and the use of such a term as "nepheline andesite," which is almost a contradiction in terms if the ordinary definition of andesite is to stand. If there is one rock that can be said never to contain nepheline that rock is andesite; and it does not mend matters when we find that by "nepheline andesite" the author means "phonolite." Hence, so far as the classification of igneous rocks is concerned, this book cannot be recommended to the student, who, since he has to identify his rocks by their mineralogical content, and is rarely able to determine their silica percentage, would be led into hopeless confusion.

The chapter on the origin and variations of the igneous rocks is interesting and provocative of thought, although very speculative. The sedimentary and metamorphic rocks are also treated in a thoughtful and useful manner. Indeed the rest of the book is so good that it is a pity the author does not see fit to bring his views on the classification of igneous rocks more into accordance with the experience of the great majority of petrologists.

G. W. T.

MICROSCOPY.

The Beginner's Guide to the Microscope.—By CHAS. E. HEATH. 119 pages. 46 illustrations. 7-in. × 5-in.
(Percival Marshall. Price 1/- net.)

The microscope is now used in connection with so many different matters and the advantages of the training which it gives to hand, eye, and brain are so widely recognised that a book such as the present one, which tells in simple language what the microscope is, and how it can be used, is worthy of the most cordial welcome. We think that in this beginner's guide the author has just happily chosen those points of the greatest value and he has not gone into such detail as to bore those for whom he writes. His advice, too, is sound; as, for instance, when he urges the beginner who wishes to get a good microscope to buy no instrument nor objective that does not bear the name of a recognised maker.

W. M. W.

PHILOSOPHY.

The History of Magic, including a clear and precise Exposition of its Procedure, its Rites and its Mysteries.—By ÉLIPHAS LÉVI (ALPHONSE LOUIS CONSTANT). Translated, with a Preface and Notes, by ARTHUR EDWARD WAITE. 536 pages. 20 plates. 8¾-in. × 5¾-in.
(William Rider & Son. Price, cloth, 15/- net; vellum, 21/- net.)

By the courtesy of *Mr. Rowland Ward.*

FIGURE 237.

Wapiti-red-Deer Cross, bred at Surrenden Park, showing red deer type of head, from "Deer Breeding for Fine Heads.

A great poet* has said: "Everything possible to be believed is an image of truth." Certainly the belief in the efficacy of magical practices would not have persisted for so long had not these practices been productive of results. No doubt the phenomena thus produced must be classed as "subjective," and the question of Magic is one for psychology rather than physics. The literature dealing with the history of Magic from this point of view is, however, very slight: until the publication of this translation (by which all students are laid under a debt of gratitude to Mr. Waite) there was nothing of much importance in the English language other than Mr. Howitt's translation of Joseph Ennemoser's work.

One requires to know something of Alphonse Louis Constant to appreciate his works aright. He was lacking in the precision and accuracy of the scientific man; his reading, though wide, was careless, and he rarely, if ever, verified his quotations; he was apt to see his own theories everywhere, and it was seldom that he could resist the desire to elaborate tradition and legend. But, in spite of their many defects, his books exhibit a brilliancy of imagination and a charm of expression which render them of real value. Indeed, Constant was by no means lacking in philosophical insight, and was certainly well versed in his subject.

Magic, in Constant's terminology, was originally the absolute science of equilibrium. It degenerated, however, until it became, as it were, a disease of the imagination. Indeed, during the period of the witchcraft persecutions it became almost an epidemic, and the evil was accentuated by the fact that it was supposed that an exorcised, "devil" could not speak untruthfully, so that innocent persons were accused and convicted of the most horrible and impossible crimes on the evidence of persons suffering from nervous and mental disease. Nevertheless, according to the author, the doctrines of Magic embody profound philosophical truths, though in a distorted form. I am inclined to agree with this view; though I doubt whether Constant's assumption of a universal medium (which he fantastically calls "the astral light"), upon which the imagination can act either for good or evil, will appeal to modern psychologists.

Constant owed much to the Kabalah, *i.e.*, the books which claim to contain the secret philosophical traditions of Judaism. It is interesting to note that the cosmology of the Kabalah is definitely heliocentric, and I am inclined to think the books are worthy of more study than is devoted to them. From this source Constant derived his central doctrine of equilibrium, though he interpreted it in his own sense and applied it to every department of thought.

Mr. Waite's careful and scholarly notes, in which he corrects some of Constant's misstatements and throws

* William Blake.

further light on the obscure subject of Magic, add very greatly to the scientific value of the book.

H. S. REDGROVE.

PHYSICS.

Introductory Electricity and Magnetism.—By CARL W. HANSEL. 373 pages. 283 illustrations. $7\frac{1}{2}$-in.×5-in.
(William Heinemann. Price 2/6 net.)

This book is obviously the work of an experienced teacher, and deserves the careful consideration of all concerned in preparing for elementary examinations in this subject. The figures are excellent, and there is a refreshing absence of confused photographic reproductions. At the end of each section questions for revision are given.

W. D. E.

Elementary Experimental Dynamics for Schools. — By C. E. ASHFORD, M.A. 246 pages. 94 illustrations. $7\frac{3}{4}$-in.×5-in.
(The Cambridge University Press. Price 4/- net.)

This useful little book scarcely needs the apology which the author makes for it in his preface. The principle of approaching the study of Kinetics by an inductive method is now fairly well established, and the arguments for it are recapitulated here. In the text itself the measurement of velocity and of small intervals of time is approached by way of Fletcher's trolley and vibrating paint-brush, and the notion of variable velocity is introduced by distance-time diagrams plotted from Bradshaw on squared paper. The notions of force and of the relation between gravitational and kinetic units of force are led up to by further experimental work with the trolley and paint-brush. An experimental verification of the formula for kinetic energy is new to us. The chapter on Fluid Pressure is a link between the past and the present of our Navy, as it deals with wind pressure on sails and also with the Parsons steam turbine. Teachers of mechanics will find many hints in this book, even if they cannot afford to invest in all the apparatus which the British taxpayer supplies to our naval colleges.

W. D. E.

YEAR BOOK.

Directory of Museums in Great Britain and Ireland; together with a Section on Indian and Colonial Museums. —By E. HOWARTH, F.R.A.S., F.Z.S., and H. M. PLATNAUER, B.Sc. 312 pages. $8\frac{3}{4}$-in.×$5\frac{3}{4}$-in.
(The Museums Association. Price 10/-.)

We have received a copy of the Directory of Museums, which gives briefly but in a very useful way much valuable information with regard to the National and Local Institutions of this country, as well as the more important Indian and Colonial Museums. We learn who is responsible for the various Museums, how they came into existence, what they specially intend to illustrate, as well as what work of an educational kind is carried out by the staff. The book should be in every reference library.

W. M. W.

ZOÖLOGY.

Life and Evolution.—By F. W. HEADLEY. 272 pages. 98 illustrations. $8\frac{1}{2}$-in.×6-in.
(Duckworth & Co. Price 5/- net.)

Based on lectures delivered to the natural history class at Haileybury College, this attractive volume was first presented to the public in 1906, and its reappearance in the form of a new and revised edition affords such testimony of its popularity that commendation on our part seems superfluous.

By the courtesy of *Mr. Rowland Ward.*

FIGURE 238.
Cross-bred Altai-red-Deer, from "Deer Breeding for Fine Heads."

Among the chapters that have undergone special revision are those on flight, but when discussing (page 98) the manner in which the giant pterodactyles of the secondary epoch were enabled to sustain themselves in the air, the author appears to have overlooked an important paper published last year in the *Bulletin* of the Geological Society of France, in which Messrs. E. and A. Harlé maintain that without an atmospheric pressure much greater than at present exists flight in the case of these monstrous reptiles would have been an absolute impossibility. He might also (page 141) have referred to Sir Hiram Maxim by his proper title instead of as Mr. Maxim.

Some of the sentences in various parts of the work would also have been the better for revision, as is exemplified by the unnecessary repetition in the following statement (page 89):—"The reptile that seems to carry off the prize for speed is an Australian lizard, *Chlamydosaurus kingi*. *Chlamydosaurus* is an Australian lizard, being found in Queensland."

Apart from slight shortcomings of this nature, the book is an excellent epitome of modern views on evolution.

R. L.

Deer Breeding for Fine Heads, with Descriptions of many Varieties and Cross Breeds.—By WALTER WINANS, F.Z.S. 105 pages. 34 illustrations. 11-in.×9-in.
(Rowland Ward. Price 12/6 net.)

The first object of Mr. Winans' book is to show that the Deer should be looked after and bred as carefully as any other animal which is kept in captivity. His illustrations show how well he has himself succeeded. Incidentally, however, in the book an account is given of cross-bred deer, and by the courtesy of the author we are able to show pictures of the heads of the cross between the Wapiti and red deer as well as between the Altai and red deer. Mr. Winans has gone further and crossed a Wapiti-red-Deer hind with an Altai stag, so that he has now Wapiti-Altai-red-Deer hybrids, a cross which he believes has never before been attempted. There is much of great interest and usefulness in the book, and we may allude to the chapters on the preservation of Horns; on the precautions to be taken to avoid injury by Deer, and with regard to the times of breeding. Artists should read the notes on the action of Deer and take to heart what Mr. Winans has to say about the drawing of animals.

W. M. W.

COMETS.

By F. W. HENKEL, B.A., F.R.A.S.

THESE still mysterious bodies have always been of the highest interest both to the astronomer and the "man in the street," and though the progress of science has robbed them of much of the terror their

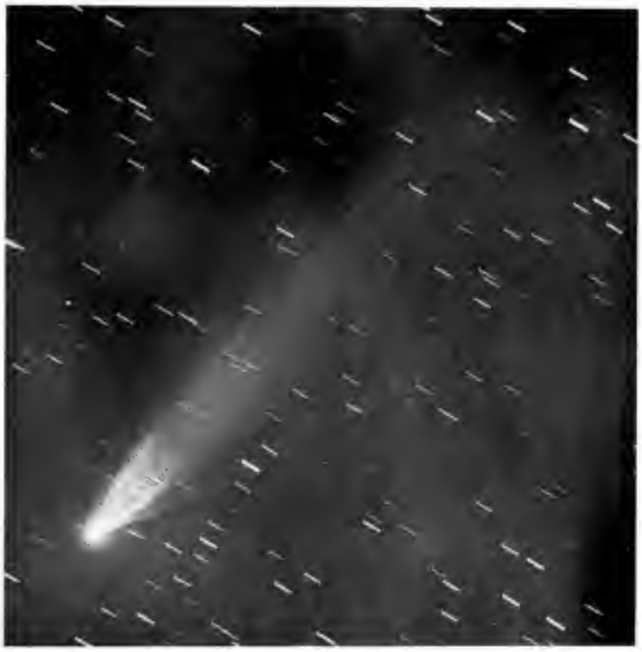


FIGURE 239. Comet 1908 III (Morehouse).

P. J. Melotte and C. R. Davidson, Royal Observatory, Greenwich. 1908, Sept. 7^d 14^h 56^m G.M.T. Position of Comet: R.A. 3^h 3^m; Decl. + 69° 38′. Reflector: Ap. 30-in. (0·762m); F.L. 11-ft. 5-in. (3·48m). Exp. 60 mins.

unexpected apparitions formerly inspired, whilst the calculations and verifications by returns, as well as discoveries of the last generation, have to some extent satisfied our curiosity as regards some of the phenomena presented by them, yet other problems have arisen demanding solution for which the data we at present possess are inadequate. The regular return of certain well-known comets, such as Halley's and Encke's, though on the one hand affording ample demonstration of the justice of the principles and methods employed by astronomers for the determination of their orbits, yet on the other hand, even for these comets, unexplained, though small deviations from their calculated paths afford material for speculation as to the nature of other agencies besides gravitation affecting their motion. Other comets there are, however, which have failed altogether to return, notwithstanding the great increase of accuracy in our knowledge of their orbits, whilst for those that do return, as well as for new comets, the remarkable changes of form that occur from day to day, and the extraordinary behaviour of parts of their substance when nearest the sun, seem to indicate the existence of matter in a physical condition unlike anything of which we have experience here, and from the want of such information our knowledge of cometary physics is necessarily defective. Thus, to the wonder and terror formerly inspired by a comet has succeeded the scientific wonder and curiosity at beholding the behaviour of "matter" under almost unimaginable conditions.

In early days, no doubt from the rarity and unexpectedness of their appearance and the remarkable nature of the appendages which many of them possess, comets were regarded with fear and trembling not only by the general public but also by the learned, and in fact, much of the terror of the former was due to the credence they gave to the baseless conjectures of the latter. This feeling has by no means died out, to judge from what one hears and reads with regard to recent comets, but its nature has perhaps slightly changed. Formerly such "wars, pestilences and the death of princes" as occurred shortly after the apparition of a comet were attributed on the sufficient principle of *post hoc, ergo propter hoc*, combined with the idea that all things had direct effect upon human destinies (the

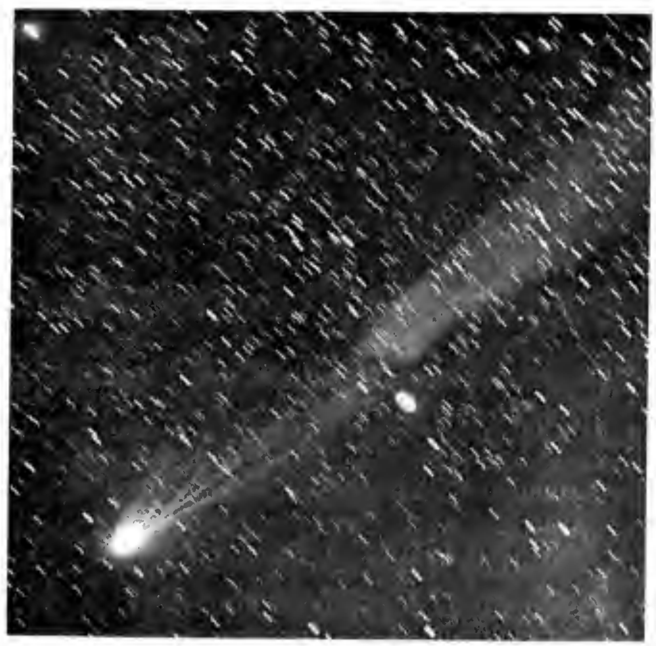


FIGURE 240. Comet 1908 III (Morehouse).

E. E. Barnard, Yerkes Observatory. 1908, Oct. 1^d 19^h 15^m G.M.T. Position of Comet: R.A. 21^h; Decl. + 71°. Bruce Doublet Lens: Ap. 6-in. (0·153m); F.L. 50·3-in. (1·28m). Exp. 65 min.

Geocentric concept of the universe), to their baleful influence; in later days for the same good reasons the weather conditions of our own earth were supposed to be modified by their presence, and examples of this are to be found in most astronomical works, as well as in our paper "Comets and the Weather" contributed to *Symons's Magazine*. Donati's comet of 1858 was thus made answerable for the hot weather prevailing that year in England, Biela's comet in 1832 similarly influenced the summer of the "year of reform," whilst the great comet of 1811 caused the ripening of the grapes in some provinces of France, resulting in one of the most wonderful vintages ever known. The same comet of 1811, appearing shortly before Napoleon's disastrous campaign in Russia, is credited with having unfavourable omens drawn from it by the Russians, but here it would appear that the omens were worse for the invading French army than for themselves. If the comet of 1769, which appeared at the time of his birth, is to be regarded as Napoleon's presiding and protecting genius, this one must be considered as his evil one. The origin of all such notions, as has been well remarked, is to be looked for in the vanity of man and his self-constituted rulers, perhaps more excusable in the days when our little earth was looked upon as the centre of the Universe than in our own, but none the less utterly without foundation. The natural desire of the human mind to resolve mysteries was satisfied by the pretended explanations of those who knew no more than their questioners, whilst the bold confession that we are all ignorant and merely as children picking up a few pebbles on the shore whilst the great ocean of truth lies unexplored (Newton) was reserved for later days. Though the encomium of Pope upon Newton

> "Nature and Nature's laws lay hid in night,
> God said, let Newton be, and all was light,"

is, of course, in excess of the truth and as we have seen, Newton himself did not think so, yet there probably has never been any work of human genius greater than the incomparable "Principia." Here, for the first time, it was definitely laid down that a body moving under the influence of a central force (such as gravitation) varying inversely as the square of its distance from the centre of force, will describe one of the conic sections, an ellipse (circle as a special case), parabola or hyperbola. It had been previously suspected that one or two comets moved in long ellipses or parabolas and Dörfel in 1680 showed that the great comet of that year moved in such a path. Newton showed that its motions were entirely in accordance with gravitational principles and the parabolic elements of its orbit were calculated according to methods given by him. This comet approached unusually close to the Sun when nearest, and for a short time must have "been heated to a temperature many times that of molten iron" (Newton). Halley considered that this comet moved not in a parabola but in a very long ellipse, giving it a period of five hundred and seventy-five years, which led Whiston in his "New History of the Earth" to speculate that it was to an earlier return of this comet that the Noachian deluge had been due, and that at a later return it would cause the destruction of our planet by fire! However, Encke's later calculations, ascribing a period of eight thousand eight hundred years to the comet, are to be preferred to Halley's result, so that Whiston's speculations need not be further considered.

Figure 241. Comet 1908 III (Morehouse).

P. J. Melotte and C. R. Davidson, Royal Observatory, Greenwich. 1908, Oct. $3^{d}\ 9^{h}\ 4^{m}$ G.M.T. Position of Comet: R.A. $20^{h}\ 44^{m}$; Decl. $+ 68° 58'$. Reflector: Ap. 30-in. (0·762m); F.L. 11-ft. 5-in. (3·48m). Exp. 30 min.

The three curves known as the conic sections; parabola, ellipse and hyperbola, as their names imply, may all be obtained by cutting a cone in different ways by a plane, but perhaps they may be more intelligibly defined to the non-mathematical as being obtainable by throwing the shadow of a circular disc upon a plane surface, such as a table. If the disc be held parallel to the table, we get a circle, if obliquely an ellipse, a closed oval curve; if we hold it edgeways to the light we have a straight line. If now we raise the disc so that its highest point is on a level with the source of light, we shall get a parabola, which is oval at one end, but the two sides open out and do not meet again. If now we hold the disc still higher, we shall get another curve, whose two sides will separate even further from the other. This curve is the hyperbola (or geometrically one branch of the hyperbola, there being another similar branch).

Whilst the planets move in ellipses little differing from circles in most cases, the comets in general are found to move in orbits so nearly parabolic (whilst in the small part of their path during which they are visible to us), that only a few are known whose motion is otherwise, all three curves differing but little near the vertex. Thus the orbit of a newly-discovered comet is always first calculated on the assumption that its motion is parabolic; another reason being that the necessary calculations are simpler than for an elliptic or hyperbolic orbit. A strictly parabolic orbit, however, is practically impossible, for the smallest diminution of speed due to planetary action would change it into an ellipse, whilst an increase would convert it into a hyperbola. The remarkable fact that so many cometary orbits closely approximate to a parabolic form must have important bearings on any theory as to their origin, though there are reasons for suspecting that the true orbits are not really parabolic, but very long and eccentric ellipses. A comet moving in a parabola (or hyperbola) will be seen only once, never to return; whereas, one moving in an ellipse, the latter being a closed path, must return again sooner or later, though thousands, or even perhaps millions, of years may be required to complete one revolution round the sun, their centre of force; the common focus of their orbits. A very few comets have been *suspected* to move in hyperbolic orbits, but the deviation in excess of parabolic velocity is always so small, that it may reasonably be doubted whether any known hyperbolic-moving comet has been certainly detected. The vast majority appear to move approximately in parabolas, a considerable (and increasing) number in ellipses whose deviation from circularity is much greater than that of the planetary orbits, but not always so great as that of some double-star orbits.

In 1682, a comet was observed by Newton, Halley and others, and on examining the circumstances of its motion Edmund Halley computed its orbit on the supposition that the latter was a parabola. Comparing his results with former observations and computing other orbits from the necessarily imperfect determinations of position of earlier days, he found that in 1531 and 1607, comets had appeared which moved so nearly in the same path as this one that he ventured to assert its identity with them, and to predict its return in 1758 or 1759. Though he could not expect to witness this event himself he wrote on the subject: "If it should return according to our prediction about the year 1758, impartial posterity will not refuse to acknowledge that this was first discovered by an Englishman." It is well known that his prediction was completely verified, and the comet's latest return (after 1758 and 1835) is so recent that the details must be familiar to all readers of "Knowledge." The true glory of a nation, not obtained at the expense of any other, nor involving the sacrifice of precious lives, is shown more by such achievements than by deeds of homicidal conquest, and we may be justly proud of the names of our countrymen Newton, Halley, Herschel, Cowell, Crommelin, and so on,

Figure 242. Comet 1908 III (Morehouse).
E. E. Barnard, Yerkes Observatory. 1908, Oct. 15^d 12^h 57^m G.M.T. Position of Comet: R.A. 19^h 27^m; Decl. $+50° 16'$. Bruce Doublet Lens: Ap. 10-in. (0·254m); F.L. 50·3-in. (1·28m). Exp. 82 min.

in connection with the history of this comet, whilst not detracting from the honour due to Clairaut, Pontecoulant, Max Wolf and other "foreigners" who have assisted in the same field. At its last return the brilliant development of the tail phenomena, and so on, made the comet an object of great beauty and interest to observers in more favoured latitudes than our own (where the prevalence of moonlight and the short summer nights prevented or hindered observation) showing that the idea that the comet, through the loss of matter driven off at former returns, would be less conspicuous than of old, was groundless. In fact, it is safe to assert that at no previous return known to history has the comet been so brilliant, whilst its early discovery by photography and long visibility have enabled its changes from day to day to be registered with a completeness hitherto unapproached. In addition to the physical phenomena of interest developed, it is of interest to note that there remains an outstanding difference between theory and observation, whereby the comet's return to perihelion occurred three days later than the date indicated by the final previous calculations of Drs. Cowell and Crommelin, which difference is not due to the action of any known material in the Solar system. This may, perhaps, be accounted for as the result of the action of an unknown planet, but the present writer has suggested that this may be an effect of the resisting medium. Halley's comet moves in the retrograde direction (that is to say "clockwise" or opposite to that in which the planets and many of the known periodic comets move), and as there is some evidence that Encke's comet (a *direct* moving comet to be referred to directly), is slightly accelerated by such an action it may not be unreasonable to suppose that the opposite effect may be experienced by a retrograde one. The comets are bodies of such infinitesimal mass, combined with great volume, that their density must be inappreciably small, so that an action quite unobservable for the more massive planets may well be sensible for them. The most remarkable of the regularly returning comets is that of Encke. Its periodicity was first detected by the astronomer of that name, from the comparison of the orbits of comets which appeared in 1786, 1795 and 1805, with that which was discovered by Pons in November, 1818, and from his researches on its motion, continued up to the time of his death, the comet has ever since been known by the name of Encke's comet. It has the shortest period of any known comet, rather over one thousand two hundred days. But it was not long after it had been observed at some following returns (1825, 1829 and 1835) that Encke found a slow progressive diminution of its period, and was led to conjecture the existence of a "thin ethereal medium," which, continually resisting the comet's motion, drew it slightly nearer towards the Sun than would otherwise be the case, this diminution of distance (by Kepler's third law) involving a diminution of period. This diminution continued at the following returns, after the death of Encke. His comet has been carefully studied by Von Asten, and more recently by Dr. Backlund, for whose researches the gold medal of the Royal Astronomical Society was given in 1909. He finds that the diminution in period has not been quite regular, but has undergone changes, falling, after 1858, to three-fourths its former value between 1861 and 1868, two-thirds only from 1871 to 1895, and since 1895 having had only half the value it had before 1860. If, then, we attribute this "acceleration" to the action of a resisting medium, which tends to bring it nearer the sun, we obtain the somewhat paradoxical result that the nearer the comet approaches the sun the less is its motion affected. But the seeming contradiction may be explained if, as the late M. Faye suggested, the medium has some motion of its own. "A comet moving in a resisting medium of this kind will not be precipitated upon the Sun, but the principal effect will be a change (diminution) in the eccentricity of its orbit. This will become more and more nearly circular, but after a time the axis will no longer decrease." In fact, a stationary resisting medium is incomprehensible, unless it be infinite in extent, for otherwise it would have been long since precipitated upon the surfaces of the sun and planets. Professor See has shown the action of a resisting medium in past ages in effecting the approximate circularity of the planetary orbits, and here we seem to have indications of the present action also of such as still remains

FIGURE 243. Comet 1908 III (Morehouse).

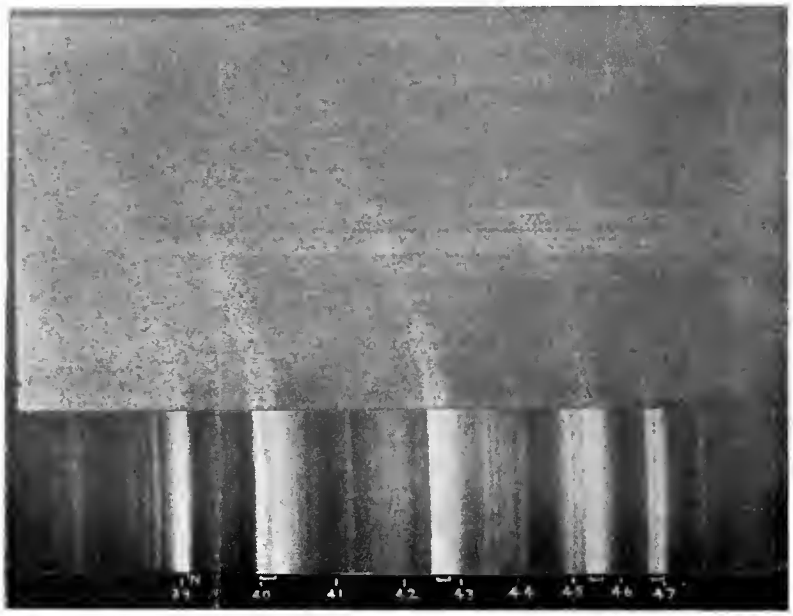
P. J. Melotte and C. R. Davidson, Royal Observatory, Greenwich. 1908, Oct. 30^{d} 7^{h} 47^{m} G.M.T. Position of Comet: R.A. 18^{h} 59^{m}; Decl. $+25° 18'$. Reflector: Ap. 30-in. (0·762m); F.L. 11-ft. 5-in. (3·48m). Exp. 10 min.

unabsorbed by the larger bodies of our system. As our knowledge of cometary orbits becomes more exact, it seems reasonable to suppose that other comets will be seen to be similarly affected. Faye's comet of 1843, Winnecke's comet (1858 ii) with a period of six years, and one or two others (Tempel Swift's and Brorsen's comets) have also been suspected to show some evidence in their motion of such action, but the evidence is somewhat conflicting, since the difficulties in the way of determining the "undisturbed orbits" of comets with sufficient accuracy to prove so small a "residual effect" are many. A comet cannot have its place fixed with the precision that is possible for a planet. The perturbations due to planetary action are very important, and few comets have been observed at more than five or six returns over very limited portions of their orbits. Halley's and Encke's comets alone have been observed at many returns, and it happens just for these that we do seem to have some evidence of the action of a resisting medium, accelerating the direct moving comet and retarding the retrograde one. In addition to Faye's explanation of the *varying* effect of resistance, Dr. Backlund is inclined to think that (neglecting possible electrical actions) there may be a resisting medium forming a sort of meteoric ring, whose density diminishes as we approach the Sun within certain limits, and that the diminution of resisting effect may be a measure of this. Sir John Herschel suggested that since the phenomena of comets' tails show that matter is violently repelled from the comet by solar action, the loss of such matter at each return will render its proportion to the attracted material less, and thus the "effective mass" will increase, and, consequently, the comet will complete each revolution in a shorter time. But it seems difficult to imagine how such a change can produce an effect of *several hours' diminution* in the period of Encke's comet, and, of course, it cannot explain the retardation of Halley's comet.

FIGURE 244. Comet 1908, III (Morehouse).
P. J. Melotte and C. R. Davidson, Royal Observatory, Greenwich. 1908, Nov. 19^d 6^h 4^m G.M.T. Position of Comet: R.A. 18^h 51^m; Decl. $+2°$ 20′. Reflector: Ap. 30-in. (0·762m); F.L. 11-ft. 5-in. (3·48m). Exp. 30 min.

Amongst the most remarkable of recent comets we may easily give the foremost place to that discovered by Morehouse on September 1st, 1908, which was continuously and extensively observed. (See Figures 239-245). It underwent many remarkable changes during that time, and considerable discrepancies occurred in the accounts of its peculiarities. At its first detection, and for some weeks later, it was a somewhat diffuse cloudy-looking object, with barely a trace of nucleus and a short tail, which was even visible to the naked eye at Copenhagen on September 20th. Towards the end of the month, however, changes took place resulting in a complete disruption, and on the 30th the tail was entirely gone. Photographs taken on October 2nd show new faint tails, whilst on October 14th a tail at least 7° long was shown. The following day the comet had broken in two. Photographs taken in the United States show two great condensations in the tail, about ½° from the head: a bright, short, spike-like projection, with one end between the two masses and the broad end attached to the comet, formed the new tail (Chambers). Further changes took place from day to day. Endless streamers shot out from the main body of the tail, which was violently bent and twisted as though it had encountered a resisting medium (November 15th). On November 19th, straight jets were given off by the head. The comet repeatedly lost its tail and formed new ones, which varied in type, "condensations, waves, straight rays, and twisted funnels made up its wonderfully active tail."

The spectroscopic observations of this comet were not less remarkable than the visual ones, and have led to a great increase in our knowledge of cometary physics. Admirable photographs were taken by the Comte de la Baume Pluvinel and M. Baldet, with the prismatic camera: by Messrs. Frost and Parkhurst, at Yerkes; by Dr. Curtis and others, at the Lick Observatory. Most comets hitherto observed have given continuous spectra, due to reflected sunlight, and a number of bright lines or bands, whose nature varies from one comet to another and whose identification has been a source of some controversy. Most commonly these bands have been identified as "hydro-carbon," since comparisons of cometary spectra with the spectrum of olefiant gas and other hydro-carbons gave a very close correspondence in position and appearance. There is also a banded spectrum due to carbon monoxide, and another identified with cyanogen. The earlier observations of Pluvinel and Baldet indicated the presence of cyanogen, and the absence of continuous spectrum, but others arrived at contradictory results. The presence of carbon monoxide, the doublets, twelve of which only were detected by Professor Fowler in the laboratory spectrum of this substance, was indicated by twenty-one in Pluvinel and Baldet's results, and these bands can be arranged into a series, as pointed out by Professor Fowler, in a paper in *The Astrophysical Journal*. Additional demonstration of their results is obtained from photographs taken by Dr. Curtis, of the Lick Observatory (Figure 245), the carbon monoxide spectrum being placed below that of the comet for easy comparison. Out of the five or six recent comets which have shown the low-pressure carbon monoxide spectrum, it was only in this comet that the bands were bright in the head as well as in the tail. Observations by Campbell and Albrecht, at Lick, showed the "presence of carbon and cyanogen, though the" second cyanogen band was apparently absent. New radiations suggested as due to nitrogen and other substances, also, were suspected from some photographs.



By kind permission *of Professor A. Fowler, F.R.S.*

FIGURE 245. Comet Morehouse (1908 c) March 20th, 1909.

Upper part of figure. Objective spectrogram 7h H. D. Curtis, Santiago, Chile. Lower part of figure, spectrogram of Carbon monoxide, pressure 0·01 mm. A. Fowler, South Kensington.

Professor Newall has suggested that the apparent similarity in the spectra of many comets is not so much due to a similarity in the materials of which they are composed, as to the fact that these "hydro-carbons, nitro-carbons, &c.," are present in the regions near the sun through which the comets pass and are "rendered incandescent by some processes connected with the motion of the solid parts (including dust) of the head of the comet through the vapours, or with the emission of some influence from the comet head."

In comets, as has been suggested by more than one writer, we seem to have the development of light without sensible heat, phenomena of luminescence; the repulsion of their tails by the sun is attributed to the agency of light-pressure, though other theories have been invoked also. The action of the resisting medium upon the orbits of these bodies, and possibly upon the materials of their tails, is another point about which we are gradually gaining additional information.

CORRESPONDENCE.

CONSIDERATIONS ON THE PHYSICAL APPEARANCE OF THE PLANET MARS.

To the Editors of "KNOWLEDGE."

SIRS,—The article by Mr. E. M. Antoniadi on the above subject in your last issue contains statements which I think should not pass without comment. The interesting questions arising from the markings on the planet Mars and the true nature of the markings themselves are by no means so conclusively settled as is assumed by Mr. Antoniadi in his article.

He has stated only one side of the case, and to my mind the arguments of the advocates of what Mr. Antoniadi calls "the canal myth" have not been properly stated or answered. It is, I think, well that readers of "KNOWLEDGE," some of whom may have had no previous acquaintance with the subject, should know that the matters contained in Mr. Antoniadi's article are not established truths.

I have never before seen it stated that "canals" appear straight and not curved at the edge of the disc. It has been my own experience that no markings, of the nature of canals or otherwise, can be seen near the limb of Mars, owing, obviously, to the planet's atmosphere; and I had previously understood that this experience was universal. It is stated in the article that Mr. Denning could see, with his ten-inch reflector, the true nature of the Martian canals. Is it not extraordinary that Professor Lowell with his twenty-four inch refractor has apparently failed to do so? The following passage, "areographers forget . . . that what is clear and sharp on such a small disc so far off ought to be represented as exceedingly vague on drawings three inches in diameter," possibly supplies an explanation of the apparent telescopic blindness of certain observers. This is what the statement amounts to: You may see a system of sharply defined lines on the disc of Mars, but when representing them in a drawing you must give them an uncertain foggy appearance. If you are sketching a distant balloon, and can quite distinctly see all the ropes as very fine sharp lines against the sky, you must represent them in your sketch as vague, uncertain bands.

I am afraid that I must, with all respect, disagree with the following passage on point of fact: "The student who passes many consecutive hours in the study of Mars with medium-sized instruments is liable to catch rare glimpses of straight lines, single or double, generally lasting about one quarter of a second." I have myself studied Mars with a nine-inch reflector, and have seen and held for considerable periods several of the larger "canals." The sensitiveness of observers varies very much, and also the visibility of "canals" is not always the same. It is a mistake for any one observer, however practised, to take his own experience and apply it to observers in general. Bearing in mind the great fluctuations in visibility of the markings on Mars—and indeed markings which come out strongly at one season will be practically invisible at another—the contrasts shown in Figures 190 to 193 lose some of their point. Mr. Antoniadi pours great ridicule on the advocates of comparatively small telescopes. He discusses this by no means settled question as if aperture were the only thing to be taken into consideration. In order to counteract the effects of the secondary spectrum, the greater the aperture of a telescope the greater must be its focal length. With telescopes of very great aperture it has proved, so far, a mechanical impossibility to make the focal length sufficiently great. In the perception of the existence of faint stars and strands of nebulosity, for which these telescopes of great aperture are especially suited, exact definition is not important; but in the case of planets, perfect definition is of more importance than light-grasp.

Definition depends, too, not only on the telescope, but also to a very large degree indeed on climatic conditions, which Mr. Antoniadi has not taken into account in his article. Professor Lowell has, at the Flagstaff Observatory, probably the finest possible equipment for planetary work. The climatic conditions at Flagstaff are undeniably better than those enjoyed by any other observatory. His twenty-four-inch refractor is, as refractors go, optically perfect. In planetary work his best results are obtained with the aperture stopped down to eighteen inches. The results obtained by Professor Lowell in planetary work are a testimony to the advantages of his observatory. His photographs of the planets, notably of Saturn and Jupiter, are, I believe, admitted to be unequalled. Professor Lowell is the greatest advocate of the theory of the artificial origin of the canals. He has succeeded in obtaining photographs of Mars on which canals appear. Yet Professor Lowell, who, with every advantage and equipment, has made the study of Mars the chief work of his life, and who certainly has more right to speak upon the subject, as an observer, than any other astronomer, is not mentioned by Mr. Antoniadi in his article.

84, Dartmouth Road, Brondesbury, N.W. — J. E. MAXWELL.

THE DOUBLE (AND BINARY) STARS.

To the Editors of "Knowledge."

Sirs,—There are some statements in Mr. Henkel's paper in April "Knowledge" that require qualification. He writes: "The discs (of stars, that is) seen by the naked eye, being optical illusions, are effects of irradiation." Now, no one sees "discs" with the naked eye at all; as is well known, they are only seen when magnifying power is applied. Moreover, they are not effects of irradiation at all, but of "diffraction"—interference phenomena, in fact.

He says that Herschel said, in his own words, "he went out like Saul to seek his father's asses, and found a kingdom." It was not Herschel who said this, but Schwabe, and it was said in relation to the discovery of the periodicity of sun-spots.

Mr. Henkel says: "*Perhaps* as many as twelve thousand such couples are known," meaning double stars. There is no "perhaps." Burnham's list contains thirteen thousand six hundred and fifty-five. *Re* catalogues, neither Struve's "Mensurae" nor Lewis's Catalogue is now the standard authority, but Burnham's.

There are other too positive statements upon matters where facts are doubtful and opinions differ, but I pass over merely doubtful assertions. EDWIN HOLMES.

THE FOURTH DIMENSION.

To the Editors of "Knowledge."

Sirs,—I have no desire to quarrel with Mr. Henkel's tentative "working definition" of "reality" as "that which exists independently of any human mind perceiving it." But I would qualify "reality" so defined as "objective," *i.e.*, universally valid; for we obviously cannot deny reality to our individual ideas, though we may usefully distinguish between this reality, which is subjective, *i.e.*, only true for the individual, and that which is "objective," as defined above. And I would add that, in order to conceive of a world existing independently of any human mind perceiving it, we must conceive of it as existing in some other mind. So that Mr. Henkel's definition does not answer my objection.

Concerning the objects of vision, Mr. Henkel's position is not easy to state in philosophical language. He appears to argue that our visual percepts arise from the same causes as our tactual percepts, and that in order for any such cause to give rise to a two-dimensioned visual percept, it must be capable of giving rise to a three-dimensioned tactual percept. This may, indeed, be true. But its truth or falsity does not affect the argument, because in either case the fact remains that the objects of vision (*i.e.*, the visual percepts) are two-dimensioned. And Mr. Henkel's objection to my theory of the fourth dimension was that it was built upon the assumption of the existence of objects having less than three dimensions, which Mr. Henkel said did not exist. But vision does immediately acquaint us with two-dimensioned objects. Whether the causes of our visual percepts are capable of producing three-dimensioned tactual percepts is a question which does not affect this fact. The existence of such causes is an inference and is not given immediately by experience.

But, indeed, Mr. Henkel admits the existence of a one-dimensioned object of experience, *i.e.*, time, and thus seems himself to demolish his objection to my theory.

The Polytechnic, Regent Street, W. — H. S. REDGROVE.

P.S.—As I have already intimated, I do not intend to discuss the question further with Mr. Johnston, but I must correct two misstatements in his letter. In the first place, my letter in your February issue was not written, as Mr. Johnston says, to express surprise that he had not gone into more detail in his former letter, but to point out that as he had not taken, and would not take, the trouble to acquaint himself with the arguments upon which my theory was based, he was incompetent to criticise it. In the second place, Mr. Johnston is in error when he says that in my letter in your March issue I gave my "argument in more detail, so it is possible for more criticism to be made." What I merely did in that letter was to answer objections raised by Mr. Henkel. If Mr. Johnston really wanted my argument in more detail, he could have found it at the references I gave. If he had done that it might have been possible for him usefully to criticise the theory in question.

PROBLEMS OF LIFE AND REPRODUCTION.

To the Editors of "Knowledge."

Sirs,—I hold that it is rank impertinence of an author to controvert the judgment of the critic. It is, then, merely a matter of interest to note that after about a dozen criticisms of my "Problems of Life and Reproduction," many in lay papers. the first to tax my writing as "a bit over technical and involved" should be the writer in "KNOWLEDGE." But he continues: "We have been most interested in the article on the transmission of acquired characters; but we are somewhat disheartened by a footnote at the commencement to the effect that another author has collected a number of facts in favour of this theory since the first appearance of this article, which ought surely to have afforded sufficient reason for rewriting." From this presentation it might be supposed that the tendency of the article was *against* the theory; but that additional evidence has accrued *on the same side* since an article in favour of a certain view was written is surely no reason for rewriting it, only for indicating what is the nature of the additional support. Now this is precisely what I have done. The preface, dated August, 1912, at the time of the paging of the corrrected galley slips, into which large additions were introduced, states: "In the revision, indeed, I have endeavoured to bring everything up to date, and have not hesitated to do so, without note or comment, wherever no question of priority was involved; but where this was the case I have pointed it out by the inclusion of new matter in square brackets, [ ], according to established custom."

The footnote to which "R. L." refers deals with a paper of Semon's, of 1911, which is in the nature of a "Bericht." On page 189 of this essay will be found bracketed a statement of evidence published in the Mendel Jubilee Volume of that same year. Another point is illustrated by an added footnote (page 195), utilising the views of Professor Dendy in his "Evolutionary Biology," which appeared in 1912. A postscript deals with an argument of Sir Ray Lankester's, which appeared in the Encyclopaedia Britannica in 1911. In fine, the whole of the essays were revised, added to, retrenched, or rewritten (one of them, as stated in the Preface, almost completely so), in order to bring them up to date. Neither Mr. Murray nor I would have been satisfied with any revision stopping short of this in a volume of the "*Progressive* Science Series."

Such matters as these are not matters of the personal judgment of the critic, but of the conscience and conscientiousness of the author criticised. You will, therefore, I am sure, allow me to set myself and my publisher right in the eyes of your public.

MARCUS HARTOG.

UNIVERSITY COLLEGE, CORK.

HORNETS AS PETS.

To the Editors of "KNOWLEDGE."

SIRS,—I read with much interest the paper by Mr. G. Hurlstone Hardy on the above subject. When a boy I kept many colonies of Hornets, Wasps, and Humble Bees, and can confirm Mr. Hardy's statement that they may be adopted as pets with very little danger. I used to bring broods home from the fields, queens and all, and place them in properly prepared holes in the grassy bank which I made in the garden. I had some very strong families of them, and spent many hours every day sitting as close to them as I possibly could and counting the numbers flying in and out hourly. In this way I could gauge their daily increase of strength and it was astonishing how they multiplied. By watching them closely many little facts were learnt concerning their habits; but all these are probably well known; though I have never read a book descriptive of these insects.

They are very far from being savage or aggressive if treated in a proper manner; they are very industrious, but, if molested, can be fierce and swift to use the terrible means which Nature has provided for their protection. They are most interesting creatures and capable of furnishing many hours of recreation and instruction to students. I shall never forget the regret I felt when paternal admonitions led me to destroy my favourites. Neighbours, however, could not stroll in their gardens without a cloud of my hornets and wasps hovering threateningly around their heads, and serious representations being made to that effect I had to remove the menace.

Hornets are like certain other supposed vicious things in animate nature. If allowed to pursue their own way without interference they are rarely the assailants. People are not always just to creatures endowed with powerful means of self-defence. We are apt thoughtlessly to obstruct them and then, should we suffer for our temerity, usually put the blame on the wrong shoulders. Hornets and wasps are capable of good as well as harm; but they carry nasty weapons, and so the public regard them as fit objects for extermination.

I have great regard and respect for these insects; they merit more considerate treatment and it is painful to see that thousands of the poor queens are hunted down and killed every spring for a paltry compensation.

W. F. DENNING.

BRISTOL.

NOTICES.

INSECT LIFE.—Messrs. Jack announce a new and comprehensive work on "Insects: their Life-Histories and Habits," by Harold Bastin. Written in plain language and thoroughly up-to-date, the work covers the whole field of insect life, and will be profusely illustrated in colour and black and white.

GREAT WESTERN RAILWAY.—No railway claims more attention nowadays than the Great Western, which is the subject of the latest volume in Messrs. A. & C. Black's "Peeps at Railways" Series. The author, Mr. Gordon Home, has given a very readable, informative, and exhaustive account of the history and the present activities of the line and of many of the places of industrial and historical importance that it serves. The work is fully illustrated in colour and black and white.

THE LEITZ OPTICAL WORKS.—In connection with the completion of its 150,000th compound microscope, the firm of Ernst Leitz has issued an interesting pamphlet, giving portraits of its present members and some remarkable details showing the development of its work at Wetzlar. The establishment was founded in 1849, but it was not until the present senior partner acquired control of the business in 1870, that rapid progress began to be made. At that time the annual output of microscopes was about sixty, in 1881 it was six hundred, in 1903 six thousand, and now this number has been doubled. The 100,000th Leitz microscope was presented to the late Professor Koch in 1907, and the 150,000th has now been given to Professor Erhlich of Frankfort-on-Main. Correspondingly, the staff has increased in number since 1870, when twenty persons were employed, until now it consists of nearly one thousand workers.

THE ALCHEMICAL SOCIETY.—The fifth General Meeting of the Alchemical Society was held on Friday, May 9th, at 8.15 p.m., at the International Club, Regent Street, S.W. The chair was occupied by the Honorary President, Professor John Ferguson, M.A., LL.D., F.I.C., F.C.S., of Glasgow University (whose monumental bibliography of alchemical works is well known to students), and a paper by the Venerable J. B. Craven, D.D., Archdeacon of Orkney, was read, entitled "A Scottish Alchemist of the Seventeenth Century: David, Lord Balcarres." The paper contained particulars concerning the life of Lord Balcarres and hinted at the possibility of Rosicrucian sympathies. The author has been permitted to examine what remains of Balcarres' library, and has found therein a manuscript translation of the famous "Fama Fraternitas," antedating the earliest published translations. The paper also contained particulars of other interesting manuscripts in this library, and concluded with an old Fifeshire legend showing the fantastic views which were once held concerning the Rosicrucians.

The above meeting was followed by the Annual General Meeting of the Society. It is interesting to learn from the Secretary's and Treasurer's reports that the membership is on the increase and that the finances of the Society are in a satisfactory condition.

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

JULY, 1913.

EDITORIAL.

SEEING that many of our readers find it trying—especially in artificial light—to read "KNOWLEDGE" owing to its being printed on art paper, we have decided to make a change. Henceforth a surface which is not highly glazed will be used for the letterpress; but justice will still be done to the illustrations by putting them on the paper which has recently been used for the whole Magazine. Under these circumstances it becomes necessary to point out to our contributors that illustrations which are to be inserted in the body of the text must be line drawings, while those in tint or photographs which are to be reproduced for the plates must be suitable as to size, and those which are to go on the same page should be as similar as possible in character.

We take this opportunity of thanking all those who have been helping us to carry on the Magazine and of asking our readers to make suggestions as to articles, especially when they can indicate where suitable material is to be found. Particularly should we welcome astronomical photographs and drawings which would be suitable for plates, and illustrated descriptions of original work which is of general as well as special interest.

As we have said on previous occasions, we are always ready to hear from our subscribers who have anything to say with regard to the improvement of the Magazine, and also as to what features at present existing might with advantage be emphasised. It is obvious that the larger the circulation the more money there will be to spend on the Magazine, and in conclusion the Editors invite everyone who takes a general interest in the paper to coöperate with them and to do something to make it more useful and more widely known.

THE FOURTH DIMENSION AND ITS BEARING ON THE CAUSE OF UNIVERSAL GRAVITATION.

By A. G. BLAKE, F.R.A.S.

OUR ideas of the dimensions of a body are very largely derived from the circumstances in which these dimensions may undergo variation. Thus we speak of a piece of paper as being of two dimensions because of the great difficulty of changing its thickness compared with the difficulty of changing its length or breadth.

In "flatland"—a hypothetical region where motion confined to two dimensions only is possible — it is quite conceivable—nay, it is a necessary assumption if we are to allow the possibility of concrete bodies in it—that bodies should have a certain thickness in a third dimension which would be invariable in individual bodies, but not necessarily uniform among different bodies. Thus the sum total thickness of bodies in "flatland" would be fixed and invariable. To the inhabitants, who would be incapable of realising thickness, this would result in the conservation of some physical attribute peculiar to bodies of two-dimensional space.

In seeking evidence of a fourth dimension, then, we must draw our inferences from the conservation of some physical attribute peculiar to three-dimensional space. The most obvious—indeed, the only one—is the Conservation of Mass. We cannot, however, infer that mass is the three-dimensional perception of a four-dimensional thickness; for the mass of a body is directly alterable by changing its three known dimensions by simply cutting or breaking the body. If we change only three dimensions of a four-dimensional body the fourth must remain unchanged. Suppose (L), (B), (T) to be the units of length, breadth, and thickness, (M) the unit of mass and (F) the unit of "fourth dimension."

Then, since mass varies directly as volume,

$$(M) = \mu\ (L), (B), (T), \text{ when } \mu \text{ is some constant.}$$

But since the fourth-dimensional unit is a constant for any one body, and (F) is the unit, we may put

$$(M) = (F), (L), (B), (T).$$

$$\text{Therefore } (F) = \frac{(M)}{(L), (B), (T)} = \mu = \frac{\text{mass}}{\text{volume}}.$$

But $\frac{\text{mass}}{\text{volume}}$ is what we call density.

Accordingly, in our three-dimensional universe every body has a thickness in a fourth dimension, which is variable in different bodies, but invariable in the same body, and that fourth-dimensional thicknest is the body's density.

That this fits in perfectly with analogies drawn from two-space is easily shown. Thus in "flatland" we may consider a two-dimensional body with a small thickness in the third dimension. A "flatlander" would cut down its length and its breadth, but would be powerless to alter its thickness, so that its volume would vary as its area. Extending this to three-dimensional space, we may cut down a body in three dimensions—length, breadth, and thickness—but we cannot alter what we may call its fourth or extent in a fourth dimension, so that its mass varies as its volume. In fact, mass in four-space corresponds to volume in three-space and area in two-space. The volume of a three-dimensional body is infinity times as great as the volume of a two-dimensional body. The mass of a four-dimensional body is infinity times as great as the mass of a three-dimensional body (*i.e.*, one whose density is nil).

Though we cannot directly change the extent of a body in its fourth dimension we can do so indirectly by taking advantage of the principle of the conservation of mass and compressing the body in three dimensions. The two-dimensional equivalent to this is that in two-space, though it is impossible directly to alter the third dimension; yet by compressing it in two dimensions the third will be increased, while the volume will remain constant. For in two-space the chief physical principle would be the conservation of volume, though under what aspect volume would present itself to "flatlanders" we can never tell.

Having shown how a body's density may be our perception of its thickness in a fourth dimension, I shall endeavour to explain the cause of Universal Gravitation—why any two bodies in space will attract each other, and why the force of attraction will vary directly as the mass and inversely as the square of the distance separating them.

For the purposes of my theory I assume that matter is surrounded on all sides by an ether of vast extent in every direction—in all four dimensions. I shall show hereafter that the very great density implied in the last clause is not incompatible with absence of gravitation power. In this ether an immense number of waves is being propagated in every possible direction; the waves themselves may be small, but their number renders them capable of exerting a finite and constant pressure at every point. Consider a body poised freely in space. For simplicity let it be a homogeneous sphere. This body will cast a penumbral shadow (if I may call it so when light-waves are not involved) out into space in every direction. As an example, I will take the case of a body situated near the centre of a hollow sphere, the inner side of whose shell is aglow with light. Consider a particle distant d from the body, where d is infinitesimal compared to the radius of the illumined sphere. Now the diminution of light occasioned by the body as seen from the particle is obviously proportional to $\frac{1}{d^2}$. Now consider a similar system in the ether I have postulated. Let the body be A and the particle p. Then the diminution of pressure along Ap occasioned by the interception of waves by the dark body is proportional to $\frac{1}{d^2}$. But since the waves come in every direction and *in all four dimensions*, the diminution is also proportional to the length, breadth, thickness, and "fourness" of the body A. Therefore, the pressure along Ap (taking sense into account) is

$$\left(K - \frac{\lambda M}{d^2}\right) \text{ when } \lambda \text{ is a constant.}$$

But the pressure on p from the other side in the opposite direction pA is equal to K.

Accordingly the particle is being pressed towards the body A with a force equal to

$$K - \left(K - \frac{\lambda M}{d^2}\right) = \frac{\lambda M}{d^2},$$

a force directly proportional to the mass and inversely proportional to the square of the distance.

It is perfectly plain from the foregoing that the ether might be possessed of great density, since it bears the waves which cause gravitation itself, and therefore obviously cannot gravitate.

This theory also accounts for the instantaneity of gravitation. The most refined observations have failed to disclose any lapse of time between cause and effect where gravitation is concerned, and this would be wholly inconceivable were gravitation an inherent property of matter.

THE NEW ASTRONOMY.

MEETING OF THE PHYSICAL SOCIETY.

EXCEPT for the time spent on a paper on wireless detectors, the whole meeting of the Physical Society on Friday, May 30th, was occupied by a lecture by Professor Bickerton and a discussion on his theory of the origin of new stars. The lecturer began by showing that so many agencies tended to bring about stellar impact that these events must be scores of thousands of times more frequent than mere chance encounters would suggest. In fact, the impact of suns must be an important cosmic law. He then showed that all collisions of suns brought about by gravitation must be oblique; that is, of a grazing character. Some fifty years ago Dr. Johnstone Stoney had deduced this fact. It was accepted by Lord Kelvin, Sir Robert Ball, and Arrhenius. These eminent men had traced out in some detail the results that they thought would ensue. Owing to an oversight their work was valueless. They did not detect the fact that in solar grazes the shearing force available was millions of times greater than that necessary to cut the most tenacious of nickel steel, and that consequently grazing suns tear one another and the parts actually meeting coalesce to form a third star of such extreme thermodynamic intensity as to be explosively hot. Hence the problem of the encounter of suns must be taken in two parts: the new third star and the torn bodies of the suns.

Professor Bickerton then showed that the problems of all cosmic encounters must be divided, whether the collisions be between dense bodies such as suns or rare such as nebulae, meteoric swarms, or interpenetrating sidereal systems. In each case a central furnace, an explosively hot third body, must be formed. It was then shown that in any explanation of novae three most extraordinary criteria had to be satisfied. These were the thermodynamic intensity, the complex light-curve, and the long series of abnormal spectrograms. Every one of the current hypotheses failed in at least two, and most of them failed utterly in all three, criteria.

The induction that every nova is a third star torn from grazing suns satisfies all three criteria in the utmost minutia of detail. By the process of exhaustion this theory was the only explanation left. The shearing force available might be based on a velocity of two hundred and fifty miles a second, a velocity five hundred times that of a Krupp shell; that is, an energy of unit mass or kinetol a quarter of a million times that of our swiftest projectiles. The surface to be sheared is proportional to the square of the diameter of a sphere, whilst shearing force is as the mass; that is, as the cube of the diameter; and as the mass of the suns is quadrillions of times that of any military projectile there remains no question but that grazing suns shear one another. According to Dr. Crommelin, Nova Persei was estimated to have a maximum intensity ten thousand times that of the Sun. That is, were this tremendous blaze kept up by fuel, it would require to be stoked with six million times the entire coalfields of the earth each minute of its maximum. The impact of suns is the only known source of such a suddenly developed store of energy.

Professor Bickerton next pointed out that the third star would be formed in an hour, would expand, and would dissipate, giving a light-curve with a sudden uprise as novae always exhibit, whereas the commonly received explanation of Seleger and Halm, that of a sun entering a nebula, must give a light-curve almost horizontal. The explanation given in the lecture followed that in "KNOWLEDGE" (September, 1911), as did also the explanation of the series of spectrograms. Professor Bickerton stated that although such physical agencies as pressure might account for some of the peculiarities of the spectra of novae there was no need to bring in anything but the Doppler principle. This, taken in conjunction with the deduced properties of the third star, was sufficient to account for any physical fact even of so complex spectra as those of Nova Geminorum as obtained at Cambridge.

The Chairman, Professor Schuster, F.R.S., stated that the whole theory was extremely suggestive, and that Professor Bickerton had devoted a third of a century to its study. There was one point he should like discussed, and that was the high velocity of hydrogen referred to. Experimentally it had been shown that, no matter how enormous the pressure to which the gas was subject, the velocity of escape never rose above that of sound.

Professor Bickerton replied that the velocities observed in novae was a question of temperature, not pressure. The velocity of sound was a question of thermodynamics. If the compressed hydrogen had the enormous temperature attained during and subsequent to the collision the velocity of sound would be proportionally increased.

A hearty vote of thanks was accorded to the lecturer.

THE MAKING OF A MICROSCOPE.

By WILFRED MARK WEBB, F.L.S.

With Illustrations from Photographs specially taken by Messrs. Lascelles & Co.

THE microscope has come to be used in so many branches of scientific research, and, we may add, of everyday commerce, that it has occurred to us that a short illustrated account of the way in which the instrument is made would be of interest to our readers. Accordingly Messrs. W. Watson & Sons were approached, and they kindly gave permission for their works at High Barnet to be visited, and afforded all the necessary facilities for taking the photographs from which our illustrations have been made.

The work may well be divided into two parts, and we may consider it under two headings: firstly, the making of the metal stand and fittings; and secondly, of the optical parts, or, in that slang which the Royal Microscopical Society is content to use, "brass" and "glass." Figure 246 shows a general view of the machine shop where the metal parts of microscopes, and also of telescopes, field glasses, and so on, are got into shape. It may be said at once that the rough castings (see Figure 250) are not made at the works. The first process through which the foot, for instance, of a microscope is put is grinding, by which the flat surfaces are made true, as shown in Figure 247.

The surfaces which cannot be ground are milled—that is to say, cleaned up in the machine provided with a revolving wheel furnished with a number of cutting teeth (see Figure 249).

At the back of the machine shop is a room containing the forges and also an interesting machine, shown in Figure 248, which gives a very great mechanical advantage, by means of which the brass tubing used for the bodies of microscopes and other instruments is brought to the exact size required; the tubing is pulled over a metal core of the exact diameter which is required through a hole in an iron plate which corresponds with the outside measure. It may be added that the tubing is made smaller during the operation and is lengthened considerably, while its hardness is very greatly increased.

Turning to other parts of the microscope stand it is not necessary to describe the turning and screw-cutting in connection with various fittings; but to give some idea of the accuracy which has to be obtained it may be mentioned that in the case of the screw-threads in telescopes which are made for Government an error of only $\pm \cdot 0005$ of an inch is allowable. In a smaller shop special work is done. For instance, it is found necessary, when making the surfaces true which are to be moved by the fine adjustment of the microscope, that this should be done on a planing machine worked by hand, as shown in Figure 251. The processes of blackening and bronzing differ but little, if at all, from those in use in the case of other metal work, and we may leave the making of the stand on one side for a moment to consider the very important question of lens grinding.

The special optical glass which is imported for the purpose of lens-making is received in small slabs, of which half a dozen are shown in Figure 252. These are slit up into pieces, which are of the required thickness and size, by means of an apparatus similar to that used for slicing precious and ornamental stones. It is, for all practical purposes, a circular saw in the form of a revolving metal disc, the teeth of which consist of diamond dust hammered into its edge. The machine and discs used are represented in Figure 253, where a block of glass partly sawn through is seen in position.

The next operation is to trim up the square pieces of glass so as to make them approximately circular by clipping them with shears. They are then ground or roughed into shape (see Figure 254), and afterwards taken to the glass shop, a view in which is seen in Figure 261. Here the larger lenses for eyepieces and low-power objectives are polished and made true, and we illustrate the details of the process in Figure 255, where blocks of lenses are seen, showing how convex, concave, and plane surfaces are produced. The polishers are fastened to a crank which causes them to rotate with the particular motion required. It should be mentioned that fine rouge is used at this stage.

Small microscope lenses are fastened on to a block in the same way and held by the hand into a revolving cup, as seen in Figure 256, while very small ones for high-power objectives are fixed singly to handles and polished individually. A pair of holders may be seen lying on the table in the figure just mentioned.

From time to time as the work proceeds the lenses are tested with a proof plate, the surface of which, in the case of convex lenses, of course, will be concave, and *vice versa*. The method of applying this is seen in Figure 257 in the case of a good-sized lens, and the proof that the latter is accurately ground is shown when it is brought into contact with the plate by the formation of a perfect series of Newton's rings. After the lens is polished its edges have to be ground, and we illustrate this in Figures 258 and 259 in the case of a large lens, and also that of one which is to be used in the making of a one-twelfth objective. Putting together one of the latter is, of course, a most delicate process and requires great skill. The flint and crown glass constituents of the lenses have first of all, as in other cases, to be cemented together and then the whole series has to be mounted in the metal fittings and adjusted. This is done at Messrs. Watson & Sons' works by means of measurements, with the result that very few of the finished objectives, which are turned out in considerable numbers, do not pass the test the first time.

Now we may consider that we have all the parts of

FIGURE 246.
The machine shop at Messrs. W. Watson & Sons' Works, High Barnet.

FIGURE 247.
Making flat surfaces of a casting true with a grindstone.

FIGURE 248.
The machine for drawing out brass tubing.

FIGURE 249.
Milling or cleaning up the parts of a casting.

FIGURE 250.
Rough castings as received at the works.

FIGURE 251.
Planing the surface of a fine adjustment by hand.

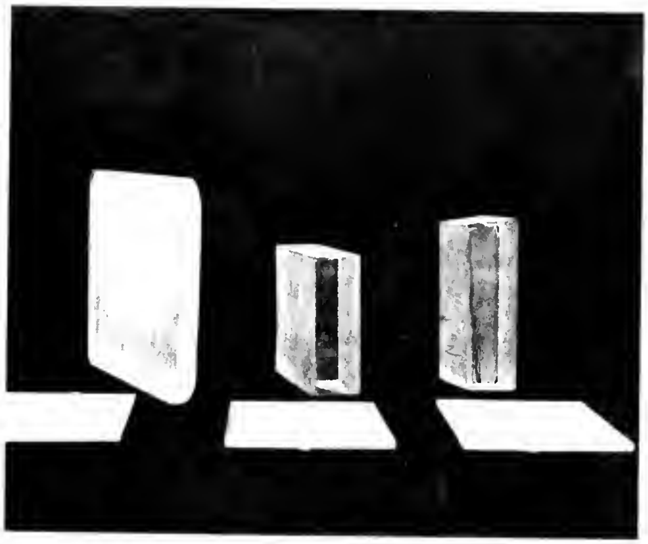


FIGURE 252.
Optical glass as imported.

FIGURE 253.
Machine for slitting the glass.

FIGURE 254.
Roughing or getting the lenses into shape for polishing.

FIGURE 255.
Lens polishing machine with blocks of lenses.

Figure 256.
Grinding small lenses by hand.

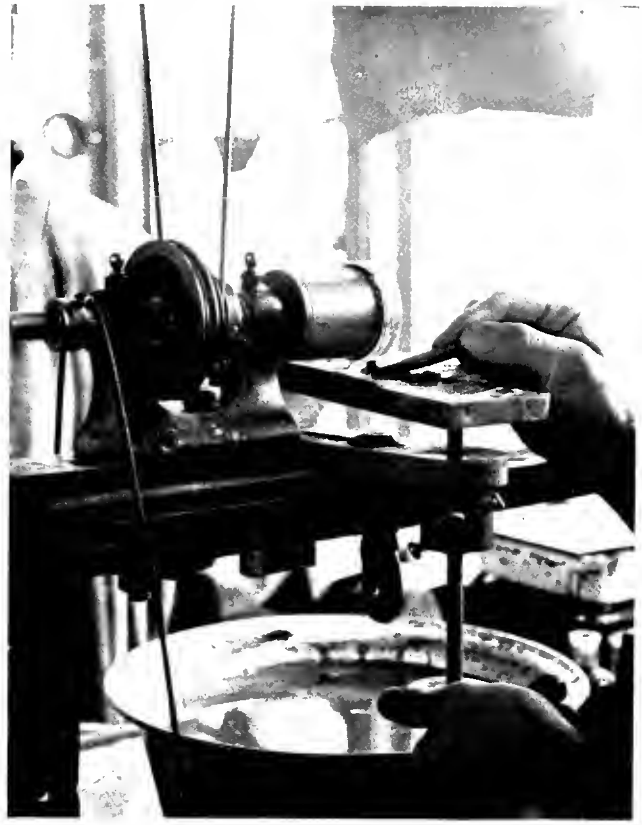


Figure 258.
Grinding the edge of a finished lens of considerable size.

Figure 257.
Testing a lens with a proof plate.

Figure 259.
Grinding the edge of a lens for a one-twelfth objective.

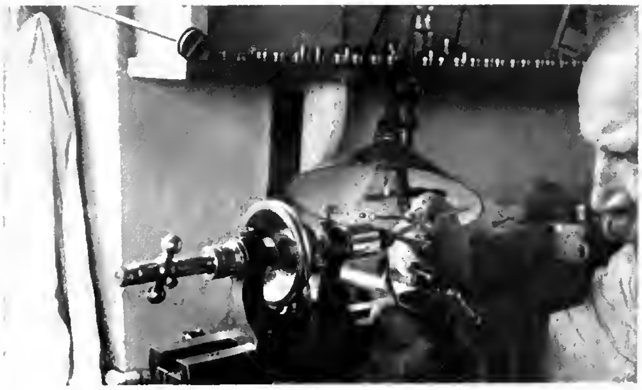


Figure 260.

Mounting the lenses for a one-twelfth objective.

Figure 261.

A view in the glass shop.

Figure 262. A microscope stand (H Edinburgh Student's) with its components and their individual pieces.

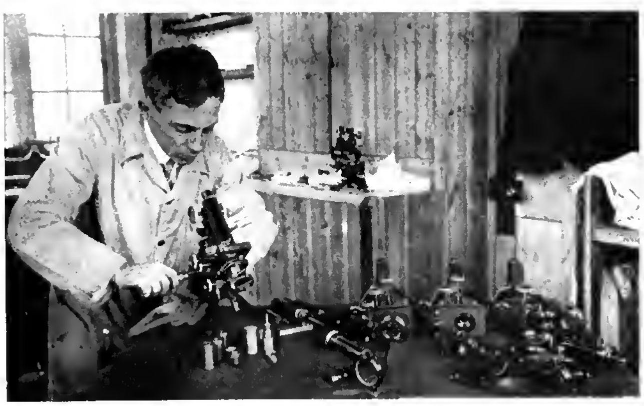


Figure 263.

Assembling a microscope.

Figure 264.

The testing-room examination.

the microscope ready, and to give some idea of how many of them there are we show in Figure 262 the more important portions of an H Edinburgh Student's Microscope and the separate pieces of which they are made up. It may surprise some of our readers to learn that there are sixty-four of these and ninety-six screws in the stand alone.

To assemble a microscope is the term used for putting the stand together—that is, combining the stage, foot, limb, and mirror (see Figure 263). After this the instrument has to go through the testing room examination (see Figure 264), when it is ready to leave the works and be fitted with such eyepieces and objectives as its future owner needs for his work.

CORRESPONDENCE.

QUADRATURE OF THE CIRCLE.

To the Editors of "KNOWLEDGE."

SIRS,—In "KNOWLEDGE" for November last you published a letter from me touching the quadrature of the circle. In this letter I asked certain questions on the subject. I also stated that I had ascertained *by geometry* that the perimeter of a circle is equal to a certain triangle described on same.

Up to date no reply to the questions referred to has appeared in "KNOWLEDGE," and I am still holding in abeyance the geometric solution referred to pending satisfactory answers from some source to these queries.

What I wish to be informed on is:—

1st, Has the solution referred to above ever been published or made known before it appeared in "KNOWLEDGE," *i.e.*, either in ancient or modern works?

2nd, Has it ever been satisfactorily proved or disproved in any way by any author?

One gentleman did write to you on the subject, but he made no reference whatever to these questions, although he criticised the solution.

In reply to this writer I give Figure 265, showing that the solution is exact and not approximate only.

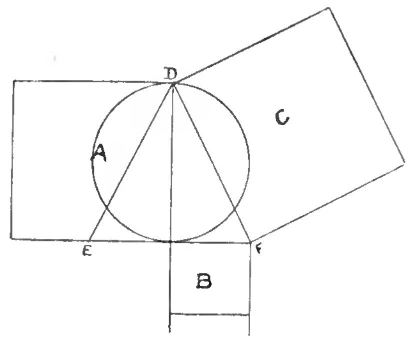


FIGURE 265.

By ordinary geometry the square C is = A and B together.

Let diameter = 1.
The square A = 1.
And square B = ·25.
And therefore square C = 1·25.
Also square on E D F will = 5 (1·25 + 4).
And square on E F will = 1.
Therefore E D F = √5 and E F = √1.
And therefore E D F E = √5 × √1.

Arithmetic of the Quadrature.

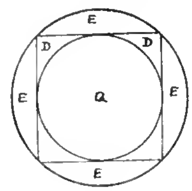
I also send Figure 266 for the purpose of showing that my geometric solution referred to above can be verified by arithmetic.

Attention may be drawn to the following points:—

1st, The whole of the ratios given are based on the square root of 5 and the square root of 1 (which, of course, is 1), and that they are therefore commeasurable.

2nd, The ratio of the circumference of the circle to its diameter is identical with the ratio of—

(*a*) The area of the outer circle, minus the square to
(*b*) The area of the square, minus the inner circle, *i.e.*, the ratio of (*a*) to (*b*) or of E to D in the diagram.



A The inner circle-area √5 + √1 + ·25 (½ radius).
B The square-area √5 × √1 + E ÷ 2.
C The outer circle-area √5 × √1 + √2 + (·25 + √2).
D The four spaces D singly or together.
E The four spaces E singly or together.

FIGURE 266.

Ratios (taken inversely, etc.):

Circumference to diameter ... √5 × √1
E to D ... ... √5 × √1
The square to the lesser circle √5 × √1 − 2
The greater circle to the square √5 × √1 ÷ 2
A to E ... ... √5 × √1 ÷ 2 − $\frac{E}{2}$
A to D ... ... √5 × √1 × √1

Table 46 shows the results of using any different ratio from √5 × √1:

TABLE 46.

Ratio of Perimeter to Diameter.	Area.	Spaces E Equal.	Spaces D Equal.	Ratio of E to D.
3	·75	·5	·25	2
3,2	·8	·6	·2	3
(√5 × √1) 3,236, etc.	·809, etc.	·618, etc.	·1909, etc.	(√5 × √1) ·3236, etc.
3,3	·825	·65	·175	·3714, etc.
3.5	·875	·75	·125	6

These figures (and any further calculations that may be made on the same lines) show conclusively that the figures of the ratio "√5 × 1" are the most "symmetral" that can be produced in conjunction with Figure 266.

Therefore, if they are not the true figures of the circle, there must be some other figures or polygon (regular or irregular) to which they do apply; and it will also follow that this other figure is a more symmetrical figure than the circle—which is impossible.

On the strength of what I have advanced above, I hope some scholar will now answer the questions given above.

BRISBANE, GEOMA.
QUEENSLAND.

THE FACE OF THE SKY FOR AUGUST.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 47.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Uranus. R.A.	Uranus. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Aug. 3	8 51·9	N. 17·6	9 48·6	N. 15·1	8 53·1	N 12·4	5 48·3	N. 21·1	4 6·1	N. 20·1	18 41·7	S. 23·3	4 56·8	N. 21·0	20 31·6	S. 19·6
,, 8	9 11·1	16·3	14 12·9	S. 17·1	8 39·5	13·9	6 12·0	21·4	4 19·9	20·7	18 39·9	23·3	4 58·7	21·1	20 30·8	19·6
,, 13	9 30·1	14·8	18 55·9	S. 27·8	8 32·9	15·5	6 36·0	21·4	4 33·6	21·3	18 38·2	23·3	5 0·5	21·1	20 30·0	19·7
,, 18	9 48·8	13·2	22 58·6	S. 7·7	8 37·7	16·7	7 0·2	21·3	4 47·2	21·8	18 36·9	23·4	5 2·1	21·2	20 29·2	19·7
,, 23	10 7·3	11·6	2 34·6	N. 19·3	8 54·8	17·0	7 24·7	20·9	5 0·7	22·2	18 35·8	23·4	5 3·6	21·2	20 28·5	19·7
,, 28	10 25·7	N. 9·8	7 21·1	N. 27·0	9 22·4	N. 16·1	7 49·2	N. 20·2	5 13·9	22·6	18 35·3	S. 23·4	5 4·9	N. 21·2	20 27·8	S. 19·8

TABLE 48.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Mars. P	Mars. B	Mars. L	Mars. T	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
Greenwich Noon.	°	°	°	°	°	°	°	h. m.	°	°	°	°	h. m.	h. m.
Aug. 3	+11·7	+6·0	60·7	+18·3	−34·7	−8·5	157·5	1 12 *m*	−5·3	−1·6	143·0	97·5	5 56 *e*	7 15 *e*
,, 8	13·6	6·3	354·6	+18·3	33·9	7·2	109·0	4 32 *m*	5·1	1·6	212·7	129·1	4 2 *e*	6 23 *e*
,, 13	15·4	6·6	288·5	− 5·1	33·0	5·9	60·5	7 51 *m*	4·9	1·6	282·3	160·6	11 58 *e*	5 31 *e*
,, 18	17·1	6·8	222·4	−21·1	32·1	4·7	12·0	11 11 *m*	4·8	1·6	351·9	191·9	10 4 *e*	4 39 *e*
,, 23	18·7	7·0	156·3	−17·1	31·0	3·4	323·6	2 29 *e*	4·7	1·6	61·3	223·2	8 10 *e*	3 47 *e*
,, 28	+20·1	+7·1	90·3	+ 7·4	−29·9	−2·2	275·3	5 48 *e*	−4·6	−1·6	130·7	254·4	6 17 *e*	2 55 *e*

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Mars, T is the time of passage of Fastigium Aryn across the centre of the disc. In the case of Jupiter, L_1 refers to the equatorial zone; L_2 to the temperate zone; T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

THE SUN continues his Southward march with accelerated speed. Sunrise during August changes from 4.23 to 5.13; sunset from 7.49 to 6.48. Its semi-diameter increases from 15′ 47″ to 15′ 53″. Outbreaks of spots in high latitudes should be watched for.

MERCURY is in Inferior Conjunction at Noon on August 4th; then it is a morning star, reaching West Elongation (18° from Sun) on 22nd. Illumination increases from 0 to $\frac{7}{10}$. Semi-diameter diminishes from $5\frac{1}{2}$″ to 3″.

VENUS is a morning star, having passed West Elongation July 4th. Semi-diameter diminishes from 9″ to 7″. At beginning of month $\frac{5}{8}$ of disc is illuminated; at end of month $\frac{3}{4}$. Being North of Sun it is favourably placed for Northern observers. It is 18′ South of Neptune $30^d\ 0^h\ 38^m$ *m*.

THE MOON.—New $2^d\ 0^h\ 58^m$ *e*; First Quarter $9^d\ 4^h\ 3^m$ *m*; Full $16^d\ 8^h\ 27^m$ *e*; Last Quarter $25^d\ 0^h\ 18^m$ *m*. New $31^d\ 8^h\ 38^m$ *e*. Perigee $3^d\ 11^h$ *e*, semi-diameter 16′ 36″. Apogee $19^d\ 8^h$ *m*, semi-diameter 14′ 44″. Maximum Librations, 10^d 7° W., 12^d 7° N., 26^d 7° E., 26^d 7° S. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

TABLE 49. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.		h. m.	
Aug. 8	BAC 4814	6·5	8 33 *e*	185°	8 53 *e*	219°
,, 12	Lacaille 7730	7·0	10 11 *e*	81	—	—
,, 13	BAC 6628	5·9	9 26 *e*	100	10 40 *e*	230
,, 15	χ Capricorni	5·3	9 31 *e*	105	10 32 *e*	202
,, 18	BAC 8129	6·3	8 15 *e*	68	9 22 *e*	232
,, 19	BAC 8184	6·4	3 9 *m*	117	3 42 *m*	169
,, 20	BD − 0°6	7·6	—	—	1 38 *m*	179
,, 24	BD + 24°599	6·6	—	—	11 41 *e*	225
,, 26	BD + 27°723	6.5	3 39 *m*	52	4 46 *m*	280
,, 26	BAC 1848	5·6	—	—	10 51 *e*	298
,, 26	136 Tauri	4·6	11 9 *e*	157	11 22 *e*	189
,, 28	47 Geminorum	5·6	4 57 *m*	120	5 59 *m*	249

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

The grazing occultation of 136 Tauri on 26th should be carefully observed; sometimes more than one disappearance or reappearance takes place in such cases, owing to irregularities in the lunar outline.

MARS is a morning Star, semi-diameter $3\frac{1}{2}''$, defect of illumination nearly a second. It is 1° North of Saturn, $24^d\ 5^h e$. It will reach Opposition early in January, so the season of observation is commencing.

VESTA is in opposition August 4th, magnitude 6·1. Ephemeris for midnight:—

		R.A.		S.Dec.
		h m		°
August 2...	...	20 59·3	...	23·2
,, 8...	...	20 53·6	...	24·0
,, 14...	...	20 48·1	...	24·6
,, 20...	...	20 43·1	...	25·1

It will be interesting to compare it with Uranus, which is not far distant. Their magnitude is about the same, but their aspect different.

JUPITER was in opposition on July 5th. Polar semi-diameter, $20\frac{1}{2}''$ in mid-August.

TABLE 50.

Day.	West.		East.		Day.	West.		East.	
Aug. 1	2	○	34	1●	Aug 17		○	1234	
,, 2	21	○	34		,, 18	13	○	24	
,, 3		○	1324		,, 19	32	○	14	
,, 4	31	○	24		,, 20	312	○	4	
,, 5	32	○	14		,, 21	3	○	124	
,, 6	31	○	4	2●	,, 22	12	○	34	
,, 7	43	○	12		,, 23	2	○	143	
,, 8	12	○	3	1●	,, 24	4	○	23	1●
,, 9	421	○	3		,, 25	41	⊙	2	
,, 10	4	○	123		,, 26	432	○	1	
,, 11	413	○	2		,, 27	4312	○		
,, 12	432	○	1		,, 28	43	○	12	
,, 13	431	○		2●	,, 29	41	⊙	3	
,, 14	43	○	12		,, 30	42	○	13	
,, 15	21	○	3	4●	,, 31	4	○	23	1●
,, 16	2	⊙	43						

Configuration at $9^h\ 30^m e$ for an inverting telescope.

Satellite phenomena visible at Greenwich, $1^d\ 0^h\ 31^m m$ I. Tr. E., $0^h\ 35^m\ 53^s m$ III. Ec. R., $1^h\ 9^m m$ I. Sh. E., $10^h\ 26^m\ 51^s e$ I. Ec. R.; $5^d\ 0^h\ 33^m m$ II. Tr. E.; $6^d\ 11^h\ 0^m\ 52^s e$ II. Ec. R.; $7^d\ 10^h\ 15^m e$ III. Oc. D., $10^h\ 34^m e$ IV. Sh. E.; $8^d\ 0^h\ 0^m m$ I. Tr. I., $0^h\ 46^m m$ I. Sh. I., $9^h\ 18^m e$ I. Oc. D.; $9^d\ 0^h\ 21^m\ 36^s m$ I. Ec. R., $8^h\ 44^m e$ I. Tr. E., $9^h\ 33^m e$ I. Sh. E.; $13^d\ 9^h\ 3^m e$ II. Oc. D.; $15^d\ 8^h\ 19^m e$ IV. Oc. D., $8^h\ 42^m e$ II. Sh. E., $11^h\ 6^m e$ I. Oc. D., $11^h\ 14^m e$ IV. Oc. R.; $16^d\ 8^h\ 14^m e$ I. Tr. I., $9^h\ 10^m e$ I. Sh. I., $10^h\ 32^m e$ I. Tr. E., $11^h\ 28^m e$ I. Sh. E.; $17^d\ 8^h\ 45^m\ 8^s e$ I. Ec. R.; $18^d\ 10^h\ 30^m e$ III. Sh. E.; $20^d\ 11^h\ 25^m e$ II. Oc. D., $22^d\ 8^h\ 27^m e$ II. Sh. I., $9^h\ 15^m e$ II. Tr. E., $11^h\ 18^m e$ II. Sh. E.; $23^d\ 10^h\ 3^m e$ I. Tr. I., $11^h\ 5^m e$ I. Sh. I.; $24^d\ 0^h\ 21^m m$ I. Tr. E., $7^h\ 21^m e$ I. Oc. D., $10^h\ 40^m\ 2^s e$ I. Ec. R.; $25^d\ 7^h\ 53^m e$ I. Sh. E., $10^h\ 8^m e$ III. Tr. E., $11^h\ 9^m e$ III. Sh. I.; $29^d\ 8^h\ 49^m e$ II. Tr. I., $11^h\ 2^m e$ II. Sh. I., $11^h\ 39^m e$ II. Tr. E., $30^d\ 11^h\ 53^m e$ I. Tr. I.; $31^d\ 8^h\ 12^m\ 5^s e$ II. Ec. R., $9^h\ 11^m e$ I. Oc. D.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant.			Remarks.
	R.A.		Dec.	
	°		°	
May 30 to Aug	333	+	28	Swift, streaks.
June to Aug...	310	+	61	Swift, streaks.
,, to Sep. ..	335	+	57	Swift.
,, to Aug....	303	+	24	Swift.
July to Aug...	308	−	12	Slow, long.
July 25 to Sept. 15	48	+	43	Swift, streaks.
July to Sept.	335	+	73	Swift, short.
July to Aug....	280	+	57	Slow, short.
July to Oct. ..	355	+	72	Swift, short.
Aug. 10-13 .	45	+	57	Perseids. Swift, streaks.
,, 15 ..	290	+	53	Swift, bright.
,, 15-25 ..	291	+	60	Slow, bright.
,, 25 ..	5	+	11	Slow, short.
Aug. to Sept. .	353	−	11	Rather slow.
,, ,,	346		0	Slow.
Aug. to Oct. 2	74	+	42	Swift, streaks.
,, to Sept...	63	+	22	Swift, streaks.

The Perseids may be seen from July 19th, radiant 23° + 52°, advancing 1° per day in R.A.

TABLE 51. NON-ALGOL STARS.

Star.	Right Ascension.	Declination	Magnitudes.	Period.	Date of Maximum.
	h. m.	°		d.	
T Herculis	18 6	+31 ·0	6·9 to 13	165	* May 2, Oct 13.
RY Ophiuchi...	18 12	+ 3 ·6	8·2 to 13	153·3	July 14.
W Lyrae	18 12	+36 ·6	7·3 to 12	196·5	May 28.
RS Draconis	18 40	+74 ·2	8·4 to 12	281	June 29.
SU Sagittarii...	18 59	−22 ·8	8·3 to 9	88	May 18.
R Aquilae	19 2	+ 8 ·1	6·2 to 11	337	May 15.
W Aquilae	19 11	7 ·2	8·2 to 13	489	July 24.
R Sagittarii	19 12	19 ·5	7·0 to 13	269	Aug. 16.
T Sagittae	19 18	+17 ·5	8·3 to 9·5	156·7	June 14.
AF Cygni	19 27	+46 ·0	7·0 to 8·0	94	May 11, Aug. 13
TY Cygni	19 30	+28 ·1	8·7 to 13	354	June 22.
RT Aquilae	19 34	+11 ·5	7·6 to 12	325	Sept. 4.
RT Cygni	19 41	+48 ·5	6·6 to 12	190·5	Mar 22.
TU Cygni	19 44	+48 ·8	8·5 to 14	225	July 21.
X Aquilae	19 47	+ 4 ·2	8·2 to 10	348	Aug. 18.
RU Aquilae	20 9	+12 ·7	7·9 to 14	276	Aug. 22.
R Sagittae	20 10	+16 ·5	8·5 to 10	70·6	July 20, Sep. 29.
AI Cygni	20 28	+32 ·2	8·6 to 9·7	173	Aug. 27.
V Cygni	20 38	+47 ·8	6·8 to 14	418	June 29.
T Aquarii	20 45	− 5 ·5	6·8 to 13	202·7	July 30.
R Vulpeculae...	21 1	+23 ·5	7·1 to 13	136·8	Aug. 30.
T Cephei	21 8	+68 ·2	5·2 to 11	387	Oct. 24.
SW Pegasi	21 18	+21 ·6	8·7 to ?	175	July 10.
YY Cygni	21 19	+42 ·0	8·5 to 9·5	378	Sep. 29.
S Cephei	21 36	+78 ·2	7·0 to 13	486	June 24.
V Pegasi	21 57	+ 5 ·7	7·8 to 14	303	Sep. 8.

β Lyrae minima Aug. $10^d\ 7^h m$, $23^d\ 4^h m$, Period $12^d\ 21{\cdot}8^h$.

Algol minima Aug. $8^d\ 4^h\ 51^m m$, $13^d\ 10^h\ 29^m e$, $31^d\ 3^h\ 22^m m$, Period $2^d\ 20{\cdot}8^h$.

SATURN is a morning star, coming into a better position for observation. Polar semi-diameter $8\frac{1}{2}''$. P. is $-4°\cdot7$; ring major axis $41\frac{1}{2}''$, minor $18\frac{1}{2}''$. The ring is very widely open. It is of interest to examine the exact amount of overlap beyond the planet's pole.

East Elongations of Tethys (every fourth given), 4^d $11^h\cdot7m$, 12^d $1^h\cdot0m$, 19^d $2^h\cdot3e$, $27^d 3^h\cdot6m$; Dione (ever third given), 5^d $2^h\cdot5m$, 13^d $7^h\cdot7m$, 21^d $0^h\cdot8e$, $29^d 6^h\cdot0e$; Rhea (every second given), $6^d 1^h\cdot7m$, $15^d 2^h\cdot8m$, 24^d $3^h\cdot8m$. For Titan and Iapetus E.W. mean East and West Elongations, I. Inferior (North) Conjunctions, S. Superior (South) ones. Titan, 2^d $5^h\cdot7e$ W., 6^d $5^h\cdot3e$ S.; 10^d $8^h\cdot9e$ E., 14^d $9^h\cdot4e$ I., 18^d $6^h\cdot0e$ W., 2^d $5^h\cdot6e$ S., 26^d $9^h\cdot1e$ E., 30^d $9^h\cdot1e$ I.; Iapetus, 20^d $8^h\cdot6e$ W.

URANUS was in opposition on July 29th. Semi-diameter, $1\frac{3}{4}''$. At end of August, 2° S.E. of ρ Capricorni.

NEPTUNE is too near the Sun for observation, having been in conjunction on July 19th.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 18^h to 22^h, next month 20^h to 0^h, and so on.

CORRESPONDENCE.

NOTE.—*We have received a communication from Dunford Bridge relating to Professor Thomson's note on reproductive harmony in the wild duck (see "Knowledge," Volume XXXVI, number 538, page 187), and one from "Old Planter," but as the writers have forgotten to attach their names, according to our rule, we are not able to print the letters.*

ASTRONOMICAL PHOTOGRAPHY.

To the Editors of "KNOWLEDGE."

SIRS,—Would you be so kind as to give me some hints about astronomical photography. I have an ordinary quarter-plate hand-camera, and a $2\frac{1}{4}''$ refracting telescope. I should be extremely grateful for any advice on the subject.

W. P. WILLIAMS.

ARLINGTON PARK COLLEGE,
CHISWICK.

In answer to the above letter, Mr. J. Milton Offord, F.R.M.S., has kindly sent the following note.

SIMPLE DIRECTIONS FOR PHOTOGRAPHY WITH A SMALL TELESCOPE.—Photography of the Sun may be taken with a very small telescope, using an enlarging lens in place of the eyepiece and a screen close over the plate. The exposures are so short that a fixed telescope will answer.

For the Moon use the fastest plates obtainable with an enlarging lens. Exposures of about one second at full aperture can be given and the amount of enlargement possible is dependent on the aperture of the telescope. Images about one-inch diameter with a two-inch telescope should show a good deal of detail.

Planetary photography is beyond the reach of a small telescope, except in the case of Venus, where the crescent form can be photographed with an enlarging lens.

For stellar photographs use the telescope as a guide to an ordinary camera firmly attached to it. With patience, good photographs may be taken by keeping a bright star in the centre of the field of the guiding telescope. This is best done by bisecting the out-of-focus image of the star with cross wires in the eyepiece. Even a simple pillar and claw stand may be used, but it is essential to balance well the telescope and secure a comfortable rest for the observer's head and arm.

The apparatus needed is quite simple: a light-tight tapering box, securely fastened to the outside of the eye end of the telescope leaving the rack tube free; a focusing glass, finely ground, with its centre rendered transparent by a microscopic cover glass being cemented to it with Canada balsam; a plate-holder as light as possible; a simple magnifying glass in a screw mount for focusing, and a dark card to cover the object-glass end of the telescope will be required. The enlarging lens is important; it takes the place of the ordinary eyepiece, and the best form is a triple-cemented lens on Steinheil's principle, as used for dissecting microscopes; cost about 10/-. This kind of lens passes a great deal of light and gives sharp images.

To take a photograph, say, of the moon: First obtain the actinic focus, if a refracting telescope, by trial. To do this mark the draw-tube roughly in fractions of an inch, say for half an inch, round the visual focus; then make a number of exposures at different focal lengths until the best result is obtained. When this is found, the focusing lens can be adjusted to view the moon through the central clear space in the ground glass, and with the telescope at best actinic focus, made to give good visual focus and fixed there, so that ever after when focusing with this lens it will be the true focus for photography.

Having obtained the focus, cover the object glass with the cap. Set the telescope in advance of the Moon and wait until the Moon's image will be central, having the plate open, and then expose by removing and replacing the card. It is best to have the card larger than the aperture and hold it in front for a while before exposing, to prevent shaking the telescope, quickly moving it to one side and back again to expose.

For developers Metol Hydrokinone or Paramidophenol are good. For plates, Imperial Flashlight or Lumiére Sigma answer well; they should, of course, be backed.

THE "FOURTH DIMENSION."

To the Editors of "KNOWLEDGE."

SIRS,—There is one statement in Mr. Redgrove's letter in the June number of "KNOWLEDGE" to which I ought to reply He says that he had "already intimated" that he did not intend to discuss the question further with me. This is not correct; what he said does not bear this meaning. However, I have no wish to continue the correspondence, and, since he does not wish to reply to my letter in the April number of "KNOWLEDGE," I am quite content that what is contained in that letter should remain the final statement of the issue between us.

JOHN JOHNSTON.

HENDON, N.W.

THE PLANET MARS.

To the Editors of "KNOWLEDGE."

SIRS,—A copy of your Journal for May, 1913, has been sent me, apparently to call my attention to, and perhaps secure my comment upon, an article denying the reality of the canals of Mars. Comment on the argument is unnecessary, but the statement on the first page, that Schiaparelli is responsible for the theory of their artificiality, should be corrected. The blame for the discovery rests wholly on me. His theory was that they were natural channels, though, with the magnanimity and open-mindedness of genius, he wrote to me before his death: "Votre théorie devient de plus en plus probable."

PERCIVAL LOWELL.

LOWELL OBSERVATORY,
FLAGSTAFF, A.T.

THE TRUE CAUSE OF SEA-SICKNESS.

By H. NORMAN BARNETT, F.R.C.S.

THE questions "To what is sea-sickness really due?" "Is there any cure?" have often presented themselves to the minds of the general public.

There is probably no ill which flesh is heir to that has a more constant interest, especially in these days of travel; for it presents itself to the week-ender crossing from Dover to Calais as well as the traveller to the Far East or West.

There is no minor ailment—minor so far as its pathology is concerned—which causes so much discomfort, none which gains so little sympathy from those unaffected by it, and has had such divergent prescribing with so little good result.

There are many theories of the cause of sea-sickness. I have had proof of the untrustworthiness of most of them. What is known as the "endolymph" theory is, however, scientifically accurate and supported by much practical evidence of its truth.

Having once found a cause which is a satisfactory explanation of the various phenomena of sea-sickness, its prevention and even cure become a comparatively simple matter; for we have in the bromides drugs which, when properly handled, are capable of good results in the treatment of this disorder.

The sickness which occurs when crossing the Channel or the Irish Sea, and vanishes when the boat reaches its destination, is vastly different from that arising in the Indian Ocean during the south-west monsoon, when for a week the ship is violently pitching, so that even seamen have difficulty in remaining in their bunks at night. Supposing a patient to be in delicate health, or suffering from some concomitant ailment, the results may be most serious.

I have met many cases where great prostration had to be faced; others where haemorrhage threatened a phthisical patient. Many patients who are often thoughtlessly ordered abroad for their relief or cure may be reduced to a very serious condition. I am glad to note a change in this respect, but many are still sent on long sea voyages who could be much better treated in a sanatorium at home.

Sad cases are often seen of those in the second and even third stages of phthisis who have been enabled to take the voyage with much financial difficulty, and have to make it as one of three or four in a small third-class cabin. Such patients, often unable to touch the food—good, but rather coarse—are particularly bad subjects should the ship encounter rough weather. They are usually violently ill, and have to remain in lower-deck cabins, with every porthole closed. The atmosphere of such a cabin teems with tubercle bacilli and other forms of germ life inimical to health. The result is that the unfortunate patient lands, if he survive, on some distant shore a piteous wreck, friendless, probably almost penniless, in every way worse than when he left England, having on the journey probably caused infection to more than one cabin-mate.

The only class of phthisical patient that should be allowed to go for a long voyage on a passenger ship is one in the first stage of the disease, who can afford to have an entire first- or second-class cabin, with plenty of air space, to himself. If bad weather be met with, fair ventilation can then be secured. This minimises the risk of sea-sickness for the patient, and danger to others is avoided. A sea voyage is very beneficial for those suffering from surgical tuberculosis so long as the cases are not too advanced.

I would designate *sickness at sea* as that which is produced in a person whose digestive organs are at fault in one way or another, and which is often confounded with true sea-sickness. I feel sure that all who give any thought to the matter will find an explanation in this of cases which are evidently not explicable on the theory to which I shall presently refer. They are, in fact, cases of severe sick headache which might occur anywhere.

The origin of sea-sickness is not so apparent as many seem to think. That the exciting cause is the motion produced by a ship on a rough sea is the indefinite reason assigned, but it should be remembered that there are many predisposing causes and circumstances that modify the exciting one.

Predisposing Causes may be divided into those connected with the stomach, those connected with liver, those connected with the nervous system, and those connected with the ship.

Those connected with the Stomach have had too great stress laid upon them. In the healthy individual symptoms referable to the stomach are secondary, being the result, not the cause, of the malady. In those who are suffering from gastric disturbance, either chronic or acute, or who go on board a ship with an overloaded organ, the condition will prove a predisposing cause to "sickness at sea," or even to the true ailment, by rendering them more liable to react when any abnormal condition of things is experienced, such as the motion of the ship if rough weather be encountered.

Those connected with the Liver we may dismiss with a word, since what has been said above of the stomach will apply equally to the liver. A sluggish liver—one which is not secreting actively—is a very bad companion for the sea-voyager, but it is not of so much importance as a predisposing cause as one might think from reading the advice given by some writers.

Those connected with the Nervous System are very important. Nervous fear or association of ideas will produce nausea without being on board a ship. I know of one lady who has made several voyages to India, on each occasion suffering much from sickness, who dare not venture to a dock or wharf, as on seeing the shipping violent nausea is produced. Apart from such remarkable effects as this, nervous anticipation of sickness or of danger from the sea is a potent predisposing cause. Again, persons who are generally neurasthenic, though without particular reference to the sea, are usually bad subjects; while with those who have had brain injury or are liable to epilepsy the sea will, as a rule, have an easy victory. So inconsequent a thing as a nervous headache is a predisposing cause of some importance. In fact, any condition of the nervous system which is not perfectly normal is liable to render the person under it a prey to *mal-de-mer*.

Those connected with the Ship. The ship itself is important, not only as an exciting, but also as a predisposing cause. A ship which is a bad sea boat, and takes heavy seas aboard, one in which the vibration is great, or which has a marked list, often induces sickness, when much worse weather with more actual motion on a better sea boat will not do so. This result is no doubt due to nervous influences at work, such as apprehension of danger from the noise of large quantities of water falling on the upper decks, and many other sounds which are more marked on a badly found ship than on a well-found one.

The Exciting Cause is mainly the motion of the craft on a rough sea. This motion is communicated through a special sense to the brain, and thence to the stomach as a secondarily affected organ. The exciting cause, however, is not quite so simple as it may appear at first sight. Thus we find that a pitching motion produces sickness much more quickly than a rolling one; that a person accustomed to the long, slow movements of a liner on great oceans may easily succumb to the short motion of a small ship in land-locked seas. It is found if one lies down on going aboard, or when a storm is blowing up, that sickness can often be averted; and also that if the weather becomes gradually worse passengers can generally stand it who would certainly be ill if they were subjected to a sudden storm or went straight from dry land to a boat on rough water.

It is, in my opinion, due to a complete misunderstanding of the true cause of sea-sickness that so few cases have been relieved and remedies of little or no value have been prescribed. Most people seem to have taken it for granted that, since vomiting and nausea are prominent symptoms, the disease is due to gastric disturbance. As well might it be said that vomiting in the case of a tumour of the brain is due directly to gastric trouble.

It will be well here to review the various theories put forward before taking up that which I consider to be the true cause.

There can be no doubt that symptoms of gastric disturbance are the most prominent, and, to the casual observer, or the scientific one who has not seen a great deal of this complaint, they appear to be the only ones. Those—and they are many—who hold that such symptoms are primary maintain that the motion produced by the ship creates a disturbance of the stomach and its contents, which sets up a feeling of nausea, followed in due course by vomiting. It is not clear why a particular movement should affect the mucous membrane of the stomach in this way, or why the motion of pitching should have a greater effect than that of rolling. Much confusion would be avoided if it were remembered by those who advance this theory that there are many persons whose digestive organs are weak or easily affected by any unusual condition. In these cases, no doubt, *sickness at sea* is set up, and stomachic medicines do good. To arrive at the truth the exceptional must be eliminated and the average insisted on; otherwise cases could be found to bear out apparently any, even the most extravagant, theory.

The theory that while the gastric disturbance is the primary one the brain has something to do with the origin of the sickness, but rather as a predisposing than exciting element, is held by some.

Some hold that in a sluggish liver, which reacts on the stomach, we have the true and only cause which is responsible for sea-sickness. Such a view leaves inexplicable many of the symptoms associated with the condition.

The theory of imagination is advanced to show that the primary nausea and the secondary vomiting are figments of a diseased imagination, and if persons so afflicted went on board ship determined not to be sick they would probably not suffer. This savours rather too strongly of Christian Science to be worthy of consideration.

Zing is of opinion that sea-sickness is due to a high degree of cerebral anaemia, induced by the pitching of the ship, caused by some obscure action of the vasomotor centres comparable to the mode of action of the emotions. It is doubtful if the brain is anaemic during sea-sickness; the good effects of the bromides point to the reverse. He also holds that the stomach is not directly concerned in the act of vomiting, which he considers Nature's method of replenishing the depleted cerebral circulation. The vasomotor centres are certainly disturbed, as evidenced by the flushing and subsequent chilliness experienced in sea-sickness. The disturbance I believe to be due to the emotion of fear, since this and profound depression are symptoms of the disorder. Such disturbances are but symptoms, and by no means account for all phenomena of the condition.

There are some who hold that it is through the sense of sight that sea-sickness is produced, the sight of the waves, the motion of the ship's masts, and other objects seen at sea being conveyed through the optic nerve to the brain. The effect of atropine on some cases is pointed out as confirmatory evidence of this theory

In considering the action of the sea upon special senses, and through them upon the brain, we are coming into the region of scientific reasoning and leaving that of empiricism. It is, however, to another special sense we must look for a true explanation. There are some cases in which the sense of sight plays an important part; but there are great difficulties in the way of accepting disturbance of this sense as the cause in all cases, or, indeed, as the true cause in any, the effect of atropine notwithstanding. The cases benefited by this drug are those in which physical fear is a prominent feature. The temporary impairment of sight by atropine—a bandage would have the same effect—calms the nervous system by preventing the patient *seeing* the motion of the water and the ship.

Thus it is a well-known fact, and one in my own experience, that a traveller will be made ill by observing the motion of a passing ship, who does not become so by feeling that of the one on which he is travelling. Nor does the optic nerve theory explain the cases, with which all are familiar, where the patient, having been asleep in fine weather, or when the ship is in dock, wakes up violently sick when the motion of a rough sea ensues.

It is to the organ which is closely allied to the sense of hearing, which has to do with equilibrium and the indication of the perpendicular position, that we must turn for a satisfactory explanation of the many phenomena of sea-sickness.

It will be well, before proceeding to indicate the way in which the effects are produced, to review briefly the anatomy and physiology of the part.

The internal ear is divided into the cochlea (or special organ of hearing), the vestibule, and the semicircular canals. It is the last that claim our attention. These canals are hollowed out of the petrous portion of the temporal bone: they are three in number, each one being placed at right angles to the other two. Each osseous canal contains a membraneous one, the lining epithelium of which secretes a fluid called *endolymph*.

The auditory nerve divides into two at the bottom of the internal auditory meatus: the anterior branch goes to the cochlea and special organ of hearing; the posterior is distributed to the semicircular canals. We have between this nerve and the vagus nerve a distinct connection by means of the facial nerve, along which impulses can be conveyed to the stomach from the semicircular canals.

In so far as the vomiting of sea-sickness is a reflex act it is possible that the sympathetic nerve has also something to do with the causation of sickness, when the terminal branches of the posterior division of the auditory nerve are irritated.

The anatomical direction of the canals themselves should be remembered—*i.e.*, two vertical and one horizontal.

The semicircular canals have two functions: (1) that directly connected with hearing, by collecting in their fluid contents sonorous undulations from the bones of the cranium; (2) that indirectly connected with the sense of hearing, by informing us as to our equilibrium, by means of the constant alterations in pressure of the fluid within the canals.

This is closely associated with coördination of muscular movements. It has been found that when the horizontal canal is divided in a pigeon a constant movement of the head from side to side occurs. When one of the vertical canals is divided, up-and-down movements are produced. These movements are associated with loss of coördination, as after the experiment the bird is unable to fly in a proper manner.

Having regard to these anatomical and physiological facts, and in view of the proofs derived from observation of the signs and symptoms of sea-sickness, there can be little doubt—

That the true cause of sea-sickness is irritation of the terminal fibres of the auditory nerve distributed to the membranous labyrinth;

That the irritation is conveyed, through the nerve connections mentioned above, to the vagus, and possibly to the sympathetic, and thence to the walls of the stomach;

That it is primarily an irritation of cranial nerves;

That this irritation is caused by the motion of a ship on rough water, but not by this alone. Any motion which is contrary to that usually experienced by the fluid contained in the semicircular canals will cause a set of symptoms exactly similar to those of sea-sickness.

Our semicircular canals constitute a sort of human spirit-level. It is not difficult to conceive that any motion which will more or less violently throw the fluid against its containing walls, richly supplied with delicate nerve-endings in direct communication with brain and stomach, will produce symptoms referable first to our equilibrium, then to the cerebrum, and finally to the stomach. This is what occurs in sea-sickness.

In searching for the true pathological cause of any condition it is a usual and proper rule to find out under what varying conditions similar symptoms are produced. Such a survey has not been accorded to sea-sickness. It was concluded that the person affected was suffering from a sort of bilious attack, produced by the unusual motion, combined, perhaps, with the smell of oil, and so on, on a steamboat. Such a lax way of viewing causation would have been condemned in any other disease, but a good-humoured laugh at the sufferer, combined with advice as to diet and the ordering of a couple of pills, has more or less satisfied a large proportion of the profession, if not the public. It is strange that this should be so, as the symptoms of an ordinary bilious attack are not at all similar to those of well-marked and true sea-sickness. Let us therefore try to find if similar symptoms are produced under other circumstances.

If the body be rotated rapidly, and an attempt be then made to walk, it will be found that staggering has been produced, clearly proving that coördination has been interfered with. This is owing to the endolymph having been subjected to unusual movement. Nor, if rotation be continued, is incoördination the only symptom: headache, giddiness, slight double-sight, rapid pulse, flushing followed by chilliness, and distinct nausea will in turn be experienced—these being produced by the irritated endings of the auditory nerve conveying sensation to brain and stomach. If we compare the above set of symptoms with those of sea-sickness a marked similarity is at once seen.

It is a well-known fact that some children are unable to use a swing owing to nausea, giddiness and headache being caused, while other children and many adults suffer in a minor degree. Here, again, the endolymph is subjected to an unusual motion as compared to that caused by our ordinary movements.

There are also those who experience when on a switchback railway or a water-chute one or more of the above symptoms, undoubtedly due to a similar cause.

The high dive and violent horseback exercise have been known to produce in those unused to such sports disagreeable effects of a nature akin to those of *mal-de-mer*.

In my own personal experience, and that of most other sufferers, it is the pitching motion that produces the most severe form of sea-sickness. In a rolling ship the nausea and vomiting are much less and of shorter duration. Have we in this fact any proof of the endolymph theory? Undoubtedly; since it is the fluid in the vertical canals that is affected in pitching, and, as they are two to one, we naturally suspect double the effect. In rolling, on the contrary, the fluid in two canals is practically at rest, only one—the horizontal—having its fluid level and pressure on its walls much changed.

The proportion of those who do not overcome sea-sickness, if long on board ship at one time, is small; usually, after a more or less prolonged apprenticeship, the nerve filaments become accustomed to the motion. If, however, the ocean be exchanged for the sea or channel, where the waves are short, and the liner of twelve thousand or more tons replaced by the boat of eight hundred tons, sickness in many cases will return, even in the case of old seamen.

Such a fact cannot, I think, be explained on any other hypothesis of the causation of the malady than the endolymph theory; accept that, and the explanation is easy. The fluid, which has become accustomed to one motion, is subjected to another of a different character, and the new one produces its effect. Should the circumstances be reversed and the large ship substituted for the small one, sickness will not, as a rule, be produced; since the motion of the former is better borne, the endolymph being more agitated by short seas on a small boat. A person who suffers under these conditions is not necessarily a bad ocean traveller.

Sea-sickness produced during sleep is a stumbling-block to those who believe that the optic nerve is the medium for sensation producing sickness, and is difficult to explain by any process of reasoning but the one. The endolymph is, of course, influenced by motion whether the person is awake or asleep; the effect, however, is considerably lessened by the recumbent position. Hence it is a wise precaution, advocated by many who do not grasp the true reason, for a person liable to *mal-de-mer* to lie down when starting on a short passage. Such advice is obviously not of much use to those starting on a long sea voyage, with continued bad weather, unless supplemented by treatment.

Some persons after a short voyage, on which they have experienced bad weather, continue to feel the motion after landing. This is a very direct proof of the origin of the sensations felt on board ship, the explanation being that the fluid in the canals has accustomed the nerves to the feeling of the motion, which they do not lose for some time.

It is found that, however ill a person may be, the moment the ship runs into perfectly calm water all symptoms vanish, except perhaps the sensation just referred to. Such would not be the case were the stomach seriously at fault, but is explained by the action of our "spirit-level."

It is a curious fact that, in these days of scientific accuracy, the bromides are sometimes prescribed by those who speak and write of sea-sickness being of gastric or hepatic origin. I can see only one legitimate reason for prescribing bromides—namely, belief in the nervous origin of the ailment—and I would point out, as a further proof of the pathology advanced above, the very direct effect they have in subduing symptoms.

I am not aware that such weight of practical and scientific proof can be brought forward in support of any other theory of the pathology of sea-sickness. The endolymph causation, indeed, can hardly be regarded as theory; the evidence of its being the true cause is, short of ocular demonstration, to my mind complete. Gastric symptoms are certainly prominent, but not more so than in many conditions where they are admittedly secondary. The symptoms referable to the semicircular canals and the brain are so evident that there is no mistaking them, though, to a great extent, they have been ignored in the past.

THE SUBLIMINAL SELF.

By J. ARTHUR HILL.

I.

THERE has probably always been a suspicion, among thinkers, that we are greater than we seem to be. For one thing, the idea flatters our natural vanity—or, to put it more mercifully, our hopes and longings and aspirations—and is a hospitable refuge, giving ampler air and spaciousness in times of suffering, due to our limitations. It is expressed in many forms and places. In the Bible, mortals are referred to as "gods" (Psalm lxxxii, John x); in Christian theology the Divine and human natures are united, not in one unique instance, but in all (*e.g.*, Dante, near the end of the "Paradise" and elsewhere); in Plato's "Republic" the human soul descends from supernal realms, drinks of Lethe, and forgets its previous experience (limits itself, puts off its greatness, takes on the form of a servant); and this *kenosis* is closely paralleled in some of the teachings of Hinduism. The standard modern expression of the idea is that of Wordsworth in the "Ode":—

> Our birth is but a sleep and a forgetting!
> The Soul that rises with us, our life's Star,
> Hath had elsewhere its setting,
> And cometh from afar:
> Not in entire forgetfulness
> And not in utter nakedness,
> But trailing clouds of glory do we come
> From God, who is our home.

And elsewhere, in a sonnet, he finishes with the often-quoted line: "We feel that we are greater than we know."

Until recently these ideas were left to the domain of the speculative philosopher, or poet, or prophet. But within the last quarter of a century or so they have more and more claimed the attention of the scientific man, and they have more and more obtained the support of actual, scientifically observed facts.

II.

If there is something mental or psychical in us beyond the bounds of our own minds or souls as we know them in self-consciousness, how are we to discover this something; how become aware of it? The answer cites various classes of fact, and the inferences to be drawn from them.

(1) *Subliminal Sensation.*—One small fly walking over the back of my hand arouses no sensation. It is not felt. But if there were six flies instead of one I should feel them. Thus, six times nothing produces something; or, to put it the other way, a given amount of sensation is produced by a certain stimulus, but when the latter is decreased by five-sixths the remaining sensation is not one-sixth of the original sensation, but, on the contrary, is *nil.* In other words, there is a "threshold"; below this threshold of intensity a stimulus produces no conscious sensation; but we suppose that it produces a subconscious or subliminal one. Something in us perceives the one fly, even if the normal mind does not. This is borne out by various experiments in hypnosis, whereby the subliminal can be put—as Professor James used to say—"on tap." Consciousness is like a spectrum-band. There are sensations which we do not normally become aware of, as there are rays of light which we cannot see.

(2) *Subliminal Intellection.*—For this the evidence is ample. There is no doubt whatever that something in us thinks, reasons and calculates without the normal consciousness knowing anything about it. The most striking experiments on this point are those of Dr. J. Milne Bramwell, who ordered hypnotised patients to carry out some action after their arousal from the trance—as, for example, to make a cross on a piece of paper at the end of a specified period of time, reckoning from the moment of waking. In the normal, waking state, the patient knew nothing of the order; but a subliminal mental stratum knew, and watched the time, making the patient carry out the order when it fell due. The period varied from a few minutes to several months. For instance, Dr. Bramwell would say to the hypnotised patient: "You will feel impelled to make a cross on a piece of paper, and will do so, putting down the time also. This is to take place at the expiration of 24 hours and 2,880 minutes." This is one of the actual cases: the order was given at 3.45 p.m. on Saturday, December 18th, and it was carried out correctly at 3.45 p.m., December 21st. In other experiments the periods given were 4,417, 8,650, 8,680, 8,700, 11,470, 10,070 minutes. All were carried out correctly. In the waking state the patient was quite incapable—as most of us would be—of calculating mentally when these times would elapse. But the hypnotic stratum could do it, and could ensure that the order should be carried out at the exact moment of falling due. In one instance the time happened to expire during the night. The patient made the cross on paper at her bedside at the correct time, apparently without waking, for she had no recollection of having done it.*

We may say, then, that not only is there some subliminal part of our minds that can calculate, but also that this something can calculate better than the ordinary waking consciousness.

The same conclusion is arrived at by consideration of the performances of "arithmetical prodigies." It

* *Proceedings, Society for Psychical Research,* XII., p. 185.

is often found that these curiously endowed people can solve in a few seconds—and sometimes almost instantaneously — problems which would utterly baffle most ordinarily educated people, and which would take an average arithmetician a quarter of an hour's rapid work with pencil and paper. Yet these prodigies—who, by the way, are often, like Dase, Buxton and Mondeux, of very low mental power so far as their normal faculties are concerned—are entirely unable to tell how they do it. They do not consciously work the sum out. They let it sink into their minds and then wait for the answer to be shot up. It is like putting the plum-pudding into the geyser to be boiled; or like putting the pig into the Chicago machine. It goes in pig and comes out sausages. The intermediate processes are hidden from us. The calculation is made subliminally — below the threshold of ordinary consciousness.

Subliminal Memory. — The results of hypnotic experiment and of the study of pathological cases of split personality (such as Dr. Morton Prince's Miss Beauchamp) are sufficient to prove beyond question that the subliminal memory is wider than the normal one. Many things which we "forget" seem to slip down below the threshold, thus becoming lost to ordinary consciousness, but remaining accessible by hypnotic methods. Or it sometimes happens that they are recovered in sleep, when the conscious self is in abeyance, and the other strata of the mind come to the top. Or they turn up in automatic writing with planchette or a pencil. In a recent striking case, reported to the Society for Psychical Research, an automatic writer had communications from a "spirit," who called herself Blanche Poynings, and gave a great deal of historical detail which the automatist did not consciously know. But it was afterwards found that Blanche Poynings was a character in a novel which the automatist had had read to her many years before, and the novel contained all the historical details given. All this had been "forgotten." It had slipped down below the threshold. But the subliminal strata still retained it and could produce it (in the usual mystifying spirit style) when tapped by a borehole, sunk, so to speak, through the upper level of consciousness, by means of automatic writing.

Subliminal Emotion.—This is a reality also, though perhaps less provable. An interesting example of the necessary evidence occurred in Mrs. Verrall's experience with automatic writing some time ago. [Mrs. Verrall is a classical lecturer at Cambridge; translator of "Pausanias"; widow of Dr. A. W. Verrall, late King Edward Seventh Professor of English Literature.] This automatist, without experiencing conscious emotion, found the tears running down her face when she roused herself from a semi-conscious state in which she had been writing automatically. The script, on examination, turned out to contain references to two friends who had died under tragic circumstances; but Mrs. Verrall was quite unaware of the contents of the script until she had read it. Evidently some part of the mind was not only thinking and remembering and making the fingers write without conscious direction, but was also feeling and suffering, and making the eyes overflow without the conscious mind knowing why. (*Proceedings S.P.R.*, XX., p. 15.)

Subliminal Creation.—This is the best proved of all, for most of us prove it for ourselves every night. In dreams every one of us becomes novelist or dramatist, inventing situations—usually absurd to the waking mind—which are absolutely novel in our experience. And, to step at once to the higher plane, it can be said, without fear of contradiction, that all works of genius, all creations, are uprushes from subliminal depths. They are not produced by taking thought. The process is felt to be quite different from that of the faculty which thinks and reasons consciously. It is more a waiting than a working. "All is as if *given*," said Goethe. (*Alles ist als wie geschenkt.*) The inspiration comes from below the threshold. Many great writers amply bear out Goethe's dictum. Ibsen wrote "Brand" in three weeks in a state of feverish exaltation, scrambling out of bed to write down, half asleep, the lines which rose tumultuously to the surface of his mind. Charlotte Brontë could write freely on some days, while at other times the story hung fire for weeks at a time, refusing to unroll itself; then a volcanic burst, and she would write furiously until she was ill with the strain. In her preface to Emily's "Wuthering Heights," discussing the rightness of creating such characters as Heathcliff, she states the case in unsurpassed language:—

"But this I know; the writer who possesses the creative gift owns something of which he is not always master—something that, at times, strangely wills and works for itself. He may lay down rules and devise principles, and to rules and principles it will perhaps for years lie in subjection; and then, haply without any warning of revolt, there comes a time when it will no longer consent to 'harrow the valleys, or be bound with a band in the furrow'—when it 'laughs at the multitude of the city, and regards not the crying of the driver'—when, refusing absolutely to make ropes out of sea-sand any longer, it sets to work on statue-hewing, and you have a Pluto or a Jove, a Tisiphone or a Psyche, a Mermaid or a Madonna, as Fate or Inspiration direct. Be the work grim or glorious, dread or divine, you have little choice left but quiescent adoption. As for you—the nominal artist—your share in it has been to work passively under dictates you neither delivered nor could question—that would not be uttered at your prayer, nor suppressed nor changed at your caprice. If the result be attractive, the World will praise you, who little deserve praise; if it be repulsive, the same World will blame you, who almost as little deserve blame."

This would be endorsed by Scott, who dictated "The Bride of Lammermoor" while ill and in an abnormal mental state, and found a great part of the story quite new to him when he read it in the book. Also by Stevenson, who tells us that he wrote fifteen chapters of "Treasure Island" in fifteen days, then stuck completely; "my mouth was empty; there was not one word of 'Treasure Island' in my bosom"; but again the tide rose, "and behold! it flowed from me like small talk," and he finished it at the rate of a chapter a day. It is interesting to remember, in this connection, that Stevenson used to *dream* most of his plots, as he describes in "Across the Plains."

Similar statements of experience could be culled from other fields of creative art. Perhaps it is even more marked in music than in literature Mozart, for example, had a vivid perception of the extraneous nature of the afflatus—extraneous, that is, to the conscious mind; and, among painters, Watteau frankly and quaintly avows himself puzzled at the "queer trick he possesses," evidently not knowing in the least how he did it. Indeed, no genius *does* know "how he does it." If he knew, he could teach others to do it also. No, it is not the knowing part of the mind that is the agent, nor is it any part that the consciousness can understand. The power lies deep buried in the subliminal levels. It is only its results—its exfoliations—that we see.

It is established, then, that there can be mental or psychic activity of many kinds—sensational, intellectual, reminiscent, emotional, creative—over and above anything that the conscious mind is aware of. Science has proved that we are greater than we knew. The hinter horizons of the mind have receded and fled away. New vistas open out in metaphysical psychology. The soul is become immense, immeasurable. We are suddenly transplanted from a cellar dwelling to the illimitable prairie. Not only do we not know what we shall be, but we do not even know what we are. Like Malvolio, therefore, we may again "think nobly of the soul." The Psalmist, quoted approvingly by Jesus, said: "Ye are gods." A blinding and stunning thought! But, whether we go so far as that or not—and, after all, it is not a very great thing to say, for we are certainly more wonderful creatures than many of the Greek and Norse gods—we can at least subscribe to that profoundly wise and suggestive triplet of Emerson's, who in so many of these things had a curiously prophetic instinct:—

> Draw, if thou canst, the mystic line,
> Severing rightly his from thine,
> Which is human, which divine.

III.

The late Professor William James used to say that he thought the most fundamental problem in philosophy was that of the One and the Many. How can a Universe which is Whole and One, containing everything that is, both material and immaterial—how can this One Thing be at the same time Many? And if we start with the manyness, this and that tree and house and mountain and country, this and that microbe, blade of grass, butterfly, how are we ever going to visualise them as one, when they are so incontestably disparate? The problem is at present insoluble. We can begin at either end, but there is no meeting-place in the middle. One remains One, and Many remains Many.

But in the region of mind or soul the modern doctrine of the subliminal self—which, first propounded by Myers twenty-five years ago, was afterwards hailed by James as the greatest modern advance in psychology, and which is continually being buttressed by new facts—is at least pointing to a kind of solution to this problem. Human minds are many, it is true; but they are closely alike, and in all biological science it is found that close similarity points to a common source. In some sort, then, it is to be surmised that all human minds descend from a common source. But the phenomena of psychical research—telepathy, to name only one—indicate that there is absolute *connection* between the minds here and now existing, in ways over and beyond those accounted for by the known senses. And there is reason to believe, though the evidence is too complex to specify here, that in telepathy and allied phenomena it is the subliminal part of the mind that is active. These and other considerations point to the supposition that though our ordinary normal consciousnesses are severed from each other, and apparently distinct, so that we have to communicate with each other by the clumsy means of speech and writing, we are nevertheless all in connection with each other in the subliminal levels. To vary the metaphor, each of us is like a stream of water issuing from one of the thousands of taps in a city, but the water is the same, coming from the same reservoir. The same soul thinks in all of us. The One *is* the Many.

It may be said that this conclusion is a speculative and abstract proposition. On the contrary, it is extremely practical; for it has close connection with human action. Remember how we feel about our brothers and sisters; how we stand shoulder to shoulder with them, feeling that the interest of the family is a common interest, for which each individual is bound to fight. Remember also how, broadly speaking, the individual's welfare is bound up with that of the family, and what is good for it, is also good for its component units. And now think what would happen if all men, or even all civilised and educated men, could regard humanity at large as one huge family, one in interest and, further, one in reality and essence, being joined together in that subliminal region, the individual separation of the conscious minds being illusion, due to ignorance of our real nature. Would not a revolution be effected? I am sure it would. And, sooner or later, it will. The religious doctrine of the brotherhood of man was a noble moral inspiration but its appeal was to the affective side, and it was consequently inoperative against the coldly intellectual. But it is now supported by science. Knowledge now goes hand in hand with faith and love. A new dawn begins to send up its shafts of light in the East. A new era is at hand.

According to present conventions, it is bad form to be in earnest about anything; the proper thing is to cultivate a manner of light banter which shall give an impression of cleverness and wit. The popularity of the fashion is very comprehensible; for there are always plenty of people who wish to seem clever but are not. And the trick of it is easily acquired. Be cynical and flippant about everything, and you will get the credit of having seen through the illusions of the world, and of being a deeply wise man who conceals his wisdom. But it is a pose and an affectation. There is really no disgrace about being serious, at least occasionally, nor in being honest, even almost habitually! If I seem too solemn or too enthusiastic in my vision of the future when the unity of mankind shall be more fully realised, I appeal from the decadent trifler of to-day to the vigorous thinker of to-morrow—from Philip drunk with sophistication and selfishness to Philip sober with clear eyes and better ideals. Better times are coming. We are beginning to see that we are not a "concourse of warring atoms," but a vast multitude of units which fit together and make up an organism; and that what is good or bad for the organism is good or bad for the units. Solidarity and homogeneousness are the watchwords. Individualism has been over-accentuated. We must see humanity steadily, and see it whole—a whole, however, within a still larger Whole of the entire Cosmos.

SOLAR DISTURBANCES DURING MAY, 1913.

By FRANK C. DENNETT.

MAY has been remarkable for the small amount of disturbance upon the Sun. The disc has been examined every day, but on twelve occasions (1, 3, 6, 8, 12, 13, 19, 20, 22, 23, 29, and 31) it has appeared to be quite free from disturbance, bright or dark. Short-lived pores were noted on three (11, 16, and 25), and faculae on the remaining sixteen. The longitude of the central meridian at noon on May 1st was 224° 27′.

On May 1st and 2nd the granulation of the photosphere was noted as being very fine all over the disc. On the 11th there appeared to be very many minute pores in the central portion of the disc and in northern latitudes. One showed as a small irregular umbra near the central meridian (94°) with large faculic flecks about it.

On the 16th, in the afternoon, pores showed in high latitudes both north and south, well to the west of the central meridian, which was 24°.

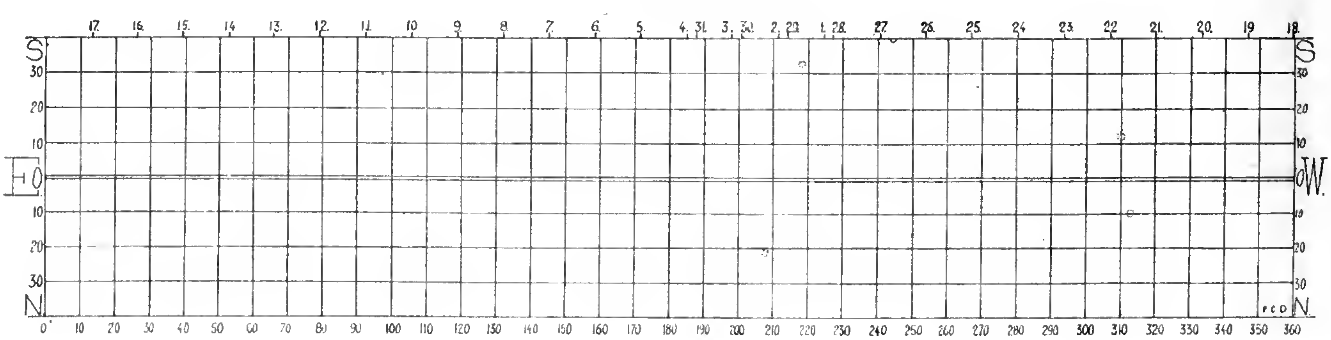
On the 25th, at 5.15 p.m., in high latitude south-east, about six days on the disc a small pore showed in a rough-looking area, nearing the central meridian, which was 264° 13′. Unfortunately no measures were made in either of these cases.

The faculic display was also of a most meagre description. On the 4th and 5th a faculic cloud was measured at longitude 244°, south latitude 40°. On the 14th and 15th a small bright facula was situated at 339°, 68° South; on the 16th and 17th a small facula at 312°, 10° North, and on the 17th, a paler one at 310°, 12° South; on the 24th a pale one at 218°, 33° South, and another at 208°, 21° North. Perhaps the most interesting one was a brilliant granule, less than 7° from the South Pole, seen on the 26th, 27th, 30th, and June 4th.

Other faculae were seen, but not measured, near the western limb on the 21st and 28th; south-western on the 7th, 10th, 17th, 18th, and 30th; south-eastern on the 10th, 14th, 15th, 17th, and 25th; and north-eastern on the 2nd, 9th, and 10th.

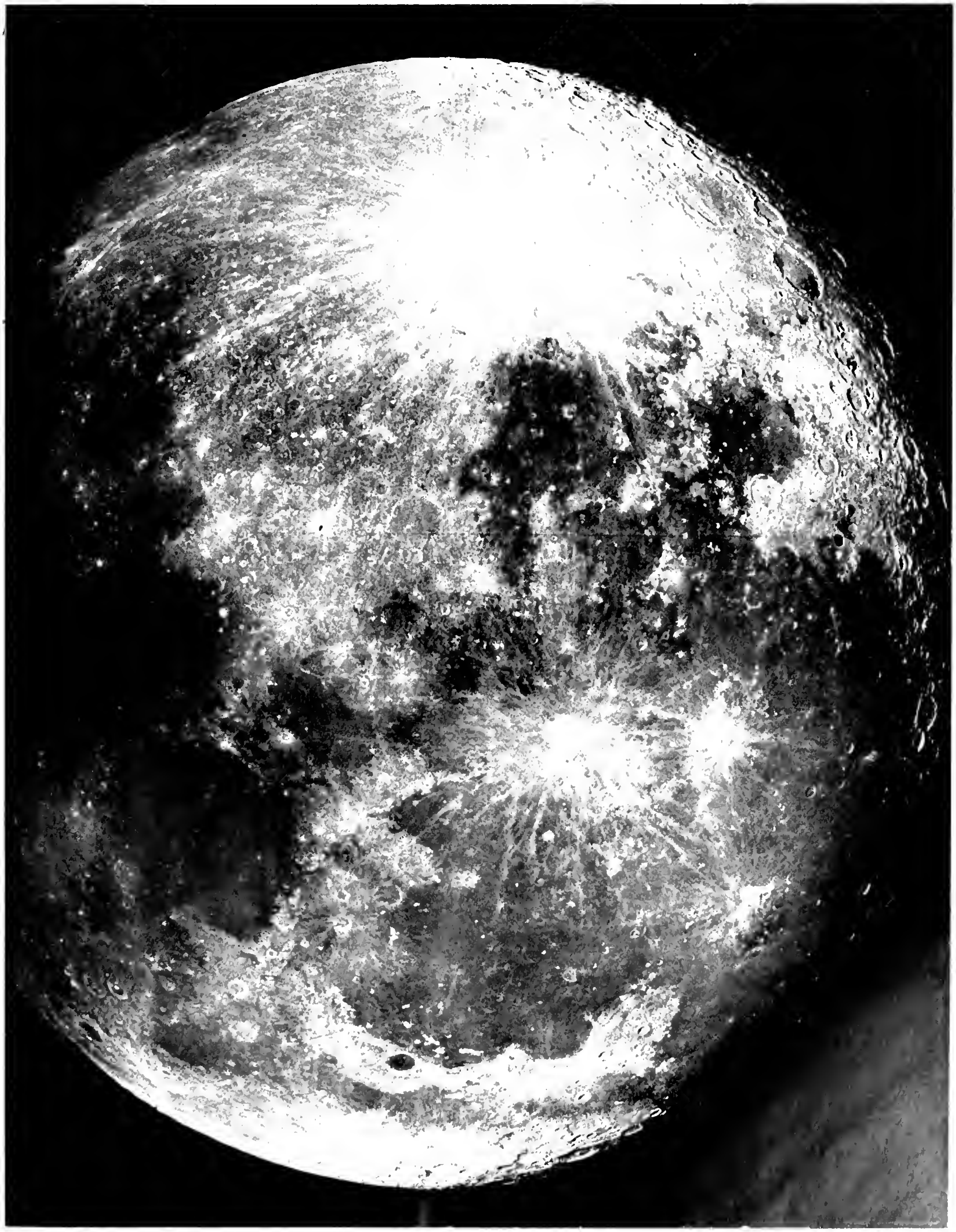
The Chart was constructed from the observations of Messrs. John McHarg, A. A. Buss, C. Frooms, E. E. Peacock, and the writer.

DAY OF MAY, 1913.



THE MOON.

THE plate of the Moon given in Figure 267, on page 261, shows much fine detail, particularly in the Maria Imbrium, Nubium and Crisium; Tycho, Copernicus, Kepler and Aristarchus are very well defined. From the sketch-maps published in "KNOWLEDGE" during 1909 all the points to be seen in this plate may be identified. The image is shown as it would appear in an inverting telescope. The photograph was taken at Paris on November 13th, 1902, at 2.57 a.m., with the Equatorial Coudé. The aperture was 23·62-ins., the focal length 59′ 6″·6, and the exposure 0·6 of a second.



From a photograph P.

FIGURE 267. The Moon. Age thirteen days five and a half hours.

FIGURE 268.
Photographed from Store Korsnes.

FIGURE 269.
Photographed from Bossekop.

Aurora Band across the Great Bear, March 29th, 1913, 10^h 15^m.

From a photograph *by E. E. Barnard.*

FIGURE 270. Nebula ρ Ophiuchi.

Taken at the Mount Wilson Observatory April 5th, 1905, with an exposure of 4^h 30^m.
Position of the Nebula R.A. 16^h 20^m. Declination $-23°$.

ON AN AURORAL EXPEDITION TO BOSSEKOP IN THE SPRING OF 1913.

By PROFESSOR CARL STÖRMER,

(*University of Christiania*).

THE following is a short account of a new auroral expedition which I made to Bossekop in the spring of 1913 for the purpose of completing the results of my expedition to the same place in 1910.*

My assistant was the meteorologist, Bernt Johannes Birkeland, who also went with me in 1910, and is going with Roald Amundsen's expedition over the North Polar basin.

The purpose of the expedition was mainly to obtain more accurate and a greater number of auroral photographs for the determination of the form of aurora and its height and situation in space, and, further, to experiment with prism-objective photographing and the taking of cinematograph films.

Our preparations and equipment were, on the whole, the same as in 1910; but the following improvements, based upon experience gained on that expedition, were carried out.

The cameras were furnished with an arrangement whereby a photograph of an illuminated watch-face was taken on the plate simultaneously with the aurora. The time could then be read from the photograph, and also the exposure by the sector described by the second hand. This improvement I had already employed in photographing aurora in Christiania in the winter of 1910–11.

In order to avoid the waste of time in changing plates in a dark room, each station, in addition to forty cassettes, was furnished with changing boxes in which the plates could be changed in the open air. Thanks to this improvement, it was possible on some evenings to take more than eighty simultaneous photographs at the two stations.

In order to have the arms at liberty the following improvement in the telephone arrangement was made. The microphone and receiver were fixed to the chest and head and connected with the field telephone apparatus by a cord four metres in length. In this way it became possible to utilise more fully the brief moments during which the aurora displayed its greatest intensity.

For the purpose of obtaining reliable parallaxes a base of twenty-seven and a half kilometres was chosen, as against four and a half kilometres in 1910. The station at which Birkeland took up his quarters was Store Korsnes, the other was Bossekop. As assistant at Bossekop I had engaged Sergeant Ottem. The direction from Bossekop to Korsnes was almost due north.

Through the courtesy of the Telegraph Department the State telephone line from Bossekop to Korsnes was placed at our disposal every night from 7.30 p.m.

Thanks to these arrangements, we succeeded in one month in taking the following pairs of simultaneous auroral photographs at Bossekop and Korsnes :—

Day.	Number of Pairs taken.	Of these Successful.
Feb. 28...	14	0
Mar. 3...	38	19
,, 4...	23	9
,, 6...	7	1
,, 11...	86	58
,, 14...	81	54
,, 15...	81	72
,, 16...	8	2
,, 17...	14	7
,, 18...	5	5
,, 21...	23	20
,, 22...	20	12
,, 23...	1	1
,, 24...	6	6
,, 28...	5	3
,, 29...	83	64
,, 30...	71	62
April 1...	70	52
Total	636	447

On the six best evenings, the 11th, 14th, 15th, 29th, and 30th March and 1st April, the weather was clear and the aurora vivid and continuous, so that we were able to make use of every chance.

The parallaxes, thanks to the large base, were very distinct, as a rule between five and fifteen degrees, and the large number of photographs—four hundred and forty-seven pairs as against forty-four in 1910—gives very much more certain and complete results than on that occasion. If we reckon about ten measurements to each photograph, these will give more than four thousand reliable determinations of height. All important forms of aurora were photographed, and there are long series of developments.

*See *Bericht über eine Expedition nach Bossekop zwecks photographische Aufnahmen und Höhenmessungen von Nordlichtern*, mit 57 Figuren im Text und 88 Tafeln. Videnskabsselskabets Skrifter, Math-Naturv. Klasse 1911, No. 17, Christiania.

A pair of the photographs are reproduced in Figures 268 and 269 enlarged about two and a quarter times, one degree answering to two millimetres in the photographs. The time is Central European time and reckoned from 0^h to 24^h, 0^h answering to 12 noon.

With a prism-objective we succeeded in taking some photographs simultaneously with the auroral photographs, on which are seen stellar spectra and some views of the aurora lying side by side, answering to various spectral lines. The prism had an angle of 60°† and was placed in front of the kinostigmatic objective, on the principle already mentioned in my "Bericht." A systematic employment of this method will be of great importance to the study of the highest strata of the atmosphere.

Most of the cinematograph attempts were failures, as the film (Lumière) was not as a rule affected by an exposure of less than two seconds. It was only with very intense aurora that we succeeded in getting good photographs with an exposure of about one second and with about two seconds' interval between the photographs. Two or three such series were taken, thus proving the utility of the cinematograph both for taking photographs and for registering rapid changes.

The working-up of the matter collected during the expedition will be the subject of a subsequent detailed account.

† With regard to the kind of glass that would be best for the purpose, I received valuable information from Dr. Slipher when visiting the Flagstaff Observatory in the summer of 1912.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

PROLONGED OBSERVATIONS OF TEMPORARY STARS.—Professor Barnard has put the Yerkes 40-inch refractor to a very useful piece of work in following the temporary stars of recent years long after they have become invisible to ordinary telescopes. He notes that in at least two cases—T Coronae of 1866 and Nova Geminorum (2) of 1912—the Nova was identical with a previously seen or photographed star. His study was made partly in the hope that he might find some peculiarity in the aspect of faded Novae. In this he was disappointed: a few of them show longer focus than ordinary stars, and the more recent ones show slight variability, but otherwise they are indistinguishable from ordinary stars. T Coronae was a B.D. star of magnitude 9·5 before the outburst, and is now at practically the same magnitude and apparently colourless.

Nova Cygni of 1876 is now of magnitude 15, perhaps slightly variable: its appearance is hazy and the focus longer than usual. In these respects it resembles Nova Aurigae of 1891, which is a magnitude brighter, and Nova Sagittarii of 1898, which is of magnitude 15.

Nova Persei of 1901 is now of magnitude $12\frac{1}{2}$, well defined and colourless, of ordinary focus. According to Professor E. C. Pickering this star existed before the outburst as a star, photographed as far back as 1890, whose light fluctuated between magnitudes 13 and 14.

Nova Lacertae of 1910 also existed before the outbreak as a star of magnitude $13\frac{1}{2}$; it is now of magnitude $12\frac{1}{2}$, having the appearance of a small bluish-white nebula; focus five millimetres greater than usual.

Nova Geminorum of 1912 existed before the outbreak as a 13·5 magnitude star. It fluctuated in brightness last winter, and was of magnitude $8\frac{1}{2}$ last January. On February 8th, 1913, "with good seeing and at the proper focus, the Hα image was clearly seen. It was small, sharp, and intensely crimson, surrounded by a greenish-blue halo 3″ or 4″ in diameter. The normal focus, however, was not different from that of an ordinary star."

Nova Geminorum of 1903 is now of magnitude $16\frac{1}{2}$ and still fading. The Nova of the Andromeda nebula (1885) is now invisible; this may be partly from the bright background.

Professor Barnard also gives a diagram of the small stars in the region of Tycho's Cassiopeia Nova of 1572. There are several stars shown, but none of them appeared in any way peculiar.

SATURN'S NINTH SATELLITE.—Another interesting paper of Professor Barnard's describes his visual observations of Phoebe with the 40-inch. Now that Saturn is far north of the Equator he finds the satellite quite an easy object, at least as bright as magnitude 14 (it had previously been supposed to be of magnitude 16). The positions were in practically perfect agreement with the American ephemeris, which uses Dr. F. E. Ross's elements. As these were prepared several years ago, and as the perturbations are very large, this agreement is most creditable to him.

PARALLAX OF THE ANDROMEDA NEBULA.—*Astr. Nachr.* No. 4650 contains a determination of the parallax of one of the small companion nebulae of the great one, made by M. Gustaf Strömberg at Stockholm. He obtains for the parallax 0″·073 with a probable error of 0″·055. Some previous determinations had given 0″·171, 0″·132, and 0″·070 for the parallax. As the nebula is a difficult object for precise measurement it can only be claimed that the results give some slight probability to the conclusion that it has a sensible parallax, which of course if proved would negative the idea of its being an external universe.

THE STAR POLARISSIMA.—*Astr. Nachr.* No. 4650 has an article by L. Courvoisier on this faint star, which is of magnitude 9·3. It is only 10′ from the North Pole, and thus is always within the range of the field of view of a meridian instrument; also it is bright enough to observe on a clear night with a partially illuminated field, so the writer suggests that it might with advantage be used for obtaining the azimuth error of the instrument. For this purpose an accurate knowledge of its place and proper motion is required. These are investigated in the article. The proper motion is given as about 3″ per century with a probable error of one-third of itself. The star's right ascension this year is 14^h 12^m, diminishing 5^m each year.

VARIATION IN THE SUN'S RADIATION.—*Astr. Nachr.* No. 4656 contains a paper by Messrs. Abbot, Fowle and Aldrich on the simultaneous measures of the Sun's radiation at Mt. Wilson and at Bassour, Algeria. The mean value after correcting for atmospheric absorption, and so on, is 1·929 calories per square centimetre per minute. It appears to increase 0·07 calorie for an increase of 100 in Wolfer's sun-spot numbers. There is also an irregular variation of 11 per cent. which is concluded to be really in the Sun, from the fact that the two very distant stations agree in the days that give unusually high or low values.

High radiation values are accompanied by a relative increase in the strength of the violet radiations, and consequently increased contrast between the centre and edge of the Sun's disc. From this they conclude that the variation is actually in the Sun, and not due to the interposition of a meteoric screen. Haze was very prevalent in 1912: it is supposed to have been caused by the presence of fine dust in the air, from the eruption of Mt. Katmai in Alaska. When this is allowed for, the radiation of 1912 is higher than that of 1911. Hence the cause of the abnormally hot summer of 1911 is to be sought on the Earth, not in the Sun; but the Katmai dust may have had something to do with the cold summer of 1912.

BELTS ON NEPTUNE.—The same number contains a series of drawings of Neptune made by Professor T. J. J. See in 1899. They clearly show a number of curved dark belts on each side of the Equator, where there is a narrow bright streak. These drawings were made before the position of the Equator had been deduced from the shift of the node of the satellite's orbit, and it is interesting to note that the Equator in the drawings is not in the plane of the satellite's orbit, but inclined to it about 20°, which agrees with theory. Belts on Uranus were seen by Mr. Buffham, Professors Young and Schiaparelli and the Henry brothers. The four giant planets seem to be all alike in this respect, as in low density and rapid rotation.

THE SELENIUM PHOTOMETER.—A posthumous paper by Professor Ristenpart describes an application of the selenium photometer to the measurement of the diminution of light in the solar eclipse of last October. The time of minimum light is very sharply defined, the curve on each side being very steep; while this particular research is more ornamental than useful, it illustrates the power of the method, which depends on the increased electrical conductivity of selenium when light falls upon it.

SCHAUMASSE'S COMET.—The following are improved elements of this comet:—

Perihelion passage, 1913. May 15·1648, Paris M.T., Omega 53° 2′ 17″, Node 315° 5′ 25″, Inclination 152° 21′ 23″, Log Perihelion Distance 0·163514.

Ephemeris for midnight, July 3, R.A. $13^h 0^m 12^s$, N.Dec. 28° 34′; July 7, R.A. $12^h 52^m 7^s$, N.Dec. 26° 56′; July 11, R.A. $12^h 45^m 50^s$, N.Dec. 25° 29′; July 15, R.A. $12^h 41^m 0^s$, N.Dec. 24° 11′.

NAMES FOR THE units of planetary and stellar distances are suggested by Mr. J. W. Scholes. He gives Parxsecarc for the stellar unit. This is like the "Parsec" suggested by Professor Turner. "Disethsun" is suggested for the distance Earth-Sun; for myself I should have thought the term "Astron" very suitable for this, if not used for the stellar unit. For it is an obvious abbreviation of Astronomical unit of length, which has hitherto been the term used.

CONGRATULATIONS to Sir J. D. McClure on his knighthood. There must be many of our readers who have heard his lectures on astronomy, which were prepared with the most conscientious care and zeal for accuracy, and whose illustrations, both pictorial and verbal, were calculated to arrest and sustain the interest of his hearers.

OBITUARY.—I have heard with regret of the death of Mr. F. W. Henkel, who was a familiar figure at astronomical meetings and an occasional contributor to this magazine. Also of Professor Luis G. León, the energetic Secretary of the Mexican Astronomical Society. He made its journal a most readable summary of astronomical progress; he visited Greenwich a few months ago, and published an interesting account of his impressions.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

ANTARCTIC LICHENS.—In his report on the lichens of the Swedish Antarctic Expedition (*Wiss. Ergebn. Schwed. Südpolar-Exped.*, Band 4, 1912) Dr. Darbishire gives some interesting details regarding the distribution of lichens generally in the Antarctic and Arctic regions. Up to the present one hundred and five lichen species are known from the land lying strictly within the Antarctic limits, and of these thirty-two occur also in sub-Antarctic America, twenty-five in New Zealand, and sixteen in South Georgia, showing a very close affinity between the Antarctic lichen flora on the one hand and the American and New Zealand lichen floras on the other, the difference to the disadvantage of the latter being accounted for by the greater nearness of the sub-Antarctic American region to the extreme limit of the southern drifting pack-ice. The lichens of sub-Antarctic America and New Zealand are also very closely allied; for out of the one hundred and thirty-three lichen species of the former flora, one hundred and thirteen are found in New Zealand, thirty-two in the Antarctic, and thirty-one in South Georgia, the latter being evidently, from the phytogeographic point of view, a half-way house on the road from sub-Antarctic America to the Antarctic area. Moreover, about half of the Antarctic species occur also in the Arctic regions.

Of the one hundred and six Antarctic lichens, sixty-nine are crustose (encrusting forms which are applied so closely to the rock that the latter has to be chipped off in order to get specimens of the lichen), eighteen foliose (attached to the surface at various points on the underside of the thallus, but more easily removed than the crustose forms), and nineteen fruticose or shrub-like (attached only at one point): of these, the numbers found in sub-Antarctic America are respectively sixteen, five, and eleven. Of the sixty-seven species found only in the true Antarctic area and nowhere else, forty-nine are crustose, ten foliose, and 8 fruticose. The sub-Antarctic American flora includes three hundred and six lichen species, while seven hundred and forty have been found in New Zealand: of the species common to the two regions fifty per cent. are fruticose, thirty per cent. foliose, and only twenty per cent. crustose. The affinities of the lichen floras of sub-Antarctic South America and New Zealand lie mainly in the fruticose lichens which are the oldest and probably the least variable forms. The encrusting lichens are more variable and have adapted themselves more readily to local conditions, thus giving rise to new species.

Dr. Darbishire raises the interesting question of the resistance to cold by lichens, and suggests some experiments which might be made on these plants in the coldest regions. For instance, it would be interesting to determine the amount of water contained in the lichen thallus at different times and seasons; in what condition the lichens exist during the long winter; at what temperature assimilation begins, and so on. It is of little use to make experiments on the plants in warmer climates if we wish to ascertain how these lichens can live under the adverse conditions prevailing in the polar regions. Lichens are found everywhere on the outer limits of vegetation, and their chief ecological factor is their power to become quite dry and yet remain alive. No doubt it is this power which enables them to spread slowly but surely into the bleakest and most inhospitable regions. They are making their way towards the North and South Poles, and so far have been beaten in their race only by the perpetual covering of snow. If bare rocks are found in the neighbourhood of the Poles themselves there is little doubt that lichens will be found growing there.

VEGETATION OF NATAL.—An extremely interesting account of the vegetation of Natal is given by Professor J. W. Bews in the *Annals of the Natal Museum*, II, 1912. From the coast to the Drakensberg range, Natal presents three terraces (about three hundred, six hundred and one thousand metres respectively) with a mountain range above one thousand five hundred metres. The chief rivers cut back deeply into the higher topography, hence, in addition to the main terrace system there is a system of river valleys at a low level, and intervening ridges at a high level, introducing greater complexity into the conditions affecting plant-life. The soils are generally derived from poor shales and sandstones, but locally enriched by the frequent occurrence of intrusive basic igneous rocks. A table of soil analyses is given. Natal is a region of summer rainfall, and the higher hills are moister than the valleys; the rain clouds from the Indian Ocean deposit first on the coastal belt, and the rising edge of each successive terrace receives more precipitation than the intervening terrace-plateaux; mists also contribute largely to the water-supply of the plants. Extensive meteorological tables are given in support of the author's conclusions on the distribution of the vegetation in relation to climatic factors—rainfall and temperature at different periods of the year. There are great variations in illumination, from the low intensity of the bush formation to the full light of the open veld; details are given for various habitats. Interesting details are given as to the influence upon the vegetation of winds, fires, and animals (termites, locusts, caterpillars, earthworms, mammals) and man; the effect of termites ("white ants") on the soil through their tunnelling and nest-building is more than equalled by their direct effect on the vegetation through their fungus-gardening and general scavengering operations. The plant formations and associations are described and illustrated by excellent photographs, with lists of species classified to indicate dominance and biological grouping. The shore vegetation comprises (1) halophilous associations on unstable sand, including *Scaevola* and *Cyperus*, *Ipomaea Pescaprae*, and *Mesembryanthemum* associations; (2) psammophilous bush formation on fixed dunes fifteen to seventy metres high, forming a fringing belt along the whole coast of Natal, as much as fifty miles broad in Zululand, and consisting of trees with little undergrowth but many lianes; (3) lagoon mangrove formation, an interesting outlier of the Eastern mangrove flora with *Avicennia officinalis*, *Rhizophora mucronata*, and *Bruguiera gymnorhiza*, at the river estuaries where the sand-dune bush is interrupted with a *Salicornia herbacea* association on mud-flats; (4) a *Barringtonia* association just above the lagoons in wet ground more sandy in nature and not brackish.

The inland vegetation consists of evergreen dicotylous forest and grassland with summer rains and dry winters; the lower valleys have a dry climate, low winter temperature, and a xerophytic vegetation. The forest is divided into (1) coastal bush extending up to the edge of the first terrace, about five hundred metres, on south-eastern slopes facing the rain-clouds and sheltered from dry hot winds, with species which mostly extend through tropical East Africa—*Albizzia fastigiata* and *Rhus longifolia* dominant; (2) midland bush, also on the south-eastern slopes and receiving the largest rainfall in the region—vegetation in general similar to that of the coastal bush, but with *Combretum* and *Calodendron* dominant; (3) yellow wood bush, forming the larger forest areas of Natal, at one thousand metres and above, with *Podocarpus* spp. and *Olea* dominant; (4) rocky stream flora of the narrower valleys, chiefly differing from the other three types in the undergrowth which includes a rich and varied cryptogamic flora—from its more variable and indefinite character it apparently represents a migratory type in contrast to these three types, which represent the formation on stable topography; (5) thorn veld or thorn savannah, including the vegetation of the broader dry valleys, with trees (*Acacia* spp., and so on) scattered through the veld grassland.

The veld or grassland (grass savannah), widely distributed in Natal, presents two types:—(1) high veld on the open soils of the higher hills with the larger rainfall, with tall grasses which flower regularly, *Anthistiria imberbis* usually dominant and associated with *Andropogon* spp., *Digitaria*, and so on; (2) low veld on hard dry clays with valley frosts and low rainfall, with more xerophytic grasses (low-growing, more hairy), *Anthistiria* dominant but tufted and seldom flowering. Associated with the veld grasses are numerous herbs, some of which always flower immediately after the burning of the grass; the majority (including numerous bulbous monocotyledons) flower early in the season soon after the first rains and before the grass has grown tall enough to shade them; and a third class includes taller forms that grow with the grass and flower late. In marshes on wetter parts of the veld the dominant plants are grasses and sedges; actual lakes are rare, and often contain surprisingly few aquatic phanerogams, and most of the marshes are dried up more or less completely in the dry season.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

THE FUTURE OF MOTOR SPIRIT.—The problem of the future supply of motor spirit is discussed by Professor V. B. Lewes in *The Chemical World* (1913, II, 111). The trade statistics show that during the last seven years the imports of petrol into Great Britain have risen from eighteen million to eighty million gallons, whereas the increase in the world's output of crude petroleum oil has only been from 28·5 to fifty million tons. Most of the petrol imported into this country has been derived from America and the Dutch East Indies, but the increase in the demand in America has reduced the supply available for export and has raised the price of the crude oil.

Various methods are now being used to obtain a larger yield of petrol from the crude oil. The gas escaping from the wells in the oil-fields is collected and compressed, and the light spirit thus obtained is mixed with the light fractions of higher boiling-point separated in the distillation of the oil. The specific gravity of the petrol used for motors is now 0·720, as compared with 0·680 when a larger supply of the light fractions was available.

Methods have been devised whereby heavier fractions of crude oils are converted into lighter products, such as, for example, distillation in the presence of a catalytic agent like nickel, or superheating the vapours while in process of distillation.

In one American process a heavy petroleum fraction, termed "solar oil," is sprayed together with water into an iron retort packed with iron filings and heated to 600° C. The vapours issuing from the retort are fractionally condensed, and yield about thirty-nine per cent. of petrol, thirteen per cent. of solvent spirit, and thirteen per cent. of varnish.

Professor Lewes points out, however, that crude petroleum oil cannot be regarded as a lasting source of supply, and in his opinion the motor spirit of the future will probably consist of alcohol containing about ten per cent. of benzol.

At the present time about eight million gallons of benzol are recovered in coke-oven plants, while the Scotch shale industry produces each year about six hundred thousand gallons of motor spirit.

A NEW IRON BACTERIUM.—A bacillus that has a specific action upon solutions containing iron has been isolated by Mr. E. M. Mumford (*Chem. Soc. Proc.*, 1913, XXIX, 79), from the Bridgwater Canal tunnels at Worsley, Lancashire. This bacillus varies in its actions upon iron solution according as to whether it acts in the presence or absence of air. Under aërobic conditions the iron, whatever its condition of oxidation, is precipitated as ferric hydroxide, while under anaërobic conditions no precipitation of dissolved iron takes place, although any ferric hydroxide already precipitated is dehydrated and reduced to bog-ore. It is probable that in nature these two actions take place simultaneously, and account for the deposits of bog-ore found in various places.

The bacillus is a short organism about two microns in length. It is motile and forms different involution forms. It can be cultivated upon ordinary culture media and grows readily upon potato, on which it forms greenish-brown nodules.

An enzyme has been separated from the bacillus, and this also has the same specific action upon iron, its optimum temperature of activity being 70° C. Both the bacillus and its enzyme require the presence of nitrogen in the medium in order to act upon the iron salts in solution.

EFFECT OF TARRED ROADS UPON VEGETATION —Various criticisms have been brought against the use of tar upon roads on the grounds of their effect upon vegetation and animal life, and a general outline of these is given in the current issue of *The Journal of Industrial and Engineering Chemistry* (1913, V, 428). In 1910 it was shown by MM. Truc and Fleig (*Comptes Rendus*, 1910, CLI, 593) that although bituminous vapours had but little influence upon the eyes the dust from old roads produced, through its mechanical action, inflammation and other troubles.

The following year M. Mirande (*Comptes Rendus*, 1911, CLII, 204) tested the effect of various coal tar products, such as creosote and the like, and came to the conclusion that these all had a destructive influence upon plant life, blackening the leaves and causing death. Mainly on the results of this investigation has grown up the belief that the tarring of roads is injurious to the neighbouring vegetation; but quite recently this has been refuted by other investigators. For example, it has been pointed out by French engineers that tar has been used in Bordeaux for many years without any injurious effects upon the trees. In another town, however, tar was apparently responsible for the destruction of the trees in a large square; but here its action was purely mechanical, for it had been spread so closely to the trunks that it prevented water from reaching the roots.

The conclusions of M. Mirande have also been called in question in Germany, and the results of experiments made by Dr. H. F. Fischer to determine the point are to be brought before the International Road Congress which will have met (June) in London prior to the appearance of this note.

STUDIES ON THE ELEMENT ZIRCONIUM.— Pure zirconium cannot be prepared by reduction with aluminium or magnesium, but a product containing about ninety-eight per cent. of the metal has been obtained by Herr Wedekind (*Annalen*, 1913, CCCXCV, 149) by the following method. Pure zirconium oxide was mixed with finely divided metallic calcium, and the mixture placed in an iron tube, from which the air was subsequently removed with an air-pump. The reäction between the calcium and zirconium oxide was started by heating the bottom of the tube, after which the exterior of the tube was cooled by means of a current of air, and finally by placing it in cold water.

After cooling, the contents of the tube were rapidly powdered, and treated first with water, then with acetic acid, and finally with dilute hydrochloric acid, care being taken to exclude air throughout the whole process. This treatment was continued until the whole of the calcium had been removed, the water being then expelled, and the powder dried first in a vacuum and finally at a high temperature in a porcelain tube from which the air had previously been extracted. The final product, which contained a small quantity of iron, had a specific gravity of 6·44 in the melted state. It melted at 1530°C., and at higher temperatures oxidised readily. The solidified metal when filed and polished had a fine surface, which did not tarnish on exposure.

A new compound, zirconium nitride (Zr_3N_2) was prepared by heating the metal in an atmosphere of nitrogen, and this could be decomposed by hydrogen at a high temperature with the formation of the theoretical amount of ammonia.

IMITATION PEARLS FROM GELATIN.—An ingenious adaptation of the process of diffusion of salts through a gelatin film is described by Dr. R. Liesegang (*Zeit. Chem. Ind. Kolloide*, 1913, XII, 181). It is based upon the fact that when certain saline solutions diffuse into gelatin the film becomes iridescent. The best results are obtained with dilute solutions of alkali phosphates and pure gelatin in the form of a ten per cent. solution. Beads intended to serve as the foundation for the imitation pearls are dipped into the warm gelatin solution and placed on a glass plate which has previously been coated with gelatin. Round each bead is then painted a ring of the ten per cent. phosphate solution, or in place of this a mixture of the phosphate and gelatin may be used for coating the glass plate.

Gradually there is a diffusion of the phosphate into the gelatin, and the desired iridescent effect is obtained. Special precautions are taken to prevent the beads drying too rapidly, and finally the gelatin may be hardened and rendered insoluble by exposure to the vapours of formaldehyde.

OCCURRENCE OF FORMALDEHYDE IN PLANTS. —A method of detecting formaldehyde in plant juices has been discovered by MM. Angelico and Catalano (*Gazz. Chim. Ital.*, 1913, XLIII, 38). It is based upon the fact that the plant *Atractylis gummifera* contains an active glucosidal principle (*atractiline*) which gives a specific reaction with formaldehyde, and will detect a mere trace of that compound. When the juice of the plant is brought into contact with atractiline and sulphuric acid, a violet coloration is immediately produced when formaldehyde is present.

By means of this test the aldehyde has been detected in the juices of eleven plants, including lupins, maize, and so on; and its formation is apparently connected with the chlorophyll function. This is indicated by the fact that when the same plants were kept for twenty-four hours in the dark no formaldehyde could be found. The juices and distillates from several species of fungi contained no trace of formaldehyde.

GEOGRAPHY.

By Alex. Stevens, M.A., B.Sc.

BIOGEOGRAPHY OF THE ATLANTIC ISLES.—The bathymetric charts of the Atlantic reveal a long submarine plateau running along the axis of the present ocean and bounded by symmetrical valleys on the east and west. The surface of the plateau is irregular, rising into peaks which project here and there in groups as the Atlantic Isles. Far out the Azores rise from the "oceanic axis," while the foundations of the Madeiras, the Canaries, and the Cape Verde Islands lie in the eastern trough. These archipelagos are of volcanic origin, and were the seat of a recent, Neolithic, it is thought, and considerable vulcanicity. The Madeiras are continuous with the Great Atlas. The materials of the islands are uniform—trachytes, basalts, and tuffs—and all the isles present the same appearance of towering mountains, trenched by deep valleys, cut off at the sea by vertical cliffs or running out into long promontories continued by tails of islets. The ocean platform also is covered with lavas which were certainly poured forth on dry land, but were covered by the sea before subaërial denudation could leave its mark on them.

A second group of the Atlantic Isles embraces those in the Gulf of Guinea and the distant Ascension and St. Helena. But these are remnants of the foundered Gondwanaland, and display a characteristic tropical African fauna. Louis Germain ("Annales de Géographie") has worked out faunal and floral connections for the northerly groups, particularly by means of insects and fossil and living molluscs; but he draws evidence from other phyla, worms, and arthropods generally. The islands are remarkably poor in vertebrates, notably in mammals; and this poverty has been used by Wallace, who considered the few vertebrates found in the archipelagos to be imported, as an argument against the possibility of a former continental connection. But Scharff has shown that the mammals are indigenous and came from Europe by a land passage, while Osborn, less convincingly, derives the rabbit from America. It is a matter for regret, nevertheless, that no traces of a possible extinct but once flourishing mammal fauna have been brought to light for purposes of comparison with American forms. On the whole the much larger part of the fauna is circummediterranean and the smaller American.

Where the Atlantic now rolls an old - time continent supported a large and varied fauna and flora. By the close of the Cretaceous the southern Gondwanaland portion was passing beneath the waves and a narrow gulf divided the northern part from America. Later, and perhaps within the memory of the human race, this too—possibly the Atlantis of Plato and the ancients, recalled only by uncertain oral tradition—passed. The waters encroached from the west, and the shore creatures of a fauna common to Atlantis and

America were driven farther east till the last bond with the great eastern land-mass failed, and the ocean lapped the bounds of Mauretania.

GREAT EXPLORERS.—The geographical journals have recently been full of appreciations of Livingstone, and the fact has emerged that it is at least largely as a geographer that he will be remembered. To him is due a revolution in African exploration, and to his influence can be traced a beneficial effect on exploration generally. His mistakes, and particularly his curious tenacity in entertaining certain pre-conceptions in the face of contradictory facts gathered in his own work, have been made much of by certain critics. The wonder is that the accuracy of his observations and results has never been impaired under the influence of his prejudices. His maps show accuracy proportional rather to his energy in utilising stray opportunities of gaining instruction than to the extent of his training. It is related of him that he spent his time on his first voyage largely in learning from the captain of the ship how to determine positions by means of the sextant and in mastering the art. The result is that some of the stations he fixed were determined with sufficient accuracy even for many modern requirements. No man has made greater and more valuable changes on any map than he on the accepted map of Africa: to realise this one has but to glance at the series of maps earlier and later than his, published recently in the magazines. By virtue of his inborn capacity for leadership and the management of men, and his sympathetic grasp, he was able not only to bring away stores of information regarding the topographical and racial geography of Africa, but to leave behind the influence of a master mind and heart.

The Geographical Journal for June publishes an account, by Sir Clements Markham, of Vasco Nunez de Balboa, that singular man who reached Darien, "headed up in a cask," a fugitive on the ship of Enciso. At the helpless fort of Darien, in the midst of Indians, whose distrust and enmity had been aroused by Spanish cruelty and injustice, he was recognised as a born leader, and was obeyed by Pizarro himself, who was actually in charge. He regained the confidence of the natives, though with difficulty, and contrived to render the existence of the hitherto wretched fort possible. Informed by natives of the sea beyond the mountains which was always calm, he it was who first of white men saw the Pacific and stood "silent upon a peak in Darien." Superseded by an incompetent and unscrupulous gold-seeker, who had influence at Court, Nunez was nevertheless allowed to devote the remainder of his life to building ships on the western coast of the Isthmus for the exploration of the new ocean. Materials were brought from Cuba and dragged with infinite labour through the forest and over the mountains. But when he was ready with three hundred men to launch his four ships, he was "judicially" murdered by Pizarro and the rapacious Pedrarias. With the ships of Nunez, Pedrarias explored the coasts of Panama and Nicaragua. Nunez it was who rendered possible the invasion of Chile and Peru. Had he lived the conquest of the Incas had been earlier, and its story had been different.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

THE CONCEALED COALFIELD OF YORKSHIRE AND NOTTINGHAMSHIRE.—The proving of the concealed coalfield to the east of the Permian escarpment which runs from Nottingham along the boundary of the visible coalfield into Yorkshire and Durham began in 1854, when the Duke of Newcastle sank two pits at Shireoaks. Here the valuable Top Hard Coal was obtained at a depth of one thousand five hundred and thirty feet, and was found to be three feet ten inches in thickness. By far the greatest progress in the exploration of the concealed field, however, has been made since the beginning of the present century. The chief areas in which borings and shafts have been sunk are three in number: one, to the south of Nottingham, has been developed with a view to the London market; a large area has been proved in the central region between Nottingham and Gainsborough, near the navigable Trent; but the largest development has been made in the Doncaster district, where special transport facilities are available. The amount of information thus gained has become so large and valuable that it has become necessary to collect and summarise it in a publication of the Geological Survey, which has been written by Dr. Walcot Gibson.

The Nottingham and Yorkshire Coalfield is of the shape of a basin, of which only the western rim is visible at the surface, the remainder being concealed beneath successive sheets of newer formations to the east. The eastern edge of the concealed portion of the basin has not been reached in any of the borings yet made. A thickness of about four thousand feet of Coal Measures has been proved. Two borings each end respectively in the Upper and Lower Coal Measures; all the other borings and shafts end in the Middle Coal Measures.

The chief conditions which affect the accessibility of the coal in the concealed area are the thickness of the overlying strata; the configuration, structure, and folding of the Coal Measures; and the amount of denudation, if any, suffered by the latter before the deposition of the Permian. Where direct observation is possible it has been found that the Permian rests unconformably upon an even surface of the Carboniferous rocks, so smooth that a well-known graphic method has been applied to contour the surface of the hidden Coal Measures. The contour lines thus obtained are strikingly parallel, and show that the buried surface has a remarkably uniform slope directed a little to the north of east, and oblique to the north-west strike of the Coal Measures. Hence higher horizons in the Coal Measures tend to occur beneath the Permian cover than at the outcrop. At Kelham and Thorne, however, borings have shown that the Coal Measures rise, at least locally, on approaching the Trent; and if the general slope of the buried surface (ninety to one hundred feet per mile) is maintained here, the whole of the Coal Measures will be cut out by the newer formations. The area of the concealed coalfield already proved amounts to one thousand two hundred square miles.

ORIGIN OF TURQUOISE.—A theory of the origin of turquoise has been propounded by S. Paige ("Economic Geology," 1912, 382-92) to account for an occurrence of this gemstone in the Burro Mountains of New Mexico. The country rock is a Pre-Cambrian granitic complex, which has been intruded by quartz-monzonite with intense fracturing and mineralisation. The turquoise occurs in small veins within both the igneous rocks, and the veins are closely related to the surfaces of denudation. The author believes that the turquoise was formed by the oxidation of copper sulphides and pyrite in the zone of weathering, and the reäction of the resulting solutions with apatite. The latter would supply the necessary phosphorus to combine with the copper and aluminium of the solutions and thus form turquoise.

AN ENGLISH DESERT.—The Long Valley, Aldershot, is described by Alan G. Ogilvie in the June *Geographical Journal* as an area which exhibits many of the phenomena characteristic of deserts. The desert features, however, are not due to aridity, but to the ceaseless erosion effected by the hoofs and wheels of cavalry and artillery. This action has completely stripped the area of the original mat of vegetation, and has exposed the underlying sand and gravel to very rapid erosion. The Long Valley is now dissected by a system of stream-courses which reproduce all the essential features of desert wadys. These are only filled after heavy rain, and then contain rushing torrents which carry down large masses of sand and gravel. Ordinary rain showers have no effect, as the water percolates at once through the sand. Similarly the water from a continuous spring loses itself in the sand after running in a well-formed valley for about a hundred yards. The erosion due to wind is, however, more important than that of water. The wind is producing a steady lowering of the surface of the valley by blowing away the lighter particles. The finer dust is probably carried beyond the confines of the area, but the blown sand tends to form miniature dunes on its margins, especially at the north-east corner facing the prevalent wind. The desert appearance of the Long Valley is shown in a series of striking photographs which illustrate the disastrous and desolating effects of the removal of vegetation from an area the climatic conditions of which do not differ from those of the surrounding districts.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

WINDS IN THE FREE AIR.—At one of the Friday evening discourses at the Royal Institution Mr. C. J. P. Cave dealt with the subject of the "Winds in the Free Air." He has for some years devoted a considerable amount of time and work in carrying on observations in the upper air, first by means of kites and subsequently by small rubber balloons, the movements of the latter being followed by a specially designed theodolite. The lower layers of the atmosphere up to one or two kilometres are the most important to aviators. To meteorologists the higher layers offer problems of greater interest. In considering the winds in the free air it is convenient to have some datum to which to refer them, and this is known as the gradient wind. Mr. Cave divides the wind structures into five types. In the first three the wind increases above the surface and equals the gradient velocity at a height of half a kilometre or so; above this, in the first class, the wind remains more or less equal to the gradient velocity up to a height of seven or eight kilometres; in the second class the wind in the upper air greatly exceeds the gradient wind; and in the third class it falls off again to a lesser value; but in all three classes the direction remains much the same as that of the gradient wind. There are often cases of reversals when the wind in the upper air is very different in direction from that near the surface, and when it bears no relation to the surface-pressure distribution. In cases of reversal it is found that the warm wind flows over the top of the one that comes from a colder region; there must somewhere be a line where the warm current is rising, where it must be cooled dynamically, and where its moisture may condense into cloud or rain. It is interesting to note that in most cases rain occurs somewhere in the region of the reversal, and in summer thunderstorms are frequent. The last type of wind structure considered was the outflow that seems to take place from the upper layers over a low-pressure system, causing west to north winds in the upper air on the east and south sides of the depression.

Following on inquiries made by Mr. W. H. Dines on the correlation between the surface pressure and various meteorological elements at a height of nine kilometres, Dr. W. N. Shaw has suggested that the changes of pressure to which our changes of weather are due have their origin, not near the surface of the earth, as hitherto supposed by many meteorologists, but just below the level of the stratosphere at a height of nine kilometres or so above the surface. Mr. Cave says that this view is in accordance with the observed facts of the wind distribution in the different layers of the atmosphere.

HOURLY OBSERVATIONS OF CLOUD FORMS.—Mr. Spencer C. Russell, who has always been a keen observer of clouds and thunderstorms, gave, at the May Meeting of the Royal Meteorological Society, the results of monthly and hourly cloud-form frequencies at Epsom for the eight years 1903–1910. He had observed during this period, almost single-handed, the amount of cloud and also the various forms of cloud visible at each hour, day and night. This was truly a most remarkable feat of endurance, but it is a valuable addition to this little-studied branch of meteorological science. He arranged the fifteen varieties of clouds into four groups, viz. (1) upper, (2) intermediate, (3) lower, and (4) clouds of diurnal ascending currents. The upper clouds, which include the Cirrus, Cirro-stratus, and Cirro-macula, show a marked prevalence during the summer with minima during the winter. Morning and evening maxima, with a midday decline, are common to all these varieties. The intermediate clouds, which include Cirro-cumulus, Alto-stratus, Alto-cumulus, and Cumulo-stratus, are also more prevalent in the summer than in the winter. The lower forms, which include Strato-cumulus, Nimbus, Fracto-nimbus, Fracto-cumulus, Stratos, and Fog, attain their maxima in the winter months, their minimum frequency being in the summer. The clouds of diurnal ascending currents, Cumulus and Cumulo-nimbus, are independent of any seasonal variation in hourly frequency, the maxima, at noon and 3 p.m. respectively, taking place at these hours in every month of the year.

The total number of individual records made by Mr. Russell approximate close upon 100,000. The Cumulus cloud yielded the greatest number of daily values (1,622), the Stratus coming next (1,155), but the Stratus had the greatest number of hourly records (13,497), the Cumulus being next (11,414).

METEOROLOGY AND MAGNETISM AT THE ROYAL OBSERVATORY, GREENWICH.—In his Report to the Board of Visitors of the Royal Observatory at the Annual Visitation on June 7th the Astronomer-Royal gave particulars respecting the meteorological and magnetic work carried on at Greenwich. The chief results for the twelve months ended April 30th, 1913, were: The highest temperature in the shade (recorded on the open stand) was 90°·0 on July 12th. On twelve days the highest temperature equalled or exceeded 80°·0, but none of these days occurred after July, maximum readings of 70° and upwards occurring only seven times in August, and not at all after. The lowest temperature during the same period was 24°·2 on February 23rd. There were twenty-seven days during the winter on which the temperature fell as low as 32°, or less than half the average. The mean temperature for the twelve months was 49°·8. The mean daily horizontal movement of the air was three hundred and ten miles, which is twenty-six miles above the average of the previous forty-five years. The greatest recorded daily movement was eight hundred and forty-five miles on March 19th, and the least fifty-six miles on October 11th. The total rainfall was 25·61 inches, or 1·49 inches greater than the average. The number of hours of bright sunshine was one thousand three hundred and thirteen out of a possible four thousand four hundred and fifty-seven hours, giving a mean proportion of 0·295, constant sunshine being represented by one. As compared with the previous twelvemonth the deficiency of more than five hundred hours is fully accounted for by the fact that in July, August, September, and April the duration of sunshine was only about half what it was in the corresponding months.

The magnetic elements for 1912 determined from observations in the Magnetic Pavilion are as follows:—

Mean declination ...	... 15° 24′·3 West
Mean horizontal force	... 0·18528 (in C.G.S. units)
Mean dip	... 66° 51′ 46″

The Astronomer-Royal stated that in the new magnetic observatory shortly to be erected provision is made for the continuation of the long series of Greenwich observations of the variations of the magnetic elements. This series is unique as regards the length of time during which observations have been made on the same site. The care which has been taken to guard the observatory from all artificial electro-magnetic disturbances which could affect the accuracy of the observations has preserved the suitability of the site for such work. The present wooden structure, however, is old, and needs extensive repairs or renewal. The latter course was considered preferable, and designs have been prepared for a new building in the Magnetic Pavilion enclosure in the Park, where the absolute observations are made. The main feature of the building is the provision by insulation and heating for the reduction of the daily range of temperature. Also, to avoid damp, it will be above ground. The building will therefore be adapted to house a set of modern instruments. Although the change of site is small, the new and the old instruments will be run concurrently for a period sufficient to give a good comparison between the two.

THE ATMOSPHERIC TURBIDITY OF 1912.—The great deficiency of bright sunshine referred to above was not confined to Greenwich only, and it was no doubt connected with the unusual haziness that overspread most of the northern hemisphere during June, 1912. This appears to have been the result of the eruption of Katmai Volcano in Alaska. This volcano became suddenly active on June 6th, and violent explosions were frequent during the three days that followed. The eruptions continued with greatly diminished energy until the end of October, and perhaps until the end of the year. Professor H. H. Kimball, of Mount Weather Observatory, U.S.A., who has been investigating the subject, has found that in connection with the atmospheric haziness noted by many observers, but more especially by those engaged in astronomical photography, there was a decrease in atmospheric transparency of from ten to twenty per cent. The solar radiation intensities measured at the Mount Weather Observatory, after June 9th, 1912, were below the average, and the percentage of polarisation of skylight on cloudless days was abnormally low. These low values seem to be due in some measure to volcanic dust in the upper atmosphere.

INTERNATIONAL METEOROLOGICAL COMMITTEE.—A meeting of this Committee, which consists of representatives of the principal meteorological services in various parts of the world, was held in Rome from April 7th to 12th. Dr. W. N. Shaw, F.R.S., the Director of the Meteorological Office, London, is the President, and Dr. G. Hellmann, the Director of the Royal Prussian Meteorological Institute, Berlin, is the Secretary of the Committee. Among the subjects which came up for consideration were Weather Telegraphy, Weather and Agriculture, Investigation of the Upper Air, Meteorological Units, Sunshine Recorders, and Storm-warning Signals.

MICROSCOPY.

By F.R.M.S.

AN APLANATIC AND ACHROMATIC CONDENSER.—An attempt to modify the ordinary refracting substage condenser used for observation with transmitted light, so as to render it available for use as a dark-ground illuminator, has led to the construction of an Aplanatic and Achromatic Condenser. The ordinary condenser of N.A. 1.40, which consists of three lenses, though corrected for neither spherical nor chromatical aberration, is nevertheless available as a means of producing dark-ground illumination, but its deficient chromatic correction gives rise to colour effects which interfere with the quality of the resulting image: this defect can be remedied by achromatising the condenser. This quality alone would not, however, have placed the condenser on a level with the reflecting condensers, seeing that these, in addition to being naturally achromatic, are also excellently corrected with respect to spherical aberration. To compete with these the refracting condenser must needs be aplanatic as well as achromatic.

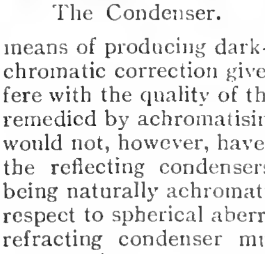


FIGURE 271.
The Condenser.

To meet this requirement the condenser constructed in 1907–8 by Leitz has recently been further improved in the matter of spherical correction. In the majority of cases objects which are observed with dark-ground illumination are examined in an aqueous medium, having a refractive index barely exceeding that of water, *i.e.*, 1·33. Every ray whose aperture is numerically greater than the refractive index of the medium containing the objects is totally reflected at the surface of the medium, as can be easily shown by a simple calculation, and the rays so reflected do not contribute to the illumination of the object. In order that the whole of the light which a condenser is capable of receiving when opened to its full aperture may be brought to bear upon the preparation, the condenser must have an aperture of 1.33, that being the refractive index of water.

The new condenser has lenses of the same diameter as the older type with N.A. 1·40; however, when used with aqueous media, it produces a more brilliant illumination than the latter. In the most recent form of the reflecting condenser, the so-called Concentric Reflecting Condenser, we have also a practical application of the above reasoning.*

As will be seen from Figure 271, the condenser consists of two doublets on either side of a meniscus and a hemispherical front lens. In its general construction it resembles an oil-immersion lens and, as a matter of fact, it is computed on precisely similar lines.

Although the condenser has been corrected as an immersion condenser its qualities will be impaired only very little when being used dry if the layer of air between condenser and slide is kept as thin as possible. In this case, however, the aperture is reduced to N.A. 1·0, since all rays of higher aperture are totally reflected.

In addition to being both achromatic and aplanatic, this condenser also satisfies the sine condition.

The focal lengths are 14·5 in immersion contact and 9·6 millimetres dry, and the effective aperture of the back lens is 26 millimetres. The light-transmitting power of the condenser is at least not inferior to that of a condenser constructed of single lenses of similar diameter; the loss of light due to absorption in its passage through the six lenses of the new condenser is fully compensated for by the manner in which the rays appertaining to the different zones are brought to a focus. This quality, coupled with the other conditions which are satisfied by the formula of the condenser, furnishes an efficient means of projecting a sharp, even, and colourless image of the source of light in the plane of the object; in the methods of photomicrography this is of great importance.

Continuous use and practical experience must show whether the refinements in the correction of the aplanatic condenser and its large aperture will secure tangible results in ordinary microscopic observations with transmitted light, both direct and oblique, especially in the case of objects which are difficult to resolve. Under the conditions of dark-ground illumination the excellent correction of the aplanatic condenser shows itself in an unmistakable manner, and every effort has been made to provide the condenser with qualities that will satisfy all the most advanced requirements of modern observation by this method of illumination. The extent to which the spherical aberration has been successfully corrected is clearly shown by the photograph reproduced in Figure 276 of the path, within fluorescent uranium glass, of the intersecting pencils of rays, which method was first used by the firm of Ernst Leitz in 1910. It will be seen that the pencils intersect within a very small area, and this furnishes an estimate of the resulting brightness of the illuminated field. By reason of the excellent correction of spherical and chromatic defects, and since also the sine condition is satisfied, the objects can be illuminated on a dark ground in such a manner that the image is seen free from colour, without distortion, and without disturbing flares.

The requisite conditions for observation against a dark background are established by the use of a central stop (see Figure 273) which rests on the carrier of the iris-diaphragm. The illumination is derived from the peripheral zones only of the pencil of light: these pencils are indicated by dotted lines in the annexed diagram, which shows the path of the rays through the aplanatic condenser and an oil-immersion lens. The image as seen in the microscope (see Figure 277), derives its existence exclusively from refracted and diffracted light emitted by the object.

The following points respecting the central stop may be noted. The disc of the smallest central stop, which is attached to the outer ring by three radial arms, has a diameter of 16 millimetres, and bears the number 0·85, whilst the ring is inscribed 1·33. All parallel rays entering the condenser within the annular zone, corresponding to an

* Cf. F. Jentzsch, *Ueber Dunkelfeldbeleuchtung*, *Phys. Zeitschr.*, XI, 1910, pages 993–1000; *Verhandl. der D. Physik. Gesellschaft*, XII, 1910, pages 975–91.

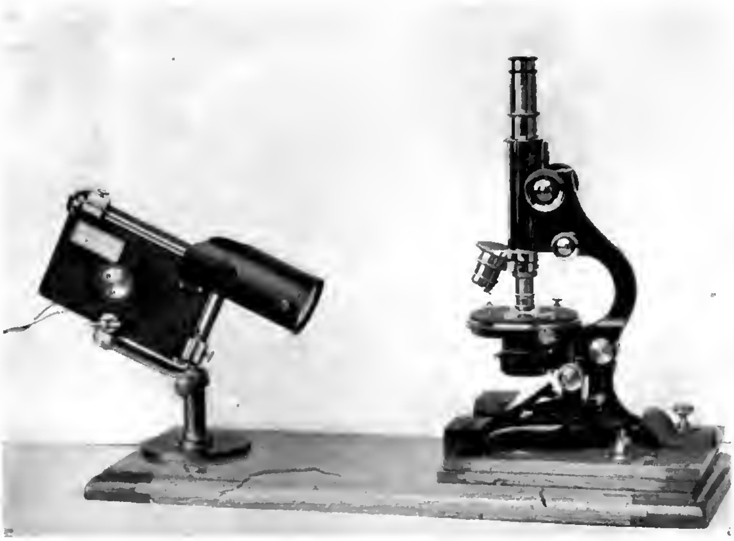


Figure 272.
A Liliput arc-lamp placed in position for use with the condenser.

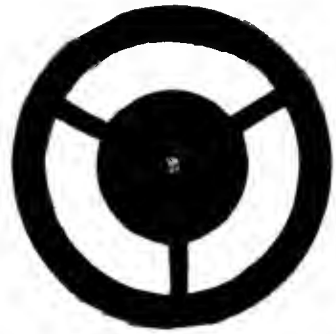


Figure 273.
Central stop.

Figure 275.
An objective with the nickel-plated part unscrewed.

Figure 276.
The intersecting pencils of light within fluorescent uranium glass.

Figure 274.
Two of the loose discs.

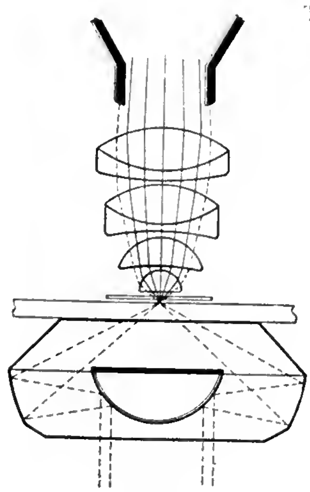


Figure 277.
Diagram of the condenser and an immersion objective. The dotted lines indicate the pencils of light.

Figure 278.
Snapshot taken upon an orthochromatic plate with the aid of a screen. Reproduced from a platinum print.
(See page 274.)

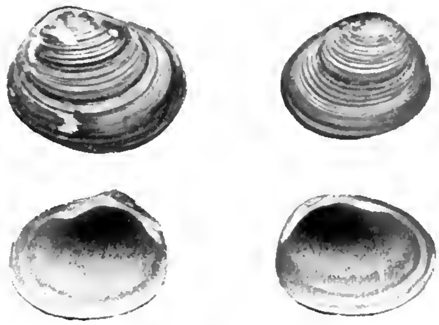


Figure 279. *P. amnicum* Müller.

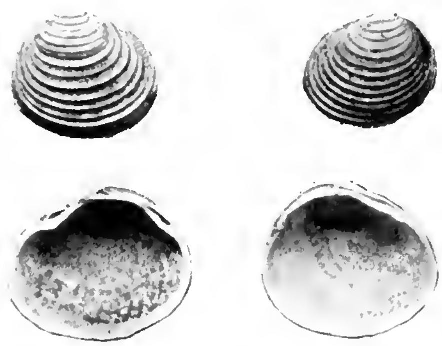


Figure 280. *P. astartoides* Sandb.

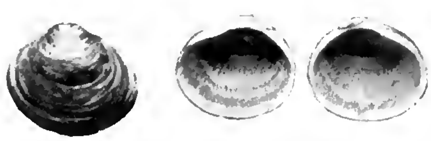


Figure 281. *P. casertanum* Poli.

Figure 282. *P. nitidum* Jenyns.

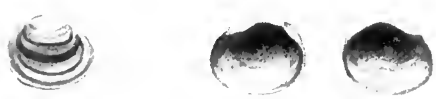


Figure 283. *P. personatum* Malm.

Figure 284. *P. pusillum* (Gmelin) Jenyns.

Figure 285. *P. milium* Held.

Figure 286. *P. pulchellum* Jenyns.

Figure 287. *P. subtruncatum* Malm.

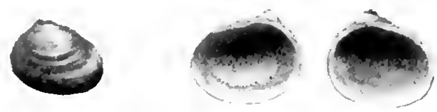


Figure 288. *P. henslowanum* Shepp.

Figure 289. *P. supinum* A. Schmidt.

Figure 290. *P. steenbuchii* Möller.

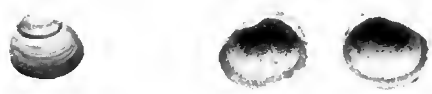


Figure 291. *P. lilljeborgii* Clessin.

Figure 292. *P. hibernicum* Westld.

Figure 293. *P. obtusale* (Lam.?) Jenyns.

Figure 294. *P. vincentianum* B. B. Woodw.

The fifteen British Species of *Pisidia* recognised by Mr. B. B. Woodward in the Catalogue recently published by the British Museum (Natural History), and a New Species described by himself.

apertural range extending from 0·85 to 1·33, are allowed to participate in the illumination. The objectives employed for observation should in these cases have apertures which are less than N.A. 0·85, such as the Leitz objectives, Nos. 2 to 5, having respectively focal lengths ranging from 24 to 5·4 millimetres, as well as the apochromatic lenses of 8 millimetres and 16 millimetres focus. To use high-power objectives, having apertures exceeding N.A. 0·85 in conjunction with the central stop, it becomes necessary to reduce their aperture to less than N.A. 0·85 by a stop situated behind the back lens. To modify the range of the peripheral zone three loose discs, two of which are shewn in Figure 274, bearing the following numbers, 1·0, 1·1, 1·2, are provided with the stop. Each disc has a central hole fitting a small pin at the centre of the immovable disc inscribed 0·85. When one of these discs is pressed down upon this pin the cone of illumination becomes reduced, so that an aperture of 1·0, 1·1, and 1·2 is respectively employed; these discs are used when observing with objectives having an aperture of 1·0. Oil-immersion lenses have their aperture reduced to 1·0 for observation with dark-ground illumination by unscrewing from the body of the objective the nickel-plated part of the mount (see Figure 275), which contains the optical system, and screwing it to an adapter fitted with a conical stop, which is so arranged that it cuts off all rays which would pass if the numerical aperture of the lens were greater than 1·0. In the case of dry lenses it is generally desirable, to obtain an intensely dark background, to employ one of the larger stops; in the majority of cases the one marked 1·0 is sufficient for this purpose. For observation with dark-ground illumination it is always an advantage to use objectives of high degree of chromatic correction—for instance, fluorite lenses or apochromatic lenses—since under the conditions of dark-ground illumination the residual colour defects of the lenses, known as the secondary spectrum, are of much greater importance than is the case in ordinary observation with transmitted light. The best source of light to use with dark-ground illumination is the Liliput Arc Lamp, which has been specially devised for this purpose. This lamp burns carbons set at right angles to one another and consumes five amperes: it is so arranged that it may be connected with the ordinary domestic electric supply by means of a plug contact. The light emitted by this lamp is rendered parallel by a condensing lens attached to the lamp casing, and is reflected by the plane mirror of the microscope into the condenser, the latter being adapted for parallel light. The lamp, being hinged, moves in a vertical plane, and should be so set that the plane mirror may be completely filled with light. The lamp should be placed at such a distance from the microscope that the observer may be able to manipulate it without inconvenience, as shown in Figure 272. When using dry lenses a ground-glass screen may be interposed between the lamp and the mirror; the contrast between a dark-ground and a brightly illuminated object is thereby intensified. When using low-power lenses having apertures not exceeding 0·40 the condenser may be used dry; with lenses of higher power the condenser should be used in immersion contact with the object slide; it will generally be sufficient to employ water as the optical medium. The adjustment of the dark field is not always an easy matter with high-power lenses; it may, however, be greatly simplified by the following procedure:—

The object should be viewed first with an objective of medium power, say No. 3 Leitz Objective, in conjunction with a high-power eyepiece. Incidentally it may here be noted that high-power oculars are particularly useful in observations under dark-ground illumination. Focus the lens in the plane of the object, the object slide being at this stage connected to the condenser by a drop of oil. By the requisite movement of the substage mirror direct the light upon the object. Under good conditions of adjustment the circle of bright light should appear in the middle of the field of view, and it should be sharp and free from colour. The condenser should be raised or lowered until the spot of light becomes as sharp as it is possible to make it. Having prepared the adjustment in this way a very small correction in the position of the mirror and condenser will be needed to secure a very perfect dark ground. These manipulations are sufficient to obtain the necessary adjustments, and there is no need to have recourse to centring screws.

The transition from dark background illumination to ordinary observation with transmitted light, and *vice versa*, can only be made in the case of a refracting and not in that of the usual reflecting condenser; for this purpose a useful special arrangement has been devised.

The ordinary conical stop with which lenses of high aperture are fitted to render them available for observation with dark-ground illumination is replaced by a small iris-diaphragm fitted to the body of the lens mount. When the lens is used for observation with an ordinary bright field this diaphragm should be opened to its full extent, and it should be partly closed for observation with dark-ground illumination. In order to pass rapidly from one mode of illumination to the other the iris-diaphragm carrier below the condenser is provided with a central stop attached to a slide by means of which it may readily be pushed in or withdrawn.

It may be useful to point out the distinctive features of a refracting condenser. In the case of a reflecting condenser the course of the rays is solely determined by a series of reflections. In refracting condensers the illuminating pencils are brought to a focus by refractions at the surfaces of the constituent lenses. In addition to these refractions, however, the rays undergo certain reflections which may impair the distinctness of the image as seen in the dark-ground field. It seems almost hopeless to construct an aplanatic and achromatic condenser which needs correction by the use of so many kinds of glass and refracting surfaces, and in such a way that every surface must be excluded from which reflected rays after successive refraction and reflection shall yet leave the condenser at such an angle as to enter the plane of the object. These indirect rays which cannot altogether be avoided, however faint they may be, impair the blackness of the background which is never the same as that obtainable with a reflecting condenser, and under these circumstances the clearness of the image may suffer.

The condenser described above, on the other hand, has the advantage of being of the nature of a universal illuminator, and in this respect it surpasses all existing reflecting condensers. Primarily, a highly refined illuminator adapted for the various purposes of visual microscopy with transmitted light and photo-micrography, its performance as a dark-ground illuminator entitles it to a prominent position among the condensers devised for this purpose. Far from being restricted in its use to high-power objectives, it illuminates a sufficiently large field to render it suitable for use with low-power objectives whose focal lengths may be as much as twenty millimetres. The only optical device of the nature of a reflecting condenser which can be regarded as a dark-ground illuminator is our old friend the concave mirror: this can be converted into a makeshift for a dark-ground condenser by covering up the central portion of the mirror. Owing to its small apertural angle the mirror can be used in this way only in conjunction with lenses of a very low power.

C. Metz, Wetzlar.

THE BRITISH SPECIES OF *PISIDIUM*.—Those who study British land and freshwater shells—and they are many—owe a deep debt of gratitude to Mr. B. B. Woodward for determining what species of *Pisidium* are British and for clearing up all the doubts and difficulties which have long surrounded these small freshwater bivalves. After examining many thousands of specimens under the microscope, and devoting his leisure hours during nine winters to the subject, he has come to the conclusion there are fifteen British forms worthy of specific rank, of which all but one (*P. astartoides*) are still living in this country. Photographs of these by the kindness of Mr. Woodward we are permitted to reproduce on page 272 (see Figures 279 to 293).

The determination of the species is based to a large extent upon the hinge characters of the shell and the form and position of the various hinge "teeth."

P. casertanum (see Figure 281) is a species which has long been known on the Continent under this name or that of

P. fontinale. P. nitidum Jenyns (see Figure 282) still stands, and Mr. Woodward points out that it has frequently been mistaken for small specimens of the last species, *P. personatum* or *P. pusillum. P. personatum* (see Figure 283) was recorded as British by Mr. Woodward in 1908. This, again, has often been confounded with other species, and its detection has helped very greatly to clear matters up. *P. pusillum* (see Figure 284), *P. millium* (see Figure 285), and *P. pulchellum* (see Figure 286) still stand. *P. subtruncatum* was identified as British by Dr. Johansen, who pointed it out to Mr. Woodward in 1901 (see Figure 287). This was looked upon as a variety of *pulchellum* by Jenyns, and is the var. *pallida* of Jefferys' *P. fontinale. P. henslowanum* (see Figure 288) is recognised by Mr. Woodward. *P. supinum* was found by Dr. Johansen near Kew Gardens in 1901. Mr. Woodward describes *P. parvulum*, which has not yet been met with in Britain, and is the smallest of the Western European species. P. *steenbuchii, P. liljeborgii*, and *P. hibernicum* (see Figures 290 to 292) are species that were not recognised till recently. *P. obtusale* (see Figure 293) is an old friend. We figure also *P. vincentianum*, a fossil form from the Pleistocene of Belgium, which is a new species described for the first time by Mr. Woodward, but which has not yet been discovered in this country (see Figure 294).

Mr. Woodward's researches have been published by the British Museum (Natural History) as a catalogue consisting of one hundred and forty-four pages and thirty plates, the greater part of which latter consists of collotype reproductions of photographs of many hundreds of shells. In the case of every species the hinges and hinge-teeth are described in great detail. Symbol maps (in accordance with those agreed upon by the British Association Committee for "The Formation of a Definite System on which Collectors should record their Captures") are also given, which show recent as well as fossil records. A detailed list of localities for each species is also included, and the synonomy, which in some cases runs into two or more octavo pages, gives some little idea of the work which Mr. Woodward has accomplished. Every collector of land and freshwater shells will now have to check his specimens of *Pisidia* and redetermine them with the help of Mr. Woodward's book which can be obtained at the British Museum (Natural History), Longmans, Green & Co., B. Quaritch, or Dulau & Co. Price 10/6 net.

W. M. W.

ORNITHOLOGY.

By WILFRED MARK WEBB, F.L.S., F.R.M.S.

THE COMMITTEE FOR THE ECONOMIC PRESERVATION OF BIRDS.—We learn from the July number of *The Selborne Magazine* that at the meeting of the Council of the Selborne Society, held on November 26th, 1912, Mr. Holte Macpherson and the Secretary were empowered to confer with Dr. Chalmers Mitchell and others, including members of the trade, as to the best steps to be taken to preserve birds which are being killed off for their plumage. Subsequently Mr. Macpherson, Mr. Poole, and the Secretary were given formal authority to represent the Society on the Committee for the Economic Preservation of Birds, to which also the London Chamber of Commerce has appointed representatives. Many leading zoölogists have joined the Committee which is now beginning active work.

In the past, bird-lovers have sought to secure legislation without stopping to consider whether the objects they seek will be obtained. On the other hand the trade has occupied itself with opposing all legal measures, and nothing has been done. It is hoped, however—now that naturalists and merchants are combining to consider the question—that some steps will be taken to preserve birds whose plumage is used in commerce. Anyone who has evidence to offer with regard to the killing of birds for trade or natural history purposes is invited to communicate with the Honorary Secretaries of the new Committee, care of the Selborne Society, 42, Bloomsbury Square, W.C.

PHOTOGRAPHY.

By EDGAR SENIOR.

PLATINUM PRINTING.—Of the many processes of photographic printing there are few which equal in simplicity, together with the beauty of the results obtainable, that known as platinum printing (see Figure 278). For while it is capable of rendering shadow detail in a most perfect manner, it is at the same time able to reproduce all the delicate gradations in the lights. Then there is the additional advantage of permanency, for which both platinum and carbon stand pre-eminent, and although the former does not enjoy the advantages attending the latter, of giving an almost unlimited choice of colours, both warm or cold blacks and sepia are readily obtainable. The papers manufactured by the Platinotype Company, Gevaert Limited, and others are of several grades or kinds, which refer to the surface, texture, and thickness. As the paper has a great affinity for moisture, special precautions have to be taken to keep it in a perfectly dry atmosphere, and neglect of this is a great cause of so many failures in practice. Therefore, in order to keep the paper in good condition, it is sent out by the makers in sealed-up tins containing a small quantity of a desiccating agent (calcium chloride) which absorbs the moisture contained in the air enclosed in the tin. In this manner the paper will keep perfectly dry for a lengthened period, the writer having found it to be in perfect condition after the expiration of two years. As soon, however, as the tin is opened the paper must be removed to a storage tube which is provided at one end with a receptacle for containing the calcium chloride, and this salt must be frequently dried and replaced in the tube; in fact, it cannot be too strongly urged upon those who use platinum paper to keep their tins in a dry place, as well as keeping the calcium chloride dry. If these points be attended to there will not be any difficulty in preserving the paper in good condition. Neglect of these simple precautions is seen in the flat, muddy, sunken-in appearance of the image. One of the first considerations is the kind of negative that will give the best result by this process; it may, however, be taken for granted that any negative which possesses good gradations from high lights to shadows will yield a good print, but that poor, flat, or thin ones will not be suitable as a rule. Before commencing printing, it is necessary to dry the printing frames, and especially the backs, thoroughly before a fire. The negative is then placed in the frame and the coated surface of the paper in contact with it, this operation being conducted in as subdued a light as possible, as the paper is much more sensitive than the P.O.P., and the effect of short exposure to light is not apparent until after the print is developed. In order to protect the paper from moisture during the time of printing it is usual to place a piece of vulcanised rubber upon it before placing the back of the frame in position; several sheets of waterproof paper can, however, be made to answer instead. The paper before exposure to light is of a lemon-yellow colour; as the printing proceeds it changes to a greenish-grey, the shadows finally becoming a blue-grey and with some negatives a slight orange-brown colour. It is not advisable, however, to continue the printing until the detail in the lights is plainly visible. The time of exposure necessarily varies with the kind of negative, but it is about one third of that required for a silver print. It is evident that the progress of printing can be inspected from time to time; but as over-printing is not made apparent until development has taken place, some amount of experience is required to know when printing should be stopped. This knowledge, however, will soon be acquired after a few trials. But it does constitute a vital point in the process. If thought desirable, one of the many forms of actinometers may be employed in printing, although they are of little use unless a number of prints are required from one negative; in which case they are a help in ensuring that the printing shall be carried to the same depth in each case. The printing having been carried far enough, the next operation is that of development. This may be carried out at once, or the exposed paper may be returned to the calcium tube until a more convenient time. The reason of its being necessary to develop the print is owing to the light having acted upon the iron salt only, and before the product formed is able to reduce the platinum salt in contact with it it becomes necessary to float the exposed paper upon a solution of either potassium oxalate or a mixture of this with sodium phosphate, known as developing salts. Using the former, a stock solution is made as follows:—

Oxalate of Potash	...	...	16 oz.
Water ...	...	...	54 oz.

For use one part of this is diluted with two parts of water. If this bath is made slightly alkaline with carbonate of soda or potash it gives slightly warmer tones, and if made slightly acid by means of oxalic acid, a colder or bluish colour results. In either case the alkalinity or acidity should only be such as to just alter the colour of the test paper used. If developing salts are used, then a stock solution of the following strength is prepared:—

Developing Salts	...	...	½ lb.
Water ...	...	...	50 ozs.

And for use one part is taken to which is added one part of water. It is claimed for this developer that it gives better half-tones, as well as a colder tone generally. Whichever developer is employed, the print is floated face downwards upon it, the print being then turned over to watch the progress of development, which should be complete in about thirty seconds. The temperature of the solution should be from 60° to 100° F. If the solution be below 60° the deposit is liable to become granular, while if too hot there is a tendency to a brown and muddy colour, although under-exposed prints may frequently be saved by use of a warmer solution for their development. As soon as the desired result is obtained the print is placed into a dish containing a dilute solution of hydrochloric acid, the strength being—

Hydrochloric Acid (pure)	...	1 oz.
Water	...	100 oz.

The prints are allowed to remain in this bath for ten minutes, after which they are transferred to a second bath of the same nature, and finally to a third, remaining for ten minutes in each. After this they are washed for about half an hour in several changes of water, a little carbonate of soda being put into the last washing water to ensure the removal of all trace of the acid. If the prints on removal from the water are placed between blotting boards and allowed to dry slowly, they will be found to remain perfectly flat and ready for mounting by any method that may be thought most desirable.

PHYSICS.

By Alfred C. G. Egerton, B.Sc.

IS SODIUM RADIOACTIVE?—It is a somewhat striking fact that potassium and rubidium are radioactive; that is, they emit spontaneously radiations consisting of negatively charged particles, or β-rays. The electrical effect produced by these rays from potassium is only about a thousandth of the effect produced by the radiations from an equal weight of uranium. Experiments seem to show that this small effect is due to β-particles spontaneously emitted from the potassium or rubidium atom, and that these atoms can therefore be described as being radioactive. N. Campbell, who made this interesting discovery, has continued his researches on the feeble activity of substances and has investigated what are termed the δ-rays—rays which are too feeble to ionise a gas and render it capable of conducting electricity. The energy in ergs necessary to ionise an atom is $4 \cdot 2 \times 10^{-11}$; hence if the velocity of the electrically charged particle which collides with the atom is less than $\sqrt{\frac{4 \cdot 2 \times 10^{-11}}{\frac{1}{2}m}}$, *i.e.*, $3 \cdot 6 \times 10^{8}$ centimetres per second, where m (the mass of the electron) is equal to $6 \cdot 5 \times 10^{-28}$ (the mass of the electron bears the same ratio to a grain of wheat as the latter does to the whole mass of the earth), the electron will not be able to ionise the atom, and can only be detected by the charge it carries and can give up to a conducting body. The velocity of such δ-rays have been measured and are of the order 3×10^{8} centimetres per second, or smaller than the velocity necessary to ionise an atom of a gas through which they pass.

Now sodium is in the group of elements which are similar to potassium and rubidium, but no radiations are detectable from it, neither does lithium give any measurable radiation. It is curious that there should be these two elements, potassium and rubidium—more or less light atoms as compared with the heavy, unstable, radioactive elements such as uranium, radium, and thorium—which show radioactivity and stand alone in this respect. Such a fact raises the question whether most elements do not emit characteristic radiations spontaneously to a slight extent, but that the radiations are moving too slowly, and the radioactive changes are proceeding too slowly, both for the rays to be detected by their ionisation or for the rays to be detected by the sum of their individual charges.

Some evidence for the radioactivity of sodium has been brought forward by F. C. Brown in *Le Radium* for October, 1912. Although no measurable radiation is emitted by it, yet from certain geological considerations there seems to be some reason for the view. Joly has calculated the age of the earth from the salinity of the ocean and the amount of salt carried down to it by the rivers. The value is seventy million years. However, from the amount of helium or of uranium in rocks a measure of the age of the earth is also obtained, and this makes the figure four hundred and twenty million years. Consequently, if the latter value is correct, there is too little salt in the ocean or too much carried down at the present time by rivers; if sodium was a member of a radioactive series of elements there would be too little sodium in the ocean and too much in the rivers, and in support of the actual fact the proportion of sodium to chlorine in the rivers would be such that the sodium would be in excess, whereas in the sea the reverse would be the case.

ZOÖLOGY.

By Professor J. Arthur Thomson, M.A.

BREEDING LEECHES.—M. Moshin Khan gives an interesting account of the breeding of leeches in the United Provinces of India. It is the occupation of a class of people called "Chohra." In April or May selected leeches are put in earthen pots with "hair-cleaning clay" and a little water, and the pots are put out of reach of all disturbances; for the leeches are very sensitive when laying their cocoons. When these are formed and have hardened, they are picked up and put into closed cups of clay, which are changed every alternate day for a fortnight. Then the breeders help the young leeches out by breaking the shells. Each cocoon contains five or six young ones. The young leeches are reared in fresh water, and the breeder gives them meals from his own body. Those that are sold for medical purposes are said to lose their power of breeding; so special "seed leeches" are put aside. A leech stops sucking at once if there is any pus mixed with the blood of the patient. The Chohra cleans a gorged leech by puncturing it dorsally near the head and pressing the blood out from the tail forwards.

AN INSECT PROTECTED BY ITS MEALS.—Dr. A. Ch. Hollande, of Nancy, reports a very interesting case of protective coloration. The flower-buds of one of the mountain mulleins, *Verbascum nigrum*, are pierced in autumn by the larva of a Curculionid beetle called *Cionus olens*, which eats the violet hairs of the stamens. The violet vegetable pigment (anthocyan) eaten by the grub passes down the food-canal and, as usual, into the blood (in some uncoloured form). It is carried to the fatty bodies and accumulates there in numberless granulations, again of a violet colour. The colour, shining through the brownish integument, makes the grub most effectively harmonious with the colour of the stamens amid which it works.

DEATH-FEIGNING IN INSECTS.—This very interesting reäction has been carefully studied by Professors H. H. P. Severin and H. C. Severin with especial reference to *Belostoma* and *Nepa*, two water-bugs. The death-feigning positions are characteristic and definite, unlike those of the dead insects. The average duration of the "feint" in *Belostoma* was eight hours, and it is proved that the length is affected considerably by the external conditions of drought and illumination. The death-feint continues even when the head of *Belostoma* is cut off, and decapitated specimens will often swim freely after arousing from the feint. Both the water-bugs studied are very sensitive to contact stimuli, and in both species there is a marked propensity to cling together and form clusters. The investigators do not think that there is any conscious effort to deceive enemies through the death-feigning. The act is non-intelligent and wholly instinctive.

FECUNDITY OF THE POMACE-FLY.—In some Lepidoptera the reproductivity of the adult female depends wholly on the nutritive conditions of the larva. In other cases like the blow-fly, almost everything depends on the nutrition, of the adult. In the pomace-fly, *Drosophila ampelophila*, the nutritive conditions of any period have their effect on the number of eggs produced and laid by the female fly. This has been shown very clearly by Emile Guyénot. Immature flies fed on potato become mature in seven to thirteen days and lay an egg per diem; but those fed on potato and yeast become mature in four to five days at the most and lay ten to fifteen eggs per diem to begin with, and twenty to twenty-five later on. Mature females fed on yeast while immature, but afterwards placed on potato diet, begin to lay a day after their emergence, and they exhaust themselves towards the end of the third day, thereafter producing only one or two in a day. But their sisters, kept on potato and yeast, continue producing a regular twenty to twenty-seven eggs every day. Thus the influence of nutrition on fecundity is made very clear.

CAVE SPIDERS.—Louis Fage has made a study of a family of spiders, Leptonetidae, whose members are almost all restricted to caves and grottos. There are some interesting features. Thus it is not usual to find more than one species in one cave, as if there were some intolerance of strangers in the darkness. The webs spread among the stalactites and roughnesses are very large and delicate. The spinners move very slowly. If there is the least disturbance they either quicken their pace or play possum with their limbs laid along their body. In most spiders the males are found only at certain seasons, but in the uniformity of the caves they are found all the year round. The reproduction is not punctuated. In the few cases where the eggs are known, the interesting feature is that each cocoon contains very few, but these are large. In some cases there are only two eggs; in *Telema tenella* there is only one in each cocoon. It is two-fifths of a millimetre in diameter and the whole spider is only about a millimetre. The adaptation here is that the young spider is vigorous when hatched. It has had the advantage of a big legacy of yolk.

INFLATION IN FISHES.—For a very long time it has been known that many globe-fishes and their relatives have the power of inflating themselves and floating on the surface. Nils Rosen has been studying the mechanism of the inflation. It is the air-sac that is filled—by swallowing movements. The air is kept in by means of circular muscles in the wall of the gullet and by a valve, or by means of a special closing muscle. As a result, the body is like a football, and if there are spines they stand out. The Diodons turn upside down and are driven about on the surface of the sea by waves and currents. It is a protective adaptation. The air-sac is emptied by the relaxation of the muscles mentioned above and—in Diodons and Tetrodons, at least—by the action of the ventral body muscles, which are adapted to this purpose.

GIZZARD OF BEETLES AND ORTHOPTERA.—It has been too hastily assumed that the gizzard of insects, like the water-beetle and the cricket, functions as a mill for grinding up hard parts. Willy Ramme finds that it is mainly an organ which allows some of the digestive juice of the mid-gut to pass through into the crop, and which works up a sort of mash of food and digestive juice. In all the insects studied the digestive juice of the mid-gut was found in the gizzard (or proventriculus) and in the crop. In *Dytiscus* the indigestible parts, *e.g.*, chitinous fragments, are kept back by the proventriculus and passed out again. In Orthoptera the indigestible debris passes on through the intestine.

FUNGUS GROWING ON HAIR OF ECHIDNA.—Karl Toldt reports the occurrence of an entirely new hair-fungus which he found spreading its hyphae over and in the cortical substance of the bristle-like hairs of *Zaglossus (Proechidna) bruijni* from New Guinea. He suggests that an examination of the hairs of the rarer mammals would reveal the existence of some new and interesting Fungi.

HOW MUCH DOES A STARFISH SEE?—At the end of each arm in the common starfish there is a little red eye. It is sheltered at the base of the terminal tube-foot, which has become altogether sensory. The eye or eye-cushion shows numerous little cups, each closed by a lens, lined by red rod-like sensory cells, clothed externally by supporting cells, and containing a transparent watery substance. Hellmuth Plessner has recently made a number of experiments at Heligoland in order to discover how much a starfish sees with these "eyes," or eye-spots. The answer is: Not very much. It does not form an image nor does it perceive a moving object. But it has considerable sensitiveness in distinguishing different degrees of light and shade. Even the skin of the starfish is responsive to differences of illumination in the immediate vicinity, but by means of its "eyes" the starfish becomes aware of distant illumination that differs, either positively or negatively, from that of the immediately surrounding area.

FERTILISATION AND CONJUGATION.—When an egg is fertilised there is an intimate and orderly union of the nuclear elements of the egg-cell with those of the sperm-cell. The number of chromosomes in each has been reduced during the ripening process to half the number which is normal for the species in question. Thus in fertilisation there is a restoration of the normal number. It must also be admitted that the spermatozoön brings with it an extremely minute quantity of cytoplasm, which probably has some significance. It is also well known that the spermatozoön introduces into the egg-cell a centrosome, which divides into two and plays an important rôle in the subsequent segmentation. The fertilising spermatozoön keeps the egg from dying, as in all ordinary circumstances it would otherwise do, and gives it some initiative to development. In certain cases (of artificial parthenogenesis) this part of the sperm's rôle can be replaced by chemical or physical stimulus. But the other main rôle—the mingling of two inheritances—is something quite apart and more distinctively vital. Now it is interesting to find that the careful experiments made by Professor H. S. Jennings on conjugation in Paramoecium, the slipper-animalcule, all point to the conclusion that conjugation does not effect any rejuvenescence, its meaning being rather to secure biparental inheritance, which often means variation. When the conditions of life are untoward, conjugation is apt to occur, and it may be followed by new combinations of qualities, some of which are suited to the altered conditions of life. In those infusorians conjugation implies a loss of vigour, but it promotes variations some of which pay by securing survival.

REVIEWS.

ASTRONOMY.

Daytime and Evening Exercises in Astronomy.—By S. F. WHITING, Sc.D. 104 pages. 26 illustrations. $7\frac{1}{2}$-in × 5-in.

(Ginn & Co. Price 3/6.)

This book is written for schools and colleges. The aim of the authoress is to encourage and direct the teaching of astronomy during the *daytime* (and night also) instead of waiting for night instruction only. The method proposed is to make practical acquaintance during the daytime with many objects and branches of astronomical work, by means of the study of models, globes, photographs, and other apparatus, as set out in forty-five exercises. She has certainly succeeded in putting a good deal of facts and questions into these hundred pages; but the book is primarily an aid to study and work, and should be useful to teachers. If the book is intended to be used here we think that, in another edition, the articles mentioned on pages xi–xiv should not be restricted solely to U.S.A. goods; but, as equally good apparatus and books are known and can be readily obtained in this country, we suggest that these be given as alternatives; many of the names now given are quite unknown here. We would further suggest some considerable reduction in the price. The Index is very meagre and of little use: we looked for six important items given in the book—four were not in the index.

F. A. B.

Annales de l'Observatoire Royal de Belgique.—Physique du Globe. Tome V., Fasc. III. 197–308 pages. $12\frac{1}{2}$-in. × $9\frac{3}{4}$-in.

(Hayez, Bruxelles.)

This is a continuation of a long series of observations made at the Belgian National Observatory at Uccle. The present part contains the Hourly Magnetic Observations made at Uccle in 1911 and their discussion by A. Hermant, seventy pages and two plates; Observations of Atmospheric Electricity in 1910 and 1911 and their discussion by A. Hermant, twenty-five pages and four plates; and the Temperature of the Sun (*i.e.*, the Earth) at different depths in 1911. From this last section it may be seen that thermometers placed at depths of $0^{m}\cdot1$, $0^{m}\cdot2$, $0^{m}\cdot3$, $0^{m}\cdot6$, $1^{m}\cdot0$, $1^{m}\cdot25$ and $1^{m}\cdot50$ all record the (mean) maximum temperatures in August, that at one and a half metres being nearly the same in September; while the (mean) minimum temperatures occur in January for the first four depths, at one yard the retardation or greater deviation from the external air temperature becomes pronounced, and the (mean) minimum is not reached until the month of February; the mean temperatures at all these depths in March and September are very similar: the range is within half and one degree (centigrade) respectively. But we think the means for such periods as thirty days are much too long and mask interesting facts.

F. A. B.

L'Astronomie: Observations, Théorie et Vulgarisation Générale.—Par M. MOYE. 396 pages. 4 plates. 43 figures. $7\frac{1}{4}$-in. × 5-in.

(Paris: O. Doin et Fils. Price 5 francs.)

This is one of an extensive series called "Encyclopédie Scientifique," published under the direction of Dr. Toulouse, Directeur de Laboratoire à l'École des Hautes-Études. There is a short account or preface of six pages on the "Bibliothèque d'Astronomie et Physique Céleste," by J. Mascart (Director of the Lyons Observatory, who is to be the astronomical editor of the series), in which there is a discussion of the influence of various other sciences upon astronomical knowledge, the reasons given for these books, and the lines upon which they will be written. It is intended to publish twenty-nine volumes upon astronomical subjects, of which this volume by M. Moye is No. 1; there are three others already published. The series is therefore a composite one so far as concerns authorship, and it is intended that each volume shall contain about three hundred and fifty to four hundred pages, with illustrations, in cloth, and be sold separately at five francs.

The spirit in which the book is written may be given in the editor's own words:—"Une notion prévaut pourtant le caractère mystique, ardu et rébartif, de la science astronomique, science réservée aux plus savants des savants et dont la moindre teinture semble donner à ses adeptes figure de profonds techniciens. Au risque de perdre notre auréole, nous avons au contraire essayé de démontrer la facilité avec laquelle on peut mettre l'astronomie à la portée de tous ceux qui veulent en apprécier les philosophiques jouissances."

The book is not a text book or handbook replete with references, authorities, quotations, formulae, calculations, or tables of figures; nor is it quite of the scrappy popular form, with speculations frequently bubbling out, appealing to the senses. It takes its place as an introductory book to general astronomy, and is just suited to young folks at high schools, in their Continental sense; for a university course it is too popular and elementary. Most of the very numerous features and facts in astronomy are referred to in a pleasant reading and concise form. The type and figures are not too fine, a frequent fault in French books; the paper is poor. We still notice the persistence of the use of French words for the constellations. When will the French astronomers come into line with the rest of the world and use the Latin designation? At the end there is a useful list of books consulted; also an index, which is very poor and incomplete. On page 277 the author erroneously attributes the discovery of the crape-ring to Bond and Dawes, and not to Galle; and the date given, 1858, should be 1850. Galle's observation of the crape-ring was made and published in 1838.

F. A. B.

CHEMISTRY.

Gas Analysis.—By DR. HARTWIG FRANZEN. Translated from the German by F. CALLAN, M.Sc., Ph.D. 120 pages. 30 illustrations. $7\frac{1}{4}$-in. × $4\frac{3}{4}$-in.

(Blackie & Son. Price 2/6 net.)

This little book should be found of great use as an introduction to the larger works on gas analysis. Little knowledge of the subject is assumed, and the directions for using all the more simple forms of apparatus are sufficiently full and clear for any beginner to follow, while excellent diagrams are provided where necessary. The book is divided into two sections, the first of which gives the methods of analysing the common gases, while the second contains some of the principal applications of gas analysis in the examination of inorganic substances. By the way, the title of this section—"Volumetric Gas Analysis"—is somewhat misleading. Tables of the chief physical data required in gas analysis are appended, but it is a drawback to an otherwise excellent book that no index is given, and that the reader has to search through the list of exercises for what he requires.

C. A. M.

Qualitative Determination of Organic Compounds.—By J. W. SHEPHERD, B.Sc. (Lond.). 348 pages. 20 illustrations. 7-in. × 5-in.

(W. B. Clive. Price 6/6.)

A successful attempt is made in this book to systematise the analysis of organic compounds upon similar lines to those followed in the examination of inorganic substances. The arrangement is distinctly novel and gives a clearer view of the principles underlying organic analysis than any other book with which we are acquainted. The first part deals with the characteristic reäctions of the different groups of organic compounds, while in the second part the reäctions are classified and illustrated by typical examples drawn from the different groups. The class to which a given substance belongs having been discovered by systematic tests, the substance may then be identified by its physical properties, and for this purpose a good tabular index is provided.

Enough has been said to show the value of the book, not only as an aid to examination, but also as a practical guide to the student of organic chemistry. It is of necessity concise, but it suffers in places from too much condensation, and this is particularly noticeable in the section on Enzymes. In this connection we notice that the author alludes to the coagulation of blood as a fermentative process—an hypothesis which lacks confirmation. The book would gain much if a section were added on the qualitative analyses of dyestuffs upon the same lines as those devised for the substances dealt with in the other sections.

C. A. M.

The Atmosphere.—By A. J. BERRY, M.A. (Cambridge Manuals of Science and Literature.)
146 pages. 5 illustrations. $6\frac{3}{4}$-in. × 5-in.
(The Cambridge University Press. Price 1/- net.)

The first impression after reading this little book is a feeling of wonder how so excellent an account of the scientific investigation of the atmosphere can be produced at so low a price. The subject is treated purely from the chemical and physical standpoint, and omits nothing of importance from the days of Galileo to the present time. Separate chapters are given to liquid air, radioactivity, the inert gases, and so on, and there is a most interesting outline of the views and speculations upon the probable composition of the atmosphere in prehistoric times. Every page of the book is readable, and all points in dispute are stated fairly and without bias. Portraits of Boyle, Priestley, and other early chemists add to the interest, and there is a good bibliography and index. In short, this is a model of what a popular scientific book should be.

C. A. M.

One Hundred Simple and Exact Mathematical Proofs that the Valencies of Carbon are Unequal.—By HAWKSWORK COLLINS, B.A. (Cantab.). 110 pages. $8\frac{1}{4}$-in. × $5\frac{1}{2}$-in.
(Morton & Burt. Price 7/6 net.)

This volume is a sequel to the author's "The Relative Volumes of the Atoms of Carbon, Hydrogen, and Oxygen when in Combination," reviewed in "KNOWLEDGE" for January, 1912. In it Mr. Collins shows how his method of calculating molecular volumes may be extended to bodies containing the halogen elements. So far as the results go the atomic volumes of chlorine, bromine, and iodine in combination with carbon are constant, being 23·01, 27, and 32·75 respectively, whilst carbon, hydrogen, and oxygen have the same values as before. The calculated values are in extraordinarily good agreement with the experimental results of various investigators, as was also the case in the former volume. In view of this fact it is difficult to understand why Mr. Collins's calculations do not receive greater attention from physical chemists. His books are certainly worthy of this, whatever views may be held concerning his theory of valency. As I mentioned in the former review, Mr. Collins explains the fact that hydrogen may have, according to the configuration of the molecule, any one of four different values, by the theory that the valencies of carbon are unequal. No doubt this would explain it; but more than one alternative hypothesis is possible; and so this peculiarity in the calculated atomic volume of hydrogen cannot be regarded as proving the inequality of the carbon valencies. Further calculations dealing with the molecular volumes of compounds containing other elements are promised by Mr. Collins, and will no doubt be awaited with interest by those who can value calculations of this sort, and can appreciate the labour involved in making them.

H. S. REDGROVE.

ECONOMICS.

The Economics of Everyday Life.—A First Book of Economic Study. By T. H. PENSON, M.A. Part I. 176 pages. 48 tables and diagrams. $7\frac{3}{4}$-in. × $5\frac{1}{4}$-in.
(The Cambridge University Press. Price 3/- net.)

This work forms an admirable introduction to the science of economics, and should meet the requirements of both the general reader and the student who is just commencing a study of the subject. The author's language is clear and simple; he is careful to give accurate and precise definitions to the terms he employs ("wealth" and "labour" may be noted as particular instances); and the frequent use of diagrams aids greatly in enforcing the meaning of the text. Part I of the work is divided into four books, dealing respectively with introductory matters, production, exchange, and distribution. Part II will deal with consumption, taxation, and trade unions and coöperative societies.

A few points call for criticism. Mr. Penson explains the construction of demand and supply curves, but he omits to point out that if both curves are drawn to the same axes, the market price of the commodity dealt with (under the simple conditions considered) is given at the point where the curves intersect: this would probably not be obvious to readers unacquainted with graphic algebra. In dealing with the division of labour Mr. Penson notes both the advantages and the disadvantages, but, whilst insisting on the former, unduly depreciates the latter. Up to a certain point (*i.e.*, into trades and professions) the advantages are immense and the disadvantages very slight. But when division is carried to the extent of incomplete processes, the gain to the community (or, rather, to certain members of it) is, I suggest, outweighed by the loss to those who are engaged in carrying out such incomplete processes. It is thus that the factory system arises with its many evils, especially the non-ownership by the workmen of the tools of his trade, which largely destroys his liberty and tends to make him the slave of the capitalist. Moreover, the happiness of a community depends, not only upon its wealth (*i.e.*, upon what it possesses), but upon what it does; and it cannot be denied that the carrying-out of incomplete processes is soul-destroying work, though such considerations, perhaps, belong to ethics rather than economics.

In enumerating the advantages of the large retail store over the small business Mr. Penson says that "the large scale tends to the accumulation of large amounts of capital in few hands, and thus to the amassing of large fortunes" (page 77). I cannot in the least understand in what sense this can be held to be a genuine "advantage."

In concluding the volume Mr. Penson writes: "Whether or not the existing system of distribution satisfies the claims of justice or achieves the best social results is quite outside the scope of the present work. In dealing with this question as with others the aim has been to point out and to explain things of everyday occurrence, to illustrate and to arouse interest in the economics of everyday life." That, of course, is the right attitude to take in an introductory work, in which economics must be treated as a natural, and not as a normative, science. Normative economics must come afterwards; but from the first, I think, we must be impressed with the fact that, whilst the skill and ability of the workman or organiser are inseparable from the man himself, capital *is* separable from the capitalist; hence that, whilst the workman and the organiser are of value to the community, and should be remunerated for their services, the capitalist is not only useless, but acts as a clog on the free flow of money.

H. S. REDGROVE.

ETHICS.

The Faith of all Sensible People.—By DAVID ALEC WILSON. 124 pages. $6\frac{1}{2}$-in. × 4-in.
(Methuen & Co. Price 2/6 net.)

The title of this book, and the claim made for it that the title is justified, strike one as somewhat pretentious, and the author's style savours of dogmatism. But the book contains a good many sound common-sense maxims on a variety of topics, which show the predominant influence of Confucius. The writer believes in evolution, but rejects the theory of natural selection as unproven, though he offers no alternative thereto. In passing, I might note that the acceptance of natural selection as a scientific law by no means involves the acceptance of the materialistic metaphysics which frequently go along with it. Mr. Wilson has a keen dislike of transcendental metaphysics, and he asserts that we do and can know nothing of a life after death, if such there be. This, of course, is sheer dogmatism. Experimental psychology has not yet said the last word on the subject, nor is it scientific to reject, without examination, the testimony of the religious consciousness. When, however, Mr. Wilson discourses on the value of knowledge, of perseverance and hard work, and on the advantages of the married state, most readers will agree with him. He explains that his object in writing the book was "to distil knowledge from current speculation" and to "show to the man in the street in plain words that the materialism so widely believed is not science but pseudo-science." But though I can fully sympathise with this object, I do not think it has been accomplished in "The Faith of all Sensible People."

H. S. REDGROVE.

MATHEMATICS.

The Nature of Mathematics.—By P. E. B. JOURDAIN, M.A. 92 pages. $6\frac{1}{2}$-in. × $4\frac{1}{4}$-in.

(T. C. & E. C. Jack. Price 6d. net.)

This is a volume in the series entitled "The People's Books." Mr. Jourdain does well to indicate the practical value of mathematics and in emphasising the importance as concerns the history of mathematics of Mach's view that "science is dominated by the principle of the economy of thought." But from the standpoint of the general reader the book cannot be regarded as satisfactory. In the first place there are no diagrams to assist him in understanding the text. Moreover, the explanations, notably in the case of logarithms and "imaginary" quantities, are wholly inadequate to his needs. Dealing with the latter subject, the author says, "If we are given the equation $x^2-1=0$, its solutions are evidently $x=+1$, or $x=-1$, for the square roots of $+1$ are $+1$ and -1." He has not explained the multiplication of negative quantities, and so to the non-mathematical reader the "evidently" will come as a surprise. There is much else in the book of a similar nature. Of course, in so small a compass it is impossible to deal with the vast subject of mathematics adequately, but I think much of the space filled with talk about the "logical basis of mathematics" might have been better occupied with something about modern non-Euclidean geometry, and, if possible, vector-analysis as well. Mr. Jourdain distinguishes between mathematics and our knowledge of mathematics, and I gather that when he speaks of mathematics as having a purely logical basis he is denying that it is an empirical science. Mathematics, no doubt, makes larger use of deduction than any other science, but like all other sciences it is inductive at the basis. It is experience, not logic, that enables us to assert that $1+1=2$.

H. S. REDGROVE.

The "Method" of Archimedes, recently discovered by Heiberg. (A Supplement to "The Works of Archimedes," 1897.) Edited by Sir THOMAS L. HEATH, K.C.B., Sc.D., F.R.S. 51 pages. 15 figures. $8\frac{1}{2}$-in. × $5\frac{1}{2}$-in.

(The Cambridge University Press. Price, 2/6 net.)

Heiberg's most valuable find is of the greatest value to those who are interested in the history of mathematics; that portion of it consisting of a work hitherto supposed to have been irretrievably lost is here presented in a convenient English dress and in modernised terminology. The Greek geometers, in their formal treatises, present the subject matter in a purely logical form, giving no hints as to the methods they employed in making their discoveries. The "Method" of the great Archimedes is, however, not a formal treatise, but a letter to a student; and in it he lays bare the manner in which he discovered a number of propositions concerning the areas, volumes, and centres of gravity of certain figures. The two chief propositions concern the volumes of two solids with one or more curved surfaces, which can be expressed exactly in terms of rectilinear solids. The method of discovery is a peculiarly interesting and ingenious one, making use of the mechanical concepts of moments and equilibrium, for which reason Archimedes did not regard it as supplying rigid proofs of the propositions discovered by its aid. He therefore supplied what he regarded as sufficiently rigid proofs of the propositions, partly here and partly in other works, though nowadays the mechanical proofs would be quite rightly regarded as sufficiently rigid. It is interesting to note that, in one case at least (namely, in the mensuration of the sphere), the order of discovery is not that of logical development; a fact which may very well be advanced against the once common idea that the best order of presentation in the teaching of geometry is the logical one. Students of the history of mathematics are under a large debt of gratitude to Sir Thomas Heath for this most valuable translation.

H. S. REDGROVE.

ORNITHOLOGY.

British Birds' Nests: How, where and when to find and identify them.—By RICHARD KEARTON, F.Z.S., F.R.P.S. 518 pages. With many plates and illustrations. $9\frac{1}{4}$-in. × 6-in.

(Cassell & Co. Price 14/- net.)

Mr. Kearton's book is really a new edition of his "British Birds' Nests," with the addition of the best pictures that were published in another of his volumes, entitled, "Our Rarer British Breeding Birds," with others which have been more recently secured. A feature of the present book is the arrangement by which it is easy to find particulars of the nesting sites and materials as well as the eggs of many of our British Birds. The coloured plates of the Lapwing's nest and eggs, as well as that of the Tree Pipit's nest, are exceedingly good; and the figures of eggs reproduced by the three-colour process from actual specimens adds greatly to the usefulness of the work. It is evident that many photographs of the birds, especially those of the more timid ones, such as the Water Rail, must have been a great trouble to secure; and among the interesting points incidentally mentioned is one concerning Rooks which built on chimney-pots. As a book of pictorial records Mr. Kearton's "British Birds' Nests" is most charming, and as a book of reference is of considerable merit.

G. K. W.

PSYCHOLOGY.

Psychology.—By HENRY J. WATT, M.A., Ph.D., D.Phil. 90 pages. 8 figures. $6\frac{1}{2}$-in. × $4\frac{1}{4}$-in.

(T. C. & E. C. Jack. Price 6d. net.)

This is a volume in the series entitled "The People's Books." It is an interesting little introduction to the study of psychology, written upon somewhat different lines from that of most elementary text books on the subject, being less formal and schematic. Its condensed style, free use of technical terms (the meanings of which are not always explained), and the emphasis put upon the as-yet-unsolved problems of psychology cannot do otherwise than make it a somewhat "difficult" book for the general reader.

In dealing with the question of the empirical distinction between sensation and imagery, Dr. Watt points out that the mere degree of intensity does not supply an adequate basis of distinction. He adds: "The distinction of sensation and imagery must therefore depend upon our ability to say whether an experience has come about through impression from a real object or not. This is often expressed by saying that in dreams we take our imaginations for reality, because we have no reality by us to compare with them." This begs the question at issue; for what this question asks is: How can we distinguish between reality and imagination, or, rather (so as not to perpetuate the common misuse of the term "reality"), how can we distinguish objective from subject reality? I think that Berkeley adequately answered this question to the effect that sensations occur in definite orders and series ("laws of nature") lying without the control of our will, whereas imagery occurs, to a large extent, in what order we please.

There is a short but telling criticism of the Lange-James theory of the emotions in the book, and Dr. Watt well concludes by insisting on "that magnificent jewel that delights the eyes of all men and never wearies—the reality of effort."

H. S. REDGROVE.

ZOÖLOGY.

A Bibliography of the Tunicata, 1469–1910.—By JOHN HOPKINSON, F.L.S. 288 pages. 9-in.×$5\frac{1}{2}$-in.

(Dulau & Co. Price 15/- net.)

When Mr. John Hopkinson was preparing for publication Alder & Hancock's "British Tunicata" he compiled a bibliography for his own use, bringing matters up to the year 1870, and later, after consultation with Canon Norman, he decided to extend it to the year 1910. This has now been printed and forms one of the volumes published by the Ray Society for the year 1912. The care with which Mr. Hopkinson works is well known, and though he has been assailed with various difficulties he has produced a volume which will be of very great assistance to students of the Tunicata, while he has made up for any little deficiencies due to the printing of the work in two parts by appending an addenda of twenty-five pages.

W. M. W.

The British Parasitic Copepoda.—By THOMAS SCOTT, LL.D., F.R.S., and ANDREW SCOTT, A.L.S. Volume I. Copepoda Parasitic on Fishes. 256 pages. 2 plates. 9-in.×$5\frac{1}{2}$-in.

(Dulau & Co. Price 15/- net.)

This, the second of the volumes published by the Ray Society to subscribers for the year 1912, consists of the text of Messrs. Scott's work, with two plates. The bulk of the plates will appear as a volume for 1913. The Ray Society published in the years 1878–1880 a monograph of the British Free and Semi-parasitic Copepoda, by Dr. G. S. Brady, and from this those forms which were truly parasitic on fish were expressly omitted. Dr. Brady suggested that they should be dealt with in a separate volume, and Messrs. Scott have now produced it. With very few exceptions recent specimens have been examined and carefully dissected. The result is a series of very careful descriptions, to which are added details of the habitats.

W. M. W.

NOTICES.

THE ROYAL INSTITUTION.—A General Meeting of the members of the Royal Institution was held on the afternoon of June 2nd, the Duke of Northumberland, President, in the chair. Mr. L. R. Guthrie, Mr. G. W. Heath, and Mr. R. Malcolm, were elected members. The Chairman reported the death of the Right Hon. Lord Avebury, a member of the Institution for sixty-four years, and a resolution of condolence was passed.

SECOND-HAND PHYSICAL APPARATUS.—Messrs. Newton & Company announce that owing to the great development of their optical business they can find neither time nor space for their Philosophical and Physical Apparatus Department, and are therefore disposing of the whole of their stock at a low valuation. A catalogue has been issued, including demonstration apparatus in Electricity, Chemistry, Pneumatics, Sound, and so on.

ADDITIONS TO THE ZOÖLOGICAL SOCIETY'S MENAGERIE.—The number of additions to the Zoölogical Society's menagerie during the month of May was two hundred and sixty-eight, and among those which are new to the collection are two White-bearded Gnus (*Connochaetes albojubatus*) received in exchange, two Naked-tailed Mice (*Uromys bruijnii*) from Dutch New Guiana, presented by Mr. A. F. R. Wollaston, and a Chestnut-faced Barn Owl (*Strix castanops*) from Tasmania, which was purchased.

THE EAST COAST.—The east coast affords an opportunity for good work in Natural History and Archaeology, and we recommend to those who are thinking of spending their holidays there, a little book entitled "On the East Coast," by Percy Lindley, fully illustrated in half-tone and colour, which has just been issued by the Great Eastern Railway Company, and can be obtained gratis from the Superintendent of the Line.

BOOKS ON BIRDS.—Ornithologists will be interested in a catalogue which Messrs. John Wheldon & Company have just issued containing more than fifteen hundred titles. Besides general works dealing with the subject under geographical headings, sections are devoted to migration, to game and domestic birds, as well as to bird protection. No less than eighteen editions of "The Natural History of Selborne," by Gilbert White, are included under "Selborniana," with other works relating to the great field naturalist.

A NEW CAMERA.—We have received an intimation that in anticipation of the holiday season, to which the taking of photographs adds a great charm, the Optical Works of Messrs. Goerz are introducing a new "Tenax" camera. The working of this is simplicity itself, and it has an accurately graded shutter as well as all the movements required. Added to this it is fitted with one of the world-famous Goerz lenses, and the scientific worker who wants a camera will feel quite happy in taking advantage of what has been done for his lay brethren.

ENGLISH MICROSCOPES.—We have pleasure in calling attention to Messrs. James Swift & Sons' catalogue of Microscopes and Accessories. In runs into seventy pages and contains figures and descriptions of the more important of the well-known microscopes which this firm produces. There are some pieces of apparatus of particular use in certain cases that may be mentioned, such as the Stevenson Binocular Microscope for delicate dissection; the simple cone camera for attachment to the draw tube of the microscope, and the stereoscopic photomicrographic attachment designed by Professor Herbert Jackson, which gives perfect stereoscopic photographs of suitable subjects under the microscope.

MACMILLAN'S NEW BOOKS.—The catalogue of new books which has just been issued by Messrs. Macmillan contains among the notes, some details of the life of Miss Octavia Hill, and in the classified list of books recently issued we notice several on Archaeology and Agriculture. Mayo's "Diseases of Animals" has been increased in price from 6s. 6d. net to 8s. 6d. net, and "Franklin's Electric Lightning" from 10s. 6d. to 12s. 6d. Volume XC of *Nature*, September, 1912–February, 1913, is now ready, price 15s. net.

NESTING BOXES.—The great benefits which many birds confer on the agriculturist and the forester have long been appreciated in foreign countries, and recently it was pointed out in the press how the Thirlmere plantations had been saved from the attacks of the larch saw-fly owing to the provision of nesting sites by the Manchester Corporation. In this connection it is interesting to chronicle that the Royal Agricultural Society has specially invited the Selborne Society to send a representative series of its very successful nesting boxes to the Forestry Exhibition, which will be held in connection with the Royal Show at Bristol from July 1st to the 5th.

THE EMU.—Messrs. Witherby & Co. have been appointed European Agents for *The Emu*, the organ of the Royal Australasian Ornithologists' Union, and copies of that publication can now be obtained at 326, High Holborn.

THE NATIONAL PHYSICAL LABORATORY.—The Annual Meeting of the General Board of the National Physical Laboratory was held recently at the rooms of the Royal Society, when the report and accounts for the year 1912 and the statement of work for 1913 were presented and approved for transmission to the President and Council of the Royal Society.

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

AUGUST, 1913.

THE STREAMLESS DOWNS AND THEIR DRY VALLEYS.

By G. W. BULMAN, M.A., B.Sc.

ONE of the most striking things on the Chalk Downs of the south of England is the absence of streams.

> "We have no waters to delight
> Our broad and brookless vales,
> Only the dew-pond on the height
> Unfed that never fails."

And the reason is obvious. The substratum of chalk is so pervious that the rain sinks into the rock at once, and none can run off to form streams. Another feature of the Downs are the numerous dry valleys, which look as if they had been carved by water. We may call the coëxistence of the two features the puzzle of the physical geography of the Downs. If there are no waters to cut them out, to what do we owe "Our broad and brookless vales"?

In the "Memoirs of the Geological Survey" ("The Geology of the Country round Eastbourne") we find the following suggestion by Mr. Clement Reid:—

"Such a feature in the pervious chalk cannot be accounted for by any change in the amount of rainfall; it points to other conditions which have now passed away. It is in all probability a relic of the Glacial Epoch, which in these southern districts did not lead to an accumulation of ice, but caused the rocks to freeze to a great depth, thus rendering them impervious to any rain that might fall in the summer. During that period the chalk would be cut into valleys in the same way as any impervious rock, instead of immediately absorbing the heaviest rain, as it does at the present day."

Any suggestions coming from so distinguished a geologist as Mr. Clement Reid must be received with due respect, but there seems to be more than one fatal objection to this explanation. It assumes, in the first place, that the porous chalk became saturated with water to the surface, and was then frozen hard. But if the rain sank into the chalk as it does to-day this could never happen. Even after the wettest season the line of saturation never rises to near the surface.

In the second place, is there any ground for the belief that during glaciation the ground would be frozen to great depths? As a matter of fact, in glaciated regions to-day ice and snow seem to keep the earth warm. For there always seems to be water under the glacier and ice-sheet. Mr. Reid, however, seems to suggest that the southern parts of the country were not covered with ice or snow during glaciation. But we cannot hypothesise a sufficiently heavy snowfall in the north to produce glaciation, and none or very little in the south. Nor can we suppose there was a summer rainfall sufficient to cut the valleys without admitting a corresponding snowfall in the winter. Would not, then, the Downs be covered with snow and the ground thus kept from freezing? And even if summer began with a frozen ground, would it not begin to melt simultaneously with the first rain? We further venture to think that if these dry valleys in the chalk had been carved during the glacial period they would now show signs of filling up. For there must be some movement of material into them from the higher ground at the sides, and there has been time for some to be almost obliterated. But instead of thus growing less they seem rather to be still in course of formation.

We venture, therefore, to suggest as a tentative hypothesis that our dry chalk valleys are the lines of underground waters comparable to the Oueds of the African deserts; not as to origin, but in the fact that they are underground rivers. The Oueds of the Sahara are buried rivers, but to-day no rivers are to be seen, only more or less fertile valleys in the desert marking their courses. The rivers have been buried by the drifting sand, but their waters still pass along the old channels. In a different way we suggest that the waters of the Downs have become underground streams, which have made their own now streamless vales. Suppose the line of such a valley lies among the main dip, and that rolls in the chalk cause minor dips on both sides towards this. The rain sinking into the chalk will descend till it reaches an impervious substratum. Then it will soak on both sides towards the central lines of the valley. Reaching this it will, along with what reaches it directly from the surface, flow or soak along the main dip. All the time it is dissolving and carrying away the rock, and the surface gradually sinks in, as it does in the formation of swallow holes. Thus we suggest that the dry valleys of the chalk are due to subsidence caused by underground waters directed by the slopes of the strata.

The action of the underground water would be assisted in a small degree by that of the surface. For when a channel was once formed the rain water would tend to collect in the hollow in the form of soaked soil or subsoil. Here, then, the solvent action would be greater, and the making of the valley hastened. The whole is a tentative hypothesis only, but one that seems worthy of careful consideration. And, apart from any inherent probabilities in their respective suppositions, it appears to possess this advantage over the glacial hypothesis, that it views the valleys as still in the making. Mr. Reid's explanation, on the other hand, looks upon them as completed in the Glacial Epoch. And we think that there is evidence that the denuding forces are still at work, for otherwise would they not show signs of filling up? There must be a certain amount of slipping and sliding and washing of matter into the valleys from the sloping sides which would tend to obliterate them. But they do not, as we have said, appear to be growing less.

It is possible, however, that some of these valleys date back for their initiation to the time when the chalk was covered by Tertiary deposits, sandstones, clays, limestones, and so on. In these strata streams might cut out valleys in the ordinary way. When these rivers had got down to the chalk, their beds would contain sufficient clay, and so on, to prevent them altogether being absorbed. The chalk itself might have become impregnated with clay to a certain depth, and so have become impervious. This might last long enough for the stream to cut down the chalk to a certain extent. Finally, however, all clay and impervious chalk would be swept away, and the rain sink directly into the ground as it does to-day. But we need not suppose that the river which cut the valley has actually gone. It may, so to speak, have sunk into the ground, and be still carrying on its work of excavation. Obviously, at any rate, the water which normally runs off as streams and rivers is in some fashion working its way through the rocks below.

We may carry the idea of underground streams and rivers a little further. The invisible waters of the downs flow finally into a great subterranean lake which lies in the rocks beneath the lower valley of the Thames. There they are joined by a similar set of streams from the chalk hills north of London. For the chalk of the south of England dips beneath the strata of the London basin, and rises again to the north. The Tertiary rocks of the London basin, in fact, lie in a syncline or trough of the chalk, and in this the water collects. So a part of the rain falling on the Downs finds its devious way to the great subterranean reservoir over which is built the Metropolis. When an artesian well is sunk through the Tertiary beds and a part of the chalk an abundant water supply gushes out. The waters which should "delight our broad and brookless vales" go unseen to supply the deeper wells of the city of London.

ADDITIONS TO THE ZOÖLOGICAL SOCIETY'S MENAGERIE.

THE registered additions to the Society's Menagerie during the month of June were 295 in number. Of these 144 were acquired by presentation, 35 by purchase, 56 were received on deposit, 15 in exchange, and 45 were born in the Gardens. The following may be specially mentioned:—

One Pudu Deer (*Pudu pudu*), from Chili, and two Patagonian Cavies (*Dolichotis magellanicus*), from Patagonia, presented by Mr. Albert Pam, F.Z.S., on June 2nd.

Three Pumas (*Felis concolor*), born in the Menagerie on June 13th.

Two Canadian Beavers (*Castor canadensis*), from Canada, received in exchange on June 5th.

One Savanna Sparrow (*Passerculus savannah*), from North-East America, new to the Collection, purchased on June 18th.

One Ceylon Mynah (*Acridotheres melanosternus*), new to the Collection, presented by Dr. Philip H. Bahr, F.Z.S., on June 29th.

One Golden-fronted Woodpecker (*Melanerpes flavifrons*), from Brazil, new to the Collection, purchased on June 5th.

One Calthrope's Parrakeet (*Palaeornis calthropae*) from Ceylon, new to the Collection, deposited on June 29th.

One Condor (*Sarcorhamphus gryphus*), from Chili, presented by Mr. Albert Pam, F.Z.S., on June 2nd.

Two Crested Screamers (*Chauna cristata*), bred in the Menagerie on June 19th.

Two Sun-Bitterns (*Eurypyga helias*), from South America, purchased on June 16th.

One Kagu (*Rhinochetus jubatus*), from New Caledonia, received in exchange on June 27th.

Two Spiny-tailed Skinks (*Egernia depressa*), from Australia, new to the Collection, purchased on June 10th.

A collection of Snakes from Sierra Leone, including three Sooty Snakes (*Boodon fuliginosus*), new to the Collection, presented by Mr. Guy Aylmer, F.Z.S., on June 18th.

A collection of Snakes from India, including one Forsten's Tree-Snake (*Dipsas forstenii*), new to the Collection, received in Exchange on June 2nd.

Two Gopher Frogs (*Rana aesopus*), from North America, new to the Collection, received in exchange on June 2nd.

THE HAIRS OF ANIMALS.

By C. AINSWORTH MITCHELL, B.A. (Oxon), F.I.C., and R. MORRIS PRIDEAUX, F.I.C.

THE study of the hairs of animals has been singularly neglected, notwithstanding the many questions of scientific interest that it involves. With the exception of silk and wool, which now have a fairly full literature of their own, little will be found in textbooks about other animal fibres and the curious differences in structure shown by the hairs of different species of animals. In the present article, therefore, we wish to give a general outline of the nature of hair, together with some account of observations that have been made by us and not hitherto published.

In the popular view, wool and hair are usually regarded as something quite distinct, but the difference is one of degree rather than of kind. Wool may be defined as a particular variety of hair of fine texture characterised by having a more or less curled form and a surface covered with scales which tend to overlap each other. As a rule there is no medulla.

This distinction between hair and wool is by no means sharp, and it is not uncommon to find the same animal producing both types of fibres. For example, in the hair of the goat there is a lower layer of woolly fibres, and a similar mixture of the two sorts of fibre may be observed in the coats of certain breeds of dogs, such as the Bedlington terrier (Figure 299).

In the case of the Siberian sheep the nature of the hair varies with the seasons, the coat being of a hairy type in the summer, but changing to wool in the winter. The predominance of woolly fibres in the coats of ordinary breeds of sheep is largely the result of the animals having been kept for generations under exceptional conditions, and of special breeding to produce this result. When the ordinary domestic sheep is allowed to run wild, it will in the course of a generation or so produce a fleece containing a large proportion of straight fibres.

The character of the scaling upon wool is an important factor for distinguishing between the products of different breeds. For example, in the wool from the merino sheep, the scales go round the fibre, so that the microscopic appearance suggests that of a Malacca cane, with closely set joints (see Figure 295), whereas in the wool from cross-bred sheep the scales are smaller and cover only a small section of the axis of the fibre (see Figure 296). In healthy wool the scales cover the area of the fibre completely, but in certain diseased conditions the cortex will appear bare in patches. It is not uncommon, however, to find in the wool of lambs that have not yet been shorn numerous fibres from the tips of which the scales have been completely stripped by friction (see Figure 297).

The scales on the hair of animals are best examined by oblique illumination by throwing the iris diaphragm out of the optical axis of the instrument. This causes the projecting edges of the scales to catch the light in such a way that they stand out clearly.

The number of scales on a given area varies greatly. For example, Hanausek found that in one millimetre length the number of scales showed the following variations:—

Sheep's Wool (ordinary)	97	White Alpaca ...	... 90
,, ,, (merino)..	114	Brown ,, ...	... 150
,, ,, (Saxony)..	121	Vicuna... ...	... 100
Angora Wool	53	Camel's Hair ...	... 90

The cortex or surface beneath the scales frequently shows longitudinal streaks, and in the coarser types of hair a medulla or central canal may be present. This medulla may be continuous along the length of the fibre, or it may show interruptions in places, or stop abruptly. It often shows cells of characteristic form, while in other cases it is made up of granular particles. It is best examined under the microscope, with the iris diaphragm reduced to a small aperture.

Frequently it will be found that when both woolly and hair-like fibres are produced by the same animal, the former show no indications of a medulla, whereas the latter have a pronounced medulla. A good instance of this may be seen in the hair of the Cashmere goat and in that of some of the small American goats. In vicuña fibres from *Auchenia vicuna*, fine woolly hairs without medulla predominate, whereas in alpaca hair from *Auchenia paco* most of the fibres are coarse and show a medulla.

The wavy structure of woolly hairs, which is most pronounced in the finest varieties of sheep's wool, appears to be due to contractions, which are caused by the cells upon the cortex being uneven. In types of wool which approximate more nearly to hair, as, for example, that of the Angora goat or mohair, there is only a slight tendency towards curling.

Another point to which attention must be given in differentiating the fibres of different species of animals is the distribution of the pigment in the cortex. In studying this feature under the microscope as much light as possible should be transmitted through the fibres. This will cause all signs of medulla and scaling to disappear, but will render the disposal of the pigment very distinct.

In the case of sheep's wool, fibres containing black or brown pigment are relatively uncommon, whereas in the hair of the camel and many other animals, they are of frequent occurrence.

Arrangement of the pigment in dashes or lines, or in a congeries of dots, is often characteristic of the hairs of particular animals, as may be seen by reference to the illustrations of the hairs of the bears and some of the apes. The Himalayan goat or serow produces hair (see Figure 298), which may be taken as typical of the bristle type of fibres. Among the hairs will be found some so heavily charged with pigment that in places they are quite opaque. Other bristles, however, of equally coarse character contain but little pigment. In both these types of fibres the medulla is very pronounced (A), nearly down to the base, while in the dark-coloured fibres the pigment extends nearly the length of the hair (C). In some of the fibres of a less coarse nature there is no medulla, and the scaling is less pronounced.

From what has been said the general points to be studied in examining the hairs of animals will be readily understood, but it may be of interest to amplify our remarks by reference to the fibres of particular animals, and especially those of allied species.

In the hair of the dog, as in the case of sheep's wool, considerable differences will be found in the fibres produced by different breeds, the wire-haired dogs having hair of different type from the silky-haired dogs. In the woolly hair of the Bedlington terrier, to which allusion has already been made, the scaling projects and no medulla is visible, so that the general appearance of the fibre resembles the wool of an Angora kid (see B, C, Figure 299). The stoutest type of hairs (D) are of a bristly character and show a pronounced medulla, while intermediate between these extremes are fibres showing an interrupted medulla, fine scaling, and faint longitudinal markings.

It is interesting to note that the coat of the native Australian dog, the dingo (see Figure 300), has fibres of the three types and shows to an even more pronounced degree an analogous cellular structure of the medulla.

On the other hand, the few remaining hairs of the Mexican hairless dog (see Figure 301) show a very different structure. In the fibres without medulla the surface is covered with fine scales, resembling that upon the hairs of some of the apes, while the other fibres have a very coarse medulla which does not show the cellular structure usually found in the hairs of ordinary breeds of dogs.

In the fur of the wolf (see Figure 302) the cellular structure of the medulla is apparent in some of the fibres, whereas in others there is a very broad continuous medulla. In the former the scaling causes the edge of the hair to appear sharply serrated, while in the latter the edge is nearly smooth and the scaling very fine. The type of fibres marked A is intermediate between these extremes.

Wide variations in structure are also shown by the hairs of the African jackal (see Figure 303). These include coarse black and white bristles, having an opaque medulla (A) and ending in a fine point (B), and fine woolly hairs which are well covered with scales. In the latter the medulla, which in places has a chain-like appearance, stops near the apex, where the fine scaling resembles that of merino wool.

Similarly, in the fur of the fox (see Figure 304) the fibres contain a small proportion of bristles having a wide medulla which becomes intermittent towards the tip, which ends acutely (C). Most of the hairs, however, are soft and curly, with scales projecting from the edges, and this, in conjunction with the structure of the medulla, gives to the fibre the appearance of a jointed chain.

Coming next to the cats it will be noticed that in the fur of the domestic cat, the fibres end in a very fine point, while the scaling is well marked, and all show a medulla which here and there is interrupted. In the full-grown animal the medulla may be wide and show a reticulated structure (C, Figure 305), but in the case of the kitten the hairs have projecting scales and a medulla made up of a series of single cells.

It is interesting to note that the leopard shows fibres of an analogous character, the medulla in some being wide and continuous (see Figure 306), while in others, which show fine scaling, it is intermittent. Examples of the unicellular structure of the medulla seen in the hair of the common kitten may also be found.

Mention may also be made here of the so-called sea-cat of Chili, which is valued for its fur. The fibres are of the most variable type. On the fine hairs the scales are very prominent but not plentiful, and in some cases (C) project so much as to give a feathery appearance to the hair. The fibres terminate in a somewhat blunt point, and have a medulla which ends near the base (see Figure 307).

The reticulated structure of the medulla which is shown by some of the fibres of the cat is much more pronounced in the hair of the brown rat (see Figure 308). These are of the bristly type, with scaling well marked towards the base, and end in an abrupt point.

Examples of hairs from the fur of different species of bears are shown in Figures 309–311.

In the fur of the Himalayan bear some of the fibres are dark brown and very opaque, while others are

FIGURE 295.
Merino Wool.

FIGURE 296.
Irish Wether.

FIGURE 297.
Lamb's Wool.

FIGURE 298.
Himalayan Serow ♀.

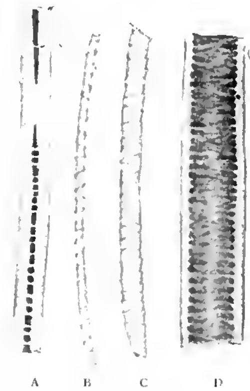


FIGURE 299.
Bedlington Terrier.

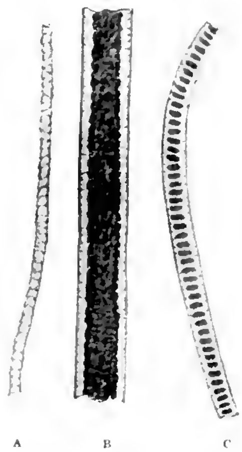


FIGURE 300.
Dingo Puppy.

FIGURE 301.
Mexican Hairless Dog.

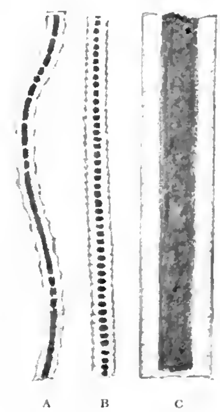


FIGURE 302.
North American Wolf.

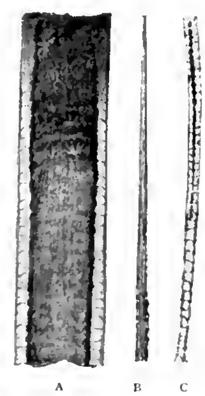


FIGURE 303.
African Jackal.

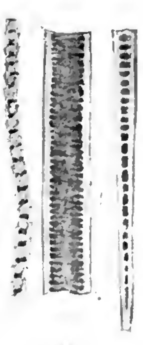


FIGURE 304.
Common Fox.

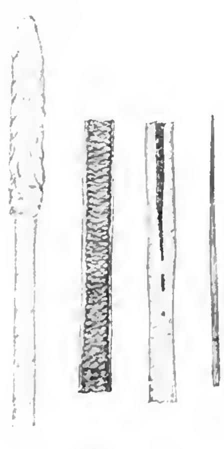


FIGURE 305.
Cat.

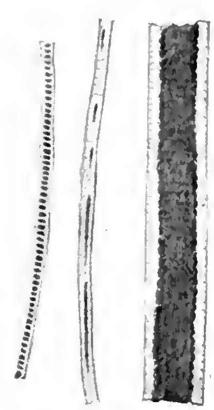


FIGURE 306.
Nigerian Leopard.

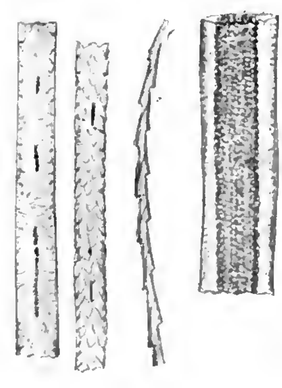


FIGURE 307.
Sea Cat.

HAIRS OF ANIMALS × 104.

HAIRS OF ANIMALS × 104.

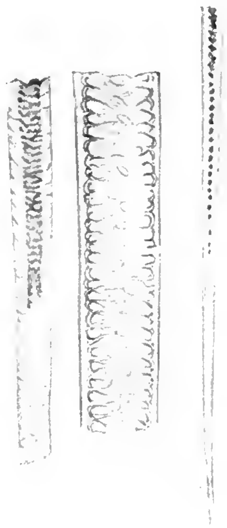


FIGURE 308.
Brown Rat.

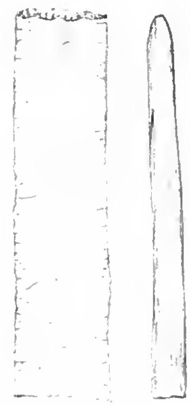


FIGURE 309.
Himalayan Bear.

FIGURE 310.
Russian Bear.

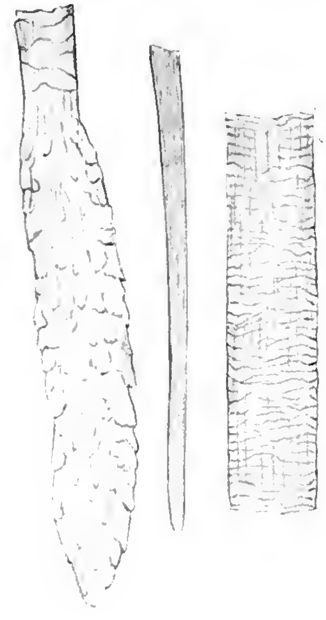


FIGURE 311.
Sloth Bear.

FIGURE 312.
Kangaroo.

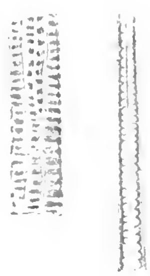


FIGURE 313.
Rabbit.

FIGURE 314.
Sable Antelope.

FIGURE 315.
Human Hair.

FIGURE 316.
Young Chimpanzee.

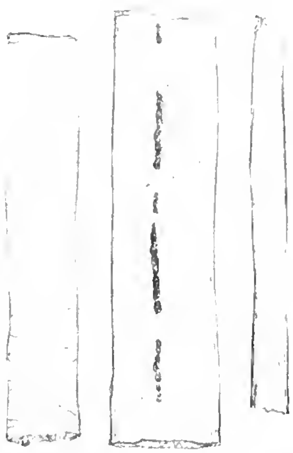


FIGURE 317.
Old Chimpanzee.

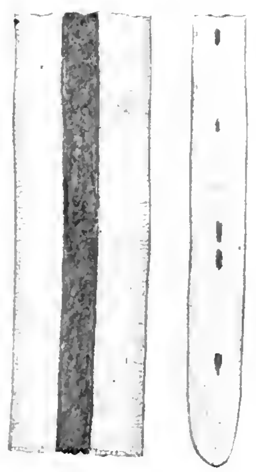


FIGURE 318.
Orang Utan.

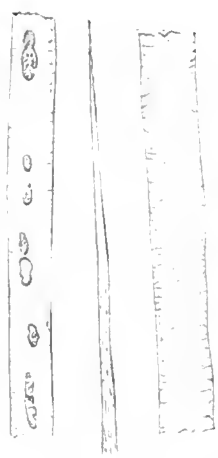


FIGURE 319.
Gibbon (hind foot).

FIGURE 320.
Human Hair (axillary).

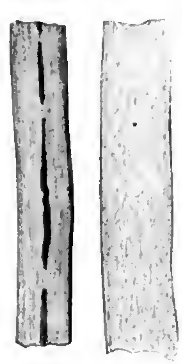


FIGURE 321.
Hair of Negro.

paler and show well-marked scaling and an ill-defined medulla.

The Russian bear also shows the two kinds of fibres, but the medulla, when present, is much more pronounced.

In the hairs of the sloth bear the medulla is usually absent. The pigment is deposited in lines in the same way as in the hair of the other bears, while in the central portion of the fibre the scaling is close and well marked.

Hairs of very distinctive types are shown by the kangaroo (see Figure 312) and the rabbit (see Figure 313), the structure of the medulla and the scaling being very characteristic in each case.

A single example of the hair of the antelopes is given (see Figure 314) which shows two portions of a fibre from the coat of a Rhodesian sable antelope. The hairs are long and coarse and show a broad opaque medulla extending from the base nearly to the tip (A). The scaling on the cortex is fine but well defined.

There is no difficulty in distinguishing between human hair and the hair of any of the lower animals, but the numerous points of resemblance between the hairs of allied species of animals suggested the possibility that man's nearest relation among the animals might also show analogous resemblances to human hair.

Apart from its scientific interest, the point is of practical importance, since it is frequently necessary in forensic work to ascertain whether a particular hair belonged to a human being or to an animal.

To investigate this question we have made a study of widely differing types of human hair, and have compared them with the hair of some of the principal species of anthropoid apes.

The hair shown in A, Figure 315, was taken from the head of a newly-born female child, and it is remarkable that the fibre has many more points of resemblance in common with the hair of some of the lower animals such as the merino sheep, than are to be found in adult human hair. Thus on the hair of the young child (B) the scales are very scanty, while in adult human hair they become more numerous and more compressed. There is also a tendency towards a jointed structure, which disappears in the hair of the adult (see C, Figure 315).

In the hair of the young chimpanzee (see Figure 316) it will be noticed that one of the fibres (B) resembles the hair of the young human child, with the exception that the scaling is less pronounced; but in the other fibre (A) there is a clear medulla. Again, in the hair of the old chimpanzee (see Figure 317) it will be seen that part of one of the fibres, near the base, resembles adult human hair, but that here, again, the scaling is less pronounced than on human hair. In this hair, however, a medulla interrupted in places will be found, while at the top the disposal of the pigment differs from that usually found in human hair.

The hair of the orang utan (see Figure 318) and of the gibbon (see Figure 319) also shows points of resemblance to human hair, but there are also many distinguishing features.

A medulla is much more common in the hair of the higher apes than in European human hair. In a lecture to the Selborne Society it was stated by one of us (Mitchell) that apparently a medulla was not formed in human hair.

Since then our investigations have led us to modify this statement considerably.

It occurred to us that since the axillary hair in man is probably a vestige of his former ancestry, it was in such hair that a medulla would be most likely to be found. This was confirmed by a study of the hair from the human arm-pit (see Figure 320). In some of these hairs there was a narrow irregular medulla (A), with dots of pigment, but no scaling visible, while others equally stout showed no medulla, but were covered with fine scaling which was well marked near the base.

The remarkable result of this examination led us to examine the hair of a negro, in which it appeared probable that the relationship between the hair of man and the apes might be traced more closely than in the case of European human hair. The result is shown in Figure 321.

The fibres were coarse, and usually showed a narrow medulla, which in some cases was continuous throughout the whole length of the hair.

The pigmentation was so pronounced in some of the fibres as almost to obscure the tract of the medulla, while other hair contained a much smaller amount of pigment. Apparently the amount of pigment had no bearing upon the occurrence of a medulla. In all the fibres the scaling was ill-defined.

A comparison of these hairs with the hair of the apes, especially the orang utan, shows how close are many of the resemblances. In fact, it appears justifiable to conclude that the hair of the negro resembles that of some of the higher apes much more nearly than it does the hair of the average European.

We intend to continue the study of this interesting branch of our subject, and should be grateful if any reader of "Knowledge" would forward to us any authenticated specimens of hairs of out-of-the-way races of mankind.

Note.—All the illustrations are drawn to the same scale of magnification (104 diameters).

CORRESPONDENCE.

MARS.

To the Editors of "KNOWLEDGE."

SIRS,—In your issue of June there appeared on the above subject a letter, signed J. E. Maxwell, which contains so many errors and misrepresentations that their complete refutation seems to me necessary.

In the first place there is a confusion in the very purpose of that paper, since its author chiefly disagrees with me on an idea of mine which he himself adopts. It is stated in my article, on pages 193–196, that although there are no straight lines on Mars, yet this truth would not be accepted without opposition, and that the astronomer of the *future* will sneer at these wonders. Hence I made it quite clear that my arguments and proofs had not yet secured *public* recognition, and that, consequently, at present they are not established truths. Yet the author of the letter in question, in his anxiety to contradict, overlooks that he appropriates my idea by proclaiming that my views "are not established truths." But even otherwise considered, the argument has no bearing; for when an investigator is sure that he enunciates the truth, he cannot but remain utterly indifferent to the acceptance, or temporary non-acceptance, of his results by the public.

The correspondent in question next says that he has never before seen it stated that "canals" appear "straight and not curved at the edge of the disc." And yet canals are drawn straight near the limb by Schiaparelli, Perrotin, Terby, Guiot, Wilson, Cerulli, Lowell, Douglass, and others. Further, from one of the numerous papers in which this peculiarity was pointed out, I shall quote a passage in "KNOWLEDGE" for 1894, page 250, where we find that "the 'canals' when near the edge of the disc are apt to be represented as much straighter than they could possibly be." With ordinary care and prudence such public display of unaquaintance with the subject treated could easily have been avoided.

Another glaring oversight is the assertion that "no markings . . . can be seen near the limb of Mars, owing obviously to the planet's atmosphere." That this is just the reverse of reality is proved by the photographs, which show all dark markings quite as intense near the limb as near the centre of the disc. The apparent character of the bright limb, due to contrast with the dark sky, is naturally not even suspected here.

There is nothing extraordinary in the fact that Mr. Denning discovered the true nature of the minor detail on Mars with a ten-inch, while Mr. Lowell failed to do so "with his twenty-four-inch." For, to say nothing of the superior ability and experience of the former of these two observers, the effective difference between their telescopes is not the difference of ten and twenty-four, as erroneously pointed out on pages 238, 239, but the difference between ten inches and thirteen and a half inches, since this last is the usual aperture to which the twenty-four-inch is stopped down on Mars.

The writer of the letter quoted next fails to understand the effect of magnification of a planetary disc on the sharpness of its markings. Yet nothing can be clearer. Inasmuch as the fine lines flashing on Mars are usually flashing on a disc having the apparent size of a sixpenny piece held at the distance of two feet from the eye, they ought to be represented quite sharp on such a small disc held at the above distance. But on a three-inch drawing, seen at one foot, the sharpness would cease, just as the sixpenny piece enlarged photographically to six inches would show nothing but very vague details. Should further corroboration be needed on this point, it could be found on the best photographs of Mars, which, while revealing more delicate detail than any ever drawn prior to 1909, yet show all markings diffuse on a disc smaller than one inch in diameter.

On page 239 doubt is cast on the fact that the narrow straight lines on Mars are seen only by glimpses. Here, again, we have a confusion of the straight fine lines with the diffused streaks, held steadily. My experience, like that of Terby and others, is that the lines are always flashing for a small fraction of a second; and as this was also Schiaparelli's experience, I shall be excused if I accord a greater weight to the Martian observations of Schiaparelli than to those of an unknown amateur.

With regard to Figures 190 to 193, page 194, we are now asked to believe that the structure of the planet was geometrical and furrowed with straight lines on 1909, September 18th; that it was natural and irregular, without lines, two days later, on September 20th, and also on October 5th; and that it was again geometrical with straight lines on November 3rd. The manifest impossibility of such an assumption proves that my drawing, corroborated, as it is by Professor Hale's wonderful photograph, shows Mars practically as he is (so far as our present optical means go), and that the rude sketches of Mr. Lowell and M. Jarry-Desloges, which fail to reveal the coarser details, break down altogether under the crucial and unanswerable test of photographic comparison. Behind the impersonal confirmation of photography, I am awaiting all critics with a smile; and the overwhelming superiority of large telescopes, displayed every day on double stars, and by the spurious satellite to Sirius discovered at Mr. Lowell's observatory, thus receives an additional, though useless, corroboration.

I granted some years ago, and still grant, that Flagstaff may enjoy the finest atmospheric conditions for astronomy. But as the aperture there is some thirteen and a half inches, Mars is defined in Arizona as if he were from two and a half to three times more distant than in the three largest refractors of the world. This is the reason for which a few seconds of perfect seeing at Yerkes, Lick, Meudon, or Mount Wilson have done more for the recognition of the true character of the Martian spots than the laborious canal records of nine whole apparitions at Flagstaff. Does the correspondent know that the arëographer who drew more straight lines on Mars than any other—Professor A. E. Douglass—in a visit paid me in 1910, declared all the canals which he was seeing for years with Professor Lowell's very telescope at Flagstaff to be illusive.

Discussions on such a one-sided affair as the canal question are, of course, useless. Yet the present letter, besides refuting opposition, has also rendered clear the position of the believers in the linear canals, which is: (*a*) that, within certain limits, the more distant a heavenly body is from the observer, the better he distinguishes the details of its surface; (*b*) that, within wide limits, the greater the confusion of vision of an object, the sharper its perception; and (*c*) that the laws of perspective, on which our knowledge of the universe stands, are wrong.

When the defenders of a theory are reduced to question the truth of natural law for its support they merely betray the rout of their reasoning.

E. M. ANTONIADI.

PARIS.

HEN BIRDS WITH MALE PLUMAGE.

To the Editors of "KNOWLEDGE."

Sirs,—Regarding the statement by your correspondent (the Director of Melbourne Zoölogical Gardens) that hen-pheasants and so on, assume the plumage of the male bird under certain conditions, it may interest your readers to know that when visiting Folkestone Museum a few years ago I saw there a stuffed specimen of a cockerel which a card near explained had formerly worn hen plumage, and even laid eggs. The bird had been the property of a farmer in the vicinity whose name is attached to the card.

A. ATKINSON.

HARROGATE.

SOME NOTES ON THE HISTORY AND SIGNIFICANCE OF THE THEORY OF SPONTANEOUS GENERATION.

By H. STANLEY REDGROVE, B.Sc. (Lond.), F.C.S.

A BELIEF in the spontaneous generation of such forms of life as mice, maggots, lice, and other vermin out of dirt and decayed organic matter was at one time universally held, and was explicitly taught by Aristotle (see the fifth book of his "History of Animals"). The first work of importance to throw doubt on this theory was done in 1668, when the Italian Redi showed that no maggots were bred in meat, if flies were prevented from laying their eggs on it. In 1683, however, A. van Leeuwenhoek discovered, by the aid of the microscrope, those forms of life, invisible to the naked sight, that are known as "bacteria." This discovery seemed to give considerable support to the doctrine of spontaneous generation, or abiogenesis (as it is now generally called), it being found that, however carefully bodies of organic origin were screened from contamination by outside sources, bacteria invariably made their appearance in them. In the middle of the nineteenth century, however, Pasteur found that if the bodies were first sterilised by heat and prevented from coming in contact with any air other than that which had also been sterilised, no bacteria were developed: milk, for example, he found would keep good for any period in these circumstances. Pasteur's results are accepted by practically all modern biologists and bacteriologists. Professor Charlton Bastian,* however, has more recently carried out numerous experiments with results apparently altogether opposed to those of Pasteur. Indeed, he states that he has obtained growths of bacteria and torulae in inorganic saline solutions containing sodium silicate or colloidal silica (preparations of mineral origin) which had been completely sterilised by heat and preserved in hermetically sealed tubes. It is evident that abiogenesis must have taken place at some period of the world's history, for certainly no life could have existed on the earth when it was in a molten condition; and if one argues (as has been done) that life was first conveyed to this earth by meteorites from other planets, apart from the intrinsic difficulties of this theory, it merely transfers the problem of the origin of life to another planet without in any way simplifying it. Given the right conditions, therefore, there seems no valid reason why spontaneous generation should not take place now; though it is, perhaps, difficult to understand how organised forms of life, such as bacteria, could be immediately produced from inorganic matter; but, as Professor Bastian indicates, the production of the bacteria and torulae in his experiments may have been preceded by the formation of ultra-microscopic specks of unorganised life. Another question that may be asked in connection with these experiments arises out of the fact that protoplasm, which is the material basis of all forms of life, contains carbon as one of its essential elements. Must we assume that a transmutation of the elements occurred in Professor Bastian's experiments? Or is it possible for silicon to take the place of carbon in protoplasm? However, Professor Bastian's results have not met with general acceptation. It is a pity that his experiments are not repeated by other competent biologists; some degree of certainty in the matter might then be obtainable.

In 1905 Mr. Butler Burke thought he had succeeded in obtaining living "cultures" by the

* In Professor Bastian's experiment *very* dilute solutions of sodium silicate containing either (i) a few drops of *liquor ferri pernitratis* (ferric nitrate solution) or else (ii) a very small quantity of ammonium phosphate and phosphoric acid were placed in sterilised glass tubes and hermetically sealed. They were then heated to temperatures varying from 115° C. to 145° C., and afterwards exposed to diffused sunlight. After several months they were opened, and the sediment formed by the chemical reaction between the salts when the solutions were heated was examined microscopically. Microphotographs (× 700) of various examples of organisms either observed in the sediment or cultivated therefrom are shown in Figures 325–330, which are reproduced on page 292 from "The Origin of Life: being an Account of Experiments with certain superheated saline Solutions in hermetically sealed Vessels" (Watts, 1911, 3s. 6d. net), by kind permission of Professor Bastian. These figures are as follows:—

FIGURE 325. Solution (ii). Heated to 130° C. for 10″. Mass of Torulae ("Yeasts").
FIGURE 326. Solution (ii). Heated to 135° C. for 5″. Group of vacuolated Torulae.
FIGURE 327. Solution (ii). Heated to 135° C. for 5″. Bacteria.
FIGURE 328. Bacteria cultivated from tube shown in Figure 327 as found on ninth day.
FIGURE 329. Solution (ii). Heated to 130° C. Mass of Torulae with four Bacteria. Cultivated (ninth day).
FIGURE 330 (from the Second Edition of "The Origin of Life"). Solution (i.). Heated to 100° C. for 20″ on three successive days. Mould of *Streptothrix* type. (× 300).

In the case of the experiments, the results of which are shown in Figures 327–329, Graham's pure colloidal silica was used in place of sodium silicate. It was found necessary to use freshly prepared silica or silicate solution.

It is interesting to know that in control experiments, in which the tubes were opened within a day or two of sealing, no organisms were observed.

action of radium salts on sterilised bouillon, and his experiments produced a "nine days' wonder" at the time. Mr. Soddy, however, showed shortly afterwards that the phenomenon was of a purely chemical nature, no living matter being produced.

Quite recently, Professor Leduc has described certain inorganic preparations (called "osmotic growths") which resemble living bodies in some respects. An "osmotic growth" may be obtained by dropping a piece of a soluble calcium salt into a solution of carbonate, phosphate, or silicate. The dissolving calcium salt is diffused into the solution and produces an insoluble carbonate, phosphate, or silicate of calcium, forming a colloidal membrane around the partly dissolved calcium salt. This membrane offers far more resistance to the passage of dissolved salt than it does to that of water. Hence pressure is set up and water flows into the membrane, distending it until all the calcium has been used up and the membrane can no longer bear the pressure. The phenomena resemble, in a way, those of growth and assimilation of nutriment as exhibited by living beings, and the distended membranes assume forms not unlike those of certain species of marine life. It is only by a stretch of imagination, however, that we can speak of such "osmotic growths" as possessing life; but they do help to illustrate the difficulty there is of drawing a hard-and-fast line between living and non-living matter. (See Figures 322–324.)

Seeing that life as manifested in this world is always associated with protoplasm, the suggestion readily arises that protoplasm, so to speak, is naturally alive; that the chemist has only to synthesise this body in order to produce living from non-living matter. A good deal of attention has been drawn to this theory by Professor Schäfer's recent presidential address to the British Association on the origin of life. But the theory is not a new one. Similar views have been expressed by Professor Haeckel; and the present writer in 1909, as the result of a somewhat different manner of viewing the question, expressed a conviction that chemists had only to synthesise protoplasm in order to produce living matter.* This synthesis has not yet been carried out, but no doubt it will one day be brought about. Since the day in 1828 when Wöhler first synthesised urea from ammonium cyanate, and thus broke down the artificial (though convenient) distinction between inorganic and organic bodies, chemists have succeeded in building up from simpler forms of matter an enormous number of bodies hitherto only obtainable from animals and plants; and everything indicates that the progress of chemistry will continue until all organic products will be included in this category.

Does this view of the subject, however, justify us in holding a purely materialistic view of life, as some biologists (*e.g.*, Professor Sir E. Ray Lankester) seem to believe? The reply to this question depends largely upon what we mean by life. Professor Schäfer is very careful in his address, already referred to, to indicate that by "life" he does not mean "soul"; and one cannot help contrasting his cautious and scientific attitude in the matter with the somewhat unscientific impetuosity of Professor Sir E. Ray Lankester, who has informed the readers of the *Daily Mail* that for him this distinction does not exist. Considered purely as a phenomenon occurring in the physical realm, one is certainly justified in looking for a scientific, that is, a mechanistic (or materialistic, if one so pleases to term it) theory of life. But this is not the last word on the subject. Metaphysics begin where physics leave off, and the problem of life still exists for the philosopher when it has been solved by the man of science.

Looked at genetically, living matter, as we have indicated, appears to differ but slightly from that which is called non-living: the one seems to merge into the other. So must we look at life to understand it scientifically. But to understand life philosophically we must look at it when most highly developed or (to speak more accurately) manifested: not at the moment of its birth. In other words, we must study *man*. And here the distinction between the living and the non-living becomes manifest. Matter—non-living matter—is essentially inert. Man is essentially active. So far as low forms of life are concerned, the biologist may explain their apparently spontaneous activity as the result merely of reflex action; that is, as the reaction to forces operating from without, and thus involving nothing opposed to the characteristic inertia of matter. But psychology forbids us to believe that man, though subject to outside influence, is moved only from without. In fact, considered philosophically, the problem of life becomes the problem of soul and consciousness; and it is then evident that no materialistic explanation is possible. For, since matter is known to us only in terms of consciousness, the attempt to explain consciousness in terms of matter at once places us in a vicious circle from which there is no escape save by repudiating our materialism.

There seem to be only two alternatives, (i) the universe is unintelligible, or (ii) all things are the product of "spirit" (if I may use this term to designate that reality whose characteristic property is consciousness); and the first of these alternatives, I think, is put out of court by the fact that as our experience widens so do we find the universe increasingly intelligible.

Looked at from this standpoint, then, matter is the first and lowest product or manifestation of spirit. As such its properties seem to contradict those of spirit. As such it is inert and lifeless. But, itself the product of spirit, it forms the vehicle for increasingly full manifestations of spirit. The degree of manifestation depends upon the form and complexity of the matter. At the protoplasmic stage of evolution the manifestation begins to exhibit

* See the present writer's "Matter, Spirit, and the Cosmos" (Rider, 1910), Chapter IX, "On the Origin of Life."

Figure 322.

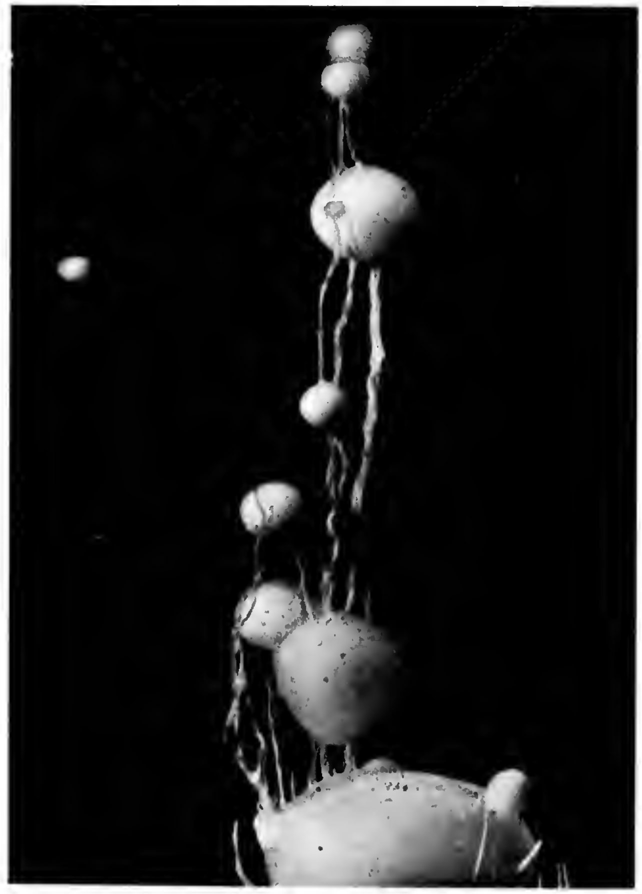


Figure 323.

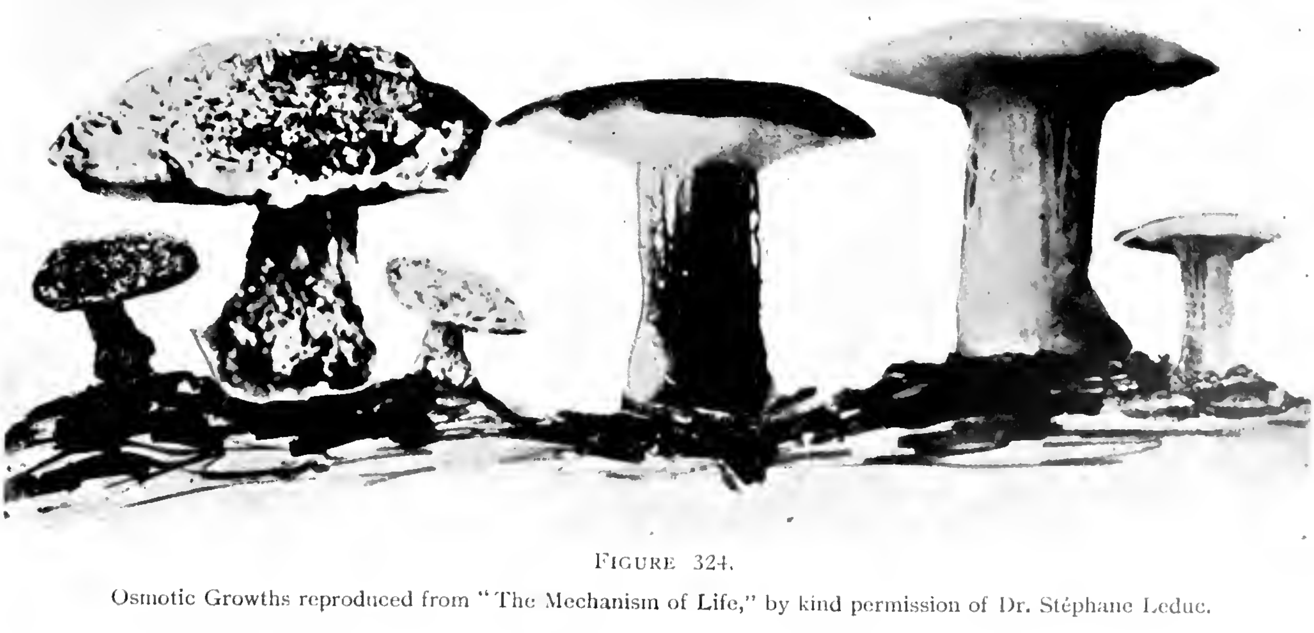


Figure 324.

Osmotic Growths reproduced from "The Mechanism of Life," by kind permission of Dr. Stéphane Leduc.

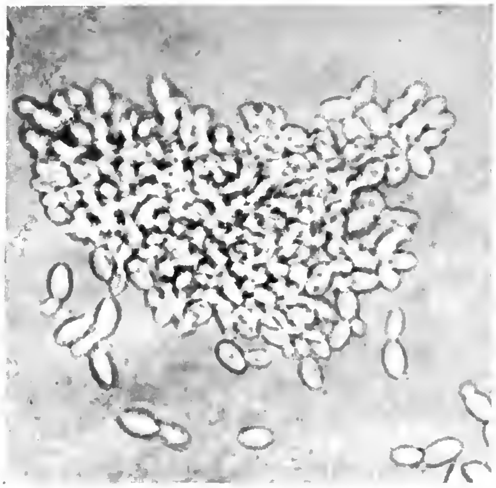


FIGURE 325.
Torulae (Yeasts).

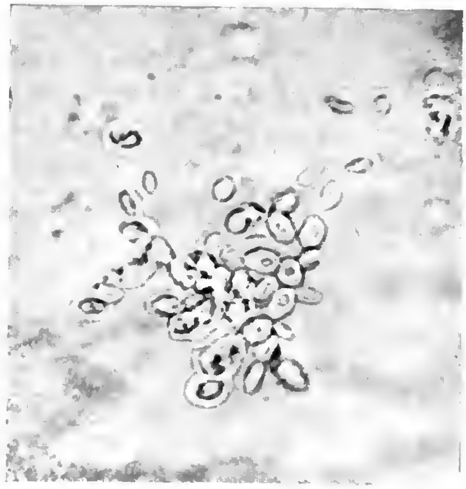


FIGURE 326.
Vacuolated Torulae.

FIGURE 327.
Bacteria.

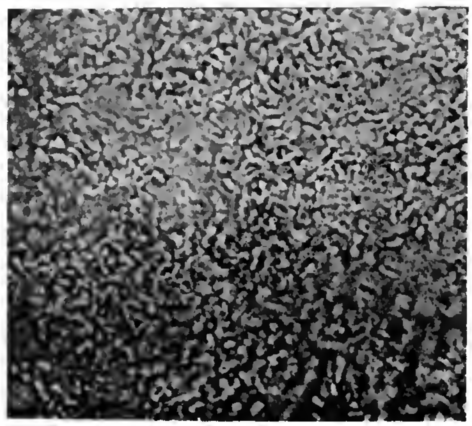


FIGURE 328.
Bacteria cultivated.

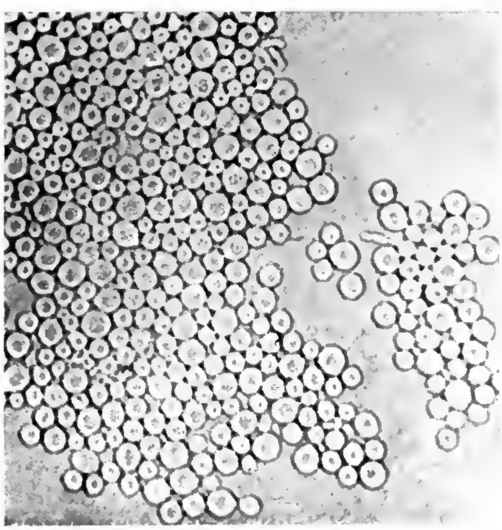


FIGURE 329.
Mass of Torulae.

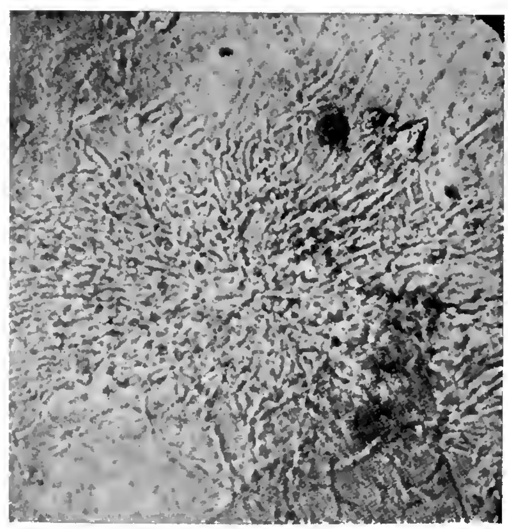


FIGURE 330.
Large Mould (*Streptothrix*).

ORGANISMS OBSERVED IN PROFESSOR BASTIAN'S EXPERIMENTS.

the properties of spirit more clearly than heretofore, and we call the matter "living" because we recognise the kinship between its spirit and that which we call "ourselves." The *raison d'être* and purpose of the whole process is, I believe, the differentiation of homogeneous spirit into individual, self-conscious units or souls capable of true happiness—the one thing of absolute value. This is only perfectly achieved in man. Of course, a theory so wide and comprehensive as this deserves more than the bald statement here alone possible. I have attempted a fuller statement, though very inadequately, in the essay already referred to; and I must also refer the reader to the remarkable metaphysical treatise of the Swedish philosopher, Swedenborg, entitled "The Divine Love and Wisdom," which is the chief source of these views concerning the ultimate significance and nature of life. My primary reason for calling attention to the theory here is to indicate how entirely it fits in with the doctrine of evolution and the latest scientific view concerning the possibility of the spontaneous generation of life.

CORRESPONDENCE.

THE NUMBER OF "DOUBLE" STARS.

To the Editors of "KNOWLEDGE."

SIRS,—In your number for June, on page 239, Mr. E. Holmes criticises a correct statement of the late Mr. F. W. Henkel as to the number of known double stars. The words he quotes are: "Perhaps as many as twelve thousand such couples are known." I take exception to his criticism; the most correct word of these ten is ***perhaps***. Further, the expression "standard authority" is out of place; there is no *one* standard authority. Let me explain. The branch of astronomy known as "double stars" (two stars in close juxtaposition as viewed from the earth) has become very expansive since I commenced observing double stars in 1881; the great increase in the optical power of recent telescopes has brought thousands of optical pairs of stars upon record. The chief merit of these modern observations is that they are made with the finest instruments and most skilled observers in this branch; many of these observations are duly recorded in Mr. Burnham's "Magnum Opus," in 1170 pages, and the total number of double stars which he gives therein is thirteen thousand six hundred and sixty-five (not fifty-five, as given by Mr. Holmes). This work was published in 1906 by the Carnegie Institution of Washington.

But of what does this consist? I opened this catalogue at random and it happened to be page 112; this is what is there (with thirty-three properly observed pairs):—

No.	Position Angle.	Distance.	Magnitudes.	Year.
5564	116°·3	15″±	8–9, 11	1830+
5568	331 ·8	7 ±	11 = 11	1834·3
5575	305 ±	20 ±	6 17–18	1820+
5577 {	70 ±	2 ±	13 14	1820+
	305 ±	25 ±	15	1820+
5578	53 ·8	4 ±	10–11, 11–12	1830+
5587	69 ·4	25 ±	9–10, 10	1830+
5588	...	...	9 ...	...
5589	35 ±	12 ±	11 12	1828+
5593 {	210 ±	135 ±	5 ...	1873·29
	130 ±	5 ±	9·0 10·0	1873·29
5596	...	Cl. IV	8 11	...
5601 {	22 ·5	15 ±	10–11, 14	1830+
	208 ·0	18 ±	14	1830+
5602	...	Cl. IV	8–9 10	...
5607	...	Cl. IV	8 11	...
5609	130 ±	15 ±	9 10	1820+
5610	...	33 ·27	... ...	1783·09
5611	...	...	9·1 ...	1902·
5612	139 ·0	15 ±	9–10, 11	1830+

Upon referring to Vol. II (notes) I find there is no further information given to Nos. 5568, 5577, 5578, 5596, 5602, 5612; to Nos. 5564, 5575, 5587, 5593, 5611 there are recent and accurate measures given; therefore the Herschel approximations might have been abandoned and not again reprinted. They are already in Smyth's "Celestial Cycle" and Gledhill's "Handbook"; Nos. 5588, 5589, 5601, 5607, 5609, and 5610 have notes, and there seems no need to have again numbered them, nor to have included them in a good reference catalogue, except among the notes or in a table in the Introduction.

The general result is that on page 112 there are fifty pairs of stars: of these, seventeen are as just quoted in detail, none of which should have so appeared in an accurate and up-to-date catalogue, except as mere notes. The whole volume is similar to this, and the 13,665 pairs or double stars may be safely reduced by at least twenty-five per centum, and we get about nine thousand pairs worthy of inclusion in the tabular catalogue: the R.A.'s and Declinations are given for an old epoch (1880). Then this only includes stars to minus thirty-one degrees; none of Innes's valuable work, or of other southern observers, is included. So Mr. Henkel's "***perhaps*** as many as twelve thousand such couples are known" is a statement not very far from the correct number at present published, mere estimations omitted. From Mr. Holmes's reference to other catalogues of double stars one is lead to believe that he is unacquainted with the contents of that excellent catalogue by Mr. T. Lewis, published also in 1906. While the catalogue of Mr. Burnham is collected from all or many sources since 1780, and is still far from complete or homogeneous in character—though a work of reference so far as it goes—that by Mr. Lewis is formed upon a definition plan, being based upon a systematic series of observations of about three thousand double stars by W. Struve, with which have been incorporated in detail all known and good observations until about 1904. Much valuable information upon the orbits of the more interesting ***binary*** stars is given—as also in Mr. Burnham's catalogue. So it may be truly called a standard work of reference for W. Struve's stars, and it will be used for many a year; it does not touch those modern pairs of bright stars with very faint stars within about 1″, observed with instruments of 25-in. to 40-in. object glasses. So much for the visual pairs, few of which are "binaries."

What of the spectroscopic binaries, which are of the greatest interest? Their known number is already considerable. None of these are as yet thought to be worthy of inclusion in a so-called ***standard*** catalogue of "double stars." Mere numbers will not make a standard catalogue; uniform quality, completeness, and up-to-date epoch and material is what we should expect.

OXFORD. F. A. BELLAMY.

P.S.—I should like to mention that this letter was written quite in ignorance of Mr. Henkel's death, and it was in type before I was informed of it.

THE AGE OF THE EARTH.

By E. JOBLING, A.R.C.Sc., B.Sc., F.C.S.

THE discovery of the embalmed corpse of one of Egypt's ancient kings or the unearthing of some hieroglyphic inscription apparently dating back to Biblical times, are items of information which, when they reach the public ear, awaken at least a transient interest in the probable antiquity of the one or the bearing of the other upon the history of the peoples of the world. The call of the past is an appeal to which few of us are really irresponsive, though in most the receptive faculty gets dulled by inactivity, due in large measure to the lack of that divination which sees interest in objects of almost everyday acquaintance.

To comparatively few, for instance, has it ever occurred that in the age and life-history of that world upon which they "live and move and have their being" is to be found a problem of keener and more lasting interest than either of the above. The indifference of the many to this question cannot nowadays be attributed to a prevalent unquestioning belief in the Scriptural computation which ascribed to the earth a longevity of between six and seven thousand years; for this form of mental paralysis is happily now a thing of the past. It can only be the absence of any acquaintance with the general trend of scientific thought which debars them from the very real pleasure to be derived from the story of man's endeavours to delve into the unknown.

After all, to determine the age of the earth is a far more difficult undertaking than to assign the mummified king to his position in the Egyptian dynasties or to unravel the hieroglyphics of a Babylonian column. The presence of a coin or inscription in the one or a scientific deciphering of the other solves the respective problems; but in the case of the earth the difficulties encountered are not so easily overcome. The shape of the earth has to be determined, its strata have to be laid bare, its oceans weighed, and a thousand and one other investigations satisfactorily completed before even the data are amassed by means of which we hope to realise the vast stretches of time that preceded the very earliest of historians. Stupendous as the obstacles are, however, sufficient is known already to fling into the misty past a beam of light powerful enough to reveal with tolerable certainty the features of the earth as they presented themselves, say, a hundred million years ago, and to dispel to some extent the darkness of an even greater antiquity, if we call to our aid a little justifiable hypothesis.

Already it has been hinted that only in quite recent times has the question been approached scientifically. Time was when "catastrophism" was the current idea, and men believed that the earth, and indeed the whole solar system, had suddenly sprung full-fledged into being at some ridiculously recent date. When, however, the foundations of geology came to be laid by Hutton and Lyell, the immensity of the time required for an orderly deposition of the sedimentary rocks or the elaboration of the organic world laid such hold upon their imagination that "catastrophism" was abandoned for the other extreme, "utilitarianism," which relegated the birth of the earth to the very beginning of time and refused to adopt any smaller chronological standard than an "eternity."

These somewhat ludicrous extremes are now, of course, replaced by more reasonable views, which owe their conception to the application of the modern scientific spirit and the ever-growing accumulation of experimental data. The iconoclast who assailed and overturned the above extravagant hypothesis was Lord Kelvin, then Sir W. Thomson, who, in the few years following 1862, published papers in which he proceeded by several physical lines of reasoning to an estimate of the earth's age so small comparatively as to make the then-orthodox geologists gasp with surprise and indignation. These estimates of his—historically interesting, if now perhaps obsolete—will be briefly dealt with first before attention is turned to other more reliable evidences advanced in recent years.

It would be as well, however, before discussing the theories if we first obtain a clear idea of the various phases of life-history through which the earth has passed in order that no confusion may subsequently arise as to the relative significance of the numerical values obtained.

Imagine, then, a vast molten globe—the product, we may take it, of the condensation of a nebular haze—rapidly rotating round the sun. The influence of the latter would be such as to develop vast tides in the liquid magma of the rotating body, one of which tidal waves, the late Sir G. Darwin suggested, might conceivably have assumed sufficiently large proportions as to disturb the stability of the whole, and to be itself trundled off into space, where it would continue to revolve around the remainder as the infant moon. Sir G. Darwin, by-the-by, has calculated the time which has elapsed since this separation to be fifty-six million years. Its birth-pangs over, what we now know as the "earth" starts upon its career as a separate member of the solar system. Probably soon after the moon's departure the earth had cooled enough to permit of the formation on the sea of magma of floating islands of scoria, which would assume larger and larger dimensions until the outer crust of the earth was entirely solid and what is called in the earth's history its *consistentior status* was inaugurated. Further cooling resulted in the condensation of some of the constituents of the atmosphere, which products would collect in pockets on the surface, and thus the configuration of continents and oceans arose. Sooner or later, yet another era would be ushered in by the commencement of those processes of denudation and deposition which, throughout the long ages following, have reared new continents upon the ruins of the old, and which still manifest their slow-moving but irresistible activities before our eyes. At what period signs of life appeared and the earth first became inhabited we cannot stay to discuss, but must revert to our original theme.

I.—Kelvin's Theories.

During mine-sinking operations it is noticeable that as the shaft penetrates deeper and deeper the temperature slowly and regularly increases. In different places the temperature-gradient is not the same; for external conditions necessarily disturb it in the topmost strata, and we have not yet delved deep enough to reach the lower regions where uniformity prevails. But from observations made an average can be taken, and from this it is possible to deduce mathematically an estimate of the earth's age. The problem resolves itself into the following. Knowing the conductivity of the earth's crust, and assuming a certain uniform initial temperature, what time must elapse before it cools to such an extent that the temperature-gradient over a certain thickness is that which we find to obtain now? The mathematical expression of this has been solved by Kelvin, who arrives at the result that the whole period since the earth was molten amounts to about twenty million years, and certainly could not exceed four hundred million years.

Another method of his depends upon the braking action which the tides exert upon the rotation of the earth. Since the earth rotates more quickly than the tidal bulge, it follows that the frictional effect thus brought into play must have slowly diminished the period of the earth's revolution. As a time-keeper, in fact, the earth loses some twenty-two seconds in each century, and though this appears a negligible quantity it nevertheless mounts to appreciable proportions when extended over millions of years. Consider, then, for a moment, what this retardation implies. We all know that the earth is not a perfect sphere, but oblately spheroidal, having, in fact, almost exactly the shape it would assume if it were all molten and revolving at its present rate. If the earth, however, had been rotating very much faster when in the liquid condition, and solidification had then taken place, the shape would differ considerably from what we find it to be now. Even if it had been rotating three per cent. faster, the difference would be quite noticeable; for a greater polar flattening would result and the disposition of the oceans could not be as at present; and since mathematical reasoning demonstrates that one hundred million years ago a three per cent. increase in the rotation would obtain, the deduction is drawn that any greater antiquity than one hundred million years can only be regarded as improbable.

The remaining argument is drawn from a consideration of the origin of solar heat and its dissipation by radiation, and led to the conclusion that the sun has illuminated the earth only during a period which is probably less than even one hundred million years and certainly not much more.

This computation, however, and to some extent the second, are based upon data which are necessarily vague and indeterminate, and in consequence much reliance cannot be placed upon the results. As will be shown presently, even the first of the Kelvin estimates has to be rejected on the score of recent discovery; so now there is not one of his methods of estimation to which exception cannot be taken.

In their day, nevertheless, they served a useful purpose; for by awakening geologists from their dream of an unlimited credit on the bank of eternity, and compelling their reluctant limitation to a less exorbitant draft, the above intrusion on the part of physics at least prepared the way for fresh lines of argument of less doubtful validity. Naturally, Kelvin's estimates were at first indignantly discredited, though without any apparent effect upon the firmness of Kelvin's attitude. In vain his opponents appealed to their ancient traditions—geologists to their succession of strata, and palaeontologists to their evolution of types, both of which were believed to require an aeon of time—he simply ignored all with disarming unconcern.

But though the most eminent of the physicists thus arbitrarily defined his isolated position, there were others in his own sphere of activity who refused to recognise the finality of his results, and were disposed rather to compromise with geologists on the question. Thus, Sir G. Darwin, in a review of the three theories, pointed out some of the uncertainties which surrounded them; whilst Professor Perry, in his inimitable style, advanced cogent reasons for believing that the Kelvin computation erred considerably on the side of underestimation. Indeed, Perry was quite willing to concede an estimate four times greater than the greatest of Kelvin's.

These more reasonable views now stand fully justified in the light of more recent knowledge. The first and, as we have mentioned, the most trustworthy of Kelvin's arguments was vitiated during the last few years of the nineteenth century by the discovery of radioactivity and its allied phenomena. This is a point, however, which has to be deferred to a later stage. It is evident that some other methods of attacking the problem were urgent, and as such have happily been forthcoming we shall proceed to discuss them.

II.—Solvent Denudation.

From a consideration of the weathering forces which on every hand mould the features of continents, Professor Joly derives a method for determining the age of the earth since the time when the latter attained its *consistentior status*.

Looking for a ready means of computing the total effect produced by the multifarious denudation agencies, he naturally turned to rivers, as being the vehicles for the removal of detritus, and exercised himself to find some constituent which, while capable of sufficiently accurate measurement, should be non-cyclic in character, that is to say, should accumulate in the sea without possibility of return. The well-known fact that the sea, and inland lakes in particular, are slowly growing salter and salter led Joly to select sodium—in the combined state, of course—as the element best satisfying the necessary conditions. The broad outline of the method is now easy to understand. The volume of the ocean has first to be estimated and then, from a knowledge of its average chemical composition, the total quantity of sodium at present in it can be obtained. This sodium must have accumulated there ever since denudation began, and if, therefore, we divide its total by the calculated amount of it which enters the ocean annually from the rivers, an uncorrected estimate of the earth's age will result.

The amount of sodium in the sea at present is known to within a few per cent., but the quantity discharged per annum by all the rivers in the world is not so well authenticated, being much more difficult to determine. The sodium content of rivers is so variable a quantity that the water of a large number must be analysed before any reliable data become available; a difficulty, of course, which time will entirely remove. The magnitude of the quantities in question will be realised from the statement that if all the salt at present in the ocean were consolidated into a uniform layer of rock salt upon the land area of the globe the earth would be covered to a depth of about four hundred feet.

Without going into numerical details the fact may be stated that the estimate of the earth's age derived from the above-mentioned data amounts to practically one hundred million years.

To this number several corrections must be applied. The most important of these refers to what is known as "wind-borne sodium," *i.e.*, to those impalpable particles of salt which are carried inland by air currents. This factor slightly disturbs the non-cyclical character of the process, but only requires a small correction (six to ten per cent.). Relatively insignificant, too, is a correction which takes into account the land deposits of sea-salts. The only other conceivable corrections are inherent in the method itself, or, more precisely, in the assumptions which lie at the basis of the method. There is, for instance, the possibility that in the remote past the conditions which determined the rate of denudation were far different from those which prevail to-day. The sun may have been much less powerful, or, on the other hand, the elements may have been more active, and therefore more destructive. Again, there is every reason to believe that the ratio of land to sea has been far from constant during the long ages of the past. But if uniformity of the past and present conditions be assumed, as indeed seems most likely, and the other uncertainties be duly allowed for, the time which has elapsed since the "waters under the heavens were gathered together in one place, and the dry land appeared," runs to between eighty and ninety million years.

A couple of years ago the fundamental assumption underlying Joly's method was challenged by Dr. Becker, who put forward some very interesting views. He pointed out that the sodium of the ocean is derived mainly from igneous rocks, and that when denudation began these rocks were the sole constituents of the earth's crust. A very different state of affairs obtains nowadays. Sedimentary rocks are the obvious features of surface strata, and the igneous rock lies buried far beneath them. Does not this imply that the rate of decomposition has changed considerably since the early days of the earth's youth? For, whereas the necessary rocks were then freely exposed to denudation influences, the upper layer of decomposition products now arrests decay. In other words, the rate of decomposition, being dependent upon the area of exposure, has diminished throughout the ages in the same way as a sum of money would diminish if subjected to a certain percentage deduction annually, each deduction being calculated on the sum still remaining at the beginning of the year. That is to say, it has varied according to an exponential law. The estimate of the earth's age, worked out on this formula, gives a somewhat smaller value than by Joly's method, *viz.*, from fifty to seventy million years.

However, the two results are of the same order of magnitude, preference perhaps being given at present to Joly's value. Let us see if this is borne out by the next computation.

III.—Stratigraphy.

The reverse of the preceding method would obviously consist in determining the rate at which the strata are being deposited; and then, from a knowledge of the maximum depth of the stratified rocks, an estimate of the earth's age readily follows. Sir A. Geikie, even before Lord Kelvin had assaulted the geological stronghold, held that one hundred million years would suffice for the history of the sedimentary rocks. More recently Professor Sollas, Professor Joly and others have discussed the question.

The uncertainties attached to the method, however, render it practically impossible to obtain any reliable result. From the observations of geologists in different parts the maximum thickness of the deposits laid down during the various geological epochs has been estimated, but the accuracy of the measurements decreases with the increasing antiquity of the formation concerned, until, when pre-Cambrian times are reached, anything but the merest guesswork becomes impossible. Even were this difficulty removed, the intermediate lapses of time which are represented by unconformities and other appearances must, of necessity, be disregarded.

When it comes to measurements of the rate of accumulation of the various strata, still greater difficulties are encountered. Theoretically, it is only necessary to measure the annual silt-loads of various rivers, as well as the catchment area, and the rate of deposition ensues. But, in practice, the rates are found to be so divergent and variable that the average counts for little. As Joly points out, we are at liberty to assume anything from a foot to a few inches deposition per century. Taking the rate of accumulation to be four inches in the century, the age of the sedimentary column, which is between sixty and seventy miles thick by the best estimate, then works out to be about one hundred million years. Sollas gets thirty millions; Joly gets eighty million years. The latter is probably the more likely of the two, so we shall not be far wrong if we consider our one hundred-million year computation as fairly near the mark.

IV.—Radioactivity.

Among the many wonderful possibilities which radioactivity has to offer, the determination by its aid of the age of the earth may be the least important; but it is undoubtedly one of the most interesting, opening up as it does such a splendid field for discussion and speculation.

In the first place, it deals the death-blow to Kelvin's thermodynamic method. The disintegration of a radioactive body is known to be accompanied by a spontaneous evolution of heat energy, and, considering the widespread character of these bodies throughout the earth's crust, the total heat developed in this way can be no negligible quantity. Indeed, so far as present estimates go, it *more* than accounts for the earth's annual loss by radiation—truly an embarrassing position for the earth, as will be shown in a moment. The supposition, then, that the earth is merely a cooling body, whose primitive stock of heat is being slowly depleted, must be modified in order to take account of the new factor. Let us examine afresh our conception of the life-history of the earth.

The fact that the molten earth contains a considerable store of long-lived radioactive elements would not appreciably retard its cooling until the *consistentior status* was reached. Then, on the formation of the surface crust, the rate of cooling would be reduced to a very small fraction of its former value; comparable, in fact, with the heat liberated during elemental disintegration. Near the surface of the earth this heat is sufficient, we have seen, to make good the radiation loss; whereas in the interior, where escape is impossible, the heat generated cannot but have accumulated during the long geological epochs. The final result is evident. Not from without, by collision with some wandering star, but from within, by her own irrepressible vulcanicity, is the destruction to come which is to return the earth to her pristine state, to begin again her life-history, perhaps for the nth time, where n represents an unknown quantity. In a similar way the long duration of the sun's heat is accounted for, and another theory of Kelvin's exploded.

But let us get back to age determination. The basis of the radioactivity method will be clearly understood if it be remembered that radium is an element whose parentage is known and whose descendants to many generations have been fairly definitely established. In other words, this singular element has been proved to be one of a series which begins with uranium and proceeds down a scale of radio-elements of diminishing atomic weight until the final stable substance, now thought to be lead, is reached. The disintegrating process is accompanied at almost every stage by a loss of what are called α particles, which themselves have recently been shown to be identical with helium atoms.

Of course, the process of degradation is inconceivably slow, though the time-rate for each stage has actually been calculated from laboratory observations. The number of helium atoms discarded during each of the transformations is likewise known. Assuming, then, that all these discharged atoms have accumulated *in situ* in any geological formation, it is only necessary to determine in a specimen mineral the ratio of the occluded helium to the still-remaining radioactive element in order to arrive at an estimate of the age of the strata from which the mineral was taken.

The Hon. R. J. Strutt, in particular, has examined from this point of view many minerals taken from strata of the different geological epochs. His results are too numerous to quote, but so far they have not been particularly satisfactory. Even in material obviously contemporaneous, for instance, the variations in the geological ages turn out to be very considerable. The weak point of the whole method seems to lie, not in the theoretical assumptions involved, but rather in the improbability of a complete helium accumulation. It appears likely that the varying experiences to which the helium-bearing formations have been subjected throughout their existence—such as changes of temperature and pressure or the solvent action of percolating waters—have all contributed to an appreciable alteration in the amount of helium accumulated. The advantage that the method otherwise possesses, in that each determination is an independent estimate of the geological age, is thus swamped by the disability just referred to, and any results which are the outcome of such a method must consequently be received with caution.

The problem has recently been approached from another standpoint, and, at first sight, one more reliable. If lead is really the ultimate product of the disintegration of uranium—and much evidence has been adduced in support of this view—then from the uranium-lead ratio supplementary estimates are possible. Professor Boltwood has attacked the problem of the age of the earth from this assumption, and is led thereby to attribute to a number of uranium-bearing minerals an age which ranges from two hundred to one thousand three hundred million years; though since the geological positions of the rocks examined are not available the figures do not convey much.

Considered broadly, the evidence of radioactivity is to assign to the earth an age considerably greater than results from any other method. This either means that the accuracy and, perhaps, the fundamental assumptions, of the other methods are impugned, or that the radioactivity method itself is founded upon hyphotheses which are not justifiable. There is even some reason for believing that the latter is not altogether out of question. Thus, though no acceleration in the rate of disintegration of uranium has yet been observed in the laboratory, it is not beyond the pale of possibility that some conditions did prevail in the earlier stages of the earth's history which are not experimentally realisable to-day, but which then determined an increase in the rate of decay. It would be unwise, however, to pursue speculation further, notwithstanding an innate desire to cast doubt upon a method which, by disturbing the gradual maturing and stabilisation of our views before its appearance, has thrown us back into what Professor Schuster describes as "the primitive state where no opinion is absurd and every hypothesis justifiable." Until further evidence of a more convincing nature is forthcoming, we may provisionally assign an age of not less than one hundred million years to this earth of ours.

Of course, this estimate takes us back only to the *consistentior status*. Whether, before that, the sun was still pouring his beneficent rays upon the earth, so that the present estimate of the earth's age is not merely an estimate of the sun's activity, or whether, instead, after solidification of the outer crust, the earth rolled through space as a dead world shrouded in darkness save "where her volcanoes glowed red in the eternal night," cannot be answered decisively. From present evidence it appears very likely that the sun shone brightly long before the earth came into existence, and the one hundred million years would not then have to be very materially increased in order to take us back to the very birth of the earth. On the other hand, it may be that the discrepancies between the results derived from a consideration of denudation and of radioactivity are to be interpreted as pointing to long aeons of time during which the earth slept as she rolled through space.

It would be an interesting diversion to consider whether the whole scheme of evolution outlined by Darwin and others could possibly be worked out within such a comparatively short period as we have accepted. Are one hundred million years time enough for that evolution of the organisms which, starting with a shapeless mass of protoplasm, determined its development through countless structures of increasing complexity, until finally man himself was reached? At this stage only the briefest of answers can be given. Eminent biologists declare that the period *is* ample and the ordinary doubts of the layman may therefore be laid aside.

The period of one hundred million years, then, which have been conceded to the earth, is from most points of view a reasonable estimate. It cannot be expected, however, that finality is attained. This estimate, like its predecessors, may have to be discarded if further investigation requires it, though as yet there seems no valid reason for abandoning it. Nevertheless, our ideas on the subject must be pliant and versatile, our minds ready to recognise the meaning of revolutionary discovery. The best attitude, perhaps, is that which regards the one hundred million years as the earth's *minimum* age, and is prepared, if occasion demands, to consider impartially an estimate of greater—it may be much greater—magnitude.

CORRESPONDENCE.

SPURIOUS DIAMETERS OF STARS.

To the Editors of "KNOWLEDGE."

SIRS,—Reading recently the papers of Sir W. Herschel, published last year by the Royal and Royal Astronomical Societies, I was surprised to see his statement that increase of magnifying power with the same aperture of object glass or mirror causes a decrease in the size of the spurious discs of stars. I was fully under the impression from reading modern works that the reverse was the case. I know that increase of aperture means decrease of diameter of spurious discs, but the other was news to me. Herschel's words are: "By many observations their spurious diameters are lessened by increasing the power, and increase when the power is lowered." In Vol. II., page 303, again he says that the diameter of spurious disc of α Aurigae with power 227 was $2''\cdot 5$, and that of α Tauri with power 460 was $1'' 46'''$, and with 932 it was $1'' 12'''$, while that of α Lyrae with power 6450 was $0''\cdot 3553$. I should be glad if some of your astronomical readers would reconcile these extracts with present-day ideas.

THEODORE B. BLATHWAYT.

CAPE TOWN.

STELLAR DISTANCE UNITS.

To the Editors of "KNOWLEDGE."

SIRS,—I notice some comments in your July issue regarding names for the planetary and stellar distance units. In my opinion the names suggested are quite impossible—ugly of look and ugly of speech. The names for any unit of measure should assuredly be short and easy to pronounce. Dr. Crommelin's suggestion of "astron" for one is quite acceptable. But why bother about the inner significance of the words at all? An arbitrary adoption would do quite as well. Why not follow the course adopted in electrical measurements? Here we have "Watts" and "Amperes"; in Astronomy we might well have "Keplers" and "Newtons." Let the former stand for the shorter or earth-sun unit, and the latter for the longer "light-year." In order to destroy the personal look about the terms they might well be abbreviated to "keps" and "newts." As alternatives the names of the men who (*a*) first determined the earth-sun distance and (*b*) who first used the "light-year" of a unit of measure might be used.

A. J. H.

ABERYSTWYTH.

A PLEA FOR A BRITISH FOLK-MUSEUM.

By W. RUSKIN BUTTERFIELD.

A PROPOSAL has recently been made to utilise the Crystal Palace and grounds for a National Folk-Museum on the lines of the famous Nordiska Museet at Stockholm, with its open-air department of Skansen.

The last two decades have witnessed the formation of folk-museums in various parts of Europe, and especially in the Scandinavian countries. In addition to the one mentioned at Stockholm, Sweden possesses others at Lund, and at Bunge in the island of Gotland; in Norway similar institutions have been established at Christiania, Lillehammer, Elverum, and Hamar; and in Denmark at Copenhagen. Their *raison d'être* is to illustrate in a concrete manner the evolution of national culture and characteristics; to trace the modes of life of the people in times past and to preserve representative examples of national buildings, domestic and other appliances, costumes, personal ornaments—in short, to bring together in one locality all such objects as best serve to reconstruct the conditions of life in their respective countries from remotest times.

In no country is a national folk-museum so necessary as in England, because in no other country is there such a dearth of distinctively national objects, and also because no other country has outgrown its past so rapidly and so completely in regard to indigenous customs, amusements, and modes of life generally. What an unalluring sight is presented, for instance, by the interiors of the smaller homes of the land at the present time. The furniture, pottery, and other objects are almost all of the factory type. Here and there, it is true, one does find an old corner cupboard, a lace christening cap, or a piece of slip-ware made at some forgotten local pottery and containing perhaps a presentation inscription commemorating a wedding or a betrothal; but these old folk-objects are few and far between. During the Victorian period especially there existed a profound apathy, if not antipathy, for what was deemed old-fashioned. Mural paintings were hidden behind coats of lime-wash, oak-panelling was torn from the walls, and immemorial seasonal customs in town and village alike dwindled to their final abandonment. No less striking were the changes wrought by the concentration of industries and by increased facilities for transport. Home industries, such as weaving and lace-making, and local crafts, like those of the potter and the basket-maker, were diverted from the villages to factories in the larger centres of population. A national folk-museum would take account of these several changes and preserve the links between the past and the present.

The British Museum at Bloomsbury and the Victoria and Albert Museum at South Kensington are national in scarcely any other sense than that they are State institutions. The splendid collections in the former tell us as much, if not indeed more, about the ancient Egyptians and Greeks than about our own peoples and our own land. The equally fine collections at South Kensington have been accumulated mainly for the special purpose of providing objects, irrespective of their place of origin, to serve as standards in the industrial and fine arts. Moreover, the methods of exhibition in these great museums are only partly in keeping with the spirit of folk-museums. Instead of displaying collections in formal series in standardised glass cases, the folk-museums assemble their objects so far as possible in related groups. But the great failing of the museums in question lies in their remoteness from the realities of every-day life. They restrict themselves too rigidly to things which are merely rare or precious, or which attain a certain artistic merit. They pay little or no concern to the ordinary man and woman. In other words, they touch the circle of national life only at the glowing centre instead of reaching to the wide periphery.

Now let us turn to the proposed scheme and see, so far as is possible in a bare outline, what it is intended to accomplish. Taking the Crystal Palace grounds first, it is proposed to establish therein an open-air museum. Of all the survivals from former times, none surpass in interest the people's homes. The first duty, therefore, of the open-air museum would be to secure ancient houses bearing in a sufficiently well-marked manner features distinctive of some period or locality. The buildings would be taken down and re-erected in the grounds with scrupulous regard to their original form. It is not contemplated, it need hardly be said, to ransack the English countryside and tear buildings from their time-honoured sites, where there is no danger of their demolition or serious mutilation, but to rescue here and there worthy and typical buildings in imminent danger of destruction. After their re-erection the houses will be provided with contemporary furniture and all appropriate appliances, the idea being to show them exactly as they appeared to the people of the time. Some of the houses might have associated with them old English gardens, with a columbarium, a well-house, a sun-dial, and clipped yews. Consider how fascinating such sights would be, not only to ourselves, but also to visitors from amongst our kinsmen in the dominions beyond the seas.

In some cases, instead of removing whole houses, it would be sufficient to secure the ceiling, a fireplace, a panelled room, or the main staircase, and to instal these in rooms in the Crystal Palace.

Besides domestic buildings, other structures would be treated in the same way, such as ancient barns and water-mills. It might even be possible to save some abandoned and decaying English church whose preservation is demanded by its age or importance. Such a church would form the most appropriate home for the display of ecclesiastical art. No doubt many people would find it hard to assent to the removal of a church from its parish, but such removal and preservation are better than decay and final ruin.

The scheme provides for the assignment of a portion of the grounds for our great national games and pastimes; here would be a maypole for the children and a bowling green for their elders. A dancing floor would be laid out for national dances, and an open-air theatre prepared for the performance of historical pageants and stage plays. At Skansen, spacious enclosures are reserved for living examples of Swedish mammals and birds. This might be imitated by a miniature British "Zoo."

As to the Crystal Palace itself, it would serve for the exhibition of objects of all sorts illustrating the daily life, occupations, and amusements of the peoples of these islands. One room could be devoted to children's toys, another to objects used by women in indoor amusements, another to the apparatus and methods of producing fire in past times (a most seductive subject), another to inventions, another to models to enable the blind to gain, by tactual means, a knowledge of some of the more interesting objects in the various departments. Space would further be required for developmental series of English metal-work, wood-carving, pottery, glass, furniture, and textiles; also for such things as hand-looms, vehicles, old surgical instruments, inn-signs, the regalia of guilds and other societies, stocks, gibbets, clocks, tallies, charms, cheese-presses, and a multitude of others. Special stress would be laid upon objects typified by ornamental lace-bobbins, carved bone apple-scoops, and costumes, as it is just such things as these that best illustrate the trend of native culture.

The framers of the scheme point out that it would be particularly appropriate if a number of rooms in the Crystal Palace could be devoted to collections relating to past and present members of our Royal house, such as portraits, ceremonial robes, and personal relics. The present writer had hopes at one time that Stafford House might be converted into a royal museum after the fashion of Rosenborg Castle at Copenhagen, but the future of that building has been settled otherwise.

A national folk-museum like this would illustrate, by means of actual objects, historical continuity. After all, the present can only be measured in terms of the past, and, unhappily, in England our past is rapidly disappearing beyond recall. If the project is delayed much longer its effectual accomplishment will become impossible. Other European countries are fully alive to the importance of preserving unbroken the records of national life. There is little in our past to be ashamed of; there is much of which we may justly be proud.

Through the patriotic action of Lord Plymouth, Sir David Burnett, and of *The Times*, the Crystal Palace grounds are now available for some public purpose. It is desirable, from every point of view, to take advantage of so unique an opportunity for promoting the establishment of a permanent and comprehensive national folk-museum. The central feature of the situation lies in the fact that, if these grounds are assigned to some other use, no other open stretch of land so near London of such magnitude can ever again be forthcoming. It is a duty we owe to posterity no less than to our forbears, to preserve, while it is still possible, the fast dissolving links that bind us with the past.

I wish to express my indebtedness to Mr. Bernhard Olsen, of the Dansk Folkemuseum, Mr. Hans Aall, of the Norsk Folkemuseum, Mr. Bernhard Solen, of the Nordiska Museet, and Dr. Anders Sandvig, founder of Maihaugen Open-air Museum, for kind permission to reproduce the accompanying illustrations; also to Dr. F. A. Bather and Professor Henri Logeman for valued assistance.

THE ARTIFICIAL RIPENING OF FRUITS.

The Gardeners' Chronicle for July 19th points out that the Arabs have for centuries ripened dates artificially by exposing them to the fumes of vinegar; and refers to the ripening of persimmons by the Japanese, who store them in a closed cask in which the national alcoholic beverage known as saké has been kept. Professor Francis Lloyd's method of exposing unripe fruits under a pressure (of from fifteen to forty-five pounds to the square inch) to the action of carbon dioxide for fifteen to thirty-six hours is also discussed. What happens in the process is not altogether clear, but we quote the following remarks:—

"Astringency is due to the action on the tongue of the tannins contained in the unripe fruit. It disappears if the tannins are destroyed, or if these bitter substances are prevented from acting on the tongue. Carbon dioxide seems to produce the latter effect, and in the following way: Associated with the tannins in plant tissues are coagulable substances. Such substances when caused to coagulate hold the tannins very strongly, so strongly, indeed, that the latter substances are prevented from giving rise to an astringent taste when the fruit containing them is eaten. In short, the coagulated substance plays the part of the coat of a bitter pill, enabling the latter to be taken untasted. The explanation may be that which has been given; but we are inclined to think that other changes are induced by carbon dioxide. For example, it is possible that the effect of carbon dioxide is to hasten the oxidation processes of the tissues, and hence to cause a partial or complete destruction of the astringent substances. Whatever be the precise interpretation of the process the important thing is to ascertain whether a similar process may be induced in our common large fruits; for although artificial ripening is primarily of importance to the grower of tropical fruits—dates, bananas, persimmons, and the like—it may prove also of service to the home grower."

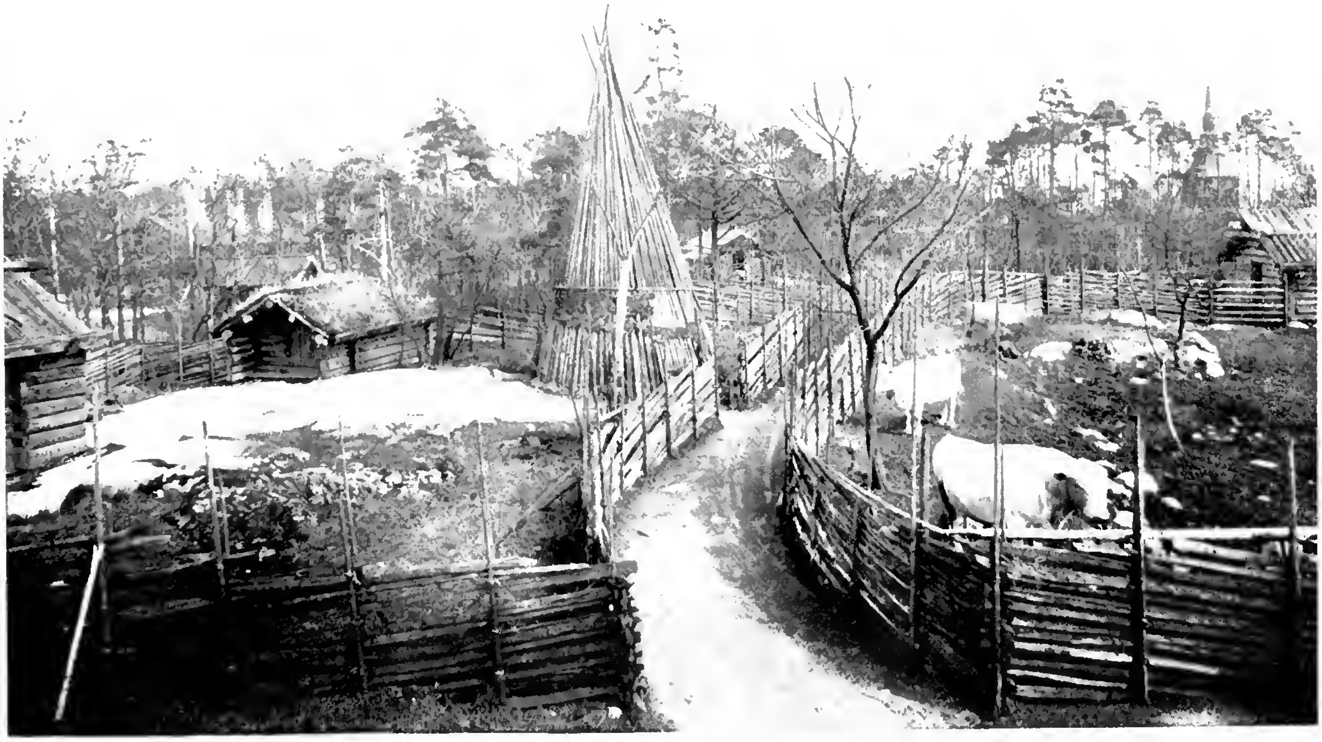


Figure 331. Assemblage of buildings within enclosures forming a "summerset," or temporary quarters occupied during cattle grazing, from Jämtland. Skansen.

Figure 332. Timber-houses from Telemarken. Norsk Folkemuseum.

Figure 333. Interior of room from a farmhouse, from Amager, near Copenhagen. Dansk Folkemuseum.

Figure 334. Farmhouse interior from Urendorf, Halsatia. Dansk Folkemuseum.

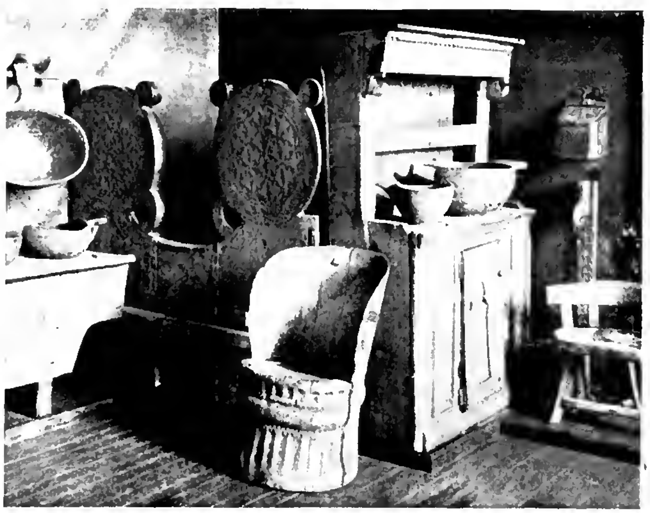


Figure 335. Interior from Telemarken. Norsk Folkemuseum.

Figure 336. Timber-house ("Rolstadloftet") from Gudbrandsdale. Norsk Folkemuseum.

Figure 337. House in the Maihaugen Open-Air Folk-Museum, Lillehammer.

Figure 338. Interior of a dwelling at Lillehammer.

THE FACE OF THE SKY FOR SEPTEMBER.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 52.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Uranus. R.A.	Uranus. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m	°	h. m.	°	h. m.	°	h. m.	°
Sept. 2	10 43·9	N.8·1	12 8·5	S. 1·8	9 56·5	N.14·1	8 13·6	N.19·4	5 26·9	N.22·9	18 34·9	S.23·4	5 6·1	N.21·2	20 27·1	S.19·8
,, 7	11 1·9	6·2	16 46·4	S. 27·6	10 33·0	11·0	8 38·0	18·3	5 39·7	23·1	18 35·0	23·4	5 7·1	21·2	20 26·5	19·9
,, 12	11 19·9	4·3	21 18·5	S. 19·1	11 8·8	7·4	9 2·2	17·0	5 52·1	23·3	18 35·4	23·4	5 7·9	21·2	20 26·0	19·9
,, 17	11 37·9	2·4	0 53·4	N. 7·8	11 43·0	N.3·5	9 26·1	15·5	6 4·3	23·4	18 36·1	23·4	5 8·5	21·2	20 25·5	19·9
,, 22	11 55·8	N.0·5	4 59·2	N.28·0	12 15·3	S.0·5	9 49·9	13·8	6 16·0	23·5	18 37·1	23·4	5 8·9	21·2	20 25·1	19·9
,, 27	12 13·8	S.1·5	9 55·2	N.15·4	12 46·0	S.4·3	10 13·4	N.11·9	6 27·3	23·5	18 38·5	S.23·4	5 9·2	N.21·2	20 24·8	S.19·9

TABLE 53.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Mars. P	Mars. B	Mars. L	Mars. T	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
Greenwich Noon.	°	°	°	°	°	°	°	h. m.	°	°	°	°	h. m.	h. m.
Sept. 2	+21·4	+7·2	24·2	+21·8	−28·7	−1·0	227·1	9 6 *e*	−4·6	−1·6	199·9	285·5	4 23 *e*	2 4 *e*
,, 7	22·6	7·2	318·2	+ 6·9	27·5	+0·2	178·9	0 24* *m*	4·6	1·6	269·0	316·5	2 30 *e*	1 13 *e*
,, 12	23·7	7·2	252·2	−16·5	26·2	1·4	130·8	3 2 *m*	4·6	1·6	338·1	347·4	10 27 *e*	0 22 *e*
,, 17	24·5	7·1	186·2	−21·4	24·9	2·5	82·8	6 20 *m*	4·7	1·6	47·1	18·2	8 34 *e*	9 26 *e*
,, 22	25·2	7·0	120·2	− 5·8	23·6	3·5	34·8	9 37 *m*	4·8	1·6	116·0	49·0	6 41 *e*	8 36 *e*
,, 27	+25·8	+6·8	54·2	+18·6	−22·3	+4·5	346·9	0 54 *e*	−5·0	−1·6	184·8	79·6	4 48 *e*	7 45 *e*

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Mars, T is the time of passage of Fastigium Aryn across the centre of the disc. In the case of Jupiter, L_1 refers to the equatorial zone; L_2 to the temperate zone; T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

The asterisk indicates the day following that given in the date column.

THE SUN continues his Southward march with accelerated speed. The equinox is passed $23^d\ 3^h\ 53^m e$. Sunrise during August changes from 5.13 to 5.59, sunset from 6.48 to 5.41. Its semi-diameter increases from 15′ 53″ to 16′ 0″. Outbreaks of spots in high latitudes should be watched for.

MERCURY is in Superior Conjunction $16^d\ 3^h e$; before that it is a morning star. Illumination increases from $\frac{7}{10}$ to Full. Semi-diameter diminishes from 3″ to $2\frac{1}{2}$″.

VENUS is a morning star, rising 3 hours before the Sun. Semi-diameter diminishes from 7″ to 6″. At beginning of month $\frac{3}{4}$ of disc is illuminated; at end of month $\frac{5}{6}$. Being North of Sun it is favourably placed for Northern observers.

THE MOON.—First Quarter $7^d\ 1^h\ 6^m\ e$; Full $15^d\ 0^h\ 46^m\ e$; Last Quarter $23^d\ 0^h\ 30^m\ e$. New $30^d\ 4^h\ 57^m\ m$. Perigee $1^d\ 7^h\ m$, semi-diameter 16′ 44″. Apogee 15^d Noon, semi-diameter 14′ 44″. Perigee $29^d\ 6^h\ e$, semi-diameter 16′ 44″. Maximum Librations, 7^d 8° W, 8^d 7° N., 23^d 7° E., 23^d 7° S. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

ECLIPSES.—A small partial eclipse of the Sun, invisible in Europe, occurs on August 31st, lasting from $8^h\ 2^m\ e$ to $9^h\ 42^m\ e$; greatest magnitude 0·15. Visible in Newfoundland, Labrador, Greenland.

A total eclipse of the Moon, invisible in Europe, occurs on September 15th, lasting from $10^h\ 53^m\ m$ to $2^h\ 44^m\ e$. Visible over Pacific Ocean, Australia, New Zealand, and so on.

A partial eclipse of the Sun, invisible in Europe, occurs on September 30th, lasting from $2^h\ 56^m\ m$ to $6^h\ 36^m\ m$; greatest magnitude 0·83. Visible in South Africa, Madagascar, Mauritius, and South Indian Ocean.

MARS is a morning Star, semi-diameter 4″, defect of illumination nearly a second. It will reach Opposition early in January, so the season of observation is commencing. The Earth is in the plane of Mars' Equator on September 6th; both poles are then on the edge of the disc.

JUNO is in opposition September 14th, magnitude 7·6. Ephemeris for midnight:—

	R.A.	S.Dec.
	h m	°
Sept. 12...	23 24·5	3·6
,, 18...	23 20·2	4·9
,, 24...	23 16·1	6·1
,, 30...	23 12·3	7·3

SATURN is a morning star, coming into a better position for observation. Polar semi-diameter $8\frac{1}{4}$″. P. is −4°·9; ring major axis $43\frac{1}{2}$″, minor $19\frac{1}{2}$″. The ring is very widely open. It is of interest to examine the exact amount of overlap beyond the planet's pole.

East Elongations of Tethys (every fourth given), $3^d\ 4^h{\cdot}9e$, $11^d\ 6^h{\cdot}1m$, $18^d\ 7^h{\cdot}4e$, $26^d\ 8^h{\cdot}6m$; Dione (every third given), $6^d\ 11^h{\cdot}1e$, $15^d\ 4^h{\cdot}2m$, $23^d\ 9^h{\cdot}3m$; Rhea (every second given), $2^d\ 4^h{\cdot}8m$, $11^d\ 5^h{\cdot}7m$, $20^d\ 6^h{\cdot}6m$, $29^d\ 7^h{\cdot}5m$. For Titan and Iapetus E.W. mean East and West Elongations; I. Inferior (North) Conjunctions, S. Superior (South) ones. Titan, $3^d\ 5^h{\cdot}7e$ W., $7^d\ 5^h{\cdot}2e$ S.; $11^d\ 8^h{\cdot}4e$ E., $15^d\ 8^h{\cdot}4e$ I., $19^d\ 4^h{\cdot}9^d$ W., $23^d\ 4^h{\cdot}3e$ S., $27^d\ 7^h{\cdot}4e$ E.; Iapetu , $9^d\ 5^h{\cdot}3m$ S., 29e $6^h{\cdot}0e$ E.

URANUS was in opposition on July 29th. Semi-diameter, $1\frac{3}{4}$″. At end of August, 2° S.E. of ρ Capricorni.

TABLE 54. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance.		Reappearance.	
			Mean Time.	Angle from N. to E.	Mean Time.	Angle from N. to E.
1913.			h. m.		h. m.	
Sept. 4 ...	BAC 4722	5·5	7 13 *e*	67°	—	—
,, 6 ...	Lacaille 6719	6·9	7 13 *e*	63	—	—
,, 6 ...	Stone 8802	7·0	7 49 *e*	89	—	—
,, 8 ...	γ^1 Sagittarii	var.	4 53 *e*	84	6 13 *e*	281°
,, 9 ...	BAC 6525	6·2	7 54 *e*	121	8 51 *e*	211
,, 10 ...	A Sagittarii	4·9	5 53 *e*	80	7 14 *e*	252
,, 14 ...	b^1 Aquarii	5·4	6 2 *e*	4	6 35 *e*	302
,, 17 ...	BD+ 9°142	7·1	—	—	9 29 *e*	270
,, 19 ...	BD+15°305	7·5	—	—	2 8 *m*	180
,, 19 ...	BD+18°347	6.9	—	—	9 14 *e*	210
,, 20 ...	BD+19°432	7·0	—	—	1 39 *m*	275
,, 20 ..	47 Arietis	5·8	2 53 *m*	116	3 43 *m*	193
,, 20 ...	9 Tauri	6·7	—	—	8 58 *e*	219
,, 20 ...	17 Tauri	3·8	11 58 *e*	62	1 9**m*	248
,, 21 ...	16 Tauri	3·8	0 17 *m*	20	1 7 *m*	289
,, 21 ...	20 Tauri	4·1	0 46 *m*	28	1 45 *m*	282
,, 21 ...	η Tauri	3·0	1 38 *m*	138	2 2 *m*	174
,, 21 ...	24 Tauri	6·8	—	—	2 8 *m*	189
,, 21 ...	BD+23°540	7·0	—	—	2 37 *m*	230
,, 21 ...	BAC 1171	6·6	—	—	3 11 *m*	221
,, 25 ...	C Geminorum	5·5	2 30 *m*	48	3 12 *m*	326

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.
The asterisk indicates the day following that given in the date column.
Attention is called to the occultation of the Pleiades on the 21st; the stars from 17 Tauri to BAC 1171 belong to the group.

NEPTUNE is too near the Sun for convenient observation, having been in conjunction on July 19th.

JUPITER was in opposition on July 5th. Polar semi-diameter, 19″ in mid-September.

Satellite phenomena visible at Greenwich, $1^d\ 7^h\ 29^m$ I. Sh. I., $8^h\ 38^m$ I. Tr. E., $9^h\ 48^m$ I. Sh. E., $10^h\ 31^m$ III. Tr. I., $10^h\ 47^m\ 41^s$ IV. Ec. D.; $2^d\ 7^h\ 3^m\ 46^s$ I. Ec. R.; $5^d\ 8^h\ 39^m\ 4^s$ III. Ec. R., $11^h\ 15^m$ II. Tr. I.; $7^d\ 10^h\ 50^m\ 6^s$ II. Ec. R., $11^h\ 1^m$ I. Oc. D.; $8^d\ 8^h\ 12^m$ I. Tr. I., $9^h\ 25^m$ I. Sh. I., $10^h\ 30^m$ I. Tr. E.; $9^d\ 7^h\ 56^m$ IV. Tr. I., $8^h\ 58^m\ 46^s$ I. Ec. R., $10^h\ 57^m$ IV. Tr. E.; $12^d\ 7^h\ 37^m$ III. Oc. R., $9^h\ 25^m\ 32^s$ III. Ec. D.; $14^d\ 8^h\ 4^m$ II. Oc. D.; $15^d\ 10^h\ 5^m$ I. Tr. I.; $16^d\ 7^h\ 21^m$ I. Oc. D., $8^h\ 22^m$ II. Sh. E.; $17^d\ 6^h\ 51^m$ I. Tr. E., $8^h\ 8^m$ I. Sh. E.;

TABLE 55. NON-ALGOL STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m.	°		d.	
RU Aquilae	20 9	+12 ·7	7·9 to 14	276	Aug. 22.
R Sagittae	20 10	+16 ·5	8·5 to 10	70·6	July 20, Sep. 29.
AI Cygni	20 28	+32 ·2	8·6 to 9·7	173	Aug. 27.
V Cygni	20 38	+47 ·8	6·8 to 14	418	June 29.
T Aquarii	20 45	− 5 ·5	6·8 to 13	202·7	July 30.
R Vulpeculae...	21 1	+23 ·5	7·1 to 13	136·8	Aug. 30.
T Cephei	21 8	+68 ·2	5·2 to 11	387	Oct. 24.
SW Pegasi	21 18	+21 ·6	8·7 to ?	175	July 10.
YY Cygni	21 19	+42 ·0	8·5 to 9·5	378	Sep. 29.
S Cephei	21 36	+78 ·2	7·0 to 13	486	June 24.
V Pegasi	21 57	+ 5 ·7	7·8 to 14	303	Sep. 8.
X Aquarii	22 14	−21 ·3	7·6 to 11	315	July 31.
TX Pegasi	22 14	+13 ·2	8·5 to 9·2	123	July 20, Nov. 20.
S Lacertae	22 25	+39 ·8	8·0 to 12·5	237·5	July 29.
R Lacertae	22 39	+41 ·9	8·3 to 13·9	299·8	July 1.
U Lacertae	22 44	+54 ·7	8·5 to 9·1	659	July 5.
S Aquarii	22 52	−20 ·8	8·0 to 14·5	279·7	July 25.
SS Andromedae	23 8	+52 ·4	8·9 to 9·6	165·8	Aug. 5.
TY Andromedae	23 10	+40 ·3	8·2 to 9·6	144	Oct. 19.
W Pegasi	23 15	+25 ·8	7 to 13	342·6	Aug. 13.
S Pegasi	23 16	+ 8 ·4	7·3 to 13·1	317·5	Aug. 10.
R Aquarii	23 39	−15 ·8	6·0 to 10·8	387·16	Oct. 6.
V Cephei	23 52	+82 ·7	6·2 to 7·0	362	Nov 20.
R Cassiopeiae...	23 54	+50 ·9	4·8 to 13·2	431·6	July 21.
Y Cassiopeiae...	23 59	+55 2	8·4 to 13·9	410	Nov. 22.

β Lyrae minima Sept. $5^d\ 2^h$ *m*, 17^d midnight, $30^d\ 10^h$ *e*, Period $12^d\ 21{\cdot}8^h$.

Algol minima Sept. $3^d\ 0^h\ 11^m$*m*, $5^d\ 9^h\ 0^m$ *e*, $23^d\ 1^h\ 54^m$*m*, $25^d\ 10^h\ 43^m$*e*, $28^d\ 7^h\ 32^m$*e*, Period $2^d\ 20{\cdot}8^h$.

$18^d\ 8^h\ 16^m\ 58^s$ IV. Ec. R.; $19^d\ 8^h\ 10^m$ III. Oc. D.; $23^d\ 6^h\ 36^m$ III. Sh. E., $8^h\ 5^m$ II. Sh. I., $8^h\ 22^m$ II. Tr. E., $9^h\ 15^m$ I. Oc. D.; $24^d\ 6^h\ 27^m$ I. Tr. I., $7^h\ 45^m$ I. Sh. I.. $8^h\ 45^m$ I. Tr. E., $10^h\ 4^m$ I. Sh. E.; $25^d\ 7^h\ 17^m\ 37^s$ I. Ec. R.; $30^d\ 7^h\ 11^m$ III. Sh. I., $8^h\ 5^m$ II. Tr. I. All these are in the evening hours, the planet setting before midnight.

Table 56.

Day.	West.		East.	Day.	West.		East.
Sep. 1		⊙	342	Sep. 16	432	○	1●
,, 2	32	○	14	,, 17	3241	○	
,, 3	321	○	4	,, 18	3	○	1^{4}_{2}
,, 4	3	○	124	,, 19	13	○	24
,, 5	1	○	24 3●	,, 20	2	○	134
,, 6	2	○	134	,, 21	12	○	34
,, 7	1	○	34 2●	,, 22		○	1324
,, 8		○	1324	,, 23	31	⊙	4
,, 9	32	⊙	1●	,, 24	32	⊙	4
,, 10	3421	○		,, 25	3	○	124
,, 11	43	○	12	,, 26	134	○	2
,, 12	41	○	32	,, 27	42	○	13
,, 13	42	○	13	,, 28	412	○	3
,, 14	412	○	3	,, 29	4	○	123
,, 15	4	○	132	,, 30	413	○	2

Configuration at 8^h *e* for an inverting telescope.

Double Stars and Clusters.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

Variable Stars.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 20^h to 0^h, next month 22^h to 2^h, and so on.

Meteor Showers (from Mr. Denning's List):—

Date.	Radiant.			Remarks.
	R.A.		Dec.	
June to Sep...	$335°$	+	$57°$	Swift.
July 25 to Sept. 15	48	+	43	Swift, streaks.
July to Sept. .	335	+	73	Swift, short.
July to Oct. ...	355	+	72	Swift, short.
Aug. to Sept. .	353	−	11	Rather slow.
,, ,,	346		0	Slow.
Aug. to Oct. 2.	74	+	42	Swift, streaks.
,, to Sept...	63	+	22	Swift, streaks.
Sep. 5-15 ...	62	+	35	Swift, streaks.
,, 6-17 ...	106	+	52	Swift, streaks.
,, 15-24 ..	14	+	6	Slow.
,, 21 ..	31	+	19	Slow, trains.
,, 27-30 ...	4	+	28	Slow.
,, 28 to Oct 9	320	+	40	Slow, small.

NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

THE LIGHT-VARIATION OF EROS.—It will be remembered that at the time of the near approach of Eros at the end of 1910 and beginning of 1911 a large variation was detected in its brightness; there was a question whether the period was five hours or two and a half hours; it appears that the full period is five hours, but that it is made up of a double wave with unequal maxima, like some variables (Beta Lyrae has the maxima equal, the minima unequal). At the opposition of 1903 Eros was far south, and Professor S. Bailey made most careful observations on the variability at the Arequipa Observatory. The visual and photographic methods confirmed each other, and showed that the five-hour period is correct; the exact value is 0·2196 day, but this has not been corrected for the changing position of the planet. Taking the minimum brightness as zero, the following tables give the excess of brightness (in stellar magnitudes) over minimum light at intervals of one-twenty-fourth of the period, beginning at principal maximum. The upper set is derived from the visual measures, the lower from the photographic:—

·63, ·57, ·44, ·27, ·10, ·01, ·00, ·06, ·19, ·34, ·47, ·55, ·56 ·50, ·40, ·29, ·14, ·02, ·00, ·07, ·22, ·39, ·53, ·61.

·51, ·47, ·39, ·28, ·15, ·05, ·00, ·00, ·07, ·16, ·29, ·38, ·43, ·43, ·37, ·29, ·16, ·05, ·00, ·00, ·07, ·21, ·36, ·47.

The two curves are in good agreement, and show a range of fully half a magnitude. The maxima differ by ·07; the reality of the double maximum is probable, but it appears possible that there is really only a single wave with half the period. The most probable cause of the variation seems to be irregular shape of the planet. In such a tiny body gravity is very weak, and insufficient to form a regular shape. This seems more likely than the suggestion made by Professor Turner that it may have spots on its surface of very different albedoes. On such a tiny world anything in the nature of cloud or snow is out of the question, for it could not retain an atmosphere. Also organic rocks like chalk are excluded. It seems not impossible that at the near approach of 1931 our giant telescopes may be able to see Eros as a tiny disc (it should be quite half a second in diameter) and detect any notable departure from roundness; double stars half a second apart are easily separated in large instruments.

There is no reason to think that Eros is the only small planet whose shape is irregular—many have therefore been observed at Arequipa for variability. Three gave definite light-curves: Sirona has a period of $0^d·403$, range one-half magnitude; Celuta period $0^d·364$, range one-half magnitude; Tercidina period $0^d·366$, range one-half magnitude; its variation had already been detected by Wolf and Wendell. Variation was suspected in Hecuba and Urania, but not fully established. It would seem that the asteroids as a class have pretty rapid rotation from the periods of those that vary.

THE WORK OF HARVARD OBSERVATORY.—We had the pleasure of hearing both Professor E. C. Pickering and Miss Cannon at the meetings of the R.A.S. and the B.A.A. in June, and we formed some idea of the immense scale of their work. Miss Cannon is directing the preparation of a catalogue of the spectra of one hundred thousand stars, which will be practically exhaustive down to magnitude 8, and will contain many fainter stars. This is, of course, made from photographs taken with a prismatic camera; it would be out of the question to obtain so many spectra with a slit spectroscope; the latter is, of course, better for large-scale spectra of bright stars, or for motion in the line of sight, which can only be deduced in an indirect and unsatisfactory way from the prismatic camera. This, however, gives a considerable amount of detail even with faint stars, and wave-lengths of lines can be deduced differentially. Miss Cannon is so intimately acquainted with all the types of spectra and their subdivisions that she can assign them to their different classes with great rapidity; subsequently her assistants identify the stars and prepare the catalogue. No fewer than fifteen Novae were discovered at Harvard by their spectra, ten by the late Mrs. Fleming. Many other stars having bright lines in their spectra have been discovered. Professor Pickering states that with a slit-spectroscope only about two per cent. of the stars' light is utilised, as atmospheric unsteadiness continually moves its image off the slit. With the prism before the object-glass there is little loss of light, no guiding is required; the spectra are given any desired width by allowing them to trail on the plate.

APPEAL FOR MORE VOLUNTEERS FOR OBSERVATION OF VARIABLE STARS.—The June number of *Publications of the Astronomical Society of the Pacific* has an article on this subject by Mr. E. Gray. He points out what a suitable field this is for amateurs with a small equipment; a good binocular suffices to observe the brighter variables, while a very large field of work is open to the possessor of a three-inch telescope: it need not be equatorially mounted, though if not it is necessary to commit to memory the field surrounding each star studied, so as to be able to identify it without loss of time. For the brighter variables the observer can make sketches of the fields for himself; for the fainter ones he should procure Father Hagen's Atlas. The article quotes the case of an observer who had only a three-inch on a tripod stand who was able to observe twenty-six variables on one evening and to finish work at 8.50 p.m. There is the charm of uncertainty about this work, for while some of the stars are regular, others are subject to large irregularities, and there is the possibility that assiduous work may find the law of these fluctuations. X Monocerotis is quoted as a typical star for which more observers are needed to follow it through all its stages (it does not go below the tenth magnitude). Beginners are more likely to persevere if they take up work that they know is of real utility than if they merely do aimless star-gazing. A further attraction is added to this field of work by the rich red colour of many of the stars.

THE PLANET ALBERT.—The same publication contains an account of Dr. Haynes's work on this planet (better known as MT). He is taking the three undoubted observations of 1911, October 3rd, 4th, and 11th, and combining them one by one with each of the other eight doubtful places, so as to get a series of orbits one of which is presumably right. Search will be made in all possible positions when a favourable opposition recurs. The planet was in opposition last spring, but only of magnitude 19 or 20. Search was, however, made with the Crossley Reflector at Lick, and three faint planets found, but it appeared that none of them could be Albert. I am glad to note that Dr. Haynes has received the degree of Doctor of Philosophy in the University of California in recognition of this work.

THE TROJAN GROUP OF PLANETS.—The same magazine has an article on this group by Dr. S. Einarsson. They nearly conform to the equilateral configuration with the Sun and Jupiter, which Laplace showed to be an exact solution of the three-body problem. The present paper shows that it is both simpler and more accurate to deal with the motion on this basis from the first than to treat Jupiter's action as a mere perturbation.

BOTANY.

By Professor F. Cavers, D.Sc., F.L.S.

THE "AFTER-RIPENING" OF SEEDS.—In many cases seeds require a long time for germination, usually owing to the exclusion of water or of oxygen by the seed-coat. After excluding such cases, however, there are some plants left in which the seed does not grow, even when the coat has been removed and the embryo put in good germinating conditions, until a certain period has elapsed, during which some change is evidently taking place in the embryo. To such cases the term "after-ripening" is strictly applied, and Miss S. Eckerson has just made a careful study of this phenomenon (*Bot. Gaz.*, Vol. LV). It has been found that seeds of various pines show a delay in germination of as much as two years, while those of ash sown in spring do not germinate until the following spring. In the latter case the embryo in the mature seed occupies about half the space within the endosperm, the rest being occupied by a mucilaginous substance; during the year that the seed lies in the ground the embryo grows in length and fills the seed-coat; hence a period of growth is necessary before germination.

The authoress has studied the delayed germination or "after-ripening" of the hawthorn (several species of *Crataegus*). She finds that food is stored in the embryo in the form of fatty oil; lecithin is also present, but there is no starch or sugar. The reäction of the cotyledons is acid, but the hypocotyl is slightly alkaline. During the after-ripening period there is a series of metabolic changes in the embryo, beginning with increased acidity, and correlated with this there is an increased water-absorbing power, and also an increase in the activity of the ferments catalase and peroxidase. Near the end of this period there is a sudden increase in the acidity and in the water content; here oxidase first appears. All of these increase until the hypocotyl is three to five centimetres long; then fats decrease and sugar appears, while hydrocyanic acid is present in the cotyledons. The after-ripening period can be greatly shortened by treating the embryo with dilute acids; the water-holding power, the acidity, and the amount of peroxidase increase much more rapidly, and oxidase appears much earlier, than in untreated embryos. Apparently there is a correlation between the acidity of the hypocotyl of *Crataegus*, its water-absorbing power, production of ferments, and germinating power. Whether the acidity is causal or merely correlative is not known, though there is some evidence that it is causal—for instance, it has been found to lead to the liberation of ferments, and to increase the water-absorbing power of colloids.

BACTERIAL NODULES ON LEAVES.—All students of plant life are doubtless familiar with the remarkable nodules found on the roots of Leguminosae and a few other plants (*Alnus*, *Myrica*, *Podocarpus*, and so on) and containing bacteria which fix free atmospheric nitrogen and thus supply the "host" plant with nitrogenous food. Faber (*Jahrb. f. wiss. Bot.*, 1912) describes an interesting and unexpected symbiosis of a similar kind which he has discovered in two tropical genera (*Pavetta* and *Psychotria*) belonging to the Rubiaceae; but here the nodules are developed on the leaves instead of the roots. The bacteria have the same power of nitrogen fixation as those in the roots of Leguminosae. They are already present in the unopened bud, lying in the cavity formed by the stipules of the leaf, and they enter the leaves themselves by way of the stomata, collecting in the air cavity just below a stoma and multiplying so as to disturb the shape of the surrounding cells of the leaf, which appear to be stimulated to vigorous division, resulting in the formation of a mass of small-celled tissue. In this tissue there are relatively large intercellular spaces, and in these the bacteria grow, though without apparently injuring the cells. After the bacteria have entered and set up the formation of the nodule or "gall," the stoma becomes occluded, shutting them in; the plant has, so to speak, swallowed the bacteria. The tissue in the swelling contains abundant chlorophyll and starch grains, but when the nodule is fully formed the starch disappears and is replaced by reducing sugar, evidently formed by fermentation of the starch. Finally, towards the close of the leaf's life the bacteria have largely disappeared from the intercellular spaces and the cells again contain abundant starch; hence the food apparently serves for the nutrition of the bacteria—as one might say, in return for the service rendered by them to the plant in supplying the latter with nitrogenous compounds manufactured from the atmosphere. In a variegated form of *Pavetta indica* these remarkable leaf nodules are conspicuous as green swellings on the otherwise white leaf.

The author believes that this represents an ideal case of symbiosis between bacteria and higher plants, though the latter gets the better exchange, since ultimately the cells of the leaf, whether or not they actually cause the death of the bacteria, at any rate absorb their dead remains; the walls of the bacterial cells become slimy, and eventually they disappear. The bacteria, which closely resemble the tubercle bacillus, occur in the seed, lying between the embryo and the endosperm, and after germination they are found occupying the growing tip of the young shoot, so that the relationship between the bacteria and the higher plant is extremely intimate and begins at a very early stage. The author killed the bacteria with hot water without injuring the embryo, and found that the young plants thus sterilised, or freed from bacteria, grew very slowly and had small leaves as compared with normal or infected plants. Sand cultures of sterilised and unsterilised seedlings showed that the former died in the absence of a supply of nitrogenous food materials, while the latter grew quite well. Precautions were taken in these cultures to exclude other micro-organisms.

CYTOLOGY OF BACTERIA.—In a long paper on the cytology of bacteria, Dobell (*Q.J.M.S.*, Vol. LVI) prefaces his own observations by a useful and interesting summary of previous work on the structure of bacteria, with special reference to the methods of fixation and staining used by the various investigators and to their conclusions concerning the presence or absence of a nucleus in these organisms. He examined a large number of forms, obtained from the intestines of various animals, and arrived at the following conclusions. All bacteria which have been adequately investigated have a nucleus; but the form of the nucleus is variable, not only in different bacteria, but also at different periods in the life-cycle of the same species. The nucleus may be in the form of a loose system of granules (chromidial nucleus); or of a filament of variable configuration; or of one or more relatively large aggregated masses of nuclear substance; or of a system of irregularly branched or bent short strands, rods, or networks; and probably also in the vesicular form characteristic of many plants, animals, and protista. There is no evidence that non-nucleate bacteria exist. The author considers it highly probable that the bacteria are in no way a group of simple organisms, but rather a group displaying a high degree of morphological differentiation, coupled in many cases with a life-cycle of considerable complexity.

BIOLOGY OF THE PITCHER-PLANT *DISCHIDIA*.—In the genus *Dischidia* belonging to the Asclepiadaceae and found in the East Indies as epiphytes climbing by adventitious roots and having fleshy wax-clad leaves, some species have, in addition to ordinary leaves, remarkable pitcher-leaves. Each of these is a pitcher with an incurved margin and about four inches deep; but their biology is very different from that of such pitcher-plants as *Nepenthes*. Into the pitcher there grows a root which arises from the stem or from the leaf-stalk close to the pitcher, and this root ramifies among the humus and other débris which is apparently largely carried into the pitcher by ants. The pitcher also catches rain-water, hence it serves as a humus collector and water reservoir; the inner surface is coated with wax, hence the water cannot be absorbed by the pitcher itself, nor lost by passing through the walls, but must be absorbed by the roots; the inner surface of the pitcher also bears stomata, and doubtless the water-vapour given out through these is condensed in the pitcher.

Some further details of the biology of *Dischidia* have recently been given by Kerr (*Proc. Roy. Dublin Soc.*, Vol. XIII) from observations made on the pitcher-bearing species *D. Rafflesiana* and on *D. nummularia* in their native habitat in the jungles of Northern Siam. The plants are associated with two species of ant (*Iridomyrmex myrmecodiae, I. cordex*). In *D. nummularia* the ants are found below the leaves, where they form nests of clay and vegetable débris in which the roots of the *Dischidia* branch; while in *D. Rafflesiana* the ants make their nests within the pitchers and plaster clay above the bases of the pitchers and over the roots. The flowers are pollinated by bees, but the ants assist in the dispersal of the seeds, removing them for food—the seeds not eaten germinate along the ants' tracks. The author concludes that in *D. Rafflesiana* the pitchers do not so much store water as serve to economise the water vapour of transpiration and also provide shelters for ants, which in return supply the roots with food material.

CHEMISTRY.

By C. Ainsworth Mitchell, B.A. (Oxon), F.I.C.

ARGON AND ITS PLACE IN NATURE.—An outline of a communication on this subject made by Sir William Ramsay, to the Chemical Society of Rome, is given in the *Chemical Trade Journal* (1913, LII, 595). The experiments of Professor Collie and Mr. Paterson, which indicated the formation of helium and neon from hydrogen, have been repeated and their results confirmed. In the opinion of Sir William Ramsay dry hydrogen becomes polymerised into helium, when subjected to the action of cathode rays in a vacuum tube, while for the production of neon the presence of oxygen is necessary. This might be derived either from a trace of moisture or from the bombardment of the glass by the rays. When the experiment was modified by placing dry hydrogen in a vacuum tube and passing an electric discharge for five or six hours between an aluminium cathode and anode, which were coated with sulphur, argon was produced, but no trace of helium or neon could be detected. Again, when the electrodes were coated with selenium instead of sulphur the gas, after the experiment, showed the characteristic lines of the krypton spectrum. The three elements neon, argon, and krypton, the atomic weights of which are in an ascending scale, have thus apparently been produced from hydrogen in the presence of oxygen, sulphur, and selenium respectively—elements which stand in an analogous relationship towards each other.

BIOLOGICAL METHOD OF IDENTIFYING SEEDS.—The precipitin method of distinguishing between the flesh and blood of different species of animals was described some years ago in these columns. In brief, it is based upon the fact that when the serum of a particular animal is injected into, say, a rabbit, the serum of the latter becomes immunised, and when subsequently the rabbit is killed its serum will give a precipitate with the serum of animals of the species to which it was rendered immune, but not with the serum of an animal of another species.

This method has now been successfully applied to the identification of the seeds of different plants, and an account of the process devised by Relander is given by Dr. Zade in the *Bull. Agric. Intel. and of Plant Diseases* (1913, IV, 200).

The seeds—wheat, for example—are finely powdered and extracted with physiological salt solution. The filtered extract is then injected, in small quantities at intervals of three to ten days, into a small animal. After a suitable period the blood serum of this animal is separated and filtered, and the filtrate tested with a few drops of an extract of the seeds under examination. If these are of the same kind as the original seed a precipitate will be produced, whereas the liquid will remain clear on the addition of extracts from other kinds of seeds.

By this method Relander obtained a precipitate on adding extracts of two-rowed barley to the serum of a rabbit which had been treated with a similar extract, whereas no precipitate was obtained with extracts of six-rowed barley. In the same way it was found possible to distinguish between American, Italian, and Norwegian clover seeds, but Finnish seed reäcted in the same manner as Norwegian seed.

By means of this test it should be practicable to distinguish, prior to cultivation, between awned and awnless varieties of wheat, which has hitherto been impossible.

CARBON TETRA-IODIDE.—An iodide of carbon, CI_4, which crystallises in ruby-red octahedra, having a specific gravity of 4·50 at 0° C. was first obtained in 1885 by the action of iodides upon organic chlorine compounds. The various reäctions by which the tetra-iodide may be prepared have recently been studied by M. Lantenois (*Comptes Rendus*, 1913, CLVI, 1385). In order to avoid decomposition of the product it is necessary not to let the temperature exceed 92° C., and the most satisfactory results have been obtained by heating lithium chloride for five days at that temperature with an excess of carbon tetrachloride in a sealed tube. A pure product could also be prepared by treating iodoform with a hypochlorite.

THE TESTING OF DISINFECTANTS.—The usual method of testing the value of disinfectants is by comparing their germicidal powers under standard conditions. This test, which is commonly known as the Rideal-Walker test, has recently been subjected to severe criticism by Messrs. Kingzett and Woodcock (*Analyst*, 1913, XXXVIII, 190), who cite the results of experiments to show that the conclusions afforded by the method are fallacious. For example, they point out that such powerful chemical agents as nicotine, prussic acid, and strychnine have little or no action upon the typhoid bacillus, and that corrosive sublimate has a much lower value than many coal-tar preparations when tested by the bacteriological method. Again, copper sulphate, which is known to possess germicidal powers, appears in the light of this test to be nearly inert. In the opinion of these chemists the Rideal-Walker test does not take into account variations in the chemical conditions, and they consider that the only reliable method of examining disinfectants as a class is to test them for the particular purposes for which they are required. At the same time they consider that there is no doubt that for coal-tar disinfectants the Rideal-Walker test is the best that has yet been devised.

GEOGRAPHY.

By A. Stevens, M.A., B.Sc.

TOPOGRAPHY, EARTH-MOVEMENTS AND ISOSTASY.—In 1909 the United States Coast and Geodetic Survey began publication of a series of bulletins* on Isostasy and the "Anomalies of Gravity," which may be said to develop along one line the work begun by Bouguer at Chimborazo, and Maskelyne at Schiehallion. The possibilities of the principle of isostasy in accounting, in part at least, for the configuration of the land surface of the globe have been for some time generally, if darkly, seen. But recently the subject has been more closely studied, and interesting accurate determinations have been made by Americans of the degree to which isostasy obtains, and of the amount of correspondence between anisostatic conditions and the irregularities of the terrestrial surface.

In these official publications isostasy was defined, a convenient and approximately correct upper limit of isostatic equilibrium fixed relative to sea-level, and accurate determinations in dynes of the actual intensity of gravity given for upwards of a hundred and twenty stations in the United States. For these stations theoretical values of the intensity were computed by three methods: that of Bouguer, the free-air method, and a new method due to Hayford, corrections being applied for topography and compensation. The deficiency or excess of the observed value over this computed value of the intensity is called the "anomaly of gravity" for the station. The United States have been mapped in areas of deficient or excessive gravity intensity, and the rate of variation shown by contouring.

As elsewhere, in the United States there is evidence of differential vertical movement in the crust of the earth. In particular the terracing of the Atlantic continental slope, the submarine canyons and valleys indenting the Atlantic and Pacific coasts, and the Post-Glacial deformation of the raised beaches of the great lakes demonstrate extensive subsidence. Deep valleys cut in the Tertiary deposits of Louisiana to depths of between two and three thousand feet, which have been filled with material containing shells representing living species only, prove recent subsidence at the coast to the extent of two thousand three hundred feet. increasing inland, it is estimated, to three thousand feet.

Post-Glacial deformation has frequently been ascribed to the tendency towards isostatic equilibrium asserting itself on the disappearance of the ice. J. W. Spencer† uses the anomalies of gravity to show the inadequacy of the weight of the ice-cap to counterbalance the earth-pressures involved. Gravity anomalies are worked out by means of constants, due to Bowie, to equivalent rock-thicknesses, and between the figures so obtained and the amounts of subsidence and distortion remarkable correspondence is observed.

Spencer attributes the topographical "bulges" to differential sinking conditioned by crustal rigidity, and invokes as the prime cause of movement shrinkage of the earth beneath the oceans and continents. Thereby continents are raised and then gradually they sink towards isostatic conditions, preserving on their submerged borders the marks of the denudation they suffered in the elevated condition. This explanation, of course, in itself presents little that is new, and possibly may require revision in the light of work in other fields of research. But it is important that a definite and quantitative study of some topographic questions has been found possible and initiated. Further work, of which we have a promise, will be looked for with interest.

GEOLOGY.

By G. W. Tyrrell, A.R.C.Sc., F.G.S.

AUSTRALITES.—The curious little bodies of volcanic glass found scattered throughout Australia, and known as australites, are the subject of a memoir by E. J. Dunn (*Bulletin No. 27, Geological Survey of Victoria*). These bodies are mostly button-shaped, with a central core and depressed rim. The latter occurs only in the more perfect forms owing to the accidents of weathering. These discoidal forms are by far the most abundant; rarer shapes are elongated cylindrical and dumb-bell shaped; others are quite irregular. The material of the australites is acid volcanic glass, identical in structure and composition with obsidian. Thin sections show that the australites have good flow-structures, and have been built up by material which flowed in from above and around their peripheries.

These bodies are regarded by Mr. Dunn as the blebs or lower portions of glass bubbles. They are very similar in form to the drop of water which collects at the base of a soap-bubble. They are conjectured to have been formed in volcanoes, and their distribution over Australia is accounted for by their dispersal through the agency of air-currents. The bubbles would be blown up to a height of five or six miles above the volcano, and before their destruction might have been carried hundreds of miles from their point of origin by the air-currents of the upper atmosphere. On the bursting of the bubbles the pendant blebs would fall to the ground, and would become embedded in whatever formation was then in process of deposition.

Australites occur in deposits representing a period corresponding with that covered by the last great episode of volcanic activity in Australia. It is uncertain, however, how far they extend back into the Tertiary era. They were formerly regarded as of meteoritic origin; but this cannot be reconciled with their chemical composition, which is utterly unlike that of any meteoritic body, with their symmetrical shapes, and local distribution.

* J. F. Hayford, "The Figure of the Earth and Isostasy from Measurements in the United States"; "A Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy" (*U.S.C. & G. Survey*, 1909); J. F. Hayford and W. Bowie, "Effect of Topography and Isostatic Compensation upon the Intensity of Gravity"; W. Bowie, "Effect of Topography and Isostatic Compensation upon the Intensity of Gravity, Second Paper" (*U.S.C. & G. Survey*, 1912).

† J. W. Spencer, "Relationship between Terrestrial Gravity and Observed Earth Movements in Eastern America," *Amer. Jour. Science*, June, 1913.

METEOROLOGY.

By William Marriott, F.R.Met.Soc.

"THE DOCTOR."—At the June meeting of the Royal Meteorological Society a paper by Mr. H. W. Braby was read on the Harmattan Wind of the Guinea Coast, which was based upon the results of five years' observations made at Zungeru, in Northern Nigeria. The harmattan blows during the winter months along the coast of Upper Guinea, from French Guinea to the Cameroons. It is exceedingly dry and brings with it fine sand which enters the crevices of doors and windows, covering everything with a film of dust. The sun is partially obscured, and distant objects become invisible. It blows intermittently from November to March, and is, generally speaking, health-giving, although its extreme dryness is trying to new residents. It is locally known as "the doctor."

The harmattan almost invariably blows from the north-east, a circumstance which justifies the presence of dust particles brought from the Sahara. In some respects the wind partakes of the nature of a Föhn. It is exceedingly dry and blows from elevated to lower regions. Mr. Braby points out that its direction necessitates there being an area of high barometric pressure to the north and of low pressure to the south. The area around the northern tropic, however, seems scarcely far enough from the equatorial regions to be the seat of a well-defined winter anticyclonic system, such as prevails in the interior of Asia at that season. The equatorial low-pressure belt is, however, now at its southern limit, and this combined with the somewhat lower winter pressure to the north appears to be sufficient to establish a north-easterly wind along the Guinea Coast.

HURRICANES OF THE WEST INDIES.—The opening of the Panama Canal in the near future will no doubt bring about a change in the long-established sailing routes and turn much of the tide of commerce of the Atlantic and the Pacific towards the Isthmus of Panama. The convergence of new routes to the Caribbean Sea and the Gulf of Mexico will necessitate the crossing of a wide area swept at intervals during several months of the year by the severest type of storm known to the mariner, viz., the West India hurricane. With the view of giving information on this subject Professor O. L. Fassig has tracked all the hurricanes which have occurred in the West Indies during the thirty-five years 1876–1910, and the results have been printed in a bulletin published by the U.S. Weather Bureau.

The hurricane belt may be defined as the area embracing the Caribbean Sea, the Gulf of Mexico, and the West India Islands. Within this area the points of origin are distributed with a fair degree of uniformity, although belts of varying frequency are clearly discernible. There is a well-marked main path of greatest frequency through the northern half of the Caribbean Sea, extending almost due east to west between the Windward Islands and Jamaica; taking a north-west crossing through the Yukatan Channel and across the western end of Cuba, the path recurves in the eastern portion of the Gulf of Mexico and across the Florida Peninsula into the North Atlantic, with a north to north-east trend. There is a secondary path, not so well defined, extending from the northern group of the Windward Islands in a west-north-west direction across the Bahama Islands and recurving east of Florida in the North Atlantic Ocean. Between these two paths lie the Greater Antilles—Cuba, Jamaica, Haiti, and Porto Rico. Of these islands Porto Rico and Haiti are comparatively free from the devastating winds near the hurricane centres; the western half of Cuba is crossed in the recurve of a large percentage of the storms of the Caribbean Sea, or those of the main branch referred to above. These two paths coincide very closely with the two branches of the great equatorial current of the North Atlantic Ocean, the main stream of which passes through the Caribbean Sea and the Yukatan Channel into the Gulf of Mexico and out into the Atlantic again through the narrow channel between Havana and Key West. Here it meets the northern branch of the equatorial current, which is more in the nature of a wide surface drift of equatorial waters passing through the Bahama group of islands, forming, later in its course, the eastern portion of the Gulf Stream.

The normal track of hurricanes for the entire season resembles a parabola in form. The first branch extends in a direction west by north, between the parallels of 18° and 20° N. lat., to the centre of the hurricane area (23° N. and 70° W.), then north-westward and north; recurving over Central Florida, the trend is north-eastward over the Atlantic along the second branch of the parabola.

The geographical centre of origin for the entire season is just off the north-west coast of Haiti. The average point of recurve is in the centre of the Florida Peninsula. The advance of the season is marked by a slight increase in the latitude of the point of recurve. The movement of hurricane paths from south to north and return southward coincides very closely with the movement of the trades and the equatorial belt of calms.

Conditions favourable for the formation of hurricanes in the West Indies begin in the month of June, but do not become well developed until the month of August. From August to the close of October is the real period for these storms. The mean daily movement of hurricanes for the entire season is about three hundred miles, or about 12·5 miles per hour. After passing the recurve there is a considerable increase in the velocity, especially in the latter part of the season. The average period of duration of hurricanes while within the zone below the latitude of 30° N. is about six days; about three days are spent in moving westward along the storm's path and two days in the recurve. After the recurve the storm enters into the region of temperate zone cyclones, and may continue its existence for many days, sometimes crossing the entire expanse of the North Atlantic and even into Europe.

HURRICANE, TYPHOON, AND CYCLONE.—These terms are applied to the same type of storm, but, as Mr. O. L. Fassig has pointed out in the paper quoted above, they are the same in essential character. To the meteorologist they are all "cyclones" or storms in which the surface winds blow toward a central area of low barometric pressure at angles varying between 0° and 90°. This broad definition includes not only the intense storms of the Indian Ocean and the Bay of Bengal, originally called "cyclones," the hurricanes of the West Indies, and the typhoons of the Pacific, but also the temperate-region storms usually referred to as "barometric depressions," "storm areas," or simply "lows," and the tornadoes of central valleys of the U.S.A., and waterspouts over the seas in all parts of the world. In all storms of this class the surface winds blow more or less spirally inward toward an area of minimum atmospheric pressure, then upward and outward at elevations varying with the extent and intensity of the storm. The term "hurricane" is restricted to cyclones which have their origin and field of action within well-defined limits, embracing the West Indies and neighbouring waters of the North Atlantic. The storms occurring in tropical regions of the Western Pacific are called "typhoons." In the Indian Ocean they retain the name originally given them by the early English mariners, namely, cyclones. It is only in comparatively recent years that the term "cyclone" was given the broader, and at the same time more technical, definition to include all so-called "revolving" storms. The temperate-region cyclone covers a greater area than the tropical variety, the diameter of a well-developed storm of the middle latitudes being over one thousand miles, and occasionally covering more than half the area of the United States; the cyclone of the tropics is generally not over three hundred to four hundred miles in cross-section, but probably penetrates to a greater height into the atmosphere than the extra-tropical cyclone. Tropical storms are accompanied by a greater fall in the barometer, resulting in more destructive winds and heavier rainfall than in the temperate-region cyclone, where the barometer falls with a more uniform gradient from the edge of the storm to the centre. In the tropical storm there is a moderate decrease of pressure to within forty or fifty miles of the centre, and then a rapid fall, which in exceptional cases may descend to twenty-eight inches and even less. This steep-pressure gradient marks the area of the destructive winds and the excessively heavy rainfall which are characteristics of the tropical storm.

CLIMATE AND HEALTH.—During last session Mr. W. Marriott read a paper on "Meteorology and Public Health" before the Institute of Sanitary Engineers, which has now been published in their Journal. He showed that a bracing climate is invigorating and acts as a tonic to the body. This is due to an open exposure and a good wind or current of air blowing over the place. This continuous flow of air over the body removes the moisture from the skin, and so causes a lowering of the temperature, which in turn produces a crisp and pleasant feeling. A relaxing climate, on the other hand, is enervating and causes a languid feeling. This is largely due to the situation being sheltered, and also to comparatively little movement of the air. Consequently the moisture from the skin is not so freely removed as when there is a continuous flow of air. Again, there is the inland climate and also the sea-coast or maritime climate. Inland the temperature, as a rule, is high during the day and low during the night, and so there is a considerable diurnal range of temperature. Along the sea-coast the temperature does not rise so high during the day nor fall so low during the night; consequently the range of temperature is less on the coast than it is inland.

Extremes of temperature—hot weather in summer and frost in winter—cause an increase in the death-rate. In summer the increase in the number of deaths is due almost entirely to cases of infantile diarrhoea. In winter the increase in the number of deaths is due almost entirely to diseases of the respiratory organs, especially among young children and old people.

Pneumonia and bronchitis are most prevalent in the colder months, and generally follow cold, damp weather with marked changes of temperature, which lower the vitality and are conducive to chills. Severe cold spells are likely to be followed by an increase of pneumonia, especially among elderly persons and children.

MICROSCOPY.

By F.R.M.S.

THE APLANATIC AND ACHROMATIC CONDENSER AND ITS USE AS AN APERTOMETER.—The Aplanatic and Achromatic Condenser possesses another useful quality, inasmuch as it can be employed as an apertometer. This property arises from the following optical facts. The iris-diaphragm being situated near the lower focal plane of the condenser, an image of it is formed thereby at a distance which may be equated at infinity. Of this image the objective forms another at its posterior focus and situated near the outer surface of the back lens on the side towards the eyepiece. The rays of a pencil of light entering the condenser in a direction parallel to its axis intersect at its anterior focus. As this is made to coincide approximately with the lower principal focus of the objective it follows that the pencil of rays which proceeds from the focus of the objective will emerge from its posterior focal plane in the form of a pencil composed of approximately parallel rays. The base of the pencil of rays appears on the back lens of the objective as a bright circle, and hence it will be seen that this bright circle of light and the image of the iris-diaphragm are situated more or less in the same plane. The diameter of the circle of light is governed by the aperture of the objective which corresponds to an equal angular aperture of the condenser. The latter again is determined by the opening of the iris-diaphragm. The aperture of the condenser can be computed from the diameter of the iris-diaphragm, thus supplying the requisite datum for determining the aperture of the objective.

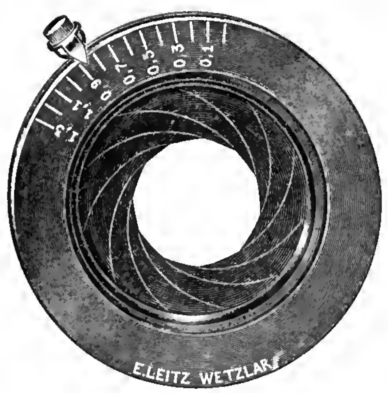


FIGURE 339.

That the condenser may be used in this way as an apertometer is due to the fact that its formula satisfies the sine condition, and not so much to its spherical and chromatic correction, the principal effect of the latter being that the condenser furnishes a more sharply defined image than an ordinary condenser.

The sine condition is expressed by the formula $\frac{h}{\text{sine}\,\alpha} = \text{const.}$

In the case of parallel incident light this constant quantity is numerically equal to the focal length of the condenser, h is the semi-aperture of the iris-diaphragm, whilst sine α with dry lenses and μ sine α with immersion lenses represents the numerical aperture of the condenser. From this it will be seen that the aperture of the condenser varies directly as the numerical aperture of the condenser as well as that of the objective. This simple relation is a convenient circumstance, inasmuch as the indices corresponding to the numerical apertures 0·1, 0·2 . . . to 1·3 are separated by uniform intervals (see Figure 339).

To calculate and register the scale of apertures become under these circumstances a very simple matter. When a preparation lies between the objective and the condenser the angle by which the rays emerge from the condenser is the same as that by which they enter the objective; that is to say, the angles which determine the aperture of the condenser and objective remain equal, since the object slide, the cover-glass, and the interval between the latter and the objective behave optically as plane and parallel plates. This being so, the angles of incidence and emergence of a ray passing through the intervening media are identical so long as the surrounding media—in this case air, water, or oil—remain the same.

The aperture may be determined in the following manner:—Focus the objective in the usual manner in the plane of the object, using diffused light; next remove the eyepiece and, placing the eye immediately above the tube, view the circle of light at the back of the objective and open the iris-diaphragm, the image of which will also be seen in this plane, until its opening just coincides with the boundary of the circle of light at the back of the objective. To use the condenser in this way it is necessary to have the mount of the iris-diaphragm graduated in terms of the numerical apertures.

It will be admitted that it would be difficult to imagine a simpler and more inexpensive device for measuring the aperture of lenses, and the manner of using it cannot give the slightest difficulty. The accuracy of the results is all tbat could possibly be desired for any practical purpose. The difference in the aperture of objectives, as found by this simple method, and its absolute value, as determined by the most exacting methods in use, is too insignificant to disclose any appreciable difference in the light-transmitting and resolving power of objectives differing to this small extent in their apertures. As a matter of fact, these discrepancies are no greater than those unavoidable and invariably existing differences in the individual objectives of the same denomination arising from slight variations in the thickness, position, and mounts of the lenses.

It is no doubt convenient to be able to determine without trouble and with practically a sufficient degree of accuracy the aperture of an objective. This, however, is scarcely the best use to which an apertometer can be put, as it is a far more important advantage that the apparatus enables the observer at any instant to ascertain and state numerically the aperture of direct light at which he is actually working, and that will give him the best results.

The reader need scarcely be reminded of the importance of the proper choice of the aperture of the condenser, and to realise how different are the effects produced by the different apertures one need only instance the case of Koch's structural and colour images: both are the result of the same optical condition—in one case with a contracted diaphragm to attempt to bring out fine structural details in unstained preparations, in the other with the condenser opened to its full extent to show deeply stained bacteria.

A condenser whose aperture can be varied in a numerically definite manner does away with loose statements to the effect that this or that investigation should be carried out with the condenser shut down to one third, a half, two thirds, and so on. Directions of this kind are far too indefinite, and are not even applicable to condensers of different maximum apertures. In future it will be as easy as it will be desirable to specify the aperture of the condenser among the other particulars relating to microscopic observations, projection, and photomicrography, such as the denomination of the lens, its magnification, and the nature of the illumination, time of exposure, and so on. This will be an easy matter, as the aperture can be read by the index of the iris-diaphragm.

C. METZ. (*Wetzler.*)

GAMASOIDEA.—Another neglected super-family of mites is the Gamasoidea, and yet entomologists are continually coming across specimens, either as messmates or parasites, on various kinds of insects. Not much notice, however, is taken of them. They are more often than not thrown away as a nuisance; yet they may be more interesting than their host. The most commonly known of all the Gamasids is no doubt ***Gamasus coleoptratorum*** and ***G. crassipes***, so often found in large numbers on the Dor beetle and others. Beetles, however, are not the only insects on which they are found; all other sorts of insects are pressed into their service either to supply them with nourishment or as a means of getting from one place to another. One family of the Gamasoidea—the Dermanyssidae—are all parasitic on warm-blooded animals.

The characteristics of the super-family are—they are without any visible eyes; they are mostly pale coloured: being generally a light brown or fawn colour they have none of the brilliant reds we find in the Trombidiums. The bodies are broad and flat. The skin is mostly smooth and tough, in some species chitinous only in parts, the other parts being thinner and paler in colour. The legs have seven segments, the tarsi has two claws with a caruncle or sucker; this caruncle assumes different forms in different species.

They prefer damp places to live in; that is to say, those that are not parasitic. They are found under stones, decayed wood, garden rubbish, stables, under loose bark of trees, in moss, and I once found a large number in a deserted robin's nest.

The Gamasoidea is divided into three families—Gamasidae, Uropodidae and Dermanyssidae. Nathan Banks, the American writer on mites, gives the following key to the three families of the Gamasoidea:—

(1) Parasitic on vertebrates: mandibles fitted for piercing; body sometimes constricted. Dermanyssidae.

Free, or attached to insects, rarely on vertebrates, never on birds. 2.

(2) First pair of legs inserted within the same body-opening as the oral tube: genital apertures surrounded by the sternum. Uropodidae.

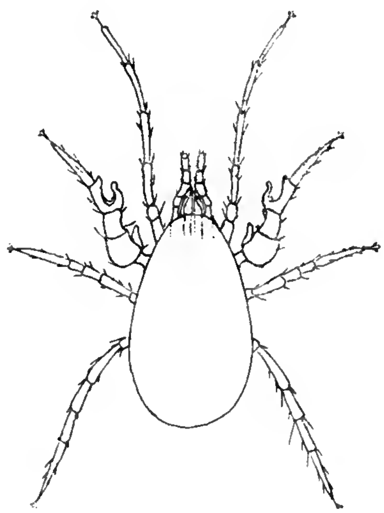


FIGURE 340.
Gamasus equestris Koch.
Drawn under camera lucida from a specimen found at Barmouth. ♂

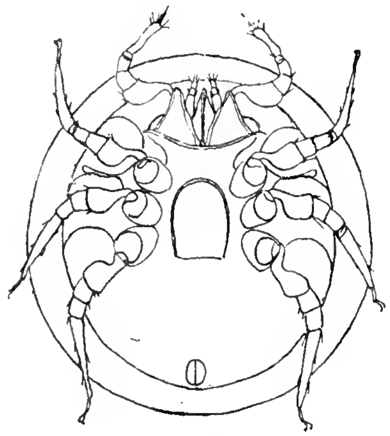


FIGURE 341.
Uropodidae.
Drawn from a specimen found in moss at Sunningdale. Ventral surface of *Cilliba cassidens.* ♀

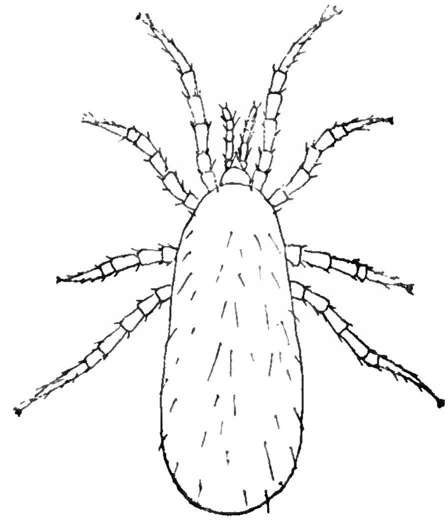


FIGURE 342.
Dermanyssus avium.
Drawn under camera lucida from a specimen from a canary.

(3) First pair of legs inserted at one side of the mouth opening, male genital aperture usually on the anterior margin of sternal plate. Gamasidae.

The Dermanyssidae are all parasitic. The best-known representative is the red mite, found in such large numbers in bird-cages and fowl-houses that have not been kept clean. This bright red colour of the mite (which is commonly known as ***Dermanyssus avium*** Dug.) is due to the amount of blood which the mite has sucked from its host during the night. In the daytime, if it can possibly hide away, it is invisible. The Dermanyssidae is split up into about half a dozen genera. There are several papers on this family, but I have not heard of any monograph.

The Uropodidae.—The most striking feature about this family is that some of its members are found attached to their host with a connecting filament which De Geer thought was of the nature of an umbilical cord by which the mite drew its nourishment. Other naturalists thought it was a silken cord with which the Uropoda tied itself to its host to prevent it being brushed off. It has since been found to be connected with the anus of the mite, and to be nothing more or less than its consolidated excrement: this connection the mite can sever at will. Banks says that these mites so attached are not true parasites, but that it is a means used by nymphs as a means of migration. This family is divided into about six genera.

The Gamasidae are the largest family of the three, containing about twenty genera. A number of papers have been published in the British Isles on the Gamasoidea in natural history and microscopical journals. Mr. Michael has given two, if not more, very interesting ones on the internal anatomy of Gamasidae and Uropoda; also one on the life-history of Gamasidae, and in 1888 described one new species. Dr. George has also described and recorded some rare and interesting species in *The Naturalist* from time to time—three species in particular, of the genus *Epicrius*. But there is no monograph on any of the three families yet, neither is there a Tierreich.

Figures 340-342 will help to convey the general appearance of each family. But, as Mr. Banks says, the Dermanyssidae and the Gamasidae are so closely allied by structure that the parasitic habits are the best character for separation.

C. D. SOAR, F.L.S., F.R.M.S.

QUEKETT MICROSCOPICAL CLUB.—May 28th.—T. A. O'Donohoe read a paper on "Minute Structure of *Coscinodiscus asteromphalus*, *Pleurosigma angulatum*, and *P. balticum*." The object of the paper was to prove that the "black dot" is the correct image of diatom structure. Photomicrographs, mostly at ×4000, were shown of fragments of the diatoms mentioned. When the edge of the fracture was sharply focused the transparent silex was shown as white and the perforations as black. On slightly raising the objective the silex was rendered as black and the perforations as white. It was therefore thought to be justifiable to relegate the "white dot" images of diatoms to the abode of Mr. Nelson's "ghosts."

June 24th.—E. M. Nelson sent a note describing Koristka's new loup.

H. Sidebottom, contributed a paper on "The *Lagenae* of the South-West Pacific." This is part two of a paper published in the April 1912 issue of the Club *Journal*. There was some discussion as to the significance or use of the very beautiful markings and decorations found in this and other groups of organisms. The President could not conceive it possible that the presence or absence of a minute projection on a sponge spicule, for instance, could make any difference whatever to the organism, especially as in the case of the sponge, the spicule is buried in the general protoplasmic mass of the animal. In the case of foraminifera the markings are invisible during life, as they are concealed under the usual gelatinous mass of exterior protoplasm.

E. M. Nelson described "A new method of measuring the magnifying power of a microscope." The "constant" of an eyepiece with a given tube-length is determined. This "constant" is found by first determining by any of the usual methods the combined magnifying power of that eyepiece on the given tube-length with a medium power objective, such as half-inch. Second, measure the exact diameter of the field by means of a stage micrometer. The product of these two quantities is the "constant" of that eyepiece with the given tube-length. Example—objective one-third of an inch, eyepiece, compensating × 8, tube-length 170 millimetres, measured magnifying power × 280, measured field 0·023 inch, product is 6·44, which is the "constant" of that eyepiece for 170-millimetre tube. The power of any other objective with this eyepiece and tube-length can be determined by measuring the diameter of its field with the stage micrometer. The magnifying power will obviously be the eyepiece "constant" divided by the diameter of the field (an objective of varying power with a negative front cannot be measured in this manner). A number of examples were given. The "constant" may also be employed for ascertaining the total magnification for any tube-length. All other conditions being the same, the total magnification will be proportional to the tube-length used.

PHOTOGRAPHY.

By EDGAR SENIOR.

USE OF GLYCERINE IN DEVELOPING PLATINUM PRINTS.—As mentioned in last month's notes on platinum printing, glycerine is of use in the development of these prints, as when added to the developer it so reduces its rapidity of action as to enable local development to be carried out without any difficulty. As the sensitive salts with which the paper is coated are almost insoluble in glycerine, this may be brushed over the surface of the exposed paper without risk of injury to the print. A mixture of glycerine and developer may then be applied with a brush and an over-printed portion of the subject may be retarded by the application of a weaker developer, or one containing more glycerine, until the other parts of the image are sufficiently strong. This method of treatment lends itself particularly to the production of vignetting effects on account of the great softening of the edges that can be obtained. The strength of the solution employed by different workers varies, but the following will be found to answer well:—

Oxalate of Potash	1 ounce
Water	3 ounces
Glycerine (pure)	1 ounce

This will form a stock solution which for use may be taken in the proportion of one part mixed with an equal volume of water. If preferred, the developing salts may be used in place of the oxalate, as with a little practice it is quite easy to control development with either. When the desired result has been obtained the prints are placed for the required time in each of the three acid baths, and finally washed and dried, intensifying under-exposed platinum prints with gold.

Some years ago Mr. Alfred W. Dolland published a method of strengthening an under-exposed platinum print by means of a solution of gold chloride applied with glycerine. The writer tried this at the time with perfect success. The procedure consists in applying glycerine to the finished print and then spreading a solution of gold chloride by means of a piece of cotton-wool or a brush, the strength of the gold solution which we used being fifteen grains in fifteen drachms of distilled water. The print rapidly gained in strength, assuming a fine bluish-black colour, and when the action had proceeded far enough the print was washed, and an ordinary amidol developer applied for a few minutes in order to reduce any remaining gold chloride to the metallic state, when a final washing completed the operation. We have quite a number of prints that were treated in this manner, which appear as fresh as when first produced, and certainly the colour in many cases produced a more pleasing effect. Platinum prints may also be intensified by a method, due to Baron Hubl, of depositing further platinum upon them. In order to employ this method the following solutions have to be made up:—

A

Sodium Formate	48 grains
Water	1 ounce

B

Platinum Tetrachloride	10 grains
Water	1 ounce

For use fifteen minims of each of the above are taken and made up to two ounces by the addition of water. The print is placed in a flat dish and the solution is poured over the dish, which is kept rocking until the desired effect is seen in the print, when the latter is washed and dried.

WARM TONES IN PLATINUM PRINTS.—Various substances have from time to time been recommended as additions to the developer in order to vary the colour of a platinum print, but the one most generally employed is mercuric chloride, as by its means, together with variations in the temperature of the developer, tones ranging from warm black to sepia are readily obtainable. Numerous formulae for use in the production of these tones have been given, although the following is perhaps as satisfactory as any:—

Mercuric Chloride	3 grains
Potassium Oxalate...	48 ,,
Potassium Phosphate	48 ,,
Water	1 ounce

The temperature at which the prints are developed ranges from 65° to 170° F., according as a warm black or one approaching sepia is desired. When warm tones are obtained the gradation is usually much softer than that of a black print from the same negative; there is therefore a tendency to general flatness in some cases. When this is the case the results may often be improved by the addition of about five minims of a two per cent. solution of potassium bichromate to each ounce of developer. As special paper is, however, made by the Platinotype Company and others for obtaining sepia prints, this should be employed, taking special care to protect the same during examination of the printing from the action of weak light as much as possible; and as these prints, unlike the black one, are likely to be affected by light when in the acid baths a more subdued light should be employed during this stage of the operation as well.

SECTOR SHUTTERS.—We have received a copy of a paper read at the Optical Convention on June 20th, 1912, by Cyril F. Lan-Davis, F.R.P.S., on the subject of sector shutters. The author, in dealing with the number of leaves comprised in shutters of this type, and showing that the position of the pivot does not affect the ratio of the total diameter of the shutter to its opening diameter, proceeds to discuss the effect that the shape of the leaves, as well as their number, has on the shutters' efficiency, showing by means of diagrams that an alteration in the form of the leaves as well as a reduction in their number results in an additional area being uncovered for equal partial central openings in the shutter. In doing this comparison is drawn between a ten-leaved shutter of the usual iris form, which opens in an expanding circle from its centre to edge (so that the amount of light transmitted by the margin is very small indeed), and one having two leaves only, which opens in a broad band that rapidly expands to the full circle. A shutter of this kind would also possess the further advantage that it could be made smaller, as the ratio of the total diameter to the aperture is only 2·1. Although shutters of this type are not yet on the market, we believe Messrs. J. H. Dallmeyer, Ltd., are making arrangements for their manufacture. We have received from Messrs. Wratten & Wainwright, Ltd., several of their booklets dealing with the subject of orthochromatic photography and the use of light filters for special purposes, such as photo-micrography, and in the illumination of the dark room. We may mention in connection with our notes in the June issue, dealing with the testing of dark-room light filters, that the firm make quite a number of special screens for this purpose, which are scientifically tested, and may therefore be relied upon to afford a perfectly safe light for use during the manipulation of the particular kind of plate "or sensitive surface" that they are supplied for use with. While reserving any further remarks for some future occasion, we may say that the name of Wratten & Wainwright is always a sufficient guarantee of the excellence of any product issued by them.

PHYSICS.

By ALFRED C. EGERTON, B.Sc.

X_3?—Professor Sir J. J. Thomson, O.M., gave the Bakerian Lecture to the Royal Society on May 22nd. In the course of an account of his recent experiments, he surmised that a gas exists, which he terms, somewhat mysteriously, X_3. When the positive rays are allowed to stream back through the hole in a hollow cylindrical cathode in a vacuum tube, through which an electric discharge is passed, they ionise the gas through which they pass. The rays produce a number of differently electrified gas particles; they give rise to:—

(i) Atoms with one unit positive charge of electricity,
(ii) Molecules with one unit positive charge,
(iii) Multiple charged atoms,
(iv) Atoms with one negative charge,
(v) Molecules with one negative charge,

and when the discharge is passed through air at very low pressure, since oxygen, nitrogen, argon, carbon monoxide and carbon dioxide, and hydrogen (from water vapour) are present, and each of them may be split up in the above ways, the character of the gas evidently becomes somewhat complicated. Nevertheless, by submitting the gas to magnetic and electric fields, the charged particles can be identified from the position they occupy on a suitably placed screen or photographic plate, when fields of known strength are applied; their mass can then be calculated. By such means there is found in the gas of tubes in which cathode rays are allowed to bombard against solids, particles which consist either of carbon with four charges of electricity or a substance of atomic weight 3 with a single charge—this latter is the substance to which Sir J. J. Thomson assigns the name X_3, because it has not itself been isolated yet in the free state, and because it should have atomic weight 3. The reasons given for considering that it is not carbon with four charges are that it can pass over red-hot copper oxide and then over potash without being absorbed, it is not changed when sparked with excess of oxygen, it can pass over metallic sodium, it is not condensed by liquid air, but is absorbed by charcoal cooled with liquid air, while it combines with mercury vapour in presence of the electric discharge, and also to some extent with red-hot copper.

It will be very interesting if this gas can be caught and examined; a new gas a little heavier than hydrogen and lighter than helium may explain much that is not yet understood.

NOMENCLATURE OF RADIOACTIVE SUBSTANCES. — A little while back an international committee assembled in order to discuss matters connected with radioactivity; one question was the standardisation of radioactive substances, and in order to be able to refer such substances to a definite standard it was settled that Mme. Curie should prepare a solution containing a known amount of pure radium, the unit of radioactivity so obtained being called a "curie." Another question was the nomenclature of radioactive substances; there are three main groups of radioactive substances—the radium, the thorium, and the actinium series. Hitherto, as the separate products of these three series have been discovered, it has been usual to distinguish them by consecutive letters of the alphabet, but sometimes when such names have been settled a product is subsequently found which lies between two such consecutive letters, *e.g.*, thorium C_1 and C_2. The question of the nomenclature of these many products was therefore postponed till such a time as it should become certain that no more intermediate products are present to be discovered. However, it is unsatisfactory that the matter was left in so chaotic a state as it is at present; for in different journals, or indeed often in the same paper, the same product is given more than one name.

There are two ways open—either each product should be given a definite name as is the custom is for the ordinary elements, or some elastic system should be devised which would not only allow for the discovery of new products, but would also give an idea of the properties of the separate products. The former system has been favoured by Sir William Ramsay in naming radium emanation "niton," Professor N. Campbell has advocated the other way.

In chemistry organic compounds are named in such a way that the chemist can tell from the name of the substance many of its properties, and also its relationships with other substances; for instance, α naphthylamine signifies that the substance contains an NH_2 group in a particular position in the naphthalene molecule. It should be possible to devise a system of nomenclature of radioactive substances from which it would be possible to tell the main properties of the substance. The nature of the rays should be prefixed to the name, the number of the product in its series should be included (for knowing this and the rays given by the product, the position of the element in the periodic table, and hence its chemical properties, would be known), and the series to which the product belongs should be the root of the name. It is probable that most of the changes, which give off α or β rays, have now been discovered, and in order to allow for rayless changes where there is no change of mass of the atom but only a difference in configuration the method used in organic chemistry to describe different isomerides (ortho, meta, and para, and so on) might be imitated.

It is to be hoped that before long the radioactive substances will be satisfactorily named.

THE MERCURY VAPOUR LAMP.—The Cooper Hewitt mercury vapour lamp has been so improved that the great objection, viz., the peculiar colour of the light, can now be overcome. The inventor has succeeded in this by placing a celluloid film stained with rhodamine behind the mercury vapour which is giving out light. The rhodamine fluoresces with a red colour, that is to say, the rhodamine is so stimulated by the violet radiations of the mercury vapour that it gives out rays of its own, which are most intense in the red. The resulting luminosity makes a fairly good imitation of daylight. Professor Wood has noticed that when such a stained fluorescent film is backed by white paper or porcelain the luminosity is much greater than when backed by a silvered surface, the reason being that only part of the fluorescent radiation emerges from the film: the rest is internally reflected and does not get out, unless a scattering reflector, such as a matt white surface, is placed behind. The effect is somewhat striking, and a considerable loss of fluorescent radiation is shown often to occur owing to internal reflection.

The "neon" light, devised by M. Claude, which has the similar advantage of the mercury vapour lamp in being very economical of current, also has the disadvantage of giving rise to a light deficient in certain colours; the light is rich in red, but deficient in green and violet. M. Claude has been able to combine his lamp with the mercury vapour lamp and overcomes this difficulty. The mercury vapour lamp works with a low voltage current, while the neon light is worked by a current of high voltage and frequency. All the same, M. Claude has succeeded in his most recent type of lamp in combining the two quite satisfactorily.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

RESPIRATION IN THE WATER BOATMAN.—A careful study of the process of respiration in this well-known insect (*Notonecta*), which rows on the surface of the water, has convinced Frank Brocher that in ordinary circumstances, at the surface, only the seventh abdominal stigmata are used, both for inspiration and expiration. When the water boatman has finished taking in air, and is about to dive, it makes more energetic expirations, and expels by all its stigmata the excess of air which it has in its tracheal system. This expelled air spreads round the body, to which a portion remains adherent, while another portion returns to the atmosphere or is entangled in bubbles about the abdomen.

THE CIGARETTE BEETLE.—Mr. Charles R. Jones has made an important study of the cigarette beetle (*Lasioderma serricorne*) in the Philippine Islands. It has been prominent for many years as a destroyer of stored vegetable products, and is one of the worst pests of the tobacco industry. All the principal tropical and subtropical tobacco-producing districts abound with it. The eggs are laid in small folds in the dried tobacco, *e.g.*, within the open tip of the cigar or cigarette, or under the overlapping edges of the wrapper. The larva, which is less than a millimetre in length to begin with, eats small cylindrical galleries in the tobacco, especially in the higher-grade tobacco. There is a little Clerid beetle which feeds ravenously, both in its larval and adult stages, upon the larvae and pupae of the cigarette beetles, and acts as a useful check. It has been shown by careful experiments that the cigarette bettle can be absolutely controlled, without affecting the tobacco, by fumigations of carbon bisulphide and hydrocyanic gas, and by using high and low temperatures.

FUNCTIONAL TEETH IN UPPER JAW OF SPERM WHALE.—It has been regarded as one of the characteristics of the Physeteridae—the sperm whale or Cachalot family—that functional teeth are confined to the lower jaw. In the sperm whale, indeed, it is well known that numerous rudimentary teeth occur in the upper jaw; but these have been held to be relatively small, embedded in the gum so that they do not reach the surface, and necessarily, therefore, altogether functionless. It is recorded, however, by Messrs. James Ritchie and A. J. H. Edwards that two out of seven specimens examined at Bunaveneader in Harris bore visible exposed teeth in the upper jaw. They lay in a row along a well-defined groove running the length of the jaw on the inner side of the depressions caused by the mandibular teeth. There were about a score, each eleven centimetres long, all but the tip embedded in the gum, far removed from the maxillary bones. The worn and scratched surface afforded proof of actual use.

LARGEST AND STATELIEST OF BRITISH COELENTERATA.—These words are applied by Professor Herdman to the giant sea-pen, *Funiculina quadrangularis*, which occurs abundantly in certain limited localities on the west coast of Scotland. There appear to be "forests" of them—flexible unbranched colonies fixed in the mud and rising gracefully into the water. The finest specimen obtained in 1912 was sixty-two inches in height, and several were about five feet. Sir Wyville Thomson referred long ago to their "pale lilac phosphorescence"; Professor Herdman notes their "pale translucent rosy tint."

SOLAR DISTURBANCES DURING JUNE, 1913.

By FRANK C. DENNETT.

THERE is very little to record by way of disturbance on the Sun during June, notwithstanding that the disc has been telescopically examined every day. The falling off of activity has been as marked as that at the beginning of 1912.

On the 1st, 4th and 8th there were traces of tiny dark spots, but these were not sufficiently evident to have their positions measured.

Even faculae have been comparatively few and far between. On the 4th, minute faculae were visible within a few degrees of both the South and North Poles. On the 14th a small facula was situated Longitude 69° and Latitude 23° N., therefore approaching the North-Western limb. There was a pale faculic patch on the 28th in Longitude 245°, Latitude 29° S., and so nearing the South-Western limb. Other pale faculae were seen North-East on the 4th, 5th, 7th and 8th; South-West on the 8th; South-East on the 7th and 8th; and near the centre of the disc on the 4th and 5th.

Whilst looking at the projected image of the Sun upon the focusing ground glass of the 4-inch photo-heliograph, formerly in use at Greenwich Observatory, when only one small spotlet was visible, a visitor was heard to remark that he was unaware the Sun ever had so few spots as one. But frequently of late the disc has presented a complete blank. By the kindness of the Astronomer-Royal we are enabled to reproduce a print from the original negative of the Sun taken at the Cape of Good Hope on the morning of April 22nd, 1913, when the disc was devoid of all disturbance except a very small group of faculae near the N.E. limb (see Figure 343 and Figure 344 given for comparison).

The observers were Messrs. J. McHarg, A.A.Buss, E. E. Peacock, J. C. Simpson and F. C. Dennett.

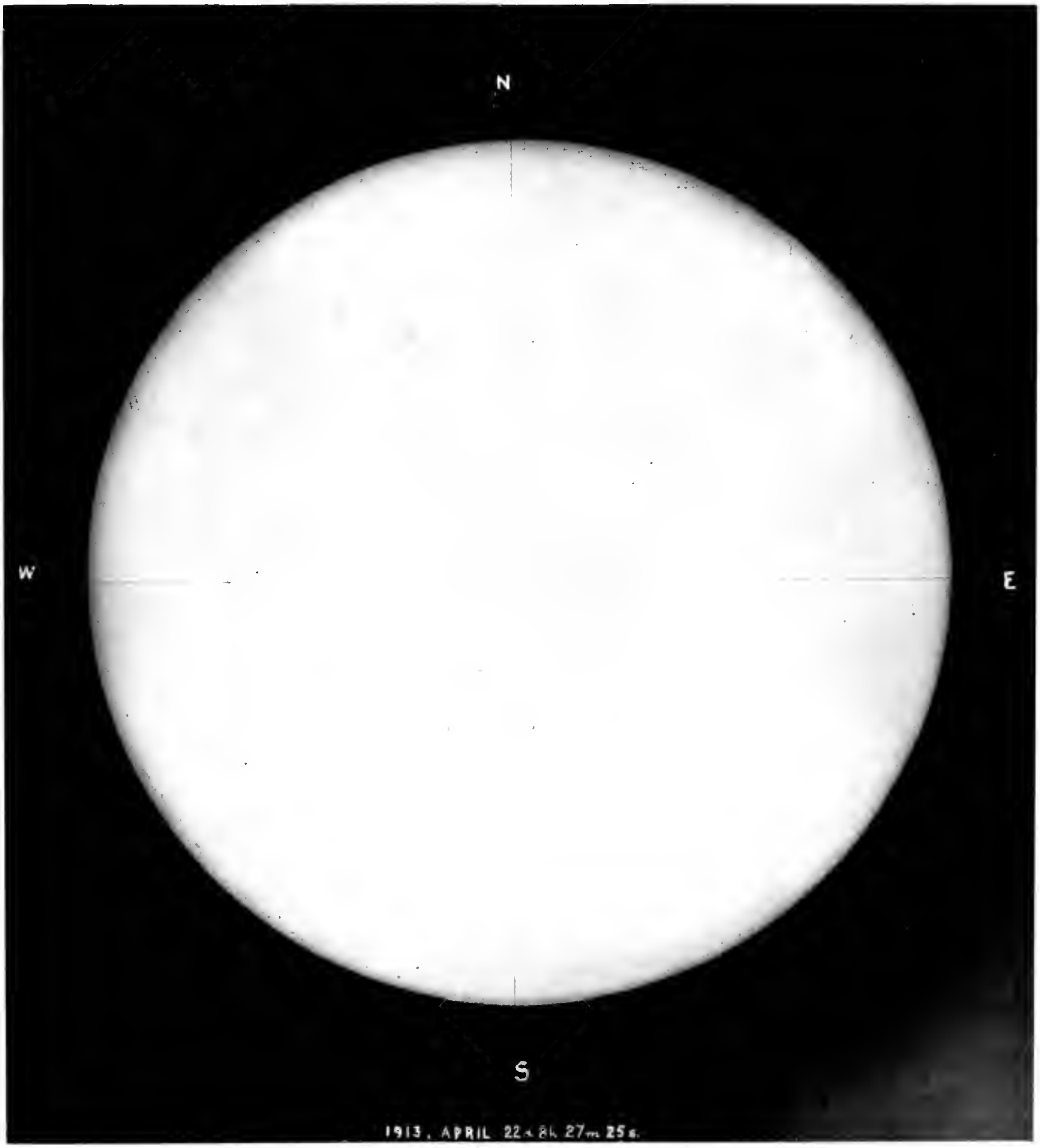


Figure 343.

The Sun practically devoid of all disturbance.

Reproduced by the kindness of the Astronomer-Royal from a print from the original negative of a photograph taken at the Cape of Good Hope on the morning of April 22nd, 1913.

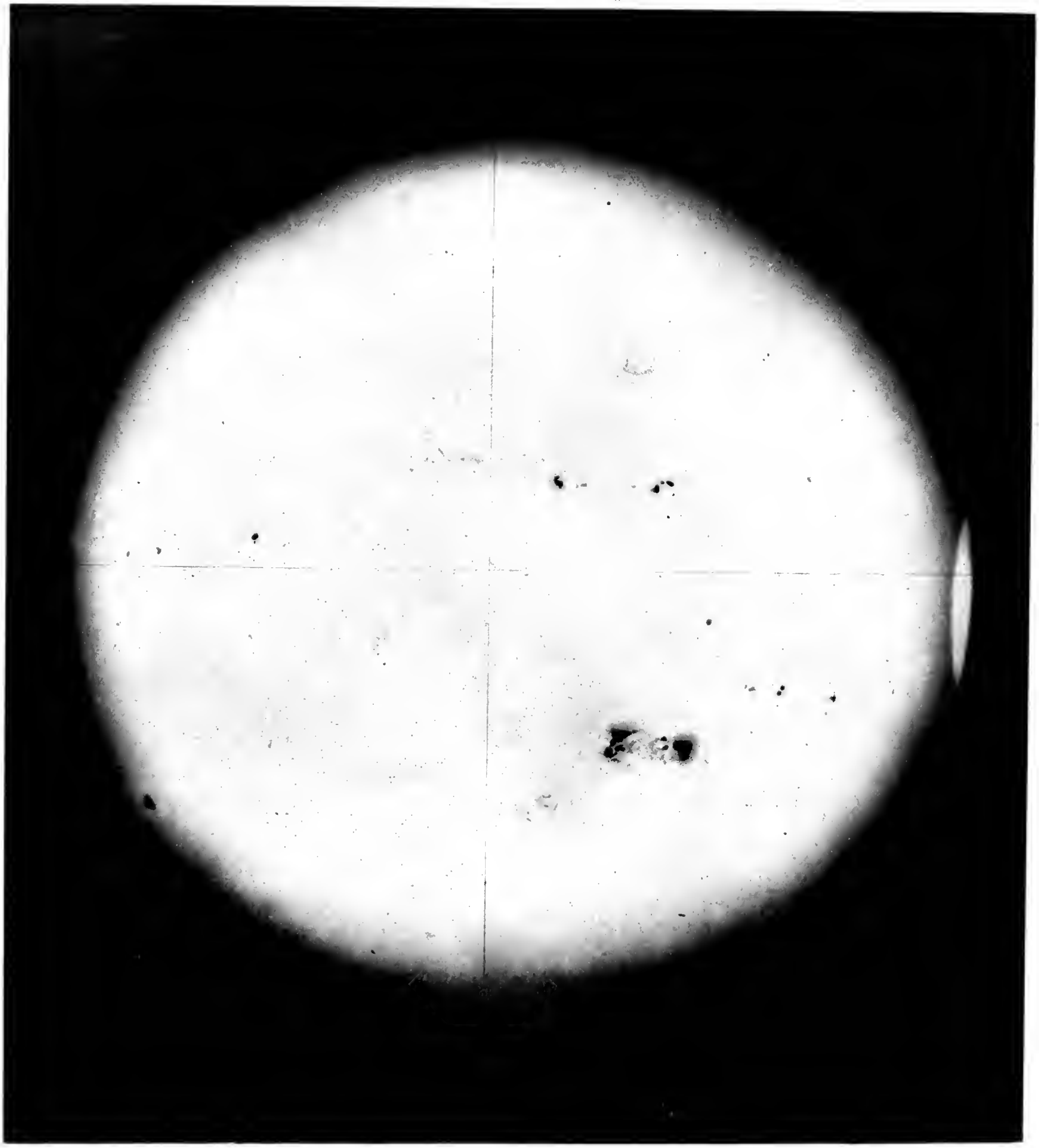


FIGURE 344.

A greatly disturbed Sun.

The Astronomer-Royal has kindly permitted us to reproduce the photograph of the Sun taken on August 8th, 1893, only a short time before the maximum activity. The great spot group is over 100,000 miles at its greatest diameter, and the longer group on the other side of the equator nearly 130,000 miles in length. This picture presents a striking contrast to Figure 343.

PLANT PROTECTION.*

Of the numerous crusades that are being carried on against the different evils that are recognised as rife to-day, such as the killing of birds for plumage, the inhumane slaughter of animals, the preservation of ancient buildings, and so on, none are of more importance than the one directed towards the preservation of wild plants.

The man in the street thinks, when he reads in the press that a hawker has been fined for selling ferns that have been carted wholesale from the woods and lanes, that that is the only cause of the extermination of beautiful wild flowers and ferns from the outskirts of large towns, spots that, maybe, he has known in his youth as a veritable paradise.

But though this is a prevalent notion it is far from being the truth, and, as everyone knows, a half-truth is often worse than a lie. The publications cited show that there are numerous and widespread other causes at work, some, such as smoke, tree-felling, golf-links—to mention only a few—equally powerful in exterminating plants. Mr. Horwood has collected information on a systematic plan from every county in the British Isles, and is able to point to some sixty causes at work in diminishing plants in particular spots or exterminating them entirely.

As Recorder of the Plant Protection Section of the Selborne Society (with Dr. Rendle as Chairman, and an influential Committee), Mr. Horwood describes the work of that body already accomplished since its formation in 1910. Not least in this direction is the publication of the leaflets† issued to the public and to schools, endeavouring to prevent over-collecting owing to nature study, or by the public in general. Fifty thousand leaflets were issued alone to the schools. The object of the Section is to create a public opinion in favour of a better treatment of wild flowers. None will gainsay the need of this.

It is further desired to achieve certain definite means of protecting plants or obtaining reservations by the help of county councils, rural district councils, landowners, and scientific societies. The last have recently been appealed to, and a fair measure of success has apparently been obtained; but it is desirable that all societies should support so worthy an object by the appointment of a corresponding secretary to assist the Section in its work. In a short notice of so important a matter as this it is impossible to state, more than briefly, the ideals of those who have set themselves the uphill task of obtaining what in Prussia is known as State protection. To the few, probably, this would be distasteful, as implying more officials and the intrusion of bureaucratic methods in scientific affairs; but without the machinery of the State, in the absence of an active and generous public support, there is apparently no present medium for enforcing what is certainly the public opinion in this matter—that is, a determination to prohibit premeditated vandalism, or, what is as bad, careless extermination from want of foresight or knowledge.

The general adoption by all county councils of the principle of obtaining a local order for prohibiting hawking on public highways would, we think, come to much the same thing as a Wild Flowers Protection Act, if, in addition, private lands could by a consensus of assent on the part of all the great landowners be protected by the framing of rules relating to private property.

In the meantime the work of this Section, which Mr. Horwood describes, should have the support of all who feel strongly about this matter. They can, moreover, we may be permitted to say, by obtaining copies of the leaflets cited, do much good in their own districts in their own way by distributing them and remonstrating on every possible occasion with those who are guilty of vandalism. And there is no doubt that any suggestions of a useful nature, or actual cases of extinction or diminution coming within the individual experience of readers of "Knowledge," that may be sent to him will be welcomed by the author of these cogent appeals as additional evidence in support of this movement for the public good.

* "The Protection of Wild Plants" (Selborne Society, Special Leaflet No. 1); "An Appeal to Nature Study Teachers" (*Ibid.*, Special Leaflet No. 2); "To the Public" (*Ibid.*, Special Leaflet No. 3); "The Need for State Protection of Wild Plants," *Westminster Gazette*, March, 1913; "The State Protection of Wild Plants," *Science Progress*, April, 1913; "The Preservation of our Wild Plants," *School Nature Study*, June, 1913. A. R. Horwood (Leicester Museum), Recorder, Plant Protection Section, Selborne Society.

† These can be obtained from the Secretary, 42, Bloomsbury Square, London, W.C.

CORRESPONDENCE.

THE PATH OF VESTA.

To the Editors of "Knowledge."

Sirs,—Professor Pickering, in an address to the British Astronomical Association, suggested last month that it would be an interesting and useful work for amateurs to trace the path of Vesta in the sky, and to compare its magnitude with those of adjacent stars; so we have made and verified a small map (see Figure 355) with the path of the little planet for alternate days in August, with all adjacent stars down to 7·5 magnitude. The designation of star by number and zone is from the Harvard Durchmusterung, and the magnitude of each is given in Table

57. For any amateur who has a good binocular glass, it may prove useful. The magnitude of Vesta on August 4th, according to Dr. Crommelin, is 6·1.

FIAMMETTA WILSON,

S. A. WILSON,

Members of the British Astronomical Association; Membres de la Société Astronomique d'Anvers.

BEXLEY HEATH.

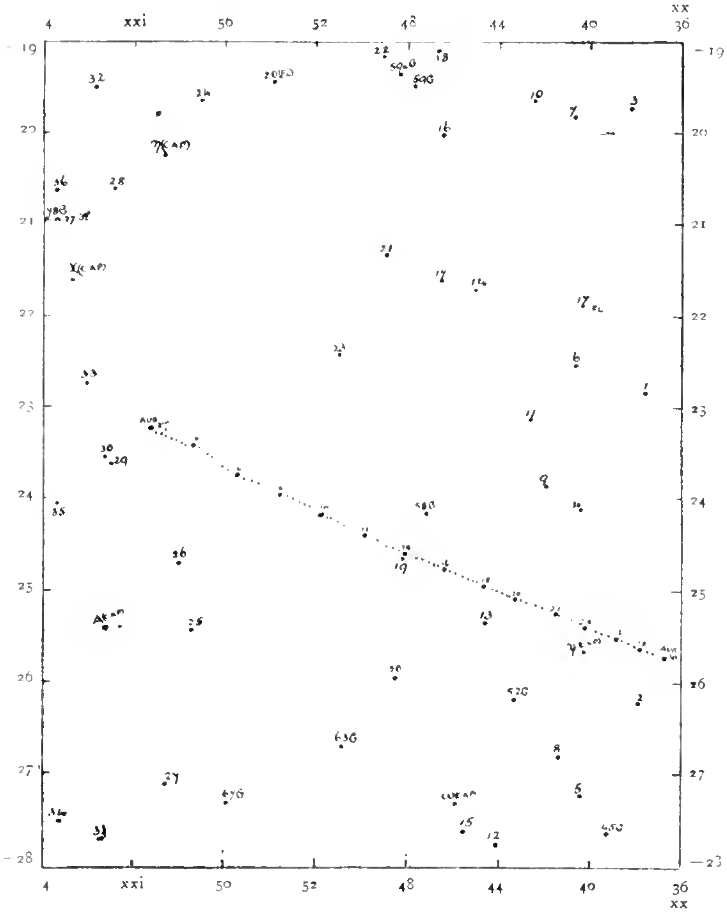


FIGURE 345.

Map of the Path of Vesta showing neighbouring Stars in Capricornis.

Star magnitudes and star numbers from Harvard Durchmusterung.

ABBREVIATIONS.—Fl. = Flamsteed. Number followed by G = number from Manometria Argentina.

TABLE 57.

No. on Map.	Star Number or Star Name in Harvard Durchmusterung.	Mag.	Epoch 1900.	
			R.A.	Dec.
			Hr. Min. Sec.	° ′
1	− 22. 5511	7·5	20 37 36	− 22 49
2	− 26. 15227	8·0	20 37 52	− 26 11
3	− 19. 5905	7·3	38 12	19 42
	45 G	6·7	39 12	27 37
	ψ Capricorni Flamsteed	4·3	40 12	25 38
	17 Capricorni	5·9	40 24	21 53
4	− 24. 16262	7·2	40 24	24 6
5	− 27. 15025	7·0	40 30	27 14
6	− 22. 5526	8·0	40 42	22 32
7	− 19. 5921	7·0	40 52	19 48
8	− 26. 15264	7·3	41 24	26 47
9	− 23. 16498	7·5	42 0	23 51
10	− 19. 5928	6·5	42 30	19 38
11	− 23. 16508	7·4	42 36	23 7
	52 G	6·1	43 24	26 9
12	− 27. 15065	7·3	44 6	27 45
13	− 25. 15067	6·9	44 36	25 21
14	− 21. 5844	6·8	45 6	21 40
15	− 27. 15080	6·8	45 36	27 37
	ω Capricorni	4·1	45 52	27 18
16	− 20. 6055	7·0	46 30	20 1
17	− 21. 5852	7·3	46 36	21 36
18	− 19. 5942	8·3	46 42	19 7
	58 G	6·6	47 12	24 9
	59 G	6·5	47 48	19 29
19	− 24. 16339	7·3	48 12	24 39
	59a G	7·3	48 24	19 22
20	− 26. 15326	7·5	48 30	25 57
21	− 21. 5864	7·5	49 0	21 20
22	− 19. 5960	7·0	49 6	19 10
	63 G	6·1	50 52	26 41
23	− 22. 5572	7·5	51 6	22 23
	20 Flamsteed Capricorni	6·2	53 52	19 26
	67 G	6·2	55 52	27 17
24	− 19. 5998	7·0	57 6	19 39
25	− 25. 15195	7·3	57 30	25 28
26	− 24. 16443	7·4	58 0	24 43
27	− 27. 15222	8·1	58 36	27 8
	η Capricorni	5·0	58 42	20 15
28	− 20. 6127	6·8	21 1 0	20 35
29	− 23. 16698	7·4	1 6	23 37
30	− 23. 16700	7·0	1 18	23 33
	A Capricorni	4·8	1 18	25 24
31	− 27. 15255	7·3	1 30	27 41
32	− 19. 6024	7·0	1 48	19 29
33	− 22. 5612	7·8	2 6	22 44
	χ Capricorni	5·3	21 2 48	− 21 36
34	− 27. 15275	7·5	21 3 12	− 27 31
35	− 24. 16495	7·4	3 24	24 2
36	− 20. 6140	7·0	3 30	20 36
	78 G	6·5	21 3 52	− 20 57

REVIEWS.

ARCHAEOLOGY.

Church Bells of England.—By H. B. WALTERS, M.A. F.S.A. 400 pages. 170 illustrations. 9-in. × 6-in. (The Oxford University Press. Price 7/6 net.)

This book taken generally is exceedingly well written, the illustrations, one hundred and seventy in number, are good, especially the one on page 11 showing a man playing on an octave of bells; see also page 31, whereon is shown a finished bell and method of casting. Other illustrations of the "copes," "cores," and moulds joined are interesting (pages 37, 39, 41), and of the completed peal on page 43. The twelve ringers at St. Paul's Cathedral (page 75) forms a good picture, and furnishes an excellent idea of what the ringing chamber there is like. Copies of old prints appear on pages 258, 259, and 260, and these show the "washing," "blessing," and "censing" of a bell in bygone days, whilst the chapter (XIII) on the decoration of the castings is particularly interesting. It is pleasing to note that the writer agrees with Canon Simpson's principle of tuning bells, and he rightly observes that it is a mistake to retain "maiden" bells in a peal when they would be the better for tuning.

In a complex work of this description there is bound to be a few "slips" which may be well to correct in a future edition. For instance, on page XIII the date of the "Clavis" is given as 1888; it should be 1788. The stating of the changes on page 83 is incorrect, and the same error occurs on page 84. It may be a printer's error on page 83 where the word "*courses*" is given instead of "*changes*," but the writer on page 141 calls "touches" "*peals*." A "peal" is the *extent* of changes obtainable, whilst a "touch" may be a number *less* than the extent.

It is stated that the second bell at Aldbourne, Wilts, was given "by anonymous donors" (page 340), but such is not the case, for the names of the donors are plainly cast upon the bell, and the full inscription is as follows:—

"The gift of Jos: Pizzie and Wm. Gwynn of Aldbourn. . Robert Wells fecit 1787.

Music and ringing we like so well,
And for that reason we gave this bell."

W. L.

CHEMISTRY.

The Interpretation of Radium. Being the Substance of six free popular experimental Lectures delivered at the University of Glasgow.—By FREDERICK SODDY, M.A., F.R.S. 3rd Edition, revised and enlarged. 284 pages. 33 illustrations. $8\frac{1}{4}$-in. × $5\frac{1}{2}$-in.

(John Murray. Price 6/- net.)

In the third edition of this work, whilst the original lecture form has been retained, many additions have been made concerning recent investigations, including a new final chapter dealing with the thorium and actinium series of radioactive elements. Controversial matters have been avoided as far as possible, but Mr. Soddy does something less than justice to the electronic theory of matter (with all its faults) when he dismisses it as based upon extravagant assumptions (page 151). Concerning transmutation Mr. Soddy shows that the study of radioactivity indicates the possibility of achieving this; but he asserts that transmutation has not yet been accomplished, entirely ignoring the experimental work of Sir William Ramsay on the subject, which certainly ought to have been mentioned, even if regarded as inconclusive. Another matter that calls for criticism, is that Mr. Soddy does not clearly distinguish between the aim of science (namely, the correlation of phenomena) and that of metaphysics, which is concerned with the source or cause of phenomena. Thus, he uses "matter" as a metaphysical concept, defining "mass" as "quantity of matter" (an exceedingly vague metaphysical expression), whilst at the same time stating that "mass" is measured by "inertia." Energy, moreover, is spoken of in the book as though it were a metaphysical entity.

Apart from these faults, however, it must be freely admitted that there is much that is excellent in the book—as, indeed, one could only expect from a man to whom the science of radioactivity owes so much. Apart from the tendency to untenable metaphysics, already indicated, the style is clear and precise, and the language is simple and adapted to the needs of the ordinary reader, who requires a general account of the new science, in which technicalities and matters of detail are avoided as much as possible.

In one chapter, which is frankly speculative, but by no means the least attractive in the book, there are some very interesting speculations arising out of the consideration of the geological significance of radioactivity and the evolution of the elements. Mr. Soddy suggests that there may have been, in the dim distance of the past, a civilisation on this earth in advance of the present, to whom the secrets of the elements were known, and that the traditional theories of the mediaeval and older alchemical philosophers (which in certain cases, as Mr. Soddy points out, seem to express at times, in allegorical form the views of modern science) were the remnant of heritage from this past.

H. S. REDGROVE.

GEOLOGY.

The Earth: its Genesis and Evolution.—By A. T. SWAINE. 277 pages. 64 illustrations. $8\frac{1}{2}$-in. × 5-in.

(C. Griffin & Co. Price 7/6 net.)

Although this work is confessedly a compilation, it may be commended to general readers and lower-grade students as a well-written and, on the whole, trustworthy exposition of the leading factors in the evolutionary history of the earth, with passing notices of the faunas of the different epochs. Scientific terms are avoided so far as possible; but the author in a very large number of instances has given references to authenticate particular statements, so that the student desirous of entering more deeply into the subject will have no difficulty in finding where to turn for further information.

Commencing with the consideration of the various theories of planetary genesis and the beginning of the earth, the author, after a chapter on the leading physical features of the latter and its movements in space, gives an excellent survey of the igneous and sedimentary rocks and their mutual relationship and sequence. Very wisely, he has omitted all reference to guesses as to the supposed age of the globe in years, remarking that these have practically no basis of fact, and also that figures of such magnitude are beyond the scope of the ordinary human understanding. The fact that nearly all the great mountain chains of the old world are of Tertiary age is brought very prominently before the reader; but it might have been added that the stupendous physical changes involved in such movements serve to demonstrate that compensating changes must have occurred in other parts of the world, and consequently that the arguments of those who urge the stability of continents and ocean-basins are of little value. Perhaps the least satisfactory parts of the work are those dealing with extinct vertebrates, with which the author seems to have but a very slight acquaintance. It is, for instance, incorrect to describe the figure of the skeleton of *Diplodocus* (page 168) as that of a restoration of the animal; while the statement (page 171) that the terrestrial dinosaur *Brontosaurus* was not unlike an *Ichthyosaurus* or a *Plesiosaurus* in form will astonish every palaeontologist. It must, too, have been a remarkably big Newfoundland dog that rivalled the ancestral elephant *Moeritherium* (or *Moerithrium*, as it is misspelt on page 196) in size. These, however, are blunders which detract but slightly from the value of an eminently readable book.

R. L.

PHYSICS.

Wireless Telegraphy. — By C. L. FORTESCUE, M.A. 143 pages. 20 illustrations. $6\frac{3}{4}$-in. × 5-in.

(The Cambridge University Press. Price 1/-.)

The series to which this little book belongs has already become widely known, and may fairly claim that it supplies "simple, concise, and reliable information." On such a subject as Wireless Telegraphy this combination of qualities is not easy of attainment. The author has succeeded in putting within the compass of 143 pages the main principles of current induction, condensers, oscillatory currents, resonance, and electromagnetic waves, along with details of the various processes of transmitting and receiving, followed by chapters on wireless telephony and on the history of the development of the whole subject. At a first glance the statements seem to be well and clearly put, and a reader who knows something of electricity in practice will doubtless find much help from a book of this kind. It is doubtful whether any book can supply such help to those who have no practical acquaintance with electricity. These, however, are becoming fewer in number. On page 132 we observe that Hertz is said to have published the results of his experiments with oscillating currents in the year 1878. Surely two figures have become transposed, for Clerk Maxwell died in 1879. It is, perhaps, unfortunate that three pages are devoted to the Marconi Agreement of 1912.

W. D. E.

ZOÖLOGY.

Text Book of Zoölogy.—By H. G. WELLS, B.Sc. and A. M. DAVIES, D.Sc. 487 pages. 207 figures. 7-in.×5-in.

(The University Tutorial Press. Price 6/6.)

Mr. H. G. Wells, when he was a teacher of Zoölogy, planned out this book, which was rewritten by Dr. Davies. Now the sixth edition has been carefully revised by Mr. J. T. Cunningham, who has added a summary of the modern ideas with regard to evolution, which we have read with very great interest.

W. M. W.

Wild Life in Wales.—By GEORGE BOLAM. 405 pages. 62 illustrations. 9-in.×6-in.

(Frank Palmer. Price 10/6 net.)

There is a wealth of interesting information in this book which deals first of all with sheep-dogs and agriculture, but as its name implies is mostly occupied with first-hand observations on the wild life of Wales. There are also included some very useful discussions as, for instance, the one with regard to the development of spots on birds' eggs. For the mole it is claimed that the damage he may do is so insignificant that it may be ignored, "while his hillocks form a good top dressing to the grass and are gradually spread by sheep, who thereby, it has been claimed, help to grind off the superfluous growth with their own hoofs." It is pleasant to learn some good also of the carrion crows, which Mr. Bolam says for the greater part of the year are nearly as assidious as rooks in hunting and destroying beetles, wireworms and so on. The lover of nature will be delighted to hear of the chough, the buzzard, the peregrine falcon, the polecat and the marten, and also to see many of the excellent photographs which have been used as illustrations, while here and there those to whom antiquities have a charm will be glad to find details of the hand-plough, the flail and the rushlight.

W. M. W.

"J." A Memoir of John Willis Clark, Registrary of the University of Cambridge and sometime Fellow of Trinity College.—By A. E. SHIPLEY, F.R.S. 362 pages. With 3 portraits. $8\frac{3}{4}$-in.×$5\frac{3}{4}$-in.

(Smith, Elder & Co. Price 10/6 net.)

To almost every Cambridge man who matriculated between the middle sixties and the earlier years of the present century the name of J. W. Clark—abbreviated at first to "J. W." and then to "J"—must have been more or less familiar. For its owner occupied a unique and prominent position at the University, while his many-sided activities brought him into contact with undergraduates of diverse types, from serious zoölogical students to the light-hearted members of the Amateur Dramatic Club. And as every *alumnus* who came in contact with Clark could not fail to be attracted by his genial, if somewhat cynical, disposition, they should all rejoice that the book escaped the dire fate of being privately published.

To the naturalist the chief interest of the book is concentrated in the appendix on Clark's long career (from 1866 till 1891) as Secretary and Superintendent of the University Zoölogical Museum; an institution which may be said to have attained its present high status as a teaching unit as the result of the energy and hard work of its Superintendent, combined, it should be added, with the assistance of the then Professor of Zoölogy, the late Alfred Newton. But Clark succeeded in making the museum under his charge a great deal more than a teaching centre by obtaining for it many collections of high scientific value to which students will constantly resort so long as they remain in existence. Of actual scientific work Clark did comparatively little, partly, no doubt, through lack of the proper training in early years and partly owing to the pressure of his administrative duties. In the early part of his career as Superintendent he published, however, some papers on sea-lions, which were of considerable value in clearing up the confusion then existing with regard to the number of species and their distinctive characters.

No one better suited to the task of writing the life of his old friend could possibly have been found than Dr. Shipley, to whom all contemporary Cambridge men owe a debt of gratitude.

R. L.

NOTICES.

BIO-ECONOMICS.—Dr. Reinheimer is about to issue, through Messrs. Kegan Paul, Trench, Trübner & Company, a contribution to evolutionary science in the form of a volume entitled "Evolution by Co-operation—A Study in Bio-Economics."

FOREIGN BOOKS.—Messrs. W. & G. Foyle have opened at 5, Manette Street, W.C., a Foreign Book Department containing, we are told, volumes in every language and on every conceivable subject, carefully arranged and classified.

SCIENCE FOR ARTISANS.—To meet the want of highly intelligent artisans for something more concrete than theory, Messrs. Constable & Company are bringing out a series of short, simply-written monographs by competent authorities under the title of "Thresholds of Science." The books will be well illustrated, and the volumes on Zoology, Botany, Chemistry and Mathematics are now ready.

HISTORICAL MEDICAL MUSEUM.—This Museum, which has been set up at 54A, Wigmore Street, is formally recognised as part of the History of Medicine Section of the International Medical Congress which is now being held in this country. The collections are due to the munificence of Mr. Henry S. Wellcome, and to the most interesting specimens and models brought together by his and his assistants' labours we hope to devote a special article in the near future.

SECOND-HAND BOOKS. — Mr. Edward Baker, of Birmingham, has sent us his catalogue of Second-hand Books, numbered 319, and among the thirteen hundred items described in it we notice many having reference to various branches of science, while there are special headings dealing with Botany, Ornithology, and General Zoölogy.

NEW EDITIONS.—Messrs. J. & A. Churchill, of 7, Great Marlborough Street, W., have nearly ready for publication the 7th edition of "The Microtomist's Vade-Mecum," by Mr. Arthur Bolles Lee; the 6th edition of the late Professor J. Campbell Brown's "Practical Chemistry," edited by Dr. Bengough; and the 3rd edition of "A Text-Book of Physics," edited by A. Wilmer Duff.

JOURNAL OF CHEMICAL TECHNOLOGY.—The Publications Committee of the Association of Chemical Technologists announce that in future the "Journal of Chemical Technology," the official organ of the association, will be published quarterly, and that the July number will be the first of the new issue.

BAUSCH & LOMB MICROSCOPES.—We have received the Bausch & Lomb Optical Company's catalogue of microscopes which contains particulars of two new stands "F" and "FF" the latter of which has a focussing sub-stage. A special feature of these microscopes is the base, which is of a modified horse-shoe form of rounded contour. These models, which embody all up-to-date bacteriological requirements have been introduced to meet the popular demand for a high-class instrument at a moderate figure. Incidentally we may mention that the Bausch & Lomb Optical Company have now sold more than eighty-seven thousand of their microscopes.

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

SEPTEMBER, 1913.

THE EXISTENCE OF LUMINOUS BIRDS.*

By COUNT L. de SIBOUR.

FEW students delve deeply in natural history without encountering the topic of luminous birds, and the pros and cons of the subject are developed by the reader with a frequency that tests the credulity of any superficial investigator. That birds having the quality of luminosity have long existed seems a fact beyond dispute. Especially true is this in England. In 1907 Sir Digby Piggott called the attention of ornithologists to the appearance of luminous birds in Cambridge, and these unusual members of the feathered family had already been noticed by others in the same county, and especially by Mr. J. H. Gurney, of Norwich, who spread the news on the Continent through the French ornithologist, M. Ternier, in *The Ornithological Review of France.*

It seems that as early as 1866, in the same county, Mr. J. A. Harvie-Brown had mentioned "moving lights" frequently seen at night. But no special attention had been paid to these reports, as they were believed to have originated in the credulous minds of country folk.

The more frequent apparitions in 1907 at last aroused the attention of naturalists, especially in France, where similar cases had been observed in the Vosges and in the Pyrenees.

According to Sir Digby Piggott, a couple of luminous birds were seen near Twiford, Norfolk, in February, 1907, by a gamekeeper, who, having killed one, identified it as a common barn owl (*Strix flammea*). In October, 1907, Mr. B. J. Purdy and Mr. Spencer saw another which was seen again on the 19th and 22nd of December. On the first occasion it seemed to have attained the maximum of luminosity, as the branches of the tree upon which it had perched were visible in the pale yellow glow. This light did not frighten the mice; for the bird was seen to drop upon them several times.

The power of the light was that of a bicycle lamp seen three or four hundred yards off, and its strength diminished considerably when the bird's flight was in a direction away from the observer. This pointed to the inference that the luminosity was confined to the breast.

According to Mr. C. L. Harman, a luminous bird was seen by him in the marshes of Haddiscoe, on the 25th day of December, 1907. Similar apparitions were recorded during the years 1907 and 1908; but in 1909 they ceased, and none has since been observed.

The glow on the breast of the barn owl is undoubtedly due to phosphorescence, and the moulting of the feathers explains its sudden extinction.

Two theories were given as to the origin of this unusual luminosity.

Mr. Gurney, who had the opportunity of observing several specimens of these birds, thought it probable that the owls had been in contact with phosphorescent wood, and that phosphorescent bacteria had attached themselves to the feathers. This opinion at first was generally accepted, especially in Norfolk, where many birds had been seen, and was apparently confirmed when Lord Lindley announced that on his property there was a

*Extracted from Articles by L. Ternier, in *The Ornithological Review of France.*

beech tree showing a patch of phosphorescence eight inches square. It was therefore surmised that the birds had inhabited holes infested by this bacterium. The other theory was that dampness and uncleanliness of the covering of the breast had favoured a sudden growth of luminous fungi peculiar to feathers. This explanation appears to have been more plausible; for in the contact theory it would seem that the wings and head, rather than the breast, would be likely to touch the sides of the hole. Yet these parts produced little or no light. Again, it would necessitate the bird being a tree-hole dweller, whereas similar cases have been observed on Canadian blue herons, for which this kind of life is impossible.

The phenomenon is not confined strictly to wild birds. Cases are also found among domestic pigeons. The locating of the light on the breast can be explained by the fact that the feathers are finer and thicker on that part of the body than on any other, except the neck. It is also a part that the bird cannot thoroughly clean, and will therefore retain the greater part of the germs and dust gathered in flight. The peculiar increase of light during flight is probably due to a chemical action of the air producing superoxygenation, as it is well known that the agitation of a medium containing phosphorescent particles intensifies the luminosity of the latter.

The balance of argument is thus in favour of the fungi theory, and the latest observations of Señor Elorza in Spain are a confirmation of it. On several nights he saw a couple of luminous birds. Upon inquiry he was informed that they had been noticed for several years, that they lived in cliffs near by, and that they disappeared in the month of May. The description given by him did not answer to that of the Barn Owl, and it is to be supposed that we are in presence of another bird, one of nocturnal habits, offering a similar case of phosphorescence. These specimens did not live in trees, but in cliff-holes. Their disappearance in May is accounted for, as in the other cases, by the spring moulting of the feathers.

It might be of interest to look back to the works of the earlier naturalists and note that several observers were aware of the existence of luminous birds. The first to record their appearance was Pliny. He mentions them in his account of the Hercynian forest (" Historia Mundi," X, 47). Two hundred years later Solin, in the twentieth chapter of his " Polyhistoria," alludes in much the same way to what the great Latin naturalist had observed: " Soltus Hercynius aves gignit, quarum pinnae per obscurum emicant et interlucent, quamvis densa nox denset tenebras." It is probable that he was not unacquainted with Pliny's works.

The first work solely devoted to luminous animals was written in 1555 by Conrad Gessner: " De raribus et admirandis herbis, quae sive quod noctu luceant, sive quod alias ob causas lunariae nominantur, et obiter de aliis etiam rebus, quae in tenebris lucent." He speaks of plants and grass shining at night, and seems to have an obscure idea of the origin of this phenomenon, which he calls " res naturae luscentes."

Finally, in 1647, Thomas Bartholin published his great work, " De luce animalium." This is a compilation, in three volumes, of observed (and some problematical) cases of luminous animals. The third book is entirely devoted to birds, and in it are mentioned the Phoenix, the birds of Diomedes, the " Incendiaria avis," which set on fire any tree or house on which it perched; the cock " cum luce consensum alit," whose feathers had robbed from the sun their brilliant metallic shine.

But among these quaint beliefs one finds observations very probably true. In 1641, at Montpellier, in France, during a short period of famine, many fowls were brought to market. Several of these birds attracted wide attention by their unmistakable phosphorescence, and Henri de Bourbon, Prince de Condé, was called to admire them. A cock was killed "who shone on all parts of his body with a remarkably strong light," "veram totius corporis lucem . . . aperte exserint." The same year, at Montebello, according to the author, there was a hen which "shone like a ball of white fire." And Thomas Bartholin, comparing these two birds, ingeniously adds: " It is a pity that the cock did not meet the hen; for we might then have obtained a breed of incandescent fowls."

A SIMPLE METHOD OF DIFFERENTIATION BETWEEN MALTOSE AND LACTOSE IN THE SOLID STATE.

A SOLID is given which reduces Fehling's Solution and does not reduce Barfoëd's Solution. The solid must be either Lactose or Maltose.

(1) Take some of the solid and place it in a clean dry test tube.

(2) Add from 5 c.c. to 10 c.c. of absolute alcohol and shake well.

[The alcohol should not be heated as Lactose is sparingly soluble in warm alcohol and might give an erroneous result.]

(3) Then filter through a clean, dry filter funnel and receive the filtrate into an evaporating dish.

(4) Evaporate the filtrate on a water-bath nearly to dryness.

(5) To the filtrate then add a few c.c.'s of diluted Fehling's Solution and warm.

[Before adding the Fehling's Solution a sample should be tested to see that it does not reduce of its own account.]

(6) If reduction takes place, Maltose is present; if no reduction, Lactose.

This differentiation can be carried out within the space of a few minutes with quite a small amount of solid and with very little apparatus. It is very useful when sugar is mixed with a protein which will prevent one from obtaining an osazone or a polariscope reading.

VICTOR FELDMAN,

THE LONDON HOSPITAL.

THE ZODIACAL LIGHT.

By the Late F. W. HENKEL, B.A., F.R.A.S.

ASTRONOMERS are generally agreed to consider this phenomenon as falling within the purview of their science, though there have not been wanting some who, by a wide extension of the term Meteorology—τὰ μετέωρα, "things aloft"—have rather included it under the latter heading. Inhabitants of towns, "those in populous cities pent," are not often favoured with a view of its delicate luminosity, the multitude of artificial illuminations completely veiling its feebler intensity. But in tropical regions it is a fairly regular phenomenon and, according to Humboldt and other observers, its brilliancy often greatly surpasses that of the Milky Way.

In our latitudes, the Zodiacal Light is best seen in the evenings of February and March, being then nearly perpendicular to the western horizon; in the autumn mornings it is to be similarly seen in the east before sunrise. As seen on a late February evening it has the appearance of a cone or lens-shaped beam of light reaching from the horizon towards the zenith, following generally the course of the ecliptic (or perhaps that of the Sun's equator), whence its name, the Zodiac being that part of the sky within which are performed the apparent movements of the Sun, Moon, and the principal planets. This cone has its base at the horizon, and its vertex is at a distance from the Sun's position varying from 50° to 90°, the breadth of the base being not less than 8° or more than 30°. Cassini and Mairan observed it, at times, not less than 100° from the Sun's place, and occasionally even further, showing its extension in space beyond the Earth's orbit. Humboldt and Brorsen seem to have been amongst the first to observe a second light in the East at the same time that there was a principal light in the West, a narrow band of fainter luminosity uniting the two, whilst Flammarion says that in the equatorial regions of the Earth the conical form disappears with the last trace of twilight, and by "night there is seen a luminous band forming a more or less complete circle in the sky, sometimes stretching from West to East, the parts nearest the Sun being the most brilliant, other regions less so, the whole of a pure white tint." In the region of the sky exactly opposite the Sun's place there is often seen a patch of several degrees diameter, more luminous than the surrounding portion, and this is known as the "Gegenschein," or counterglow. Whilst under the Tropics the light is of pure white colour, in our latitudes it is more commonly of a reddish tint, especially at its base; this is, however, probably due to the last traces of twilight. Humboldt, however, says ("Cosmos," Vol. I): "I have occasionally perceived not exactly a reddish coloration, nor the lower part darkened, nor even a scintillation such as Mairan asserts he has seen, but a sort of tremulous shivering of the light."

It is perhaps a little surprising that the zodiacal light seems to have escaped the notice of the ancient astronomers, unless we may suppose that a reference to the "trabes" by Pliny, in his "Natural History," may be so interpreted; but this is more probably an allusion to the aurora. Kepler and Descartes make obscure allusions which may be interpreted to indicate their familiarity with it; but the earliest authentic mention of the light occurs in the works of Childrey, Chaplain to Lord Henry Somerset, who, in his "Natural History of England" (1659) and his "Britannia Baconica" (1661), was the first to draw the attention of his contemporaries to the remarkable observations made by him during several previous years, in the evenings of February and March, after sunset. About twenty years later, Dominique Cassini gave considerable attention to the phenomena as seen in Central Europe, and studied them "in all their bearings with regard to space," formulating a theory of their origin which differs but little from that generally admitted by present-day astronomers. He considered that the light was produced by a ring of small planetary bodies revolving in orbits nearly in the plane of the Ecliptic and reflecting the light of the Sun. He even thought that the fall of meteoric stones or bolides might be due to the passage of our Earth through this ring. The principal difference between this and later views consists in regarding the innumerable small particles as rather forming a thin, flat sheet partly lying between the Earth's orbit and the Sun and partly beyond it, the light being due to reflection mainly, but perhaps, as we shall see later, to a small extent intrinsic also. It is by no means impossible that to the action of the denser part of this layer of "meteoric dust" within the orbit of Mercury may be due the unexplained motion of the perihelion of that planet's orbit as detected by Leverrier. Sir John Herschel says: "It may be conjectured to be no other than the denser part of that medium which, as we have reason to believe, resists the motion of comets, loaded, perhaps, with the actual materials of the tails of millions of those bodies of which they have been stripped in their successive perihelion passages."

Liais and Mayer thought that to this layer might be referred the maintenance of the Sun's light and heat, "the meteoric theory of solar radiant energy." Materials must be continually falling upon the Sun's surface, and the "arrested motion" transformed into heat, thus making up for that lost by radiation, so that the Sun might long continue in this way to heat and illuminate the planets. But the *insufficiency* of this process is a fatal objection, except as possibly affording a minute portion of the solar radiation; for, were the Sun's heat thus maintained at its present rate of emission, calculation shows that our own Earth and the nearer planets would be subject to a bombardment also, sufficient to add about fifty tons of meteoric matter on each square mile of the Earth's surface per day; whereas in reality the actual amount falling is not one-millionth of that quantity. The fall of sufficient material in such vast quantity implies the presence of a yet greater amount in the surrounding regions, and very evident effects upon the motions of the planets would also be perceived which are not observed. Nevertheless, the idea that a balance between expenditure and receipts is kept up in this way seems so beautiful an one that we may perhaps be permitted to regret that it is not true.

Long-continued observations of the light were made by the Rev. G. Jones, chaplain of the American steamship "Mississippi," during a cruise of two years round the world, and his observations and results were published in a beautiful volume during the year 1858. The final conclusion at which he arrived from the totality of his observations was that the zodiacal light is *produced by a nebulous ring having for its centre the Earth*, which lies within the orbit of the Moon; in other words, a kind of terrestrial ring like one of the rings of Saturn. Captain Wilkes, a well-known American navigator, objected to Jones's views and proposed an alternative theory that the zodiacal light is simply a terrestrial meteorological phenomenon, the result of the illumination of that part of the Earth's atmosphere upon which the sun falls vertically within the tropics. The Dutch observer Gronemann similarly considered the light to be of terrestrial origin, and denied that the relation asserted to exist between the luminous cones seen in the east in the morning and those seen in the west during the evening had been established; he also declared that it had not even been proved that they shared the apparent diurnal motion of the heavenly bodies. In 1876 Serpieri, of Urbino, presented to the Italian Spectroscopic Society a memoir dealing with the results obtained by various previous observers, and gave as his opinion that the light was of electrical origin, perhaps analogous to the aurora. Thus we see that there is still much to be done before we can be said satisfactorily to understand this mysterious phenomenon, although, as we shall point out later on, there are good reasons for thinking that the "auroral" theory of the zodiacal light arises from a confusion of ideas.

Long ago Humboldt, whose interest had been excited by finding the intensity of the light much greater in Spain than in Germany, expressed his astonishment at the variability of this phenomenon under the tropical skies of South America. Even whilst its luminosity was greatest it would for some minutes diminish appreciably, and then without warning brighten up again to its former intensity. "The strength of the light increased in a remarkable manner as I approached the Equator in Southern America. In the constantly clear and dry atmosphere of Cumana, in the grassy llanos of Caracas, on the elevated plains of Quito, and in the Gulf of Mexico, especially on the plateaux (of ten thousand to twelve thousand feet above sea level), where I stayed for some time, I noticed that its brilliancy often surpassed that of the brightest part of the Milky Way between Argus and Sagittarius, or, speaking of the part more familiar to us in the northern hemisphere, that part between Aquila and Cygnus" ("Cosmos," Vol. IV). On the whole, however, Humboldt considered that the brilliancy of the zodiacal light did not increase with the altitude of the region where it was observed. He insisted especially upon "the intrinsic variability of the phenomenon itself," but he did not dispute the possibility of the influence of varying atmospheric conditions, the greater or less transparency of the upper and lower strata of the air upon its brightness, as we have already noticed with regard to the coloration perceived in extra-tropical regions, scintillation, and so on.

Amongst others who have studied the various phenomena, Professor Searle has also devoted much time and thought to the different theories proposed. Dealing with the observations of Jones and others he concludes that the zodiacal light varies in position during the course of the year, being more to the north in autumn than in spring (of our hemisphere); atmospheric absorption has a great influence also upon its apparent position; the zone of the sky occupied by the minor planets presents peculiarities like those of the zone occupied by the light, and thus one is led to think that the latter also is due, in part at least, to small bodies moving in planetary orbits. The light does not interfere with the visibility of even faint stars, and it disappears by setting, and not by growing fainter. This last movement, due to the Earth's diurnal motion, as we have seen, was denied by Gronemann.

From observations made at sea whilst in the Tropics during 1862 Helis concluded that the change of position of the light depends more on the time of year than on the situation of the observer. Colonel Tupman made a number of observations from 1869 to 1871 in Southern Europe, and gave an account of his work in *The Monthly Notices of the Royal Astronomical Society*, Vol. XXXII. He stated that the axis of symmetry of the light with regard to the Ecliptic varied considerably during the course of the year, being almost parallel to that plane in winter and making an angle of as much as 20° with it in August and September. He also asserted that the plane of the light *did not pass through the Sun*. If this be indeed the case it would seem that the matter composing it does not turn round the Sun, but his observations differ very considerably from those of others. About the same time the late A. C. Ranyard, formerly editor of "Knowledge," was in Sicily for the purpose of observing the famous total eclipse of the Sun in 1870. He examined the luminosity of the zodiacal light with the Savart polariscope, and saw that this gave distinct signs of polarisation, thus concluding that the material giving rise to it is either composed of particles so small that their diameters are comparable with the wave-length of light, or else is composed of matter capable of giving "specular reflection." Ängstrom, of Upsala, the famous spectroscopist, concluded from his observations that the substance emitting this light is the same as that which causes the aurora. He thought that he saw the "brilliant auroral line" (5567) in its spectrum; but as the aurora is a phenomenon of far greater frequency in Sweden than in regions further south, his observations, through the possible confusion between two coëxistent phenomena, are subject to considerable uncertainty.

Acrimiz, at Cadiz, also observed a faint continuous spectrum with two brilliant lines, one yellow ("*probably* an auroral line") and another bright line in the blue, more refrangible than the F line of hydrogen, which he thought was identical with another auroral line, but which he could not identify with certainty. "As," says Professor Michie Smith, "his observations were made with an instrument whose dispersion was much too great to allow of the visibility of the faint luminosity of the zodiacal light," it seems fairly certain that this was not the phenomenon which he had observed at all.

Important observations have been made by Barnard in America, Max Wolf at Heidelberg, Innes at Johannesberg, Ferrari, Maxwell Hall, Backhouse, and others; but to enable us to arrive at a completely satisfactory theory it is evident that we must have more observations made in elevated regions, where the influence of the denser part of the atmosphere and other disturbing causes have less influence, as well as careful measurements made over a term of years. Hitherto we have had to rely mainly upon observations made too near the sea level, under unfavourable conditions, and of a spasmodic nature. Thus it can scarcely be wondered at that there are divers views and conflicting theories as to the true nature of the zodiacal light.

We have already alluded to a yet more mysterious phenomenon, the "Gegenschein" (counterglow), as Brorsen called it when he discovered it some sixty years since. It is a faint luminosity of variable size, in general more or less of the form of an oval patch, but occasionally lens-shaped, lying along the Ecliptic or close to it, its longitude differing from that of the Sun by 180°, whence its name, from its always being in exactly the opposite part of the sky. A very extensive series of observations has been made by Mr. T. W. Backhouse, the well-known astronomer, of West Hendon House, Sunderland, for more than thirty years, and he has published his results in Vol. II of the publications of that observatory. He finds that the ordinary form of the Gegenschein is nearly circular, its diameter about 7°, its centre lying a little to the north of the Ecliptic (0°·75 N. lat.). The Gegenschein precedes the "anti-solar point" in the sky by 0°·6 of longitude at the most.*

Professor Barnard being at Nashville, Tennessee, U.S.A., during the autumn of 1883, whilst searching for comets, one night noticed a feeble luminosity in the sky "near Pegasus." He thought at first that this was due to local illumination, although it was remarkably steady. The following night it was still there, and by observation of its position for several nights running he found that it moved towards the east along the Ecliptic at the rate of a degree per day. He had rediscovered the Gegenschein. Following up his first observations he continued to make numerous examinations of the object, discovering various changes during the course of the year. Fifteen years of observation convinced him that these changes are seasonal, and are repeated annually in the same part of the sky.

About the Gegenschein there is also a variety of theories. Some are inclined to regard it as due to "nebulous" matter rejected from the Earth, thus forming a kind of tail like that of a comet. Very little of such matter would be sufficient to produce its feeble luminosity, which is visible only upon a perfectly dark sky. If it be indeed true that this is the nature of the Gegenschein, then our Earth would be richer in appendages than has been hitherto supposed, possessing, perhaps, a ring or rings like those of Saturn (Jones's theory of the Zodiacal Light) and a tail like that of a comet (the "Gegenschein"). Professor Barnard, however, is inclined to consider the latter as a purely atmospheric phenomenon, notwithstanding his observations and the absence of measurable parallax, which he admits to be a weighty objection to such a view ("Popular Astronomy," No. 64). Professor Searle, whose views have been already referred to, considers that the zodiacal light is due to the reflection of sunlight by millions of minute planetary bodies and particles of "cosmical dust," too small to be seen separately. When they are directly opposite to the Sun in the sky each of these particles shines with a "full" disc like the Moon in the same position, and the vast collection of small objects fully illuminated must increase the general luminosity of this region. In other positions less of their illuminated sides are turned towards us, and therefore they are not so easily visible. Being at the same time nearest to the Earth, and full when in opposition, we have the Gegenschein. Mr. Evershed, of Kodaikanal, in India, explains the Gegenschein as produced by molecules of hydrogen and helium—the

* Celestial longitude is the angular distance, measured along the Ecliptic (*not* along the Equator) from the first point of Aries, in degrees and other units of angular measure. Latitude is the angular distance north or south from the Ecliptic towards its poles.

two lightest known gases—which are driven away from the Earth in the direction opposite to the Sun; but the absence of sensible parallax is a serious objection here also, unless we suppose that these particles are already far beyond the Moon when they are observed. Gyldén, the Swedish mathematical astronomer, has shown that meteors passing near opposition in the neighbourhood of the Earth could follow one or other of several oscillating orbits round the point of opposition before resuming their course around the Earth or Sun. Even if these minute particles were very numerous they would not exercise any appreciable attraction upon one another or much influence on the Earth, but still they would present the appearance of a kind of luminous fog in opposition to the Sun. The centre of this luminous path would be the point in the sky directly opposite the Sun: its outline elliptical and its major axis lying along the Ecliptic. Since the observed deviation from perfect circularity is but small, it must be concluded that the meteors move round the Earth in all directions, without there being many more in the ecliptic plane than in any other.

Mr. Innes has proposed a modification of an earlier theory to account for the Gegenschein. He considers that the Earth is continually bombarded by meteorites which give off "corpuscles." These latter, repelled by the Sun and Earth together, produce a kind of feeble tail, smaller than that of a comet, which is visible on a dark night in the part of the sky just opposite the Sun.

Although, as we have seen from the various accounts and views just given, there is still considerable divergence of opinion as to its true nature, and much still remains for observation, especially in regions more favoured than our own, yet we may conclude that the general character of the zodiacal light is fairly well established. It is almost certainly due to innumerable particles of matter moving round the Sun in elliptic orbits more or less eccentric, their paths lying in or nearly in the plane of the Earth's orbit in a widely extended, but comparatively thin, zone, so that the denser part has the form of a thin, flat sheet, like one of the rings of Saturn, lying partly within and partly without the Earth's orbit. As there is no definite certain limit to the Sun's corona it is possible that the inner part of this sheet is connected with the outer part of the former, and so in a *certain sense* the zodiacal light might be regarded as an extension of the corona (as the late Sir William Huggins was inclined to think); but this seems an extreme view, for we might similarly regard the planets also as so connected. There are not wanting proofs of the existence of a resisting medium whose influence in former ages upon the planetary orbits is so evident, drawing them inwards and making their paths more nearly circular than would otherwise have been the case; and though most of the material composing this medium has probably long since fallen upon the Sun and planets, yet there most likely remains enough of it in the vast regions of space separating the larger bodies of our system from one another to become visible to us by reflection of sunlight, and perhaps also by a feeble intrinsic luminosity, like that of the nebulae, as the zodiacal light.

PHOTOGRAPHIC EFFECT OF CHEMICAL REÄCTIONS.

By J. H. VINCENT, M.A., D.Sc., and J. MARLEY, B.Sc.,

London County Council, Paddington Technical Institute.

Under the above title, in Mr. Ainsworth Mitchell's Chemical Notes in "Knowledge" for March, 1912, an abstract of a paper by Matuschek and Nenning (*Chem. Zeit.*, 1912, XXXVI, 21) is given and commented on. The results were of such a striking nature and offered so interesting a field for further investigation that we tried many experiments on the same lines. Matuschek and Nenning state that many cases of chemical action are accompanied by the emission of light, which acts on a photographic plate after passing through glass. Our results differ altogether from those obtained by these authors. In a paper on this subject recently published in the *Chemical News* (March 20th, 1913), we state that "At first some slight photographic effects were noted which could not be traced to known chemical action of the kind studied by Russell, and which is attributed to hydrogen peroxide. These positive results disappeared as experience was gained in protecting the photographic plate from the action of extraneous light. As some of the experiments have lasted several weeks, the precautions against the accidental entry of light to the plate cannot be too elaborate. In all cases any vapours, and so on, arising from the substances engaging in the chemical action must also be prevented from acting on the plate. Apart from the Russell effect, due to metal screens, and so on, we have been unable to find any evidence of action on the plates.

The reäctions tested were:—

1. Action of sulphuric acid on zinc.
2. Action of hydrochloric acid on sodium-metasilicate.
3. Action of nitric acid on lead.
4. Hardening of plaster of Paris.
5. Electrolysis of water with platinum electrodes.

It is difficult to account for the positive effects observed by Matuschek and Nenning. Properly controlled experiments with vessels containing water heated electrically and with paraffin wax heated electrically, have convinced us that the heat produced by chemical action is not competent to account for the apparent positive results. We find then no evidence of any radiation capable of acting on a photographic plate after passing through glass."

THE MODERN EVOLUTION OF THE STEREOSCOPE.

By A. LOCKETT.

THE valuable aid offered by the stereoscope to the scientific investigator is again attracting notice. In astronomy, photo-surveying, the surgical applications of radiography, photo-micrography, the treatment of certain diseases of the eyes, and in many other new and often unexpected ways, stereoscopy places a fresh power in the hands both of the inquirer and the expert. Even the cinematograph is now made to give moving pictures in natural relief—a development opening out a wide vista of possibilities.

The stereoscope itself has been greatly improved of late years, and a better understanding of the principles on which it depends has led to the production of new models embodying important modifications. This being so, the time seems not inopportune for a brief sketch of the modern evolution of stereoscopic apparatus and some consideration of those factors that have to be studied in order to secure the maximum satisfaction of optical and physiological requirements. Clearly what is needed is the best practical performance, together with the greatest possible convenience and the least complication. These different qualities may not be obtainable together, but that will evidently be the most perfect instrument which enables the truest balance to be struck between them.

Like telescopes, most stereoscopes may be divided into two classes, those, namely, that utilise reflection and those depending upon refraction. A third class which relies upon neither, but includes several instruments or systems of unique character, may, perhaps, most conveniently be considered first.

The earliest stereoscope, Elliott's—designed in 1834, though not constructed till 1839—dispensed with all optical intervention, the two pictures, or rather diagrams—for photography was then non-existent — being viewed direct by the observer. The instrument thus possessed two excellent features; but, unfortunately, it was necessary to cross the axes of the eyes in a somewhat unnatural manner, which called, in many cases, for a little troublesome practice before it could be accomplished. On that account Elliott's stereoscope never came into general use.

A modified form of the Elliott instrument, devised by the writer in 1912, may be of interest. As shown by Figure 346, it consists of a tapering box, A, having two oval openings at the front for the observer's eyes and a rectangular opening at the back. In the diagram the top is removed for clearness of illustration. The box is blackened inside, and to the bottom is attached a narrow piece, B, on which slides a holder similar to those used on the ordinary American stereoscopes. The two photographs must not, as is usual, be transposed in mounting, but should be allowed to remain just as they are printed from the negative, the picture for the right eye being on the left and that for the left eye on the right. To use the apparatus it is held by the handle, D, and the stereograph is moved to and fro, keeping one eye shut, until one picture appears to fill up the aperture in the back. On opening the other eye the combined images will then usually be seen in stereoscopic relief, or, if not, a few further trials will ensure this result. The principle involved is obvious. Owing to the fact that nothing can be seen except through the back opening, placed midway between the two pictures, the right eye can only perceive the left-hand picture, while the left eye beholds only the right-hand one. At the same time they are both mentally referred to an apparently identical position, so that they coalesce and give the effect of natural relief.

For a reason to be explained later, another unique method, the parallax system of F. E. Ives, though of much later date (1903), may not inappropriately be dealt with next. By this highly ingenious method each stereograph carries its own viewing arrangement, so that no separate instrument is required. In making the negative, the two slightly different images are superposed on each other. This may be done in various ways, but that commonly adopted is to use on the camera a single plano-convex lens of about three inches diameter, placing behind this a diaphragm having two small openings two and a half inches apart. A screen ruled with fine vertical lines, about one hundred to the inch, is interposed between the lens and the plate at such a distance from the latter that it splits the two images into a series of adjacent lines, every alternate line consisting of a portion of one image only, while the intermediate lines represent parts of the other image. From the resulting negative, a transparency is made and is bound up with a line screen of the same spacing as that with which the photograph was taken, kept at a similar distance by a cardboard mask. On holding the bound-up transparency at the correct distance from the eyes, usually about twelve inches, perfect and beautiful stereoscopic relief is perceived. Figure 348 illustrates, on a much enlarged scale, the precise action of the ruled viewing screen, A being the transparency, B the screen, and C and D the eyes of the observer. It is obvious that either eye sees only the intermediate portions forming its own proper picture, while the two pictures are at the same time superposed and united. For the best result, the opaque lines of the taking screen should be twice the width of the transparent interspaces, as this prevents the parallax lines from running into each other when developed.

If we consider any two adjacent spaces of the composite transparency in relation to a single opening in the line screen, as shown by Figure 349, the remarkable similarity in principle to Elliott's early apparatus will be evident. The Ives stereograph consists, in fact, of hundreds of tiny Elliott stereoscopes, all inspected simultaneously. While the results obtained are unexceptionable, there are two obstacles to the general adoption of this system. One is the necessity of precise adjustment of the distance of the ruled screen from the plate in relation to the camera extension and the separation of the two view points, besides the corresponding care required in binding up the positive, the other being the fact that only transparencies can be made.

Yet a third method of stereoscopy, utilising neither reflection nor refraction, is the anaglyph system of Louis Ducos Du Hauron (1890) in which the two pictures forming the stereograph are printed, one over the other, in red and blue ink respectively. The resulting jumbled combination is viewed through spectacles containing a red and a blue glass, or similarly tinted pieces of gelatine. Through the red glass, the red image is invisible and the green one appears black, while through the green glass the reverse is the case. As each eye, therefore, sees only its particular picture, and the two are superposed, stereoscopic vision results. Prints of any size may be produced and viewed in this way, and the stereographs evidently occupy only half the space that would be necessary if the two pictures were placed side by side in the usual manner. The drawbacks are a considerable loss of light from the presence of the colour filters, and the fact that the prints cannot be inspected without the viewing arrangement, as is often desired. Though Du Hauron was undoubtedly the first to employ the foregoing method with printed stereographs, it should be stated that the principle was foreshadowed by Dove in 1843, and by Rollmann in 1853, while D'Almeida, in 1857, used a very similar system, but with red and green glasses for stereoscopic projection by the lantern.

Turning now to refracting stereoscopes, that of Sir David Brewster, familiar as the old box-form pattern of early Victorian days, comes first in order. Initially studied by its inventor in 1844, and communicated to the British Association in 1849, this instrument was not placed on the market till 1851, when Duboscq, of Paris, undertook its manufacture. The principle of Brewster's stereoscope is probably so well known that explanation is almost superfluous. A few words, however, may be desirable. The lenses or prisms A and B (Figure 350), cut from the two halves of a bi-convex lens and turned with their thin edges inwards, so refract the rays from the two pictures C and D that the eyes of the observer see them converged together, both images being superposed at E. Since, nevertheless, each eye sees only its own proper half of the stereograph, the result is stereoscopic relief. A more convenient form of Brewster's instrument, designed by Oliver Wendell Holmes in 1861, with the further improvement of a sliding view-holder, added by J. L. Bates in 1864, is now in general use.

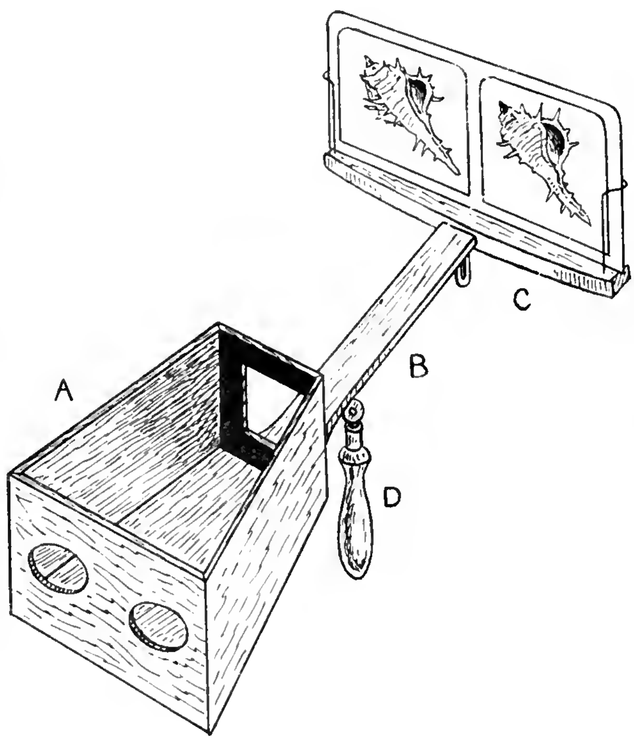


FIGURE 346.

The refracting stereoscope has the advantages that no light is lost and that the image is magnified. Counterbalancing these merits are the facts that in magnifying the prints the grain of the paper is also enlarged, detracting from the fineness of the image; that only pictures of a small and rather awkward size can be employed; that the instrument has to be focused to suit differences of vision; and, finally, that a slight degree of distortion, if not of other optical aberrations, is present. It may also be added that some observers have difficulty in combining the two images with this type of apparatus.

Variations of Brewster's instrument have been numerous. Whole lenses have, for instance, been used, as in the telescopic stereoscope of De la Blanchère, which resembled a pair of opera glasses with the two tubes adjustable as to convergence. It is not, by the way, generally known that if we look through an ordinary opera-glass pointed wrong way round at a stereoscopic slide, a single small image in relief will be seen. Another interesting stereoscope, devised by Steinhauser, had lenses contrary to those of Brewster's apparatus, causing the optic axes to cross, so that untransposed stereographs could be utilised. The chief modern improvements on Brewster's instrument, apart from the American hood and sliding holder, have been the employment of achromatic instead of single lenses, and provision

From a stereograph *by M. L. Chapuis.*

FIGURE 347.

The Bones of the Head. From a century-old anatomical preparation in Dijon Museum. To be inspected with an ordinary mirror, as described on page 332, or with the Pigeon stereoscope.

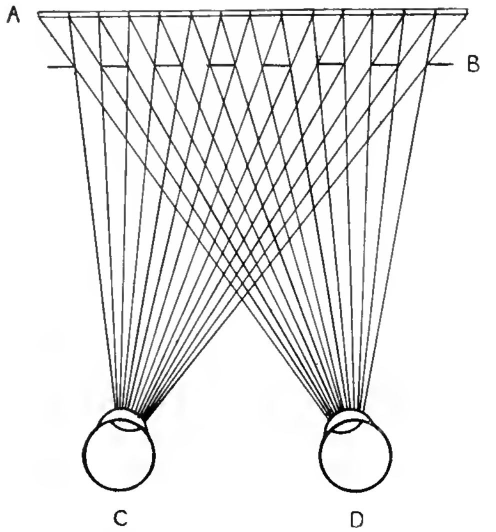


FIGURE 348.
The Principle of Ives's Parallax Stereograph.

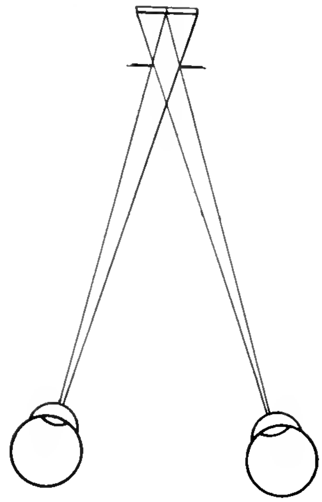


FIGURE 349.
A Diagram illustrating Analogy between Ives's system and Elliott's Instrument.

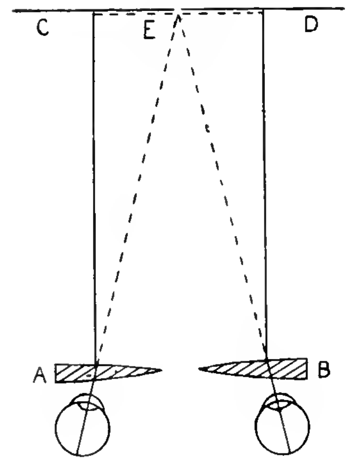


FIGURE 350.
The Principle of Brewster's Refracting Stereoscope.

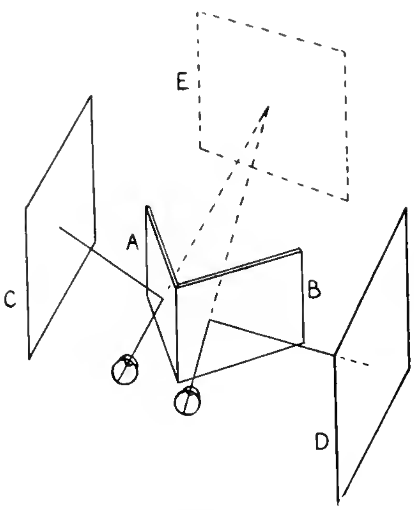


FIGURE 351.
The Principle of Wheatstone's Reflecting Stereoscope.

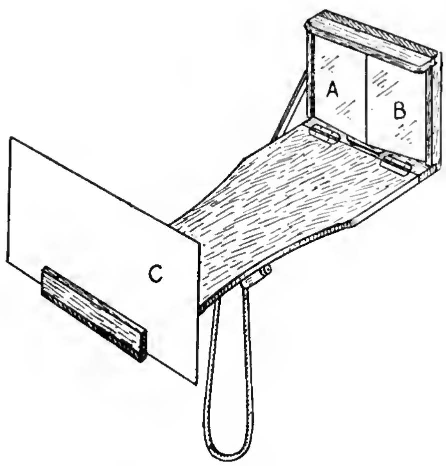


FIGURE 352.
The "Reflectascope."

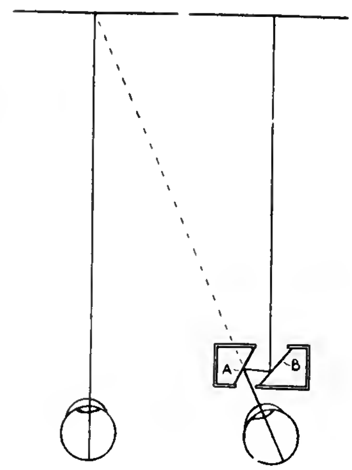


FIGURE 353.
Theodore Brown's pocket Reflecting Stereoscope.

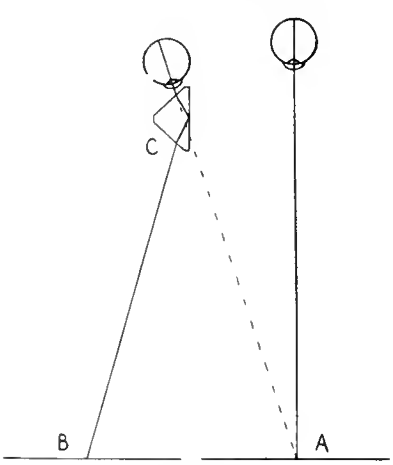


FIGURE 354.
The Principle of Pigeon's Prism Stereoscope.

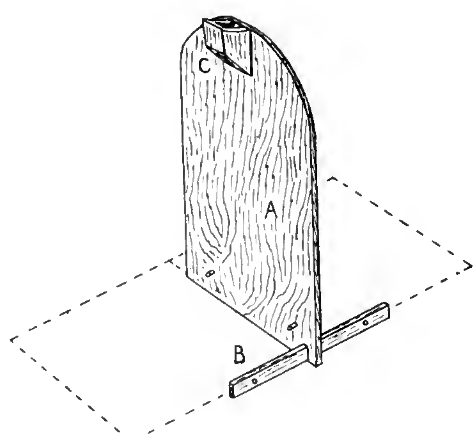


FIGURE 355.
The constructive details of Pigeon's Prism Stereoscope.

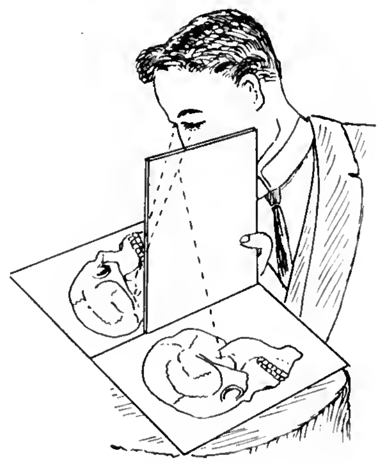


FIGURE 356.
The method of inspecting Pigeon Stereographs with an ordinary Plane Mirror.

for altering the separation between them to suit the distance between the eyes of any observer. Such refinements, however, are still only met with in the higher-priced lenticular stereoscopes.

In the opinion of many, the reflecting principle offers the fewest disadvantages, now that its earlier constructional drawbacks have been overcome. It is not without interest to trace the evolution of the reflecting stereoscope, from the cumbrousness and complexity which at first distinguished it to its latest developments and refinements. The earliest stereoscopic apparatus making use of reflection was invented by Sir Charles Wheatstone in 1838—next in order, therefore, to Elliott's apparatus. As shown by Figure 351, it had two plane mirrors, A and B, inclined together at an angle of 90°, silvered side outward, the two pictures C and D composing the stereograph being placed one at each side, and the observer viewing their images in the mirrors. As both images were reflected into an identical position at E, and thereby made to coalesce, while, at the same time, each eye saw only its own particular picture, stereoscopic vision resulted. The chief drawbacks of this arrangement were that the two pictures had to be inserted separately; that, if any adjustment were needed, both pictures had to be advanced towards or withdrawn from the mirrors simultaneously, which involved the use of a clumsy double-threaded screw; that the reflected image was necessarily reversed as regards right and left; and that the efficient lighting of both pictures, from two contrary directions, presented serious difficulties. This instrument was therefore soon superseded. It may be remarked that, besides claiming credit for the inception of the first reflecting stereoscope, strong ground exists for believing that Wheatstone was aware of the principle of—if he had not actually constructed—the lenticular form prior even to Brewster.

There have been many variants on Wheatstone's instrument, since it is obvious that the two prints and mirrors may be arranged in numerous different ways. One of these, known as the Reflectascope, is illustrated by Figure 352. As will be noticed, two plane mirrors are placed at A and B, joining at a very obtuse angle. The stereoscopic slide, the back only of which is seen in the figure, is inserted in a holder at C, and the observer, looking over the slide, sees in the mirrors a single picture in relief. The chief drawback here is that the join between the mirrors shows, though almost imperceptibly, as a thin line across the centre of the combined image. If the two mirrors are inclined inwards away from the slide, instead of outwards, the arrangement otherwise remaining the same, non-transposed stereoscopic slides may be used. In both cases the image is reversed as regards right and left.

It is an evident advantage that optical aids should be dispensed with so far as possible, in order that the eyes view the stereograph direct. Except in Elliott's instrument, the drawbacks of which have been pointed out, this desideratum is incapable of practical fulfilment. There are, however, several systems in which one eye at least regards its own picture direct. Various suggestions to that effect were made, at different times, by H. W. Dove, Brewster, and Rollmann; but, as a modern instance of efficient performance combined with convenience, Theodore Brown's tiny pocket stereoscope (1895), doubtless the smallest made, may be mentioned. In this, as shown by Figure 353, two small mirrors, A and B, are enclosed in a case, nearly but not quite parallel with each other. Looking through an aperture in the case, the right eye views its proper picture by double reflection, apparently superposed on the left-hand picture, the latter being seen direct by the left eye. The same idea is obviously applicable to a double reflection prism having sides of suitable angle.

Mirrors, to give optically perfect results, should be surface-silvered, but are then unfortunately liable to tarnish, and are very susceptible to injury by moisture, scratches, or abrasion. Reflecting prisms serve all the purposes of mirrors and are free from these disadvantages, besides being more easily cleaned. Many prismatic stereoscopes have been constructed, among which may be recorded that of Girard-Teulon (1861), in which four total reflection prisms were used, and several forms of apparatus invented by Sir Howard Grubb (1878), in which the two stereographic prints were mounted one above the other, instead of side by side. In another instrument by Grubb the two pictures of an ordinary stereoscopic transparency were thrown in superposition on to a concave mirror by means of a combination of prisms and lenses, the observer, at a suitable distance, seeing an aerial image in relief. It may be mentioned that Duboscq and also Jequezel, both in 1857, made stereoscopes having prisms as well as lenses, so that both reflection and refraction were employed. These instruments were, however, practically modifications of Brewster's apparatus.

Whether mirrors or prisms are used, it is fairly evident that a double reflection must involve more loss of light, and must require a more exact adjustment than a single one. There is therefore a special advantage in the prism stereoscope invented by Professor Léon Pigeon, of Dijon (1910), who is also known as the contriver of the compact and useful book-form mirror stereoscope named the "Dixio" (1905). In Professor Pigeon's prism stereoscope (see Figure 354) the right-hand picture, A, is viewed direct, while the left-hand one, B, is seen by a single reflection in the prism, C, apparently superposed on A. It is necessary that the left-hand print should be laterally reversed, a condition easily fulfilled, among other obvious ways, by making the prints in carbon, one by single and the other by double transfer; or, if film negatives are used, by printing the left-hand picture from the back. As shown by Figure 355, the apparatus consists of an upright panel, A, supported by a narrow cross-piece, B, the prism being mounted in a hood, C, which screens stray light from the left eye. The prints, which may be of quite large size if desired, are laid flat on a table and the instrument is placed over the central line between the two pictures, as indicated. Large prints may conveniently be hinged together by a tape glued across the back at the junction, in order that they may be kept unmixed and may fold up when not in use. For prints over 8-in.×6-in. the stereoscope should be raised in the hand, so that a longer viewing distance is obtained. Besides its ordinary purpose the model illustrated is very suitable for viewing stereoscopic illustrations in books. Another pattern, it may be stated, makes provision for the inspection of transparencies and autochromes. On the whole, the Pigeon stereoscope—the last word, so far, in reflecting instruments—certainly seems to offer a maximum of efficiency, combined with extreme simplicity. The image is exceedingly clear and brilliant, while with a front lighting absolute uniformity of illumination is easily secured. Those who would like to have ocular demonstration of the principle involved may readily do so by using an ordinary plane mirror, about eight inches or ten inches high, supporting it in a vertical position on the line between the two prints, the silvered surface being to the left, as shown by Figure 347. For the purpose of experiment an admirable anatomical study from an exhibit in Dijon Museum, taken by M. L. Chapuis in collaboration with Professor Pigeon, and reproduced by kind permission of the latter, will be found on page 329. The effect with an ordinary mirror will not, of course, be so good as with a surface-silvered one, or with the prism, but will still enable an excellent idea to be obtained of the results possible.

It may be mentioned that an ophthalmological stereoscope on the reflecting principle has been invented by Professor Pigeon, for the diagnosis and treatment of strabismus, or squinting. Besides its primary use, it may be employed for the direct study of the problems of binocular vision; for investigations concerning the function of the motor muscles of the eye and paralysis of these muscles; for the physiological fusion of colour; for the medico-legal examination of alterations in sight, real or simulated; and for many other purposes.

In conclusion, some remarks concerning the relative merits of small and of large stereographs will not be irrelevant. It has been stated by several writers that a small print inspected at a short focal distance gives really the same stereoscopic effect as a larger print viewed from a greater distance. To a certain extent this is true; but there is a grave fallacy in the reasoning, since the much greater amount of detail secured in the larger picture is overlooked. To make the matter plainer, compare the case of an enlargement made from a small negative with that of a large direct photograph the same size as the enlargement. There can be no question as to which of the two will give the more detail. The large direct print will show many things that are not visible in the enlargement, it being, therefore, clear that they are absent in the small picture. Large prints, moreover, are seen with less fatigue, make a more definite impression, need no objectionable magnification, may be made with lenses of a more acceptable focal length, and are more useful for purposes of investigation or for the deduction of measurements.

*BEDROCK.**

In the current number of *Bedrock* the "Hermit of Prague" makes fun of the Headmaster of Eton for taking seriously Miss Curtis's New Mysticism, the nature of which she explains in her book "Meditation and Health." This the "Hermit of Prague" describes as one of the numerous wholly unscientific works on "mind-healing" that for several decades have gained a curious vogue in the United States.

Under the title of "Mendelism, Mutation and Mimicry," Professor Punnett very clearly sets forth what in his mind are the leading difficulties against accepting the theory of mimicry as explaining the likeness between various butterflies. He characterises as an enormous assumption Professor Poulton's belief that a very slight accidental variation on the part of a species in the direction of a pattern which is utterly different, will be detected by its enemies and cause them to let it alone. He asks how an enemy endowed with such remarkable discrimination could fail to distinguish between mimic and model even in cases of the closest resemblance yet recorded.

The evidence in favour of the existence of pre-palaeolithic man is brought forward by Mr. J. Reid Moir, and he sums up his arguments by saying that there is one thing, and one thing only, left for the opponents of the pre-palaeolithic implements to do if they wish their views to be taken seriously, and that is to subject flints to some unguided, natural force, and produce forms indistinguishable from those which are in dispute.

Mr. Hugh S. Elliot, commenting upon Dr. McDougall's article in the previous number of *Bedrock*, says that while historically and scientifically Dr. McDougall is justified in applying the name "Materialism," to his (Mr. Elliot's) published views, the word carries with it in the public mind many connotations which are very far from the opinions of those who profess it. The name "Scientific Materialism" is suggested instead and used as a title for the article, which is an answer to Dr. McDougall.

Among the contents of the same number is a contribution by "A Business Man," which he calls "The Truth about Telepathy." The writer grumbles because Sir Oliver Lodge attributes motives to him, but we cannot say that we admire the methods of "A Business Man."

* For July, 1913.

CATALEPSY IN PHASMIDAE.

By PETER SCHMIDT.

Privat Dozent of the Imperial University of St. Petersburg.

In the following article I wish to give the results of some observations and experiments upon cataleptical phenomena in connection with an Indian insect—*Carausius morosus* Br. v. W.—an Orthopteron of the family of *Phasmidae.* The representatives of this family are all tropical or subtropical insects of green, grey or brown colour and protectively resemble the stems of the plants on which they feed. The habitat of *Carausius morosus*, which will breed during any month of the year in my laboratory, so far as I am aware, is North India and Afghanistan; but, five or six years ago it was imported into Germany *via* Hamburg and thence came to St. Petersburg, where it breeds now in almost all zoölogical laboratories. The insects are so interesting in many respects and their breeding is so easy that it is really strange that these Indian emigrants have up to the present been so little known in other countries. Their biology was studied in detail by an eminent German entomologist, Otto Meissner,* who published a valuable paper, but strangely did not notice the most interesting feature about them, viz., their catalepsy.

These green stem-like creatures with red markings on the femora of the forelegs show generally very little movement. They may sit motionless during the whole day on the stems of plants or on the sides of a glass jar (see Figure 357), and only occasionally do they begin to move, and then they creep in a very lazy way. They feed generally at night, and it is very seldom that one can see a *Carausius* eating leaves by day.

The insects may be thought at first sight to be sleeping or reposing, but closer observation and some very simple experiments will produce the conviction that we have to do here with a catalepsy exactly like that artificially produced in higher animals. Indeed, it has long been known that many vertebrates can be hypnotised and made motionless by very simple methods. If we lay a rabbit on his back on the table and fix his head and his feet for a few seconds, we shall make him cataleptic—he will lie motionless for some minutes, and his muscles will be strained as in a hypnotised human subject. The same thing can be done with a crayfish—one can stand him vertically on his head and the first pair of legs, and he will keep completely motionless for many hours as if bewitched.

Now if we look more carefully at a *Carausius* in his quiet state we shall see that his feet and whole body are rigid, and his muscles are strained as in catalepsy. Indeed, if we gently take hold of a leg with a pair of forceps, bend it, and put it in some pose or other, we see that it keeps this pose for a very long time, even if it is unnatural and uncomfortable. In the same way we can raise the head and the prothorax of the animal and move asunder the first pair of legs, so that *Carausius* takes approximately the position of a *Mantis* (see Figure 359). In such an artificial pose *Carausius* will stay for many hours.

When I had detected this interesting muscular state in the quiet *Carausius* I tried some other experiments, and after a number of trials it occurred to me, for instance, to stand the insect on its head (see Figure 358) and to give him a still more amusing pose which I have called the "wrestling bridge" (see Figure 360). In one of the experiments a cataleptical *Carausius* remained on its head for four and a half hours! And he showed not the slightest signs of fatigue.

All these experiments sufficiently demonstrate that the muscles of *Carausius* are really in a state which is named by physiologists "*flexibilitas cerea*" (*i.e.*, wax flexibility). They are strained, but not extremely as in the state of tetanus: they can be stretched more and remain in a given position. Expressly the same state of muscles is observed in the cases of catalepsy or "hypnosis" in higher animals and in man.

How strong is this rigidity of muscles is seen from the experiment shown in Figure 361. Here a *Carausius* is posed between two books with the tips of the forelegs on the one and with the end of the abdomen on the other. A very considerable weight for it, in the shape of some paper strips, has been placed on its abdomen, so that it is bent like a bow, and, notwithstanding, it will remain in the deepest catalepsy for one or more hours in this strange pose!

It is known that catalepsy has two distinguishing features: (1) a cataleptical subject does not feel pain: one may cut and sting him, and he remains in the same state of immobility; (2) the cataleptical tension of muscles does not cause fatigue. And, in fact, a cataleptical *Carausius* is completely feelingless: with sharp scissors one can cut off its antennae and feet, and, one after the other, all the segments of the abdomen; its green blood flows from the wounds, but it stays in the same pose completely motionless.

In order to awake the insect from its hypnotic sleep, a prolonged excitement of the nervous system is needed. One can excite it mechanically, for instance, by tweaking the end of its abdomen with forceps, or by giving it electrical shocks with an induction coil.

* *Zeitsch. f. wissensch. Insektenbiologie*, Bd. V, 1909, Heft 1–3.

But the electrical shocks must be very strong: weak ones do not awake the insect.

The strangest circumstance in the catalepsy of *Carausius* is that this state arises from unknown *inner* conditions. If the insect is in its active state it is impossible to hypnotise it artificially, like a cray-fish. One can lay the creature down, fix it in a given position, stroke it gently, but nothing happens: it makes responsive movements, but does not become cataleptic. Only of its own accord and without exterior excitement does *Carausius* become so. Therefore, I have called this phenomenon "autocatalepsy."

From a biological standpoint the autocatalepsy is nothing more than an accommodation to a highly developed protective resemblance. A cataleptical *Carausius* is not only motionless but remains in the same position in which the external factors—for instance a breath of wind or a fallen twig or leaf—have placed it. Its likeness to the inanimate objects is increased and the insect is given an extra chance of surviving in the struggle for existence.

My laboratory experiments have detected also some interesting points in the physiology of the catalepsy of *Carausius* (which I have described elsewhere *), but biological observations on this feature under natural conditions are wanting. Perhaps some readers of "KNOWLEDGE" living in tropical countries will give some attention to this new question and make some observations on other Phasmidae. It is possible that the catalepsy is a feature of other representatives of this interesting family.

* *Biologisches Centralblatt*, 1913, *April*.

CORRESPONDENCE.

THE NUMBER OF DOUBLE STARS.

To the Editors of "KNOWLEDGE."

SIRS,—Mr. Bellamy is correct in stating that the number of double stars in Burnham's Catalogue is 13,665. I do not know how the number I gave came to be printed.

I hope you will let me remind him I found no fault with Mr. Lewis's Catalogue. I did not depreciate his work. I have no doubt Burnham would agree *his* work was incomplete, but Mr. Lewis's is much more so in point of numbers, and especially as it is only a reference catalogue for Struvian stars, and, of course, does not include the very numerous discoveries of Burnham, and is just as defective as regards spectroscopic binaries as Burnham's.

For the rest, Mr. Bellamy merely expresses his personal preference for Lewis's, and leaves my criticisms entirely untouched.

EDWIN HOLMES.

HORNSEY RISE, N.

SIRS,—By your courtesy I offer the following conclusions upon Mr. Holmes' reply.

1. Mr. Holmes' reply merely leaves the point unanswered—that is, the "Standard Authority" (or Catalogue)—which I take to be a work wherein the particular item required may almost certainly be found. On page 293 I stated enough to show that the Standard Catalogue of Double Stars (including Spectroscopic Binaries) is still, and may long be, a *desideratum*.

2. I demur to Mr. Holmes' statement that he found no fault with Mr. Lewis' Catalogue, for as the latter is a definite and complete piece of work, it would be nearly impossible to do so; but he most distinctly does this, by depreciation, on page 239.

3. The question of my personal opinion does not enter, as I dealt with facts; so the matter may end and Mr. Holmes may enjoy in print his original criticism on this point, which was of an inaccurate, spiteful, and unnecessary character. I have already proved the first; the second and third were too obvious. Personally, I may add that I have used Mr. Burnham's Catalogue some hundreds of hours more than that of Mr. Lewis, but not as a "Standard" Catalogue of Double Stars.

F. A. BELLAMY.

OXFORD.

STELLAR DISTANCE UNITS.

To the Editors of "KNOWLEDGE."

SIRS,—A. J. H. seems to have overlooked the fact that Kepler and Newton have each places assigned to them in the Moon, and when we think of the millions of worlds waiting to be named or numbered, there is no reason to be afraid that there will not be worlds to be christened, if necessary, after the earth's great men and women. A new name for "Light Year" was not asked for in June "KNOWLEDGE" as this is easy to understand, and simple enough. In these days of greater and more and more wonderful scientific researches and discoveries, when men are trying to measure "White Nebulae" and their distances, and so on, "Andromedes," "Sirio Meters," "Star Ratios," "Units" have been mentioned as measures of astronomical distances, so that there are now several astronomical measures of length; and when we try to think of the unmeasurable, unknown, infinitude of space, with all it contains, we may safely say, "More to follow."

A short easy word is needed to represent the nearest distance of the Earth from the Moon. and the second of arc now being divided into tenths, hundredths and thousandths, it is time some simple short words or signs were used for them.

J. W. SCHOLES.

"GRIMSCAR,"
HUDDERSFIELD.

SELBORNE EXTENSION LECTURES.

To the Editors of "KNOWLEDGE."

SIRS,—It is one of the difficulties of the Secretaries of local Scientific Societies and of Institutes to find, year after year, new subjects for discussion and lecturers whom their members have not previously heard. May I in this connection, therefore, call the attention of your readers to a list of lectures which I have compiled, and which is being printed in *The Selborne Magazine* for September. The various items have in most cases been delivered before the Selborne Society, and, in my capacity as Extension Lecture Secretary, I should be very glad indeed to give any help that I could to local Scientific Societies who are wanting good lectures of general interest, at fees which they can afford to pay. I may add that in certain cases the lecturers only wish to cover their expenses. The subjects, as befits the Society which perpetuates the memory of the author of "The Natural History and Antiquities of Selborne," deal with plants and animals, with the forces of Nature, and with Archaeology. Many of the lecturers have series of slides illustrating other addresses than those of which titles are given.

In places where there are no local bodies the Selborne Society, under special circumstances, would arrange one or more lectures, which would come under the category of Selborne Local Lectures.

PERCIVAL J. ASHTON.

42, BLOOMSBURY SQUARE,
LONDON, W.C.

CATALEPSY IN PHASMIDAE.

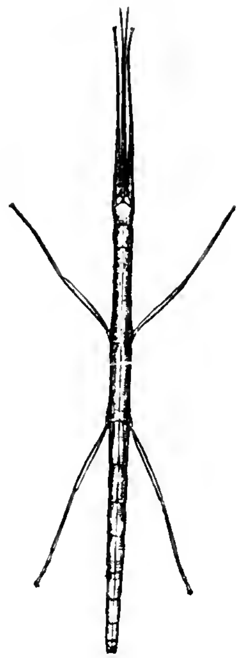


FIGURE 357.
Carausius as its sits on a branch.

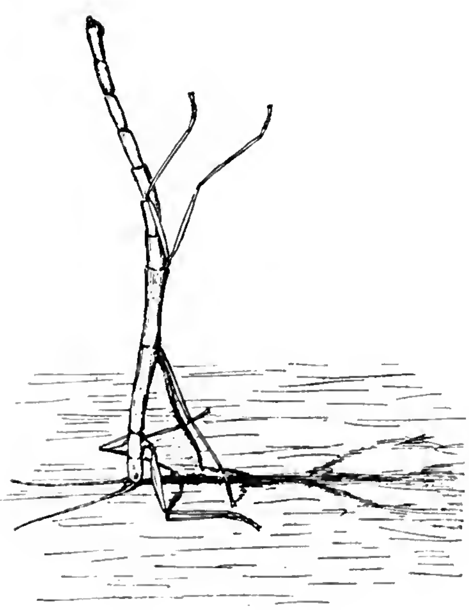


FIGURE 358.
Carausius morosus Br. v. W., standing on its head.

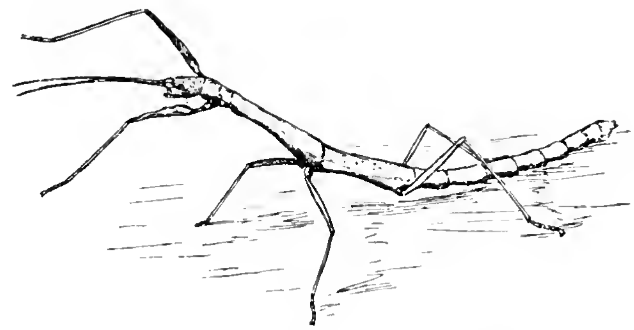


FIGURE 359. Mantis-like pose of *Carausius*.

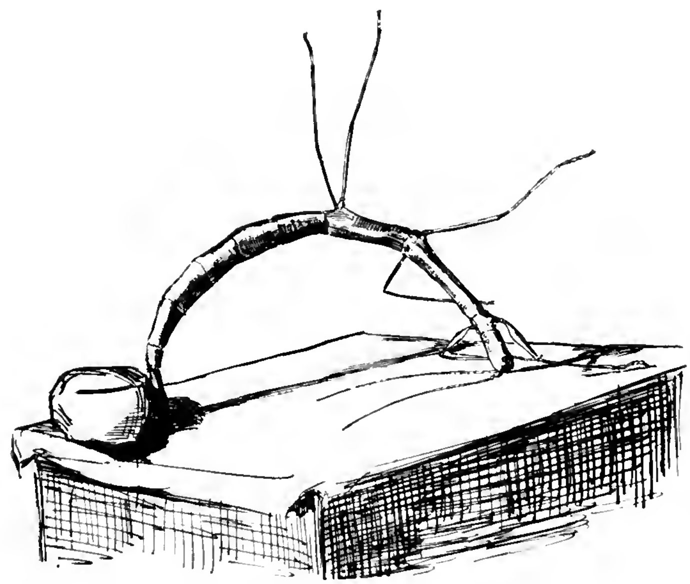


FIGURE 360. The "Wrestling Bridge."

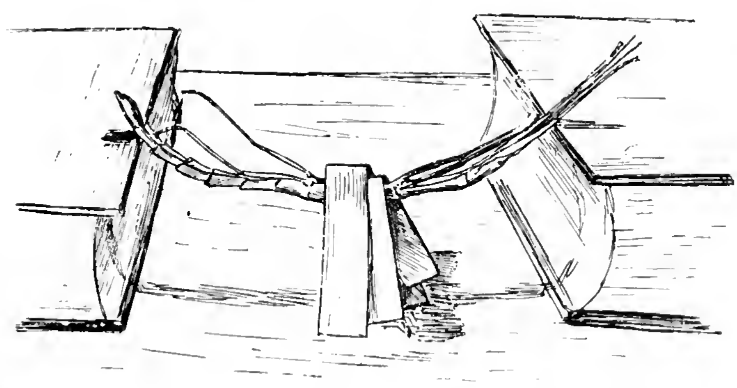


FIGURE 361. Hypnotic experiment with *Carausius*.

FIGURE 362. *Carausius* reclining.

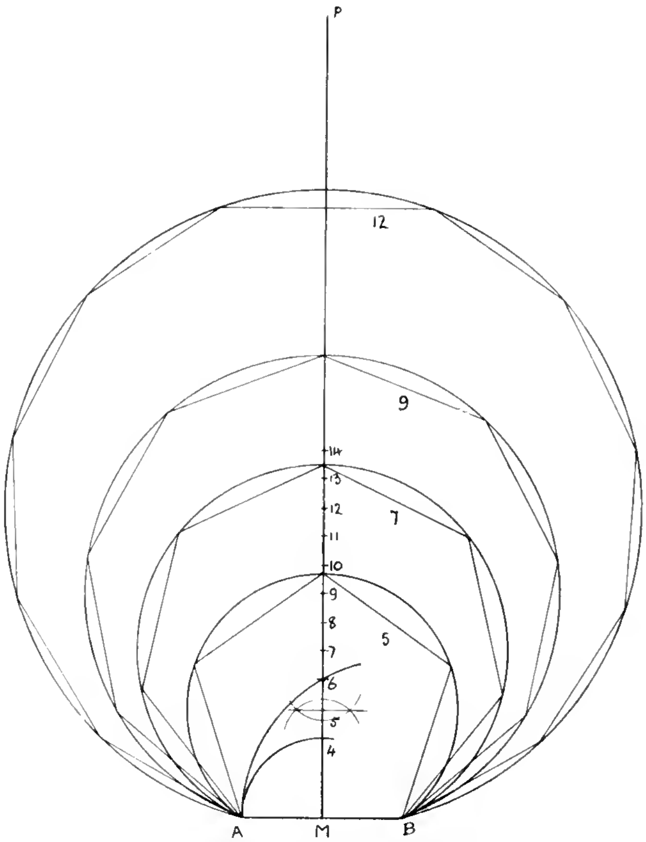


FIGURE 363.
First Method.

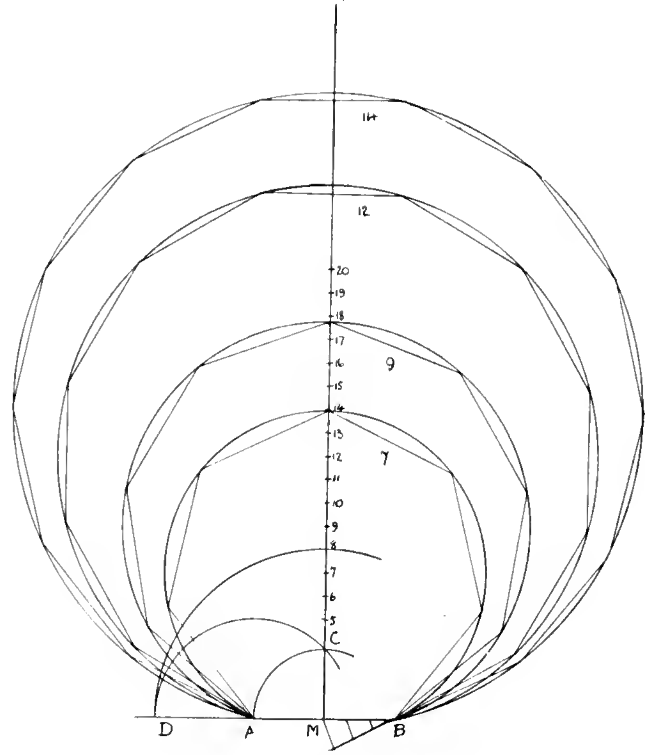


FIGURE 365.
Third Method.

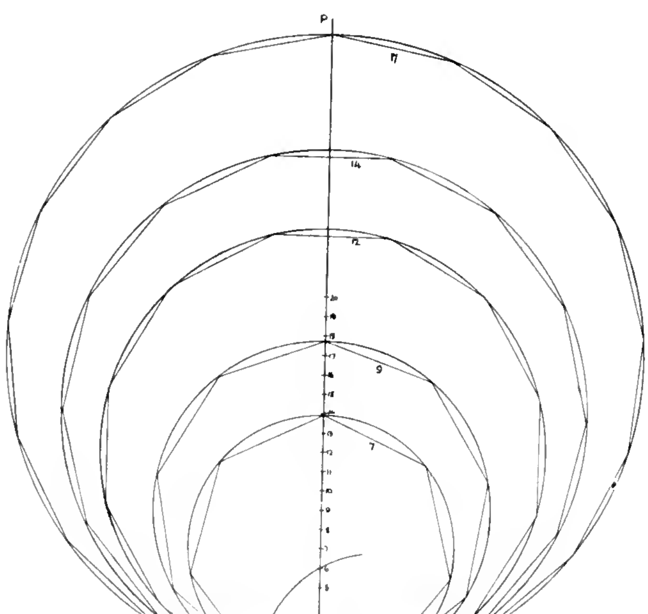


FIGURE 364.
Second Method.

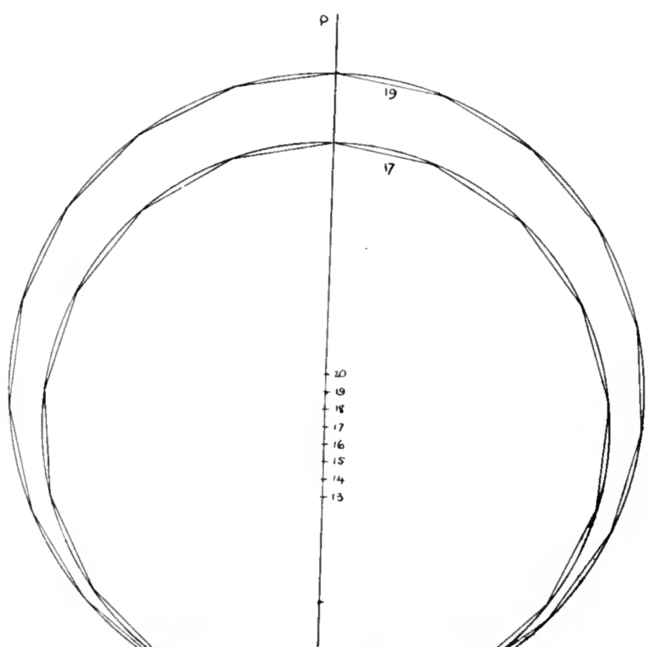


FIGURE 366.
Fourth Method.

Methods of Constructing Regular Polygons.

ON THE CONSTRUCTION OF REGULAR POLYGONS.

By H. STANLEY REDGROVE, B.Sc. (Lond.), F.C.S., and W. H. COLES.

There are simple well-known methods for constructing regular figures of 3, 4, 5, 6, and 8 sides of given length,* but the construction of regular polygons with 7 or more than 8 sides, the length of the sides being given, is a more difficult matter. There is a well-known method (which need not be described here) involving the division of a semicircle into as many equal parts as the polygon required is to have sides, which can be used with accuracy when the number of sides is either 2^n or 3×2^n (*i.e.*, 4, 8, 16, 32, and so on, or 6, 12, 24, 48, and so on), since the bisection of any arc and the trisection of a semicircle are both easily effected. When the number of sides, however, is any other number (*e.g.*, 7, 9, 10, 11, and so on), this method suffers under the disadvantage that the semicircle has to be divided by trial.

Another method is to calculate the vertical angle (θ) of the polygon by means of the formula

$$\theta = 180° - \frac{360°}{x},$$

where x is the number of sides; or the central angle (ϕ) may be calculated from the formula

$$\phi = \frac{360°}{x};$$

either of these angles is then set out. In many cases, however, these angles are not measured by an exact number of degrees, and cannot, therefore, be accurately set out with an ordinary protractor. Moreover, when x is large, an increase of 1 or more to x produces very little alteration in the size of either θ or ϕ, so that the angles would have to be measured with extreme accuracy for the method to be any good. (See Table 58.)

The following method, though not new, does not appear to be very generally known. Let A B (see Figure 363) be one side of the required polygon. Bisect A B in M, and at M draw M P perpendicular to A B and of indefinite length. With centre M and radius M A (or M B) describe an arc cutting M P in 4. This point obviously gives the centre of the circle circumscribing the square drawn on A B as base. With centre B and radius B A describe an arc cutting M P in 6. This point obviously gives the centre of the circle circumscribing the regular hexagon drawn on A B as base. Bisect 46 in 5 and, commencing from 6, mark off divisions 7, 8, 9, 10, and so on, along 6 P, each equal to 45 or 56. Then each of these points gives, approximately, the centre of the circle circumscribing the regular polygon, drawn on A B as base, containing the same number of sides as the number used to designate the point. It is a simple matter, then, to draw the circle circumscribing the polygon desired, and to step distances equal to A B around its circumference. In Figure 363 are shown polygons containing 5, 7, 9, and 12 sides thus drawn. The first three are fairly accurate. The dodecagon, however, is not satisfactory, and the method is increasingly inaccurate as the number of sides is increased; for example, if one attempts to draw a fifteen-sided figure by this method, the result is a polygon with sixteen sides.

In the present paper we propose giving the results of an investigation of this method, which has made it possible to devise three similar, but far more accurate, methods, whereby regular polygons containing as many as twenty sides can be satisfactorily and easily drawn. In the above method it is assumed that the distances of the centres of the circumscribing circles from the mid-point of the given side are in arithmetical progression. Now, the length of this distance, in any case, measured in terms of half the side as unit, is obviously given by the tangent of half the vertical angle of the polygon, *i.e.*, $\tan\left(90° - \frac{180°}{x}\right)$, where x is the number of sides; thus in Figure 363, $\frac{6\,M}{A\,M} = \tan\left(90° - \frac{180°}{6}\right) = \tan 60° = 1{\cdot}732$ (approx.). This method assumes, therefore, that $\tan\left(90° - \frac{180°}{x}\right)$ is a linear function of x. This is not actually the case, since

$$\frac{d \tan\left(90° - \frac{180°}{x}\right)}{dx} = \frac{\pi \sec^2\left(90° - \frac{180°}{x}\right)}{x^2},$$

i.e., a quantity whose value is not constant. This can also be seen from the figures given in Table 59. In column 2 are given the values of $\tan\left(90° - \frac{180°}{x}\right)$ between $x = 1$† and $x = 20$. In column 3 are

* There are also special methods for a few other polygons, but they are all tedious.

† No figures, of course, can be drawn corresponding to $x = 1$ and $x = 2$, but the values corresponding thereto are given throughout the table for the sake of completeness.

given the differences between consecutive values of $\tan\left(90^\circ - \frac{180^\circ}{x}\right)$. If $\tan\left(90^\circ - \frac{180^\circ}{x}\right)$ were a linear function of x, these would all be the same. This is evidently not the case, the difference tending to become less as x is increased. On the other hand, the differences do not vary very much after $x = 4$ is passed, and if the function $y = \tan\left(90^\circ - \frac{180^\circ}{x}\right)$ is graphed, the curve obtained does not differ very greatly from a straight line after the point corre-

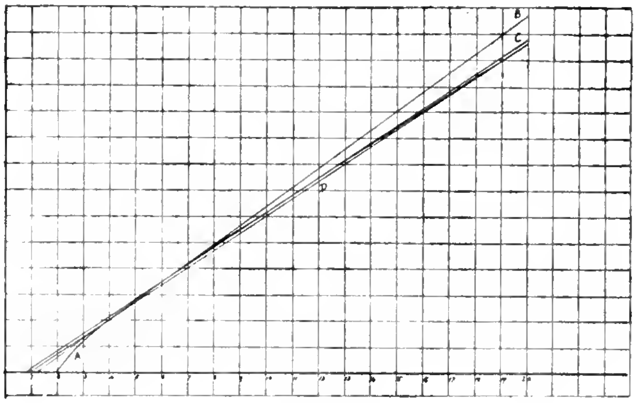


FIGURE 367.

sponding to $x = 4$ is passed. (See Graph A, Figure 367.) The above method of drawing polygons gives the centres of the square and hexagon accurately; that is to say, this method gives $y = 1 \cdot 000$ when $x = 4$, and $y = 1 \cdot 732$ when $x = 6$. Since an equal increase in x (the number of sides to the polygon) produces an equal increase in y (the distance of the centre from the mid-point of the side) according to this method, it follows that $y = mx + c$, where m and c are constant quantities. Consequently

$$4\,m + c = 1 \cdot 000, \text{ and } 6\,m + c = 1 \cdot 732,$$
$$\text{whence } c = -\cdot 464, \text{ and } m = \cdot 366.$$

Therefore $y = \cdot 366x - \cdot 464$. The values of y thus calculated are given in Column 4 of Table 59, and the differences between them and the true values of y (as given by $\tan\left(90^\circ - \frac{180^\circ}{x}\right)$), correct to the third decimal place, are shown in Column 5. As is evident, these differences are comparatively small between $x = 3$ and $x = 9$. After this they become increasingly large, as can also be seen by comparing the graphs of $y = \tan\left(90^\circ - \frac{180^\circ}{x}\right)$ and $y = \cdot 366\,x - \cdot 464$ (Graph B in Figure 367), so that this method, whilst fairly accurate for polygons with less than 10 sides, is not satisfactory when the number of sides exceeds 9.

The distance between consecutive centres is assumed in the above method to be $\cdot 366 \times$ half length of side. Referring to Column 3 of Table 2, however, it is obvious that this difference, between $x=6$ and $x=20$, is more nearly equal to $\frac{1}{3} \times$ half length of side. On this fact we base the three following methods, each of which has special advantages. We shall refer to the method discussed above as Method 1.

Method 2. Let A B (see Figure 364) be one side of the required polygon. Bisect A B in M, and at M draw M P perpendicular to A B, and of indefinite length. With centre B and radius B A describe an arc cutting M P in 6. This point obviously gives the centre of the circle circumscribing the regular hexagon drawn on A B as base (*i.e.*, $y = 1 \cdot 732$ when $x = 6$). Trisect M B (or A M) and, commencing from 6, mark off divisions 7, 8, 9, 10, and so on, along 6 P, each equal to $\frac{1}{3}$ M B. These points give the centres of the circumscribing circles. The polygons are then drawn as in Method 1. In Figure 366 are shown polygons containing 7, 9, 12, 14, and 17 sides thus obtained. The first four are very accurate, the last is affected by a slight error. The equation connecting x and y for this method can be obtained thus: Let $y = mx + c$. Then clearly

$$m = \cdot\dot{3}, \text{ and } 6m + c = 1 \cdot 732;$$
$$\text{whence } c = -\cdot 268.$$

Therefore $y = \cdot\dot{3}x - \cdot 268$. The values of y thus calculated are given in Column 6 of Table 59, and the differences between them and the true values of y are shown in Column 7. In no case between $x=4$ and $x=20$ does the difference exceed $\cdot 085$, so that this method is a good method for any polygon containing 4 to 20 sides. In every case, moreover, save between $x=3$ and $x=5$ (which cases are not of importance), this difference is less than with Method 1. Method 2 is especially accurate when the number of sides is 11, 12, 13, 14, or 15. Graph C in Figure 367 represents the equation corresponding to $y = \cdot\dot{3}x - \cdot 268$. It will be noticed how closely it lies to $y = \tan\left(90^\circ - \frac{180^\circ}{x}\right)$.

TABLE 58.

ANGLES OF REGULAR POLYGONS.

No. of Sides x.	Vertical Angle $\theta = 180^\circ - \frac{360^\circ}{x}$	Central Angle $\phi = \frac{360^\circ}{x}$
3	60°	120°
4	90°	90°
5	108°	72°
6	120°	60°
7	128° 34′ (approx.)	51° 26′ (approx.)
8	135°	45°
9	140°	40°
10	144°	36°
11	147° 16′ (approx.)	32° 44′ (approx.)
12	150°	30°
13	152° 18′ (approx.)	27° 42′ (approx.)
14	154° 17′ (approx.)	25° 43′ (approx.)
15	156°	24°
16	157° 30′	22° 30′
17	158° 49′ (approx.)	21° 11′ (approx.)
18	160°	20°
19	161° 3′ (approx.)	18° 57′ (approx.)
20	162°	18°

Method 3. Let A B (see Figure 365) be one side of the required polygon. Bisect A B in M, and at M draw M P perpendicular to A B and of indefinite length. With centre M and radius M A (or M B) describe an arc cutting M P in C. With centre A and radius A C describe an arc cutting B A produced in D. With centre M and radius M D describe an arc cutting M P in 8. It can be easily shown that this point is the centre of the circle circumscribing the regular octagon drawn on A B as base (*i.e.*, $y = 2\cdot414$ when $x=8$). Trisect M B (or A M) and, commencing from 8, mark off divisions 9, 10, 11, 12, and so on, along 8 P, and 7, 6, 5 along 8 M, each equal to $\frac{1}{3}$ M B. These points give the centres of the circumscribing circles. The polygons are then drawn as in the former methods. In Figure 365 are shown polygons containing 7, 9, 12, and 14 sides thus obtained. The first three are very accurate; the last is affected by a slight error. The equation connecting x and y for this method can be obtained thus: Let $y = mx + c$. Then clearly

$$m\ \cdot\dot{3}, \text{ and } 8m + c = 2\cdot414;$$
$$\text{whence } c = -\cdot253.$$

Therefore $y = \cdot\dot{3}x - \cdot253$. The values of y thus calculated are given in Column 8 of Table 59, and the differences between them and the true values of y are shown in Column 9. In every case after $x=6$, these differences are less than with Method 1; but after $x=10$ they are greater than with Method 2. For polygons containing 7, 8, 9, or 10 sides this method is the most accurate. The graph of the equation $y = \cdot\dot{3}x - \cdot253$ cannot be shown distinct from that of $y = \cdot\dot{3}x - \cdot268$ in Figure 367, since the two lines practically coincide.

TABLE 59.

1	2	3	4	5	6	7	8	9	10	11
			Method 1.		Method 2.		Method 3.		Method 4.	
x	$\tan\left(90^\circ - \frac{180^\circ}{x}\right)$	Differences.	$\cdot366x - \cdot464$	Errors.	$\cdot\dot{3}x - \cdot268$	Errors.	$\cdot\dot{3}x - \cdot253$	Errors.	$\cdot\dot{3}x - \cdot\dot{3}$	Errors.
1	$-\infty$		$-\cdot098$	—	$+\cdot065$	—	$+\cdot080$	—	0	—
2	0	$+\infty$	$+\cdot268$	—	·399	—	·414	—	$+\cdot333$	—
3	$+\cdot577$	·577	·634*	$+\cdot057$	·732	$+\cdot155$	·747	$+\cdot170$	·667	$+\cdot090$
4	1·000	·423	1·000*	·000	1·065	·065	1·080	·080	1·000*	·000
5	1·376	·376	1·366*	$-\cdot010$	1·399	·023	1·414	·038	1·333	$-\cdot043$
6	1·732	·356	1·732*	·000	1·732*	·000	1·747	·015	1·667	·065
7	2·076	·344	2·098	$+\cdot022$	2·065	$-\cdot011$	2·080*	·004	2·000	·076
8	2·414	·338	2·464	·050	2·399	·015	2·414*	·000	2·333	·081
9	2·747	·333	2·830	·083	2·732	·015	2·747*	·000	2·667	·080
10	3·078	·331	3·196	·118	3·065	·013	3·080*	·002	3·000	·078
11	3·406	·328	3·562	·156	3·399*	·007	3·414	·008	3·333	·073
12	3·732	·326	3·928	·196	3·732*	·000	3·747	·015	3·667	·065
13	4·057	·325	4·294	·237	4·065*	$+\cdot008$	4·080	·023	4·000	·057
14	4·381	·324	4·660	·279	4·399*	·018	4·414	·033	4·333	·048
15	4·705	·324	5·026	·321	4·732*	·027	4·747	·042	4·667	·038
16	5·027	·322	5·392	·365	5·065	·038	5·080	·053	5·000*	·027
17	5·349	·322	5·758	·409	5·399	·050	5·414	·065	5·333*	·016
18	5·671	·322	6·124	·453	5·732	·061	5·747	·076	5·667*	·004
19	5·993	·322	6·490	·497	6·065	·072	6·080	·087	6·000*	$+\cdot007$
20	6·314	·321	6·856	·442	6·399	·085	6·414	·100	6·333*	·019

Method 4. Let A B (Figure 366) be one side of the required polygon. Bisect A B in M, and at M draw M P perpendicular to A B and of indefinite length. Now, when $x=19$, $\tan\left(90°-\frac{180°}{x}\right)=6$. almost exactly; so that if a point 19 be marked on M P distant from M three times the length of A B, this will give very accurately the centre of the circle circumscribing the regular nonadecagon drawn on A B as base. Mark this point. Trisect M B (or A M) and, commencing from 19, mark off divisions along M P each equal to $\frac{1}{3}$ M B. These points give the centres of the circumscribing circles. The polygons are then drawn as in the former methods. In Figure 366 are shown polygons containing 17 and 19 sides thus obtained. Both are extremely accurate. The equation connecting x and y for this method can be obtained thus: Let $y=mx+c$. Then clearly

$$m = \cdot\dot{3}, \text{ and } 19m + c = 6\cdot000;$$
$$\text{whence } c = -\cdot\dot{3}.$$

Therefore $y = \cdot\dot{3}x - \cdot\dot{3}$. The values of y thus calculated are given in Column 10 of Table 59, and the differences between them and the true values of y are shown in Column 11. Below $x = 15$, these differences are higher than with Methods 2 and 3, and below $x = 9$ they are greater than with Method 1. This method is not recommended, therefore, for polygons with less than 15 sides. But when the number of sides lies between 15 and 20 inclusive, it is the most accurate method. The graph of the equation $y = \cdot\dot{3}x - \cdot\dot{3}$ is shown in Figure 367 (Graph D). It practically coincides with that of $y = \tan\left(90° - \frac{180°}{x}\right)$ between $x = 16$ and $x = 20$.

We have not considered it necessary to continue the investigation for polygons containing more than 20 sides, though doubtless similar methods for accurately constructing such polygons could be devised.

In Table 59 that method which is most accurate for each polygon is indicated by an asterisk. If, when using any of these methods, one has a list of errors, such as given in Columns 5, 7, 9, and 11 of Table 59, an even more accurate construction may be obtained by estimating with the eye the true position of the centre of the circumscribing circle above or below the approximate position given by the method employed.

SOLAR DISTURBANCES DURING JULY, 1913.

By FRANK C. DENNETT.

During July the solar disc has shown very little disturbance, though rather more than in the two previous months. On eight days (2, 5, 19, 21, 22 to 24 and 27) the disc appeared quite clear. On nine (7 to 14 and 30) spots or pores were visible. No observations were made on the 18th, and on the remaining thirteen days faculae were visible. The longitude of the central meridian at noon on July 1st was 137° 20′.

No. 9.—First seen on the 9th as two spotlets, the larger leading. On the 10th there were at least three umbrae in the western portion of the group and two, with a dull companion, in the eastern. The disturbance reached its maximum on the 11th, being some 40,000 miles in length; the components were smaller on the 12th, and less in the evening than in the morning. Only two pores were seen on the 13th, one still remaining on the 14th. Faculae were seen in the same area on the 16th and 17th.

No. 10.—A little group of pores seen on the morning of the 30th, which had faded greatly by the afternoon, and were gone entirely by the next day.

On both the 7th and 8th tiny black pores and bright flecks were visible in various places on the disc under best conditions, but none sufficiently conspicuous to measure.

Faculae during the month were very far from being conspicuous. There were some near the western limb on the 1st, and within the north-eastern on the 3rd and 4th. On the 20th a facula near longitude 295°, S. Latitude 35°, was approaching the south-western limb. Faculae were within the eastern limb on the 25th and 26th, also within the north-eastern limb on the 28th and 29th. On the 29th faculae were also situated at about 206°, 20° North, and 56°, 5° South. There were faculae near the eastern limb on the 31st.

Our chart is constructed from the combined observations of Messrs. J. Mc Harg, A. A. Buss, E. E. Peacock, W. H. Izzard and F. C. Dennett.

DAY OF JULY, 1913.

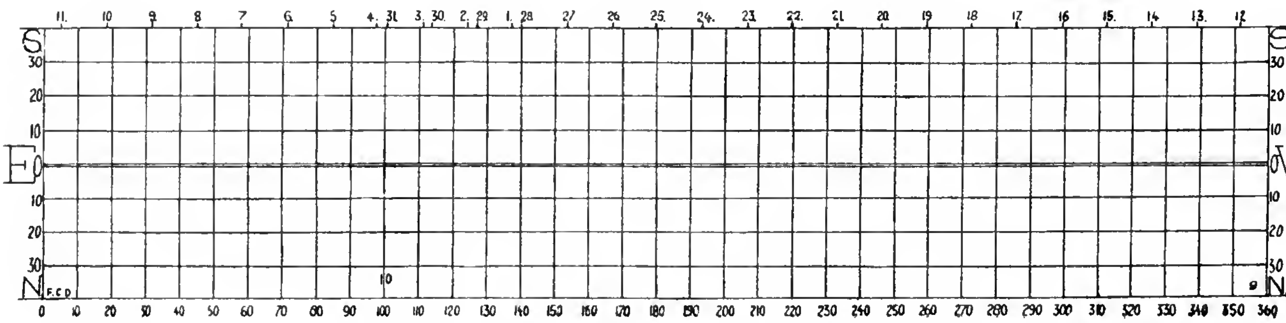


Figure 368.
Nest of the Song Thrush built against a post and lacking one side.

Figure 369.
A Song Thrush sitting in an old Kettle.

Figure 370.
An old pail in which a Blackbird annually builds.

Figure 371.
A Blackbird's nest in an old paint pot.

FIGURE 372.
A Song Thrush's nest on the top of a nesting box in which tree sparrows built.

FIGURE 374.
A Song Thrush's nest built in an open bracket basket put up for the purpose.

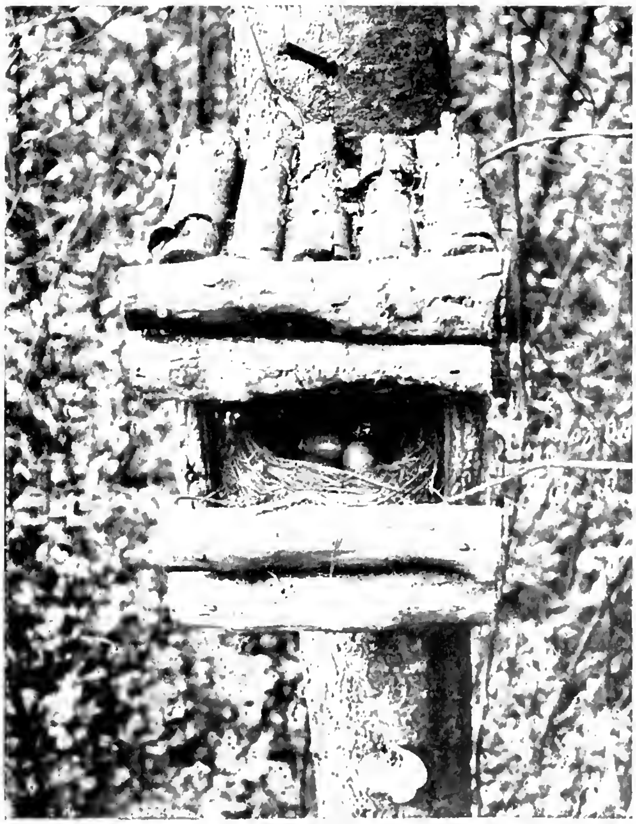


FIGURE 373.
The nest of a Blackbird built in an open-fronted nesting box intended for robins and flycatchers.

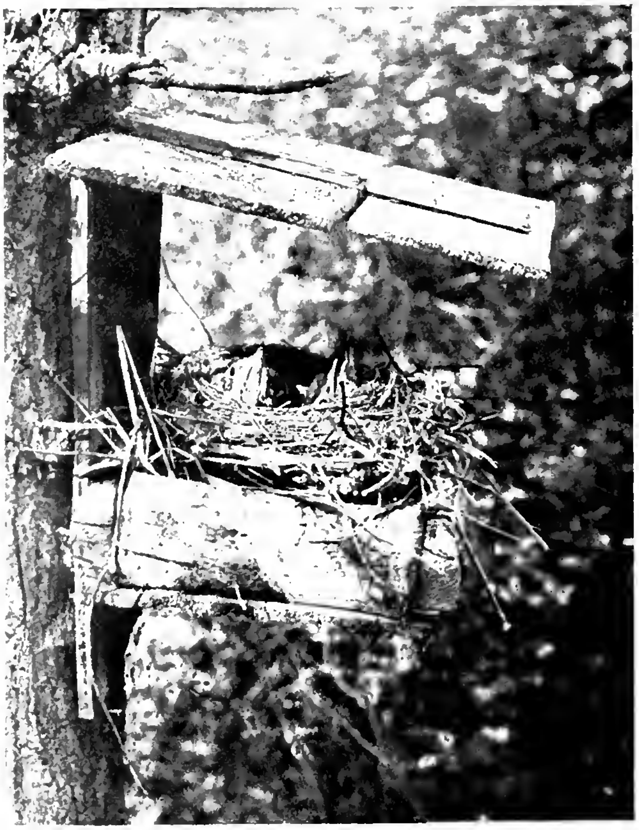


FIGURE 375.
Young Song Thrushes in a nest built on a roofed tray made for these birds or blackbirds.

THE NESTS OF THE SONG THRUSH AND BLACKBIRD.

By WILFRED MARK WEBB, F.L.S.

Chairman of the Brent Valley Bird Sanctuary Committee.

MANY of the blackbirds and thrushes which nested in the Brent Valley Bird Sanctuary during the past spring and summer built in interesting positions, and a short account of a few of the sites will be given here.

The first nest to which we may allude was that of a song thrush which was built against a flat-sided post about two feet from the ground. The interesting part about the structure, however, is that there was practically no material used on the side towards the post, but it appeared as shown in Figure 368. The hollow was therefore not circular and the nest recalled that of a martin, which is built against a wall.

In connection with the height of this nest from the ground, it may be mentioned that both blackbirds and thrushes have at various times actually placed their nests directly on the earth, though until the year 1912 it was noticed that the birds were usually unsuccessful in rearing their young. In that year, however, a song thrush which constructed a well-hidden nest under some brambles, brought up five young ones, and this spring four young birds flew from a very similar nest which probably belonged to the same old birds.

Our second illustration (see Figure 369) shows one of the same kind of bird sitting in an old kettle which in previous years has found favour with robins and with wrens. Blackbirds have chosen a similar nesting-place in the Sanctuary, but this is the first time that a thrush has contented itself with such restricted accommodation. The hen bird, it may be mentioned, like others which have chosen artificial surroundings, was very tame, and when perching on the branch outside the kettle would allow us to stand within a couple of feet of it.

Four or five years ago an old pail was lodged in the fork of a large hazel branch, and during successive seasons since blackbirds have built in it, sometimes rearing two broods of young ones (see Figure 370). Another pair of these birds built a very substantial nest in the disused paint pot which is seen in Figure 371. But some enemy or other interfered with the eggs and the nest was deserted.

Some years ago a thrush took possession of the top of one of the rough closed nesting boxes with a sloping roof put up for smaller birds, and completed its work of building in a little over a week, but the nest slipped off the box and came to grief. This year, two nests were found in similar positions and these remained quite steady, tree sparrows taking possession of the insides of the boxes. One of the nests is shown in Figure 372, and the box is becoming quite an historical one. It was occupied by the first pair of nuthatches which were recorded as breeding in the wood, a wryneck has laid in it, as well as tits and tree-sparrows.

Quite close at hand, another thrush brought off her brood on the top of a hurdle inside the shed in which the keeper was at work.

For the benefit of robins and flycatchers nesting boxes made of hazel branches with open fronts have been put up, and on two or three occasions have been taken possession of by blackbirds, with complete success. One of these, which was occupied during the past summer, is shown in Figure 373. Once or twice song thrushes have begun operations in similar receptacles, but they have not completed their work, probably because there is too little room, and as they twist round in nest-building their tails catch against the sides of the box.

Seeing that blackbirds and thrushes will take to artificial nesting-sites such as have been mentioned, and that bird lovers who were anxious for these birds to nest with some amount of security in their gardens had made enquiries, members of the Bird Sanctuary Committee were led to try the experiment of making special arrangements for these birds. Both species very commonly build on the small twigs that grow out from the lower parts of tree trunks, and trays and baskets were made of thicker or thinner branches and nailed up like brackets in their positions, as well as flat trays, which were nailed on the upper sides of horizontal branches. Very few of the latter were used, but as the others became weathered and the artificial look wore off, they came to be occupied more and more generally, until this year probably ten or a dozen were used.

The first one of which use was made some time ago was of the type shown in Figure 375, where the trays were fastened to a board and supplied with a roof of the same material. This covered bracket tray forms a very snug nesting site and during the winter a field-vole made a roof of moss to the deserted nest, and bored a small round hole in the mud lining, making himself very cosy winter quarters. In Figure 375, just mentioned, some young thrushes of this year can be seen.

Another type of bracket is similar to the last described, but instead of having at the back boards and a roof, the tray is simply fastened to two vertical pieces of split branch, the flat sides being put against the tree and those with the bark on away from it. Still yet another kind resembles the baskets which are made for ferns. This is shown in Figure 374 and contains a thrush's nest and eggs. A blackbird's nest in a similar basket was begun on a Tuesday and was seen completed with two eggs in it on the following Sunday morning, while it may be added in this connection that within two days of a new log box being put up a great tit had begun to bring in material, and before the week was out the nest was finished and contained eggs.

Some seasons ago, two examples of the Lyne nesting bush, which we believe is intended for aviaries, were sent to the Sanctuary by the inventor, and one of these put up in a hazel was occupied by a thrush in the first year, but not afterwards. We have pretty well exhausted the various places which the birds with which we are dealing have chosen in the Sanctuary, but we may mention that in *The Selborne Magazine* for August a photograph is reproduced showing a ladder hanging under the eaves of a cottage with thirteen blackbirds' nests built between the rungs. These were constructed in the same season, and several of the birds were sitting at the same time.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

PROFESSOR NEWCOMB'S LAST RESEARCHES ON THE MOON'S MOTION.—A pathetic interest attaches to the volume of the American Ephemeris Papers that has lately appeared; for Professor Newcomb, who had given a large portion of his life to researches on the Moon's motion, and was the first to find the reason of the rapidly growing error of Hansen's Tables, continued to dictate the matter of the present volume till within a few days of his death. Some thirty years have now passed since his earlier researches, in which he showed that one of Hansen's large Venus terms ought to be left out altogether, having no place in theory; that the mean motion and secular acceleration he used were also wrong, and that it was necessary to introduce a large empirical term with a period of about three centuries. These four alterations were introduced into the *Nautical Almanac* under the name of Newcomb's Corrections, and are used there to this day. There were some who denounced their introduction, which they called an introduction of empiricism into exact astronomy; this shewed a decided misconception of the situation; only one of Newcomb's four corrections was empirical, the others were in accordance with theory; besides, Hansen's Tables were themselves just as empirical, for they had a large Venus term which ought not to be there at all, its coëfficient being really quite insensible. In the last thirty years many attempts have been made to find a theoretical explanation of the great empirical term. It is now established that it cannot be due to the action of any of the known planets; at least four causes have been suggested: it might be due to a ring of planets inside Mercury's orbit, with period nearly the same as a lunation; or to want of symmetry in the sun, whose rotation is nearly the same in length as a lunation (this suggestion was made by Brown, but it does not appear tenable in view of the great differences of rotation-time of different zones of the sun); or that gravity was obstructed in passing through matter, so that a lunar eclipse causes a diminution in the sun's action on the moon (this is due to Dr. de Sitter); or that there is some connection with the earth's magnetism, the period of revolution of the magnetic pole being something like three centuries.

The object of Professor Newcomb's last research was to try to find the nature of the great oscillation with more accuracy; for this purpose he has used a very long series of observations of occultations of stars; these are capable of more precision than meridian observations, for the disappearance or reappearance is instantaneous, and can be estimated to a quarter of a second or less. The places of all the brighter stars in the zodiacal region have now been found fairly accurately, and the error of the moon's place can be deduced. I would remark that the observation of these phenomena is one in which amateurs may well take part; a three-inch telescope is amply large enough; there must be some means of getting correct time; one way of doing this is to receive the wireless signals from the Eiffel Tower. Writers in *Nature* have stated that they have succeeded in doing this, using an ordinary wire mattress as collector; a fairly good clock or chronometer is also necessary, to measure the interval between the occultation and the time signal.

After calculating the results given by the long series of occultations, which extend from 1620 to 1908, Newcomb proceeds to discuss the mean motion and acceleration, and the form of the empirical fluctuation. He finds that a single sine curve will not represent the fluctuation; there is evidence of another with a period of about sixty-four years, which has, in fact, been introduced into the new French Tables; the great term is best represented by the expression

$$12''\cdot 95 \sin \left\{ 1^\circ\cdot 31 \,(t-1800) + 100^\circ\cdot 6 \right\}$$

the period being two hundred and seventy-five years; his result of thirty years ago was

$$15''\cdot 49 \sin \left\{ 1^\circ\cdot 3187 \,(t-1800) + 93^\circ\cdot 9 \right\}.$$

The coëfficient has now been reduced by $2\frac{1}{2}''$, and the period lengthened by four years.

Newcomb gave a diagram of the fluctuations of the moon from its calculated place since 1620 in the *Monthly Notices* for January, 1909; it clearly shows the great wave and the term of about sixty-four years, and there is an appearance of a still shorter wave from the observations of the last century.

The work also discusses ancient eclipses of sun and moon; Newcomb gives little weight to the former, considering that the evidence that any eclipse was total at a given point is not convincing; indeed, this is admitted by all, and weight is only assigned to corrections which will make most of the eclipses of antiquity agree with the narratives.

Several other astronomical constants are incidentally discussed, since this long series of occultations throws light on them: among others the rate of change of the obliquity of the ecliptic; Newcomb favours Seeliger's suggestion that we should look to the denser part of the Zodiacal Light for an explanation of the discordance of this rate from theory, also of discordances in the rate of motion of the perihelion of Mercury and of the node of Venus (Newcomb had deduced $8''\cdot 76$ for the sun's parallax from the motion of Venus' node; the accepted value now is $8''\cdot 806$; the discordance may be due to the action of the Zodiacal Light). The part of the Zodiacal Light that seems to be gravitationally active is of ellipsoidal form, and within the orbit of Mercury; that is, it is only a small part of the light that we see, but the density doubtless increases rapidly as we approach the sun, so that most of the mass lies inside Mercury's orbit. This would be a more satisfactory explanation than the assumption that gravity does not vary exactly as the inverse square. Another suggestion for explaining the anomalies in the moon's motion was that they might arise from changes in the rate of the earth's rotation. Newcomb tested this question by the observed transits of Mercury; his earlier discussion seemed to indicate changes that would explain half the moon's fluctuations; but the more complete discussion seems to indicate no change in the rotation rate. The rather unsatisfactory end of the entire work is that "Until the matter is cleared up it will be impossible to predict the moon's longitude with the precision required for astronomical purposes. We shall be obliged to correct the moon's mean longitude from time to time, perhaps at intervals of ten to twenty years from observation."

THE MAGNETIC FIELD OF THE SUN.—*Nature* for July 17th contains an interesting article on Professor Hale's recent work in this direction. It will be remembered that the hydrogen vortices round sunspots gave evidence by the Zeeman effect (*i.e.*, the doubling or tripling of spectral lines) of the passage of the rays through a magnetic field, which it was reasonable to conclude was caused by the whirling motion of negative electrons. The present investigation has been a search for a similar but much weaker effect due to the general magnetic field of the sun. Great dispersion is required, as the field is weak, and the Zeeman effect slight; the new 164-feet tower telescope and 75-feet spectrograph at Mount Wilson have been used, which make one Angström = 4·9 millimetres; the distance between the D lines is 29 millimetres, or over an inch. Full details are given in *Nature* of the manner of taking and measuring the spectrograms. It will suffice to say here that the spectrograms are divided into narrow longitudinal strips, polarised in opposite directions, so that alternate members of the doublets appear on alternate strips, and the lines as a whole have an "in-and-out" appearance. The shifts follow a sine-curve fairly regularly, being 0 at the equator and poles, and reaching maxima in opposite directions at latitude 45° north and south. The maximum displacement in either direction is about ·006 millimetres. It is concluded that the north magnetic pole of the sun lies at or near the north pole of rotation, and that the strength of field at the pole is about fifty Gausses. The lines belonging to high levels of the sun's atmosphere show practically no displacement, so it is concluded that the field falls off rapidly as we ascend from the photosphere. It is incidentally suggested that the tiny pores, which appear at all parts of the sun, are incipient vortices which, under favourable conditions, develop into spots. The whole investigation is a striking illustration of the power of modern methods, especially in the hands of such a master as Professor Hale. He contemplates further researches, so as to obtain more information as to the variation of the magnetic field at different altitudes.

BOTANY.

By PROFESSOR F. CAVERS, D.SC., F.L.S.

INDIAN TIMBER TREES.—The Superintendent of Government Printing, Calcutta, is issuing a series of extremely useful notes on Indian timbers (Forest Bulletins, Nos. 16 to 21, price 4d. each), which can be obtained from H. S. King & Co., 65, Cornhill, London; Oliver & Boyd, Tweeddale Court, Edinburgh; E. Ponsonby, 116, Grafton Street, Dublin; or through any bookseller. The trees dealt with in the six bulletins just issued are, respectively, *Gmelina arborea*, *Pterocarpus marsupium*, *Terminalia tomentosa*, *Lagerstroemia lanceolata*, *Ougeinia dalbergoides*, and *Anogeissus latifolia*. Each bulletin gives the distribution, habit, and so on, of the tree, the properties and uses of the timber, minor products, if any, and much other information, and includes a specimen of the wood in the form of a thin section mounted in a stout cardboard frame. The preparation of these bulletins, and their issue at such an extremely low price, reflect the greatest credit on the enterprise of the Forest Research Institute at Dehra Dun, the officers of which are responsible for their compilation, and it would be a great boon were our home authorities to issue a similar set of notes on British-grown timbers.

THE FAMILY HYDROPHYLLACEAE.—In the great encyclopaedia of systematic botany, "Das Pflanzenreich," now being issued under the editorship of Professor Engler, there has just appeared a monograph of the family Hydrophyllaceae, by A. Brand (Heft 59, 210 pages. Price M. 10.60). Though some members of the family are cultivated as border plants (chiefly species of *Nemophila* and *Phacelia*), the Hydrophyllaceae are not represented in Europe, and though some species occur in all the other continents the great majority are American, and the family is practically concentrated in California and adjacent parts of North America. In several respects the family is one of the most interesting among the gamopetalous Dicotyledons. The geographical distribution of the genera and species presents some remarkable features, which can only adequately be explained on the view that the distribution was formerly much more extensive than at the present day; the few species which occur outside of North America—in South America, tropical Asia, Africa, and so on—appear to be remnants of former widespread genera. The systematic position and the affinities of the Hydrophyllaceae are also of great interest. The family is placed near the base of the Tubiflorae—the large series of Gamopetalae including such families as Convolvulaceae, Solanaceae, Scrophulariaceae, Labiatae, and so on. To the Boraginaceae it presents various resemblances, such as the roughly hairy leaves and stems, the coiled inflorescence (the so-called "scorpioid cyme"), the presence in various forms of scales within the mouth of the corolla-tube, and the internal anatomy; as to the last point, the family agrees with Boraginaceae and Polemoniaceae in having collateral bundles of the normal type instead of bicollateral bundles with internal phloem such as occur in the Convolvulaceae and Solanaceae. Again, the family is separated somewhat widely from the Polemoniaceae by the fact that the micropyle of the seed is directed upwards (as in the Boraginaceae), while the structure of the ovary in Hydrophyllaceae differs from that of all the neighbouring families owing to the characteristic large placentas, which only rarely fuse in the centre so as to produce a truly two-celled ovary—in most cases the placentation is parietal. Yet there is a striking correspondence between Hydrophyllaceae and Polemoniaceae as regards geographical distribution. During the twenty years that have elapsed since the Hydrophyllaceae were dealt with in Engler and Prantl's "Pflanzenfamilien," the number of known species has increased from one hundred and seventy to two hundred and thirty. Like all the other volumes of "Das Pflanzenreich," this monograph is more than a mere technical description of genera and species, the systematic portion being preceded by an interesting general account of the anatomy, pollination mechanisms, geographical distribution, affinities, and so on.

BIOLOGY OF SUBMERGED WATER-PLANTS.—An interesting resumé of various recent publications on the structure, physiology, and ecology of aquatic and marsh plants is given in the current number (Vol. I, No. 1, June) of the new *Journal of Ecology*. One of the papers reviewed at considerable length is by W. H. Brown (*Philippine Journal of Science*, Vol. VIII), and deals with the relation of the substratum to the growth of the Canadian water-weed, *Elodea* (*Anacharis*) *canadensis*, though the results have a general bearing upon the biology of submerged water-plants. Brown gives tables showing the relative growth of *Elodea* with and without the addition of carbon dioxide to the water, in tap water, and in Knop's nutrient solution, with and without soil, rooted in and simply anchored over soil or sand, and so on, and the results from this portion of his work are summarised as follows:—Sufficient carbon dioxide to keep the plant growing or even alive does not diffuse from the air into the water during winter and spring; the substratum probably serves as an important source of this gas. The *Elodea* is not dependent on its roots for absorption of mineral salts; the chief function of the roots (in this and doubtless in other submerged rooted aquatics) is to anchor the plant to the soil, which is advantageous when the soil contains organic matter and gives off carbon dioxide; plants rooted in good soil grow better than those simply anchored over the same soil. When carbon dioxide was supplied by a generator instead of by the soil, rooted and anchored plants grew about equally well; with similar soils but no external supply of carbon dioxide, floating plants grew better than rooted ones, the air being in this case the source of carbon dioxide.

Further details of Brown's important work, and of various other recent researches on the interesting aquatic flora of ponds and streams, are given in the review mentioned above, which extends to nine pages and deals with every important publication on the aquatic and marsh flora during the last two years, with references to earlier work in addition.

CUSHION PLANTS.—Another interesting article in the *Journal of Ecology* for June deals with the structure, physiology, and ecology of cushion-plants, based on an important work by Hauri (*Beih. Bot. Centralbl.*, Band 28), of which the following is a brief summary. Cushion plants are perennial, usually evergreen, more or less stunted plants of compact and usually rounded growth and dense branching, the branches being closely covered with relatively small stiff sessile leaves which are either appressed or are packed together with hairs. Hence the plant forms a living spongy cushion characterised by firmness, compactness, and closed growth, which reäcts as a whole to the factors of the environment. Details are given of the main features of these remarkable plants, under such headings as general form, branching, root system, firmness and closure, and packing material, and cushion-plants are divided into six classes (illustrated by a full-page set of illustrations) of which examples are given. In the general sketch of the biology and ecology of cushion-plants the following points are noted. (*a*) The capacity for absorbing and retaining large quantities of water, serving to regulate the temperature of the plant during alternate warming and cooling of the air, to keep the air in and around the plant relatively moist, to make the underlying soil moist and warm, and in some cases to supply water directly to the aërial organs by means of adventitious roots. (*b*) The crowding and overlapping of the leaves, serving as a protection against direct insolation, and producing wind-still and moist capillary interspaces between the branches, thus minimising loss by transpiration. (*c*) The compact growth of the branches in the cushion, which enhances the capillary arrangement due to (*b*) and serves to collect sand and other wind-borne débris as well as the dead leaves of the plant itself, besides being the main factor in producing the cushion habit itself with its obvious protective advantages. (*d*) The packing material, which enormously enhances the water-holding capacity of the cushion, provides food in the form of humus, and enhances the rigidity and hardness of the cushion. The degree of hardness attained in some cases may be judged from the fact that in some Andine species, such as *Azorella madreporica*, the plant turns off a revolver shot at point-blank distance, and specimens can only be obtained by breaking up the cushion with a hammer!

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON), F.I.C.

WILD LETTUCE RUBBER.—Mr. C. R. Fox, writing in the *Journ. Ind. Eng. Chem.* (1913, V, 477), gives an account of two species of wild lettuce which grow in the United States, and suggests the possibility of utilising them for the production of rubber. One of these, *Lactuca canadensis*, which is popularly known as "trumpet weed," yields when bruised a thick milky juice, or latex, containing over two per cent. of rubber. It also contains upwards of 13 per cent. of a brittle brown resin, which dissolves readily in alcohol and acetic acid, and a slightly acid substance with an intensely bitter taste. More than forty years ago it was stated by Maisch that the juice of this lettuce contained a bitter principle, "lettuce opium," and Mr. Fox suggests that extraction of this drug combined with the separation of the rubber might be found a profitable industry. Owing to the presence of the acid bitter principle the rubber would require washing with alcoholic alkali.

The other species of lettuce, *L. scariola*, is an annual plant, the juice of which contains less rubber (1·58 per cent.) and a smaller proportion of resin. The rubber derived from either of these plants is stated to possess excellent physical properties.

ACTION OF CAUSTIC LIME ON SOIL.—It is common knowledge that soil is materially improved by suitable additions of caustic lime, and this is usually attributed to its neutralising the free acids in the soil and rendering the plant food constituents suitable for absorption by the plant. Mr. H. B. Hutchinson's experiments, however (*Journ. Agric. Science*, 1913, V, 320), indicate that these effects do not explain the whole of the results obtained in practice through the application of lime to the soil. The germicidal action of the lime is a material factor, and it has been found that its action in this direction is more pronounced than that of volatile antiseptic agents, but is less effective than sterilising the soil by heat. The immediate effect of adding lime is to destroy the larger protozoa and a large proportion of the bacteria in the soil, and to decompose organic nitrogenous componnds. After the whole of the lime has been transformed into carbonate bacteria begin to develop rapidly, and there is an increase in the production of available plant foods.

These conclusions were confirmed by the results of practical tests with different soils. For example, the addition of 0·5 per cent. of caustic lime to a poor soil already containing sufficient calcium carbonate was followed by a pronounced increase in the crops; while treatment of a good garden soil with varying proportions of caustic lime up to 1 per cent. caused the first crop to be poorer, but the second crop to be much richer than originally.

THE ACTIVE MODIFICATION OF NITROGEN.—It has been asserted that the phenomena attributed to active nitrogen are due to the presence of traces of oxygen, but the Hon. R. J. Strutt shows (*Proc. Royal Soc.*, 1913, A. LXXXVIII, 539) that this is not the case. On the contrary, oxygen has an unfavourable effect, and when present in the proportion of two per cent. inhibits the reäctions of the nitrogen. In preparing the nitrogen for the action of the electric discharge, Mr. Strutt absorbs all traces of oxygen by means of phosphorus, and then dries the gas by passing it first through phosphorus pentoxide and then through a tube packed with copper gauze and cooled with liquid air. Finally, oxides of phosphorus are dissolved by the water which rises in the gas-holder, the latter being meanwhile covered with black cloth to prevent the action of light upon the nitrogen.

Nitrogen thus purified and rendered active by the passage of an electric discharge will combine with vaporised zinc, cadmium, mercury, sulphur, and other elements to form nitrides, which are decomposed by water, with the liberation of ammonia. It reäcts with carbon bisulphide to produce a blue polymerised carbon monosulphide and a blue nitrogen sulphide, while it decomposes sulphur chloride with the formation of the ordinary yellow nitrogen sulphide. It appears to act upon most organic compounds, liberating hydrocyanic acid, but carbon tetrachloride is not decomposed in this way.

ACTION OF OZONE ON FIBRES.—The results of experiments to determine the effect of ozone upon different textile fibres are described by Mr. C. Dorée in the *Journ. Soc. Dyers and Col.*, 1913, XXIX, 205. In each case the yarns were exposed to the action of oxygen containing 1·5 to 2 per cent. of ozone and their relative breaking strength and elongation determined after various periods. In the case of cotton and artificial silk there was but little reduction in the strength during the first hour, but subsequently the deterioration was very rapid, and after twelve hours the breaking strength had fallen from 30 to 50 per cent. This alteration in the physical properties was accompanied by a chemical change. For example, a sample of cotton-wool, containing 44·4 per cent. of carbon, showed only 43·5 per cent. after the oxidation. Flax was attacked much more rapidly than cotton, and yielded formic acid and solid acids, but dry wool was hardly affected after several hours' exposure to ozone in the presence of moisture. If the wool were first soaked in water, however, a rapid decrease in its strength and elongation was observed, while silk under similar conditions was rapidly attacked by ozone.

GEOGRAPHY.

By A. STEVENS, M.A., B.Sc.

TENTH INTERNATIONAL GEOGRAPHICAL CONFERENCE.—This conference was held at Rome in the end of March and the beginning of April. Unfortunately it had been twice postponed, and the consequent was that the attendance was only half that at the foregoing conference. It was decided that all papers notified for the postponed meetings should be read, but the authors of many of these were not present. Several of the sections held very few meetings: in one case only a single meeting was possible, and the sessions were often unexpectedly short. Possibly the most interesting discussions concerned the international map of the world on the scale of 1:1,000,000. With it, as well as with other maps on larger scales for international use, considerable progress has been made. The important question of uniformity in the spelling of names on maps, particularly on those of uncivilised and polar regions, was also raised, and we may hope that shortly satisfactory and uniform methods of spelling will be adopted.

EXPLORATION.—The Canadian Arctic Expedition left British Columbia in June to explore certain circumpolar regions, notably the area of the Parry Archipelago. Reasons based on a detailed study of tidal currents have been brought forward by Dr. R. A. Harris for supposing the existence of an Arctic continent, stretching from the 75th beyond the 85th parallel, N. latitude, and lying between one hundred and one hundred and fifty degrees W. longitude. Peary believes he saw the outposts of such a land north-west from Cape Thomas Hubbard, and Greely also supports Harris' opinion. Nansen, however, thinks the area is occupied by a deep polar basin. The expedition has been equipped and staffed for comprehensive scientific work. The operations will be based on Melville Island, and will be directed to exploration of the Archipelago and to investigation of the region to the north-west, where the supposed continent should lie. They will occupy three years.

An elaborately equipped expedition to Eastern Turkestan, under Italian auspices, and led by Dr. D. Filippi, is completely organised, and will set out shortly. The leaders will join the main party in Asia next March.

EARLY MAN IN SOUTH AMERICA.—Bulletin 52 of the Bureau of Ethnology of the Smithsonian Institution contains the results of the work of a party which investigated the human remains of Argentina. The purely geological work shows that the Pampas have been built up by wind and rivers acting alternately, as the delta plains of Eastern China are at present being formed. Huge deposits of loess are found.

Abundant evidence of the existence of man in Argentina at an early date was discovered. But the men of the Pampas were of a well-marked American Indian type, and there is nothing to indicate very great antiquity or that man has been primarily or independently evolved in South America. As is pointed out, the report contains no positive evidence against the theory of the evolution of man in that region; nevertheless, there is abundant evidence against it of the negative kind.

PROBABLE EFFECTS OF THE PANAMA CANAL.—To the March issue of the *Journal of the Royal Statistical Society* Professor L. Hutchinson contributes a suggestive paper on this subject, which Professor T. Russell Smith also discusses in the March *Journal of Geography*.

The eastern seaboard of the United States and the European centres of trade on the one hand, and on the other the markets of Pacific countries, are chiefly affected. Professor Hutchinson points out that in the market countries there is already considerable development evident; they are well on the way to supplying many of their own requirements in food and clothing, and the main increase in imports is to be expected in manufactured goods, notably of steel. Their export trade is likely to develop most in vegetable products, in meat and animal fibre, and in minerals. A statistical study of the facts confirms the general idea that of manufacturing countries Britain, Germany, and the United States will be mainly affected; and of these the foreign trade of the last shows the widest growth, while that of the first is on a downward gradient. Though the changes will not be so fundamental as those consequent upon the opening of the Suez Canal, Professor Hutchinson believes that whatever modifications political causes may impose, the commercial factors will produce an important acceleration of the advance of the trade of the United States. Professor Smith holds that the Canal will bring about "the greatest readjustment of all time" and affect profoundly the volume of trade carried by every important ocean route as well as the routes themselves.

VARIATION OF THE WATER-LEVEL OF LAKE TANGANYIKA.—An attempt has been made to assign a period and amplitude to this variation in a paper in the *Mitteilungen d. Deutschen Schutzgebieten*, 1913, No. 1. The upper limit is got from terraces marking old shores seven to ten metres above the present surface level towards the north end of the lake; and it is believed that the water reached the topmost shortly after the time of Stanley's visit (about 1878). At this time the outlet by the Lukuga to the Congo drainage system was silted up; but the bar was pierced about 1880, and there seems to be no reliable information as to whether it has been re-formed since. At Usumbura a post placed at the water edge some thirteen years ago now stands twenty metres out from the shore in ·78 metre of water, and it has been concluded that the minimum level is about one metre below the present surface, reached last about 1908. Thus the period is put at thirty years, and the amplitude at eleven metres. The fall in level, however, has been frequently checked and reversed, sometimes for a space of years, and there is no good reason to believe that a major rise has now set in. If definiteness is to be assigned to the phenomenon much more exact and continuous information must be collected over a greatly extended time.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

THE MICROSCOPIC EXAMINATION OF COAL.—Thin sections of coal are extremely difficult to make owing to the brittleness and softness of the material, and when made the opacity and homogeneity of the material frequently render the microscopic examination very disappointing. By the use of a tough cement, however, J. Lomax (*Transactions of the Institution of Mining Engineers*, Vol. XLII, Part I) has been enabled to make very thin sections of coal, and finds definite structures, each seam having its own special characteristics. In thin section most coals are found to be laminated with alternating bands of bright and dull material. Even the brightest coals when sliced show this lamination. The dull bands are chiefly composed of numerous megaspores embedded in a ground-mass of microspores; whilst the brighter portions are built of the smaller microspores with highly compressed remains of leaves and other vegetable tissues. Other coals show compressed woody tissues, sometimes in the form of "mother of coal," or having a resinous appearance with the tissue preserved. Other structures are frequently seen: some are oval and intensely resinous in appearance. These have been named *Ovalites resinosus* by Mr. Lomax. In some of the coals beautiful amber-coloured bodies of various shapes and sizes are found, to which the author proposes to give the provisional name of *Amberites*. Many species of megaspores are found in the various coals, one species being confined chiefly to each seam.

The author gives the results of the examination of many Lancashire coals, and has illustrated their microscopic appearance in many fine plates. The cannel coals are found to consist of an agglomeration of microspores, with here and there a few megaspores. Some of them grade into a material which is nothing but a black carbonaceous mudstone. The majority of the coals examined are humic coals, composed of the droppings of trees and plants in the form of spores, fruits, leaves, twigs, and sometimes fragments of flattened stems. Mr. Lomax comes to the conclusion, contrary to some recent opinions, that no great quantity of wood enters into the composition of coal; and what there is occurs mostly in the form of charcoal or "mother of coal." In the hardest, purest, and brightest coals the material has been reduced to a more or less pulpy state before carbonisation.

An interesting and important practical application of these results has been made. The author suggests that the microscopic examination of a coal-seam may be a good guide as to the inflammability of the dust likely to be given off. Many coals have been shown to be composed largely of the spores of the huge Lycopods of the Carboniferous period, plants whose descendants are the recent Selaginellas and Club-mosses, the spores of which are known to be highly inflammable. The spores in the coal have not lost their highly inflammable and explosive nature during their long entombment, and when released in the form of dust during working produce a highly explosive mixture. Many coals, moreover, contain the resinous and inflammable bodies known as *Ovalites resinosus*. Hence coals rich in megaspores and *Ovalites resinosus* are likely to give rise to a very explosive dust, and this conclusion is borne out by the microscopic examination of coals which are known to produce such a dust.

ALLUVIAL FAN FORMATIONS.—In arid regions of high relief, such as the western deserts of North America, there are huge deposits of rock-detritus in the form of confluent or interdigitating alluvial fans. These fans or cones are deposited by occasional violent torrents, and, owing to the diminishing velocity and carrying power of the water towards the lower levels, a more or less regular gradation occurs from large blocks at the upstream point of the fan to fine silt in the playas, or river-bottoms. This material is prevailingly angular, although there may be admixture of rounded pebbles due to the denudation of old conglomerates in the mountains from whence the detritus is derived. When cemented these fan-deposits are called "breccias," in accordance with current usage; but as A. C. Lawson points out (*Bulletin of the Department of Geology, University of California Publications*, Vol. VII.), the term "breccia" is so overloaded with meanings that it has no particular connotation suggestive of the kind of rock to which it is applied, or its origin. Hence Dr. Lawson proposes the new term "fanglomerate"—a particularly ugly hybrid—for the deposits described above. He also points out the scarcity of rocks of this kind in the older geological formations, even after making due allowance for possible non-recognition or disguise under other names, and suggests that this may be explained by the supposition that the combination of bold relief and aridity was not common in the geological past. It is further concluded that the period of time from the Quaternary to the present is exceptional in geological history in respect to the coëxistence of these two conditions over a large portion of the North American continent.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

THE "FERNLEY" SELF-RECORDING RAIN GAUGE.—The Southport Meteorological Observatory is considered by meteorologists to be one of the best equipped observatories in this country. When the Royal Meteorological Society held its Provincial Meeting at Southport in May last year, the Fellows had an opportunity of inspecting the Fernley Observatory and the Marshside Anemograph Station, and also of seeing the large collection of instruments at work, the great care bestowed upon them, and the remarkably clear and valuable records obtained from them. Mr. Joseph Baxendell, the Borough Meteorologist, in his Report for 1912, describes the "Fernley" self-recording rain-gauge, which he has just brought out and added to the equipment of the Observatory. In this he has introduced a new action of siphoning, and also added other improvements. Figure 376 illustrates the working of the instrument.

The rain collected by an 11-inch deep-rimmed funnel [not shown for want of space] passes through a wide pipe (C) to the cylinder (A), raising the float (B) and a new anti-friction wheels' pen-carrier, until 0·50 inch has fallen, when a cam (K) throws over a rocking-weight shown, and this, by means of a tripping-rod (J), causes the contents of a tilting-bucket

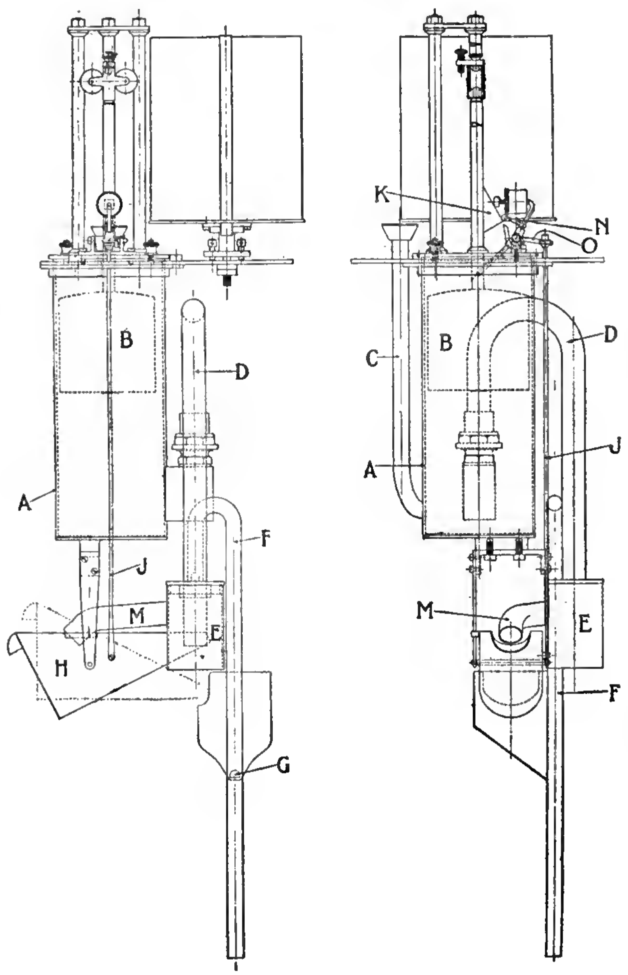


FIGURE 376.

Plan of the "Fernley" Self-Recording Rain Gauge.

(H) to be emptied into a water-air-pump (G, F). A $\frac{5}{8}$-inch bore copper syphon (D) above the pump, and leading from the side of the rain cylinder (A) to a trap (E), is rapidly exhausted by the water-air-pump and, coming into action full-bore, empties the half inch of rainfall in half a dozen seconds, the pen returning to zero on the chart. The water, escaping through a pipe (M), refills the tilting-bucket (H), which is raised or "righted" not merely by the flush of water, but also by a lever (O) that is actuated by the rocking-weight while the latter is being raised into position (through a pin and lever) by the weight of the descending float (B). A detent (N) locks the rocking-weight until rainfall has caused the pen once more to approach the top of the chart; the rocking-weight cannot, therefore, be accidently thrown over in the meantime.

This new rain-gauge, which is made by Messrs. Negretti and Zambra, works in a most satisfactory manner, and will be of great value not only to meteorologists, but also to engineers, surveyors, and all others who require continuous rainfall records of a thoroughly reliable character.

THE U.S. TORNADOES OF MARCH 23RD, 1913.—In connection with the system of low barometric pressure which crossed the United States during the latter part of March, severe local storms occurred in portions of Kansas, Nebraska, Iowa, Illinois and Indiana. The tornado at Omaha, Nebraska, on Easter Sunday, the 23rd, was most destructive. From the account in the *Monthly Weather Review* it seems that ninety-four persons were killed. as well as thirty-three horses, four cows and five mules. At Terre Haute, Indiana, the tornado was less than two minutes in traversing the city, during which time about three hundred and thirty houses were demolished or badly damaged, two hundred and fifty persons injured and twenty-one lives lost. The Weather Bureau official states: "I have talked with several persons who were caught in the tornado. They saw the funnel-shaped cloud touching the ground in places and house after house crumbled as it passed over them. They say the roar was deafening, and I was told by several persons that it could be heard for a mile. Many freakish things resulted: chickens were defeathered, the clothing was drawn off a bed through a fireplace and thence up the chimney; in one house the linoleum was raised off the floor; in another a baby was lifted out of its bed, carried a square, and laid down without injury; toothpicks were driven into the hard wood of a sideboard on which they were laid, and a splinter of wood was driven through a large phonograph horn."

ELECTRICAL STORM IN KANSAS, MARCH 23RD.—During the greatly disturbed weather conditions referred to in the preceding note, an unusually severe electrical storm occurred in the three western tiers of Kansas counties on Easter Sunday, March 23rd. From an account given by Mr. S. D. Flora we learn that during this storm windmills, especially steel mills mounted on wooden supports, became so charged with static electricity than anybody touching them received a distinct shock, and in some cases the shock was a severe one. The observer at Tribune, Greely County, reported an instance where sparks two or three inches long were drawn from a wire running to a windmill. Telephone and telegraph wires and wire fences also became charged sufficiently to give quite noticeable shocks, and in Scott County, where the disturbance seems to have been most severe, one case was reported where a prairie fire was thought to have originated from electric sparks caused by a break in a wire fence. The observer at Scott City also reported that sparks passed from a person's finger held near a horse's ear, and that the horse would shake his head as though he felt the contact of the spark. These electrical phenomena, which occurred during high south-west to west winds, were generally experienced from early morning until about sunset; and during this time the air was filled with dust and was very dry, with no precipitation during the storm, though light rain fell in the north-western part of the State early in the evening.

THE VELO CLOUD.—Dr. Ford A. Carpenter in his recently published book, "The Climate and Weather of San Diego and California," gives the following account of the Velo cloud which is such a characteristic feature in the climate of St. Diego. "While the velo cloud is common to the Pacific Coast generally, and has been observed as far north as the Straits of Fuca, this cloud reaches its perfection over the littoral region of Southern California. The velo cloud is the chief characteristic of the summer climate of the San Diego Bay region. And summer should be understood as covering all the year excepting November, December, January and February. These four months could easily be reckoned as spring-time. The screening of this region from the sun's rays is so thoroughly accomplished that, during a normal summer's day, the sun breaks through the velo cloud about 10 o'clock, the sky clearing shortly afterwards and remaining free from clouds until about sunset. That the velo cloud is effective as a sun-shield, it needs only to be stated that the average of all the July maximum temperatures since weather observations began shows a mean of about 78°.

"The cause of the formation of the velo cloud and, consequently, the cool summers of St. Diego, is, strange to say, found in the hot weather in the interior of California and Arizona. It is a unique example of the aptness of the proverb, 'It's an ill wind that blows nobody good.' The hot weather in the interior produces an aërial eddy (the 'low' of the weather map), and the difference in atmospheric pressure between the interior and the ocean results in giving San Diego cool, uniform days and nights, free from extremes, or what is really the summer temperature of the Pacific Ocean. The velo cloud should therefore be incorporated in our local vocabulary, and it should replace the misnomer 'high fog.'"

VERIFICATION OF METEOROLOGICAL INSTRUMENTS.—Dr. C. Chree, in his Report of the Observatory Department of the National Physical Laboratory, has given a list of the instruments examined at the Kew Observatory during the year 1912. The testing of barometers and hydrometers was transferred to Teddington in November, but including these it is shown that the total number of instruments —exclusive of watches and chronometers—examined during the year was 40,324, an increase of 3,875 on the previous year. The number of barometers and thermometers tested was:—

Barometers—Aneroid	... ...	261
,, Mercury	... ...	351
Thermometers—Clinical	... ...	20,909
,, Deep Sea	...	55
,, Meteorological	...	9,133
,, Standard...	...	107
,, Other forms	...	1,216

It is stated that the increase in the number of thermometers tested is due in considerable measure to the introduction of new regulations by the Home Office for cotton factories. These factories are required by law to have dry and wet bulb thermometers to show the hygrometric conditions prevailing, and the new regulations required the introduction of what was practically a new type of thermometer. Thermometers of "other forms" are also much more numerous than usual, owing partly to a specially large supply of those of the type issued in connection with the chilled meat trade.

MICROSCOPY.

By F.R.M.S.

A NEW PHOTO-MICROGRAPHIC APPARATUS.—Although one hesitates to apply the word "new" to any form of mechanical contrivance nowadays, seeing that any newness about such things partakes of the nature of a fresh arrangement of old principles or ideas, yet I venture to say that the subject of this note presents various conveniences which the photo-micrographer has not been able to enjoy hitherto. I have had this piece of apparatus in practical use for some time, and strongly commend it on account of its convenience, ease of working, and also its efficiency. Figure 377 shows a general view of the apparatus. It is here seen resting on a long narrow table which was especially designed and made for this purpose. The table bed, which is of solid oak rather more than an inch thick, is supported by one pillar at each end. The pillars divide so that the table rests on four feet with castors of the form used for billiard tables. Under the table-bed are three hanging drawers "running through" and so get-at-able equally well from either side of the table. The apparatus can be dismembered and all parts, except the long square base bar, stowed away in these three drawers. The legs of the table are fixed to the table top by nuts and bolts, so that it can be taken to pieces for travelling.

The shoes, and so on, are all tapped with the same thread, so that the various parts are interchangeable in position.

The photographic part consists of a five and a half feet long straight, solid, square steel bar or base, A.A. On this slide a number of square-fitting shoes supporting the various parts. These shoes slide quite freely, and may instantly be clamped in any position along the bar by means of milled headed screws at the lower angle. The lamp end of the bar has a one-legged shoe, B, while the camera end rests on a two-legged shoe, C. All three of these legs are adjustable by means of screws, so that the apparatus can be levelled on a non-level table. [This special table is not an essential part of the outfit. A friend has a similar piece of apparatus which is supported on a shelf firmly bracketed to the wall, and finds this entirely satisfactory.]

Now briefly to enumerate the parts. AA, the square base bar, arranged with its diagonals vertical and horizontal; B, the one-legged support, here shown resting on a thick pad of pieces of cloth (the best absorber of vibrations that I know of); D, the first sliding shoe, into which screws a round vertical metal rod or lamp support; E, the gas tap for light, which by a screw can be fixed at any desired height; E is connected to the gas supply by a piece of rubber tubing; F is the holder of an inverted gas mantle. I find the "Howelite" excellent, the light is intensely brilliant and steady, and the mantles stand a surprising lot of rough usage. When not in use I lift off the part F carrying the mantle and slip it on to a piece of round wooden rod fixed into a loose triangular foot, and keep it in one of the drawers. The next four sliding shoes have vertical brass cylindrical pillars screwed into them. Inside each pillar another tube slides. This latter can be fixed at any height by a clutch screw collar, the upper part of the outer tube being cut in two places so as to permit of the taper thread forming a throttle grip. The first of these pillars G, *i.e.*, the one next the lamp, carries a "paralleliser" or condensing lens of the crossed lens type which can be centred by three screws and springs. H, the next pillar now unoccupied, can hold a water tank if required. The one, J, here carries a contrivance for holding a two-inch square colour screen in three sides of a square rebate or groove. On the other side of the circular head are two spring clips like those on the stage of a microscope. These we may use for other colour screens, and so on. J can also be used as a stage object holder for such things as shells, fossils, suitably mounted, and so on, when photographing with a short focus objective without the microscope. K, is another shoe and pillar not occupied at the moment. L, the microscope with M, a sliding baffle tube embracing (without touching) a projecting short tube in front of the camera, thus providing a light-tight joint between microscope and camera, but without contact between these two pieces. P, the bellows of the camera, is prevented from sagging by a shoe and sliding pillar arrangement Q. At C, we have the two-footed support (cloth has been removed to show details). R, is a reflector or mirror on a separate tripod foot and sliding pillar with knuckle joint at the back, fixed at any angle at will by a screw. Thus one can stand at any place along the table edge and yet see the reflected image of the focusing screen in this reflector R. On the further side of the base bar is a long steel rod. At one end is S, a large milled head used for working the fine adjustment of the microscope. At the other end, here out of sight, but shown in Figure 383, is a grooved circular disc U. This carries a silk cord which passes round the head, T, of the fine adjustment. Details shewn in Figures 378–382—V, is a pulley-weight which keeps the silk cord taut and of even tension. Going round the camera end of the table we get the view shown in Figure 383, where S is the head of the fine adjustment focusing rod. C is the two-legged support here shown resting on pads of cloth. At R we see the back of the mirror holder with screw knuckle joint, sliding pillar, and tripod foot. At U is placed a pointed bit of white card to indicate the grooved disc on the focusing rod which carries the silk cord focusing tackle. In this view we see how the camera is supported on two U-shaped or forked uprights (detachable), so that the camera can be adjusted at any height by the screws, *b*, *b*. By removing the butterfly screws, *a*, *a*, the two supporting forks lift off their respective sliding shoes. The sagging of the bellows results from removing the supporting pillar, Q, seen in the first view.

Figure 380 shows us a little more detail as to how the microscope is supported on the metal table, *d*, *d*, which is fixed to its own pair of sliding shoes by the butterfly nuts, *d*, *d*. The three feet of the microscope fit into three ring collars, *e*, *e*, *e*, on the base plate. At *f* is shown a contrivance like a shallow pill box lid of white card. This fits the distal end of the sub-stage condenser at *g*. On this are drawn two or three concentric circles in black lines by compasses. When this light-adjusting cap is *in situ* at *g* it greatly helps in adjusting the positions of the lamp, E, F, and lens, G, so as to get an even image of the mantle mesh truly centred. If now we open the camera back and look through the microscope tube we can see at a glance (*f* being removed, of course), if our light, F, and lens, G, are on the axis of the tube. At *h* we see a new form of speculum condenser consisting of a stout clear glass rod polished at one end and ground at the other end. Before leaving this figure we may glance at the silk cord and then see it in detail in Figures 378 and 382; this being, so far as I know, an entirely new design. The letters T, U and V as before refer to the milled head of the fine adjustment screw, the grooved wheel on the focusing rod, and the weight with pulley head. The pulley head is notched, so that it can be easily detached. The cord is also easily lifted off T and U, so that it remains only attached to the table *d*, *d*. It may be noted that the edge of the table under the pulley wheels of the table is cut away on both sides to facilitate the unshipping of the focusing tackle. The silk cord is so arranged that at no part of its course does the cord rub against itself, and there is quite even tension at T. *i.e.*, no side-pull at all.

Figures 379 and 381, show us the arrangement for the light-tight connection between the microscope and camera. At M we have a double tube, which, by means of a collar, slides freely on the inner draw tube K which may or may not carry an eye-piece as we may desire. Between these (inner and outer) tubes goes a similar flange-mounted tube, N, on the front of the camera as shown in Figure 381. The camera has a loose panel front fixed by four turn buttons, so that short-focus photographic objectives may be used without the microscope in conjunction with certain other contrivances which may be held over for a further note.

This apparatus has been especially made for me under the supervision of Mr. W. R. Biss (106, Elmore Street, Canonbury, London N.,) who is an enthusiastic amateur in microscope and camera matters, and to whom is due the credit of designing many of the contrivances above mentioned.

F. C. LAMBERT, M.A., F.R.P.S.

CORRECTION.—By an accident the blocks of two figures on page 272 [Volume XXXVI (1913)] have been interchanged. The description of Figure 285 should, therefore, read "*Pisidium obtusale*" which is the most globular species, and Figure 293 should be *P. millium*, the squarest.

PHOTOGRAPHY.

By EDGAR SENIOR.

PLATINUM TONING.—Although the toning of silver prints by means of a salt of platinum has not been practised to anything like the extent that gold toning has, the method is nevertheless a useful one, and at the same time capable of giving excellent results either when used alone or following after a preliminary toning with gold. The use of platinum salts in toning certainly dates back at least forty years, but it cannot be considered as having been successful until the introduction of the chloroplatinite of potassium by Mr. Willis for platinotype printing, as attempts to use the ordinary tetrachloride of platinum more often than not resulted in failure. One of the earliest, perhaps, to devise a really simple and satisfactory process of platinum toning was the late Mr. Valentine Blanchard, who supplied a matt surface printing paper together with the toning solutions for the prints made upon it. Since then, however, numerous formulae have from time to time been published for the toning of silver prints with platinum that leave little to be desired. Collodio-chloride papers especially give good results when toned in this way. When the treatment with the platinum solution follows toning with gold the following method may be recommended:—

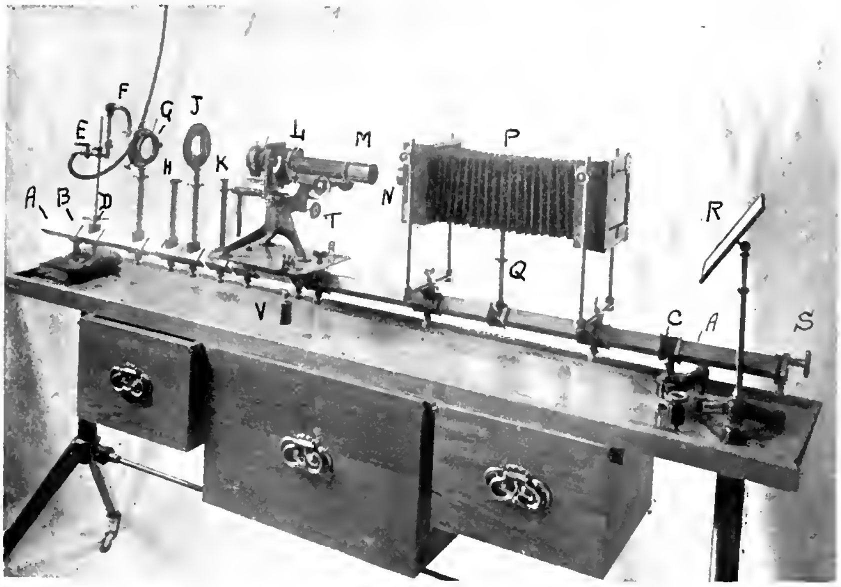


FIGURE 377.

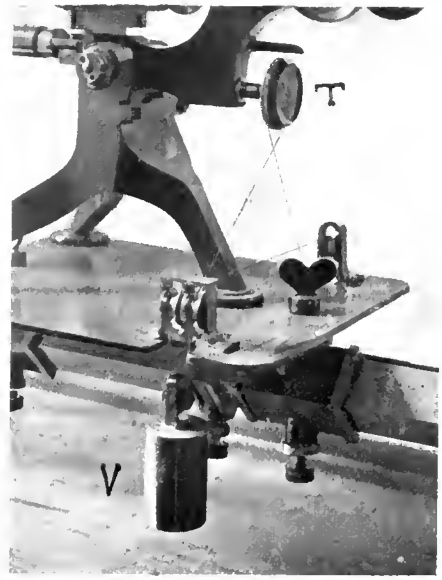


FIGURE 378.

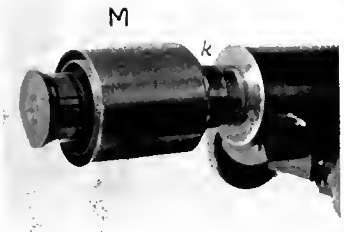


FIGURE 379.

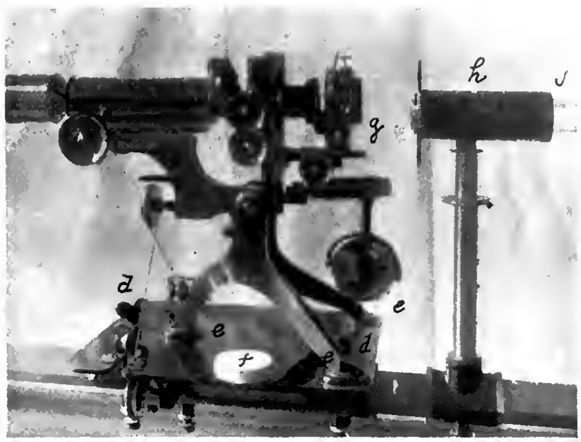


FIGURE 380.

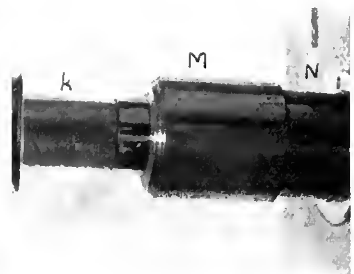


FIGURE 381.

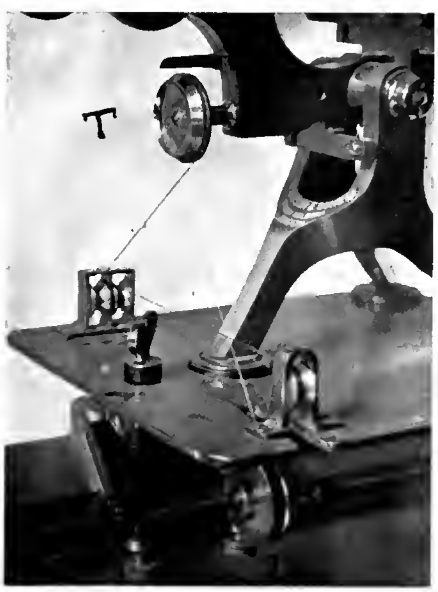


FIGURE 382.

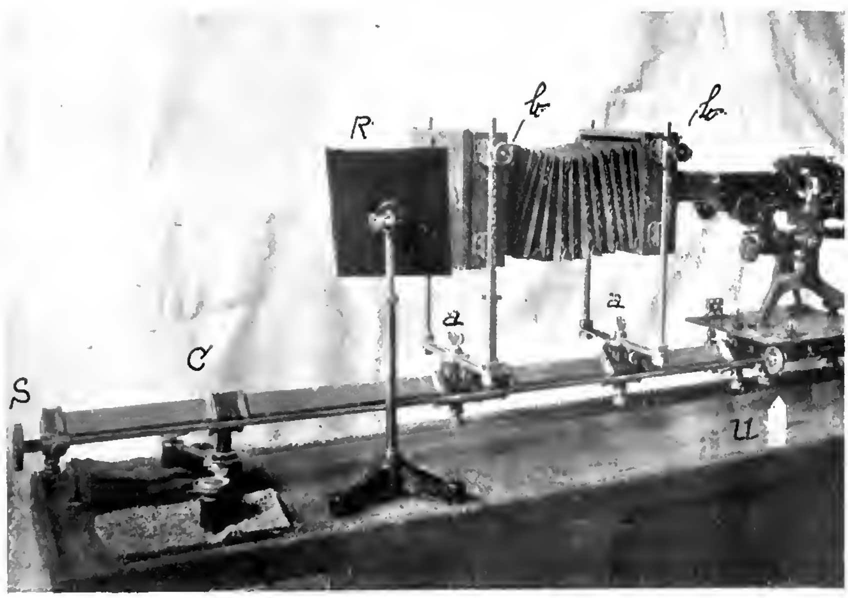


FIGURE 383.

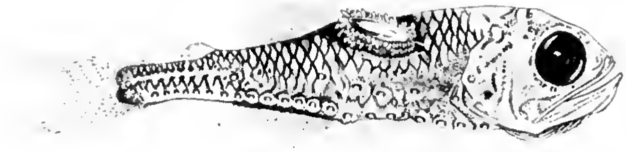


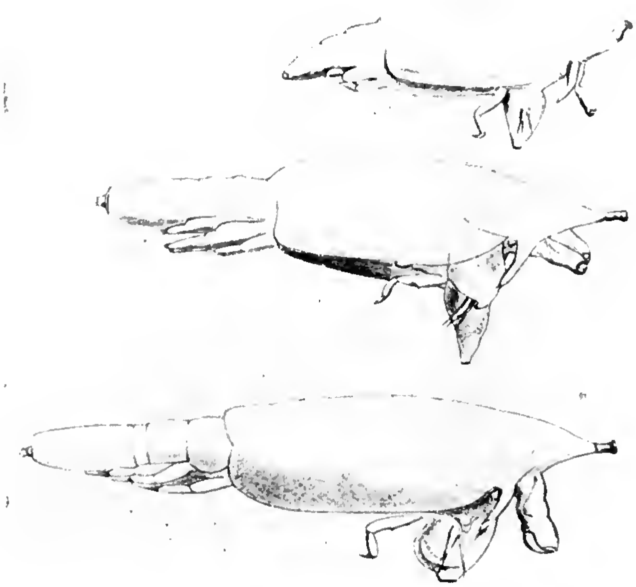
Figure 384.

The Fish (*Scopelus glacialis*) with the combined parasites, *i.e.*, the Parasitic Copepod carrying the Hydroid.

A B C

FIGURE 385.

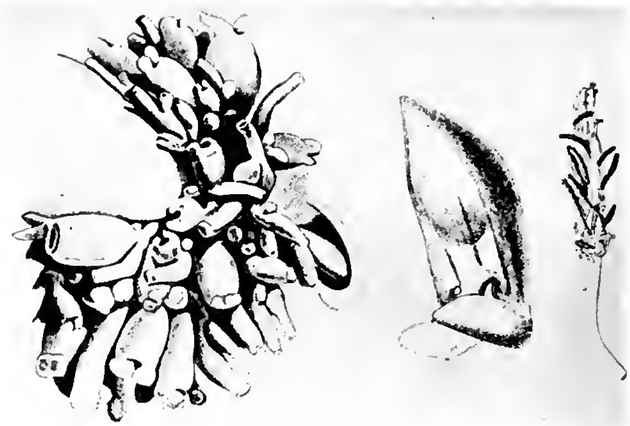
(A) The Parasitic Copepod (*Sarcotretis scopeli*) adult female with egg strings; (B) Front part of the same, dorso-lateral view; (C) Ventral aspect.



A B C

FIGURE 386.

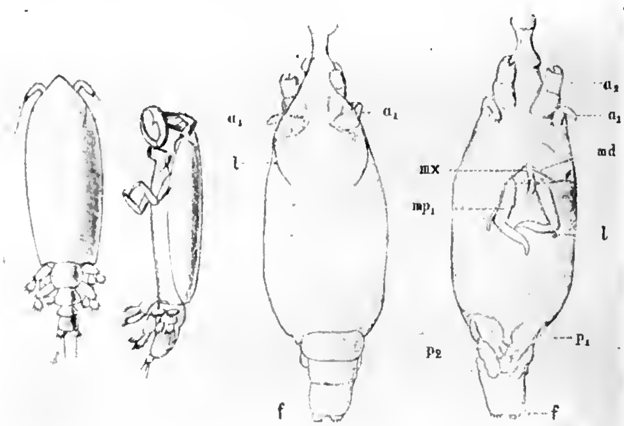
Pupal stages of *Sarcotretis*, lateral views (A) 2nd; (B) 3rd, Male specimen; (C) 4th.



A B C

FIGURE 387.

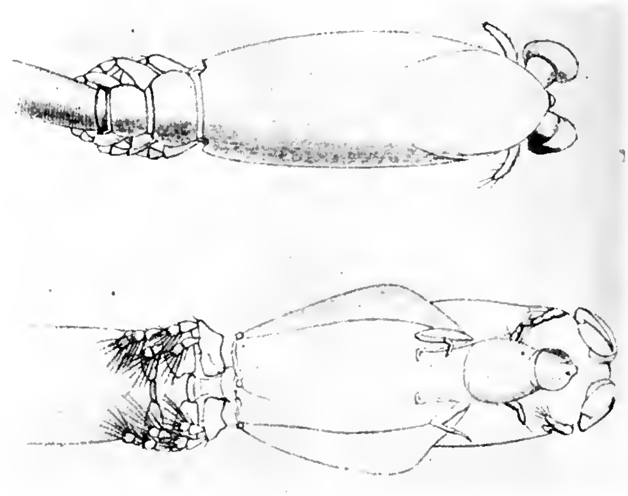
(A) The basal part of the Copepod with Polypes and Medusae-buds; (B) Large Medusae-bud; (C) Young Hydroid colony (*Ichthyocodium sarcotretis*) without Medusae-buds.



A B

FIGURE 388.

(A) Cyclops stage of *Sarcotretis*, dorsal and lateral view; (B) 1st, Pupal stage, dorsal and ventral view.



A B

FIGURE 389.

(A) Front part of young female in the boring stage, dorsal view. (B) The same somewhat more developed, ventral aspect.

A Hydroid Epizoic on a Parasitic Copepod (*see page 354*).

Wash the prints in several changes of water and then tone in the following bath—

Borax	... ...	35 grains.
Sodium Acetate	... ...	35 grains.
Water (Distilled)	... ...	7 ounces.
Gold Chloride ...	... ...	1 grain.

This solution should be made up as required, as it will not keep. The prints are toned in this to a chocolate brown. They are then rinsed and placed in the following bath—

Potassium Chloroplatinite	...	5 grains.
Water	...	10 ounces.
Phosphorous Acid, 1·12	...	75 grains.

This solution may be used over and over again until exhausted. If the preliminary toning with gold is not carried too far the final treatment in the platinum bath should yield a good black. The prints after toning are well washed and then fixed in a solution of hypo of the following strength—

Hypo	...	3 ounces.
Water	...	20 ounces.

This should be freshly prepared and about twenty grains of soda carbonate added to it when fixing platinum-toned prints, or, if preferred, the prints after toning may be rinsed, and then placed in a five per cent. solution of soda carbonate until ready for fixing. After remaining in the fixing bath for about fifteen minutes the prints should be washed in running water for two hours. When it is desired to tone with platinum only without the use of the preliminary gold bath, the following formula for the solution may be employed—

Potassium Chloroplatinite	...	½ grain.
Water	...	30 ounces.
Hydrochloric Acid ...	...	½ drachm.

or in place of the above we may use one containing chrome alum, thus—

Chrome Alum	...	120 grains.
Potassium Chloroplatinite	...	1 grain.
Water	...	10 ounces.

When the prints are toned they are placed, after a slight washing, in a five per cent. solution of soda carbonate and allowed to remain there until all are ready for fixing.

SULFINOL DEVELOPER.—A further addition to the already large number of bodies which act as developing agents has recently been made by the preparation of a substance—by M. J. Desalme—termed "Sulfinol." Those who wish to experiment with this new compound will now be able to do so, as it is being manufactured by the Société des Matières Colorante et Produits Chimiques de Saint Denis, 105, Lafayette, Paris.

Sulfinol is a bluish-grey powder only slightly soluble in water, but much more soluble in water containing soda carbonate and other alkalies. It appears to contain the sulphonic group—SO_3H, and somewhat resembles Glycin in its slowness of action. It gives soft negatives having excellent gradation and good detail in the high lights. The colour of the deposit verges on brown. The addition of bromide has the effect of greatly slowing the developing action. Sulfinol appears to be specially useful in the development of bromide prints and enlargements on account of the warm tones obtainable by its means. The developing action, however, is very slow, the image taking about three minutes to appear and requiring from seven to eight minutes for complete development; but the length of time required does not appear to cause any fogging action to take place over the lights. We append the following formula recently published by Captain R. Hergeth in "Wiener's Mitterlungen" for the preparation of a sulfinol developer for bromide paper—

Sulfinol	...	10 to 15 grams.
Soda Sulphite (Crystals)	...	40 to 50 grams.
Soda Carbonate (Anhydrous)		30 grams.
Water	...	1,000 c.c.

The soda sulphite and carbonate are first dissolved in about 200 c.c. of water and then the sulfinol added, the solution being finally made up to 1,000 c.c. with the addition of water. This developer keeps well and is always ready for use. Sulfinol may also be employed in conjunction with hydroquinone when a developer is obtained which acts much more rapidly and can be used for both plates and papers. Prints made upon bromide paper may be developed with the mixed solutions in about two minutes,—without bromide—and the image will have a pleasant warm brown colour. Some six or eight prints may be developed in the same solution, although after the first two or three it becomes much slower in its action. Finally, the sulfinol-hydroquinone developer may be said to supply the means for obtaining prints of a warm tone by direct development, and in this way is a useful alternative to that of after-toning.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

ACCESSORY CARTILAGE IN BAT'S WING.—Oskar Törne recalls attention to an interesting extra cartilage which lies to the outer side of the last joint of the little finger in all Vespertilionidae. It is not bound to any other part of the skeleton, and has considerable independent mobility. Fibrous strands of connective tissue extend from the accessory cartilage into the posterior margin of the wing, and probably move it in some independent way during flight. What the accessory cartilage really is remains obscure, and must remain so until its development in the embryo is worked out.

EXTRAORDINARY MODE OF PARENTAL CARE IN A FISH.—In one of the rivers of New Guinea the explorer Lorentz found a remarkable fish, *Kurtus gulliveri*, whose parental care has been described by Professor Max Weber. In the mature male a bony process on the back of the skull grows forwards and downwards, and forms a ring or "eye." In this, somehow or other, a wreath of eggs is attached. Each egg bears radiating filaments—over a hundred in number—which unite into strings, and these form a cylindrical band. This band passes through the bony ring, and the male carries the eggs on the top of his head. The details of the curious attaching filaments which fasten the eggs together have recently been studied by Professor F. Guitel, who compares the filaments with those of another fish, *Clinus argentatus*. The adaptation is very remarkable, and one would like to know more in regard to the manner in which the eggs come to be fastened to the bony ring.

THE HERMIT CRAB AND ITS BORROWED SHELL.—In his recently published memoir on the Hermit Crab—an admirable piece of work—Mr. H. Gordon Jackson discusses the old question whether the crustacean forcibly ejects the mollusc. Bell argued from the frequent freshness of the shells that the hermit must eat the mollusc out of its home, and fishermen sometimes catch the soldier hermit crab (*Eupagurus bernhardus*) devouring a whelk. But Mr. Gordon Jackson points out that while the argument and the observation are both sound they do not prove that the hermit crab attacks the living Gastropod. "In the first place it is not very conceivable that a hermit crab would have the strength to remove bodily, or the appetite to devour, an extremely tough animal like the whelk." In the second place it is well known that "the cod feeds very largely on the whelk, and that nothing but the operculum is ever found in the fish's stomach. The mollusc's fleshy portion (chiefly the foot and head) must therefore be bitten off while expanded—a comparatively simple matter to the active and powerful Teleost—leaving the softer (visceral) parts inside the snell." The hermit crab may then clean up the remains and ensconce itself in the emptied shell.

CHEMISTRY OF THE SILKWORM.—R. Inouye finds that the chemical composition of the silkworm is greatly changed in the metamorphosis, but there is not much difference between pupa and moth. There is no loss of nitrogen in gaseous form during the metamorphosis. During the pupal and moth stages the greater part of the fat accumulated by the silkworm is consumed. In the pupal and moth stages the waste of body protein is repaired with amino-acids, and a part of the latter is further transformed into ammonia. Splitting of the protein in the silkworm is caused by the action of some proteolytic enzyme.

GEOGRAPHICAL DISTRIBUTION OF BED-BUGS.—The family of bugs known as Cimicidae is nowadays represented all over the world—seven species in Europe, six in Africa, five in Asia, two in Australia, and seven in America. The two Australian species are importations by man, and the same two have been introduced into America. Dr. G. Horvath, of Budapest, has been recently looking into the matter, and finds reason to believe that the common bed-bug (*Cimex lectularius*) is indigenous in the Mediterranean region, whence it has spread everywhere. The other bed-bug in the strict sense is *Cimex hemipterus*, a native of tropical regions of Africa and Asia, whence it also has been transported to various parts of the world, such as the Antilles and Brazil. Dr. Horvath thinks that both species of bed-bugs were, like most of their fellow-species, parasites of bats to begin with, and that they shifted their attention from bats to man.

A MARINE BUG.—In 1878 Baron Bonnaire discovered a marine Hemipteron, *Aëpophilus bonnairei*, which lives under deeply imbedded stones at low tide. It can live for days under water—indeed, it often occurs at levels which are not uncovered except at very low tides. It also occurs higher up in the Fucus zone. More information in regard to its distribution has been recently collected by R. Lienhardt, who points out that the insect probably gets into crevices with imprisoned air. More than one naturalist has found it on the back of a starfish and among worm-tubes and the like. There are records of its occurrence from Cornwall, the Channel Islands, Wimereux, Tatihou, Roscoff, Concarneau, Ile de Ré (where it was first found), and from Galicia.

FORAMINIFERA AS WORLD-BUILDERS.—From Cambrian times or even earlier the shells of Foraminifera have contributed notably to the crust of the earth. Messrs. Heron-Allen and Earland have contrasted the contributions made in different geological ages. Thus there is but a single record of Foraminifera for the Devonian, while in the Carboniferous they began to form enormous deposits. There were many forms in the Cretaceous, but they did not form the great deposits characteristic of the Foraminiferal Golden Age in the beginning of the Tertiary times. Nowadays, as everyone knows, a few pelagic genera are building up great deposits of Globigerina ooze on the floor of the deep sea. In regard to the beds of chalk ranging from the Chalk Marl to the Upper Chalk, the authors make a useful note: "It is one of those popular beliefs which die so hard that chalk is made up entirely of the shells of the Foraminifera, and the textbooks and microscopical works abound with statements to that effect. . . . The so-called 'spheres' of the chalk are perhaps the origin of the belief that chalk is built up of the shells of Foraminifera. But, whatever the 'spheres' may be, we are convinced that they are not Foraminifera." They may be the firm tests of Infusorians. There are, indeed, plenty of Foraminifera in many zones of the Chalk, but in most cases their number is small compared with the whole bulk of amorphous matter.

A HYDROID EPIZOIC ON A PARASITIC COPEPOD

AT the Portsmouth Meeting of the British Association, held in 1911, Professor Hector Jungersen, of Copenhagen University, read a paper on a new Gymnoblastic Hydroid (*Ichthyocodium sarcotretis*) epizoic on a new Parasitic Copepod (*Sarcotretis scopeli*) infesting *Scopelus glacialis* Ros.

Professor Jungersen very kindly allowed us to copy the lantern slides which he exhibited at the time, and these are now reproduced on page 352 to illustrate his interesting description, which is as follows:—

The Hydroid coats more or less of the external part of a parasitic Copepod deeply sunk into the body of *Scopelus glacialis* (see Figure 384, page 352). It consists of:—

(1) Polypes, devoid of tentacles and growing from a network of delicate tubes in a basal membrane without perisarc; and:—

(2) Medusae-buds, arising from the base of the polypes. The largest buds possess a bell with two marginal tentacles, four simple radial canals and a manubrium. When fully developed they are set free as Medusae (Anthomedusae). This new Hydroid, *Ichthyocodium sarcotretis* (see Figure 387), is related to *Hydrichthys mirus* Fewkes, epizoic on the fish *Seriola zonata*. With the *Hydrichthys* it has to be adopted into the family of Corynidae, as defined by Stechow (1909). The Parasitic Copepod, *Sarcotretis scopeli* (see Figure 385), represents a new genus and species of the family Lernaeidae, allied to genera like *Peroderma*, *Lernaeënicus*, *Lernaea* and *Pennella*.

The adult female has an elongated body, the middle part of the long genital segment constricted into a narrow, firmly chitinized stalk; only the distal claviform part behind the stalk protrudes outside the host. Cephalothorax with dorsal shield fully preserved; two large clumsy outgrowths arise below the margins of the shield, but no other outgrowths are present. No eyes are visible. Antennules are linear, antennae cheliform, the sipho large; only one pair of maxillipeds; three pairs of abdominal feet, the two anterior biramous, the posterior with a single ramus; three free abdominal segments with terga and sterna well developed. It is found in the eastern part of the Atlantic, inserted into the body of *Scopelus glacialis*, the body wall of which it pierces, penetrating to the alimentary tract.

A series of *Metamorphosis-stages* has been found on the same species of fish, namely,

(1) A *Cyclops-stage* (see Figure 388) resembling that of *Lernaea branchialis* and capable of moving along on its host and of attaching itself by means of its strong cheliform antennae.

(2) Four *Pupal-stages* (see Figures 388 and 386) passively fixed to their host by means of a hardened secretion from the rostrum. Inside the last Pupa the copulatory form has been observed. After impregnation the female takes up parasitic life anew, but in a more intense form; it pierces the skin of *Scopelus glacialis*, and, gradually growing, it penetrates through the muscles and reaches by and by the intestines of the host.

The triple association between the Fish, the Copepod, and the Hydroid seems to be a regular one: of fourteen adult *Sarcotretes* seven carry the *Ichthyocodium*; and the loss of tentacles in the Polypes of the latter seems to show that the Hydroid in some way or other depends on the Fish for getting its food.

THE FACE OF THE SKY FOR OCTOBER.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 60.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Uranus. R.A.	Uranus. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Oct. 2	12 31.9	S. 3.4	14 28.3	S. 18.7	13 15.5	S. 8.0	10 36.6	N. 9.9	6 38.2	N. 23.5	18 40.2	S. 23.4	5 9.2	N. 21.2	20 24.6	S. 20.0	8 0.0	N. 20.1
,, 7	12 50.1	5.4	19 23.4	S. 26.9	13 44.2	11.4	10 59.7	7.7	6 48.5	23.5	18 42.2	23.4	5 9.1	21.2	20 24.4	20.0	8 0.3	20.1
,, 12	13 8.5	7.3	23 19.0	S. 5.0	14 12.4	14.6	11 22.6	5.5	6 58.2	23.4	18 44.5	23.3	5 8.7	21.2	20 24.3	20.0	8 0.5	20.1
,, 17	13 27.0	9.1	2 59.2	N. 21.4	14 40.0	17.4	11 45.4	3.2	7 7.3	23.3	18 47.1	23.3	5 8.2	21.2	20 24.3	20.0	8 0.7	20.1
,, 22	13 45.8	10.9	7 41.7	N. 26.0	15 7.1	19.8	12 8.1	N. 0.8	7 15.8	23.2	18 49.9	23.2	5 7.4	21.2	20 24.4	20.0	8 0.9	20.1
,, 27	14 4.9	S. 12.7	12 13.8	S. 2.5	15 33.0	S. 21.8	12 30.9	S. 1.6	7 23.4	N. 23.2	18 53.0	S. 23.2	5 6.5	N. 21.1	20 24.6	S. 19.9	8 1.0	N. 20.1

TABLE 61.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Mars. P	Mars. B	Mars. L	Mars. T	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
Greenwich Noon.	°	°	°	°	°	°	°	h. m.	°	°	°	°	h. m.	h. m.
Oct. 2	+26.2	+6.6	348.2	+17.5	−20.9	+5.4	299.2	4 10 *e*	−5.2	−1.6	253.5	110.2	2 56 *e*	6 54 *e*
,, 7	26.4	6.3	282.2	− 7.5	19.8	6.3	251.5	7 26 *e*	5.4	1.5	322.1	140.7	10 54 *e*	6 4 *e*
,, 12	26.4	6.0	216.3	−21.5	18.6	7.1	203.9	10 41 *e*	5.6	1.5	30.7	171.2	9 1 *e*	5 13 *e*
,, 17	26.3	5.6	150.3	−15.6	17.4	7.8	156.4	1 17 *m*	5.9	1.5	99.2	201.5	7 9 *e*	4 23 *e*
,, 22	25.9	5.2	84.4	+ 9.1	16.3	8.4	109.1	4 32 *m*	6.2	1.5	167.7	231.9	5 16 *e*	3 33 *e*
,, 27	+25.4	+4.8	18.4	+21.9	−15.3	+9.0	61.9	7 45 *m*	−6.5	−1.5	236.1	262.1	3 24 *e*	2 43 *e*

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Mars, T is the time of passage of Fastigium Aryn across the centre of the disc. In the case of Jupiter, L_1 refers to the equatorial zone; L_2 to the temperate zones; T_1, T_2 are the times of passage of the twozero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

The asterisk indicates the day following that given in the date column.

THE SUN continues his Southward march, but with slackening speed. Sunrise during October changes from 6.1 to 6.53, sunset from 5.39 to 4.35. Its semi-diameter increases from 16′ 0″ to 16′ 9″. Outbreaks of spots in high latitudes should be watched for.

MERCURY is an evening star. It reaches greatest elongation (23½° E) on November 2nd, but, being South of Sun, is not well placed for observation by Northern observers. Illumination diminishes from Full to ⅔. Semi-diameter increases from 2½″ to 3″.

VENUS is a morning star, rising 3 hours before the Sun. Semi-diameter diminishes from 6″ to 5½″. At beginning of month ⅚ of disc is illuminated; at end of month $\frac{9}{10}$. Being North of Sun it is favourably placed for Northern observers.

THE MOON.—First Quarter $7^d\ 1^h\ 46^m$ *m*; Full $15^d\ 6^h\ 7^m$ *m*; Last Quarter $22^d\ 10^h\ 53^m$ *e*. New $29^d\ 2^h\ 29^m$ *e*. Apogee $12^d\ 3^h$ *e*, semi-diameter 14′ 44″. Perigee $28^d\ 4^h$ *m*, semi-diameter 16′ 36″. Maximum Librations, 5^d 8° W, 5^d 7° N, 20^d 7° S., 21^d 6° E. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

MARS is a morning Star, in Gemini, semi-diameter 4½″, defect of illumination over a second. It will reach Opposition early in January, so the season of observation is beginning. The North Pole is now turned towards us.

TABLE 62. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.		h. m.	
Oct. 2	BAC 4867	6.4	5 56 *e*	77°	—	—
,, 4	BAC 5603	6.0	5 2 *e*	100	6 18 *e*	273°
,, 10	39 Aquarii	6.2	7 32 *e*	16	8 34 *e*	277
,, 11	45 Aquarii	6.1	0 11 *m*	69	1 15 *m*	224
,, 13	BAC 57	6.3	5 53 *e*	115	6 9 *e*	181
,, 14	ε Piscium	4.5	7 15 *e*	79	8 18 *e*	211
,, 16	27 Arietis	6.4	6 1 *e*	113	6 37 *e*	194
,, 17	66 Arietis	6.1	9 59 *e*	94	11 0 *e*	213
,, 19	BAC 1648	6.4	11 13 *e*	44	0 10* *m*	289
,, 21	BD+26°1481	7.0	—	—	8 59 *e*	234
,, 21	BAC 2383	6.5	10 21 *e*	49	11 2 *e*	314
,, 28	BD−8°3456	6.8	—	—	4 58 *m*	242

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

The asterisk indicates the day following that given in the date column.

JUPITER is now rather low in the West. Polar semi-diameter, 17½″ in mid-October.

TABLE 63.

Day.	West.		East.	Day.	West.		East.
Oct. 1	432	○	1	Oct. 17	43	○	12
,, 2	43	○	2● 1●	,, 18	42	○	3● 1●
,, 3	431	○	2	,, 19	421	○	3
,, 4	24	○	13	,, 20	4	○	$\overset{2}{1}$3
,, 5	21	○	43	,, 21	1	○	32 4●
,, 6		○	1234	,, 22	$\frac{2}{3}$	○	14
,, 7	1	⊙	24	,, 23	312	○	4
,, 8	32	○	14	,, 24	3	○	124
,, 9	31	○	4 2●	,, 25		⊙	4 3● 1●
,, 10	3	⊙	24	,, 26	21	○	34
,, 11	2	○	134	,, 27		○	2134
,, 12	21	○	43	,, 28	1	○	324
,, 13	4	○	123	,, 29	23	○	41
,, 14	41	○	32	,, 30	34$\overset{2}{1}$	○	
,, 15	432	○	1	,, 31	43	○	12
,, 16	4312	○					

Configuration at 6^{h} 30^{m}*m* for an inverting telescope.

Satellite phenomena visible at Greenwich, 1^{d} 8^{h} 22^{m} I. Tr. I., 9^{h} 41^{m} I. Sh. I.; 2^{d} 5^{h} 37^{m} I. Oc. D., 8^{h} 4^{m} 36^{s} II. Ec. R.; 9^{h} 12^{m} 41^{s} I. Ec. R.; 3^{d} 6^{h} 29^{m} I. Sh. E.; 7^{d} 5^{h} 57^{m} III. Tr. I., 9^{h} 16^{m} III. Tr. E.; 9^{d} 7^{h} 33^{m} I. Oc. D.; 10^{d} 6^{h} 5^{m} I. Sh. I., 7^{h} 5^{m} I. Tr. E., 8^{h} 24^{m} I. Sh. E.; 11^{d} 5^{h} 25^{m} II. Sh. E., 5^{h} 36^{m} 30^{s} I. Ec. R.; 13^{d} 7^{h} 44^{m} IV. Sh. I.; 16^{d} 7^{h} 54^{m} II. Oc. D.; 17^{d} 6^{h} 44^{m} I. Tr. I., 8^{h} 1^{m} I. Sh. I.; 18^{d} 5^{h} 9^{m} II. Sh. I., 5^{h} 25^{m} 43^{s} III. Ec. D., 5^{h} 29^{m} II. Tr. E., 7^{h} 31^{m} 33^{s} I. Ec. R., 8^{h} 1^{m} II. Sh. E., 8^{h} 44^{m} 34^{s} III. Ec. R.; 21^{d} 5^{h} 24^{m} IV. Oc. D., 8^{h} 43^{m} IV. Oc. R.; 5^{h} 19^{m} II. Tr. I., 5^{h} 56^{m} I. Oc. D., 7^{h} 44^{m} II. Sh. I., 7^{h} 47^{m} III. Oc. R., 8^{h} 10^{m} II. Tr. E.; 26^{d} 5^{h} 31^{m} I. Tr. E., 6^{h} 45^{m} I. Sh. E.; 27^{d} 5^{h} 18^{m} 31^{s} II. Ec. R.; 30^{d} 5^{h} 44^{m} IV. Sh. E. All these are in the evening hours, the planet setting before midnight. Attention is called to the double eclipses of 2^{d}, 18^{d}, 25^{d}. On the 25th there is only one satellite visible outside the disc. Satellites 1, 2, 4, are all near together on 30th.

SATURN is a morning star. in Taurus, in a good position for observation. Polar semi-diameter 9″. P. is −4°·9; ring major axis 46″, minor 20½″. The ring is very widely open. It is of interest to examine the exact amount of overlap beyond the planet's pole.

East Elongations of Tethys (every fourth given), 2^{d} 0^{h}·6*m*, 9^{d} 1^{h}·8*e*, 17^{d} 3^{h}·0*m*, 24^{d} 4^{h}·2*e*, Nov. 1^{d} 5^{h}·4*m*; Dione (every third given), 1^{d} 2^{h}·3*e*, 9^{d} 7^{h}·4*e*, 18^{d} 0^{h}·4*m*; 26^{d} 5^{h}·4*m*; Rhea (every second given), 3^{d} 7^{h}·9*e*, 12^{d} 8^{h}·7*e*, 21^{d} 9^{h}·5*e*, 00^{d} 10^{h}·2*e*. For Titan and Iapetus E.W. mean East and West Elongations; I. Inferior (North) Conjunctions, S. Superior (South) ones. Titan, 1^{d} 7^{h}·4*e* I., 5^{d} 3^{h}·8*e* W.; 9^{d} 3^{h}·2*e* S., 13^{d} 6^{h}·1*e* E., 17^{d} 5^{h}·9^{d}*e* I., 21^{d} 2^{h}·3*e* W., 25^{d} 1^{h}·5*e* S., 29^{d} 4^{h}·1*e* E.; Iapetus, 20^{d} 7^{h}·4*m* I.

URANUS is an evening star. Semi-diameter, 1¾″. About 2° S. of ρ Capricorni.

NEPTUNE is a morning star.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant.			Remarks.
	R.A.		Dec.	
	°		°	
July to Oct. ...	355	+	72	Swift, short.
Aug. to Oct. 2	74	+	42	Swift, streaks.
Sep. 28 to Oct 9	320	+	40	Slow, small.
Oct. 2 ...	230	+	52	Slow, bright.
,, 4 ..	310	+	79	Slowish.
,, 8 ...	77	+	31	Swift, streaks.
,, 8-14 ..	45	+	58	Small, short.
,, 14 ...	133	+	68	Rather swift.
,, 15 ...	31	+	9	Slow.
,, 18-20 ...	92	+	15	Swift, streaks.
,, 23 ...	100	+	13	Swift, streaks.
,, 29 ...	109	+	23	Very swift.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 22^{h} to 2^{h}, next month 0^{h} to 4^{h}, and so on.

TABLE 64. NON-ALGOL STARS.

Star.	Right Ascension	Declination	Magnitudes.	Period.	Date of Maximum.
	h. m.	°		d.	
X Aquarii	22 14	−21 ·3	7·6 to 11	315	July 31.
TX Pegasi	22 14	+13 ·2	8·5 to 9·2	123	July 20, Nov. 20.
S Lacertae	22 25	+39 ·8	8·0 to 12·5	237·5	July 29.
R Lacertae	22 39	+41 ·9	8·3 to 13·9	299·8	July 1.
U Lacertae	22 44	+54 ·7	8·5 to 9·1	659	July 5.
S Aquarii	22 52	−20 ·8	8·0 to 14·5	279·7	July 25.
SS Andromedae	23 8	+52 ·4	8·9 to 9·6	165·8	Aug. 5.
TY Andromedae	23 10	+40 ·3	8·2 to 9·6	144	Oct. 19.
W Pegasi	23 15	+25 ·8	7 to 13	342·6	Aug. 13.
S Pegasi	23 16	+ 8 ·4	7·3 to 13·1	317·5	Aug. 10.
R Aquarii	23 39	−15 ·8	6·0 to 10·8	387·16	Oct. 6.
V Cephei	23 52	+82 ·7	6·2 to 7·0	362	Nov 20.
R Cassiopeiae...	23 54	+50 ·9	4 8 to 13·2	431·6	July 21.
V Cassiopeiae...	23 59	+55 ·2	8·4 to 13·9	410	Nov. 22.
SS Cassiopeiae	0 5	+51 ·1	8·5 to 11·7	139·6	Sep. 6.
T Ceti	0 17	−20 ·5	5·4 to 6·9	280·6	Oct. 16 (min.)
T Cassiopeiae...	0 19	+55 ·3	6·7 to 12·5	443·0	Oct. 7.
TU Cassiopeiae	0 22	+50 ·8	7·7 to 8·5	59	Oct. 29.
TU Andromedae	0 28	+25 ·5	7·7 to 11	317	Oct. 27.
RX Cephei	0 43	+81 ·5	7·4 to 7·9	130	Oct. 24 (min.)
RV Cassiopeiae	0 48	+46 ·9	8 to 13	327	Oct. 24.
Z Ceti	1 2	− 1 ·9	8·8 to 13·5	184·5	Oct. 6.
S Piscium	1 13	+ 8 ·5	8·2 to 14·7	404·45	Sep. 6.
X Cassiopeiae	1 51	+58 ·8	8·4 to 12.2	367·0	Nov. 22.

β Lyrae minima Oct. 13^{d} 9^{h}*e*, 26^{d} 7^{h}*e*, Period 12 21·8^{h}.

Algol minima Oct. 1^{d} 4^{h} 21^{m}*e*, 10^{d} 6^{h} 48^{m} *m*, 13^{d} 3^{h} 37^{m}*m*, 16^{d} 0^{h} 26^{m}*m*, 18^{d} 9^{h} 15^{m}*e*, 21^{d} 6^{h} 3^{m}*e*, Period 2^{d} 20·8^{h}.

THE PLUMAGE QUESTION.

NEARLY thirty years have now passed since an organised effort was begun in this country to discourage the fashion of wearing the plumage of beautiful wild birds. The late Mr. George Musgrave, in the year 1885, founded the Selborne Society for the preservation of birds of beautiful plumage; rare and useful birds; and pleasant places.* About the same time, namely, on December the 18th of that year, the Rev. F. O. Morris wrote to *The Times* advocating the formation of a Plumage League and this became the plumage section of the Selborne Society. From the comments made by the Editor of *The Gentleman's Magazine* upon a letter received from Mr. Musgrave, we gather that the latter had learned the difficulty of enforcing protective Acts and relied upon persuasion to overcome the results of fashion.

A prospectus of the Selborne Society, dated December, 1885, states that its object was to discourage the wholesale destruction of birds, and that the trade had plenty of material available "in the feathers of birds killed for food, the game birds of the world, and of birds farmed or protected for their plumage." The support which the Society got from public men like Tennyson, Avebury, Leighton, John Ruskin, and Robert Browning, as well as from many lady members of the aristocracy, enabled it to wield considerable influence, and to arouse an interest in the preservation of birds.

One result of this was that in the year 1889, a special Society (now the Royal Society) for the Protection of Birds was brought into existence. Its object that bears upon the plumage question reads as follows:—"To discourage the wanton destruction of birds and the wearing of feathers of any bird not killed for the purposes of food, other than the Ostrich, but to take no part in the question of the killing of game birds and legitimate sport of that character." Of recent years the energies of this Society have been directed towards obtaining legislation which will prevent the importation of plumage, but none of the Bills which have been produced have become law; for it is obvious that without some international agreement, the trade in feathers, which is not an inconsiderable one, belonging to this country would simply be transferred to the Continent.

In the meantime fashions which call for feathers still prevail, and the killing of birds goes on. A moment's thought shows that it is to the interest of the plumage trade that the supply of feathers for which there is demand should not fail through the extinction of the species producing them. The result of domesticating the Ostrich has been little short of marvellous from the commercial point of view, and it seemed possible that if the naturalists and the traders were to find some common programme, even if their ultimate objects were by no means the same, something might be done to save species in immediate danger of extermination.

Mr. S. L. Bensusan, the well-known writer, and the Secretary of the Selborne Society happened to discuss the matter informally, and the latter brought it before the Council of the Society which empowered him and Mr. Holte Macpherson to confer with others including members of the trade. The result, after much delicate negotiation, was the formation of the Committee for the Economic Preservation of Birds. On this body there are members specially appointed by the Selborne Society and also by the London Chamber of Commerce. The British Ornithologists' Union has accepted the invitation to appoint a delegate, but the Royal Society for the Protection of Birds has not yet done so. As will be seen from the list which we print below, many of the leading zoölogists have joined the Committee which is hard at work collecting information bearing on the question.

Quite recently (on August the 4th) another Bill was brought before the House of Commons forbidding the importation of any plumage except that of Ostriches and Eider Ducks. Licences may be granted for the importation of specimens for museums and for scientific research, but no provision is made for the obtaining of feathers by fly-fishermen. The bill is open to the same objection as has been raised in previous cases; moreover, plumage forming part of wearing apparel can be brought in by the owners, and birds may be imported alive. If any attempt is made to bring in living specimens for trade purposes the amount of mortality will be very great and the result of the bill if it becomes law will be to encourage the killing of British birds for their plumage, though the Secretaries of State and the Lord Lieutenant of Ireland are given power by the Bill to make orders for the protection of wild birds independently of County and Borough Councils, probably with an eye to remedying the possible evil results to which allusion has just been made.

THE COMMITTEE FOR THE ECONOMIC PRESERVATION OF BIRDS.

F. G. AFLALO, F.R.G.S., F.Z.S.
†‡S. L. BENSUSAN.
Professor GILBERT BOURNE, D.Sc., F.R.S., Sec. L.S. (University of Oxford).
WALTER E. COLLINGE, M.Sc., F.L.S., F.E.S.
Professor A. DENNY, M.Sc. (University of Sheffield).
†C. F. DOWNHAM (Member of the London Chamber of Commerce).
F. MARTIN DUNCAN, F.R.P.S., F.R.M.S.
†G. K. DUNSTALL (Member of the London Chamber of Commerce).
Professor JAMES COSSAR EWART, M.D., F.R.S. (University of Edinburgh).
Professor F. W. GAMBLE, D.Sc., F.R.S., F.Z.S., (University of Birmingham).
Professor J. STANLEY GARDINER, M.A., F.R.S., F.Z.S. (University of Cambridge).
Professor MARCUS HARTOG, M.A., D.Sc., F.L.S. (University College, Cork).
W. D. HENDERSON, M.A., B.Sc., Ph.D. (University of Bristol).
Professor J. P. HILL, D.Sc., F.L.S., F.Z.S. (University of London).
MATTHEW DAVENPORT HILL, M.A., F.Z.S. (Eton College).
H. KNIGHT HORSFIELD.
COLLINGWOOD INGRAM.
†LOUIS JOSEPH (Member of the London Chamber of Commerce).
†Professor H. MAXWELL LEFROY (Imperial College of Science),
†A. HOLTE MACPHERSON, M.A., B.C.L., F.Z.S. (Vice-President of the Selborne Society).
Professor A. MEEK, M.Sc., F.L.S. (University of Durham).
†P. CHALMERS MITCHELL, LL.D., D.Sc., F.R.S. (Secretary of the Zoölogical Society of London).
†C. E. MUSGRAVE (Secretary of the London Chamber of Commerce).
Professor ROBERT NEWSTEAD, M.Sc., F.R.S., A.L.S. (University of Liverpool).
†HUBERT H. POOLE (Librarian of the Selborne Society).
HUGH SCOTT, M.A., F.L.S. (University Museum of Zoölogy, Cambridge).
†W. LUTLEY SCLATER, M.A. (British Ornithologists' Union).
C. G. SELIGMANN, M.B., F.R.C.P. (University of London).
The Rev. THOMAS R. R. STEBBING, M.A., F.R.S., F.L.S.
Professor D'ARCY W. THOMPSON, C.B., D.Litt. (University College, Dundee).
H. W. MARETT TIMS, M.A., M.D., F.L.S., F.Z.S. (University of London).
†‡WILFRED MARK WEBB, F.L.S., F.R.M.S. (Secretary of the Selborne Society).
W. PERCIVAL WESTELL, F.L.S., M.B.O.U.
MARCUS WOODWARD.

The Honorary Secretaries, who may be addressed c/o The Selborne Society, 42, Bloomsbury Square, would be very glad to have the names of others who would care to join the Committee.

* *The Gentleman's Magazine*, December, 1885, page 619.

† Members of the Executive Committee. ‡ Honorary Secretaries.

REVIEWS.

CHEMISTRY.

Practical Agricultural Chemistry.—By S. J. M. AULD, D.Sc., F.I.C., and D. R. EDWARDES-KER, B.A., B.Sc. 243 pages. 32 illustrations. 8-in. × 5-in.

(John Murray. Price 5/- net.)

The authors of this handbook call attention to the fact that students at agricultural colleges frequently finish their course without having grasped the essential connection between their laboratory work and the chemical changes in Nature which it is intended to make clear. For this reason they have dwelt fully on the qualitative examination of plant products, which in their experience is likely to be of more service to the general student than the study of quantitative methods. On this point, however, we should be inclined to differ from them, since there can be little doubt qualitative chemistry gains much by being taught quantitatively. It must not be inferred from this that quantitative work is neglected, for full outlines are given of methods of analysing plants and their constituents, soils, fertilisers, and feeding stuffs, and dairy products, the ground covered being that required for the London B.Sc. degree in Agricultural Chemistry. In general these methods are accurate and up-to-date, although inaccuracies may be noted in certain places. For example, in the determination of the Iodine value by Hübl's method insufficient time is allowed for the absorption, and the iodine value given for linseed oil (172) is far lower than is usual when a longer time is allowed. A little more space might have been given with advantage to some special subjects, such as, for instance, the analysis of water and the difficult problem of interpreting the analytical results.

C. A. M.

A Text-book of Experimental Metallurgy and Assaying.—By A. ROLAND GOWER. 163 pages. 50 illustrations. 7½-in. × 5-in.

(Chapman & Hall. Price 3/6 net.)

Metallurgical processes are too often learned by rote without any thorough understanding of the chemical reäctions upon which they are based. Such rule-of-thumb methods may give good results with the more common ores, but leave the metallurgist at a loss when he is called upon to assay minerals of unusual composition. The author of this book, therefore, rightly lays stress upon the necessity for the student to learn the chemistry of metallurgy, though he assumes that some elementary knowledge has already been acquired. The book has been considerably enlarged since its first appearance many years ago, and now covers the ground required for the Lower Examination of the Board of Education in this subject. The exercises are simply described and good diagrams are provided where necessary, so that the book should prove most helpful to beginners. Among the various assays is included a section on the examination of fuels, including the determination of the calorific value. The value of this would have been increased by directions for obtaining an average sample, which is one of the chief difficulties in the analysis of coal.

C. A. M.

An Introduction to the Chemistry of Plant Products.—P. Haas, D.Sc., and T. G. Hill, A.R.C.S., F.L.S. 401 pages. 9½-in. × 6-in.

(Longmans, Green & Co. Price 7/6 net.)

The aim of this book is to enable students of botany and vegetable physiology to understand the nature of the chemical changes that take place in plants, and the biological meaning of those changes. The principal groups of chemical constituents in plants, such as fats, carbohydrates, pigments, proteins, and enzymes are, therefore, described at some length, their chief qualitative reactions and methods for their estimation being also outlined in each of the sections. As a rule, the analytical methods given are full enough for a trained chemist to follow without having recourse to another work, but in some instances either too much or too little detail is given. This is notably the case in the section dealing with the analysis of the fats and oils, where the directions are more than are required for understanding the meaning of an analysis, but are not sufficient to obviate the need of reference to other books. For instance, since the analytical methods are given at length, tables of the values of the principal vegetable oils and fats should have been added as an aid to the interpretation of the results.

In this connection it may be noted that the insoluble bromide test, devised by Hehner and the present reviewer, is here incorrectly described as the "hexabromide test," whereas the evidence points to the compound being the bromide of a mixed glyceride and certainly not a hexabromide. But these are only minor defects in a most valuable book, which ought to find a place upon the shelves of every agricultural chemist and botanist. It should be added that there is an excellent index, and that full references are given in footnotes to the authorities quoted in the text.

C. A. M.

GEOGRAPHY.

Maps and Survey.—By ARTHUR R. HINKS. 206 pages. 24 illustrations. 8¾-in. × 5½-in.

(The Cambridge University Press. Price 6/- net.)

Those interested in Geography, and particularly those connected with the teaching of the subject in universities and colleges, have to thank Mr. Hinks for two valuable contributions this year to the available literature on the practical side of the science. Except for official publications of this country and the United States, the systematic works on maps and map-making in English have been special treatises by pure mathematicians, or articles in the encyclopædias. In "Maps and Survey," as in "Map Projections," the demand on the mathematics of the reader is not large, and the special needs of the geographer have been kept in the forefront.

The present volume consists of chapters on Maps, Map Analysis, Route Traversing, Simple Land Survey, Compass and Plane Table Sketching, Topographical Survey, Geodetic Survey and Survey Instruments. There are numerous illustrations, mostly of a high order, and the student who can handle and examine the instruments and engage in simple exercises easily devised will obtain from this cheap and well-written book training of a nature his predecessors found it difficult to acquire.

No doubt the parts on plane-table and theodolite work will appeal most to this class of reader, and both are interesting and well done. Here, as throughout the book, the author indicates the possibilities and particular applicabilities of each instrument, the errors permissible, and methods of obtaining accuracy. We were struck, for example, by the treatment of resection and the triangle of error in plane-table survey, and the adjustment of rounds of angles taken by the theodolite. Geodesy is a branch of the science of Geography that is not widely studied or appreciated, and the most interesting chapter on Geodetic Survey should do much towards developing a wider and more intelligent knowledge of this fascinating subject. For Geographers and Geologists alike the theory of Isostasy has no little importance and the present volume presents a useful introduction to it.

We found the first two chapters a little "slow"; and yet they contain a great deal of useful matter which can be got at by the much slower process of examining maps of many kinds of details. To learn intelligently the maps must be studied, but the book provides valuable fore-knowledge and a guide to the work. It is difficult to see how some dullness could be avoided.

In Chapter IV., a slight alteration of the text would conduce to readier grasping of the method of simple levelling.

On page 101, the figure of the prismatic compass is given as Plate XIII instead of Plate XIV, and on page 102 the special graduation of the card of the prismatic compass might be more fully treated; on page 129, the phrase, "distance $= s \tan \theta$" should read "distance is $s \cot \theta$" unless there is something wrong in the text; and on page 148 is not stated that the correction $- H^2/2L$ is an approximation to $- L (1 - \cos \theta)$. In a new edition doubtless these and other slight matters will be amended with advantage to a very excellent book.

A. S.

HORTICULTURE.

Garden Work.—By WILLIAM GOOD, F.R.H.S. 359 pages. 38 plates. Numerous figures.

(Blackie & Son. Price 5/- net.)

This is a good practical book written by a practical man who nevertheless has a theoretical knowledge of his art, and does not forget in appropriate places to say something about the structure of plants and their physiology. The bulk of the book, however, deals with cultivation. Definite instructions are given under the heading of each kind of vegetable or flower, and what is of considerable importance and value is a short list of selected varieties which the author specially recommends. Cultivation in window boxes, in frames, and in greenhouses, is also dealt with. There is a chapter on propagation and another on hybridisation and cross-breeding, while, after some words on the eradication of weeds and the aims of floral decoration, the book is completed by the consideration of the birds and insects of the garden and plant diseases. We are glad to see that the author suggests that advantage should be taken of birds which do good by destroying pests and that they should afterwards be prevented where possible from doing harm to fruit by netting the trees and bushes. A number of good diagrams have been introduced, with a series of photographic illustrations and some coloured plates. These add considerably to the attractiveness of the book, which we heartily commend to our readers.

W. M. W.

NATURAL HISTORY.

A Naturalist in Cannibal Land—By A. S. MEEK. 238 pages. 36 illustrations. 9-in.×6-in.

(T. Fisher Unwin. Price 10/6 net.)

Apart from being a stirring narrative of fortune and misfortune in collecting natural history specimens in out of the way parts of the world, Mr. Meek's book is in a way autobiographical; for it shows how he became a collector and the way in which the desire for adventure caused him to take up the career which he has so successfully followed. Of course, a good deal of the book is occupied with an account of the various finds of birds and butterflies which were discovered and sent home to Tring Museum for Mr. Walter Rothschild, but we get a very good idea of some of the habits of the natives; for instance, in the New Guinea Hill Country, when the traveller is on a journey, the natives of a village will know that he is coming many days before he gets there, and in the following way. The villages are built as a rule on the tops of spurs, and early in the morning a crier will go to a selected spot and sing across the valley to the next village. As soon as an answering cry is received the crier will chant the news he wishes to convey. Generally the message is repeated twice, and, if necessary, it will be sent on to other villages. The account of the position of women is of interest, for in some places it appears that they are becoming emancipated so far as to be able to choose their own husbands, and it is amusing to read how, on one or two occasions, Mr. Meek interfered on their behalf and became a matchmaker.

It is curious that Mr. Meek should have had so little trouble as he did with the natives, but he seems to have been most discreet in his treatment of them.

Among the interesting photographs which illustrate the book is one of an albino Native Child from the Trobiands. Another shows the Papuan kiss, which consists of the rubbing together of noses.

W. M. W.

ORNITHOLOGY.

The Food of some British Wild Birds.—By WALTER E. COLLINGE, M.SC., F.L.S., F.E.S. 109 pages. 8½-in.×5½-in.

(Dulau & Co. Price 4/6.)

Mr. Walter E. Collinge has made a really valuable contribution to economic ornithology, which is the outcome of much keen observation, and it is to be hoped that in the near future a very great deal more scientific evidence will be produced in this country, as to the good and harm which wild birds do. Mr. Collinge is also to be congratulated on his freedom from bias, and though it is possible that everyone will not agree with his findings, seeing that the habits of birds vary very considerably in different places and under different conditions, he has afforded a most useful basis for argument.

Three thousand adult birds and three hundred nestlings were examined, and twenty-nine species are discussed. Lists are given of the articles of diet by eating which the birds may be deemed beneficial, injurious or neutral, and then the whole question is summed up. We give Mr. Collinge's conclusions in each case.

Missel Thrush.—Should be kept down in fruit-growing districts for four months of the year; it does more harm than it does good in the rest.

Song Thrush.—Cannot be regarded as anything but very beneficial to the fruit grower and horticulturalist.

Blackbird.—One of the most destructive birds which the fruit-grower has to contend with.

Whitethroat.—The bulk of the food consists of injurious insects.

Blackcap.—Mr. Collinge thinks that if this bird becomes numerous it will be a very undesirable orchard pest.

We should like for sentimental reasons to hear a better account of this bird.

Great Tit, Blue Tit and Wren.—Distinctly beneficial to the fruit grower.

Goldfinch.—The worst that can be brought against this species is that it probably aids in the distribution of weed seeds.

House Sparrow.—If it were no commoner than the Robin it would more than compensate for the harm which it does.

Chaffinch.—For two months or more does great harm to sprouting corn; it requires reducing in numbers.

Linnet.—A harmless bird.

Bullfinch.—In fruit-growing districts it should be destroyed.

Yellow Bunting.—Generally speaking may be regarded as beneficial.

Starling.—Considerably reduced in numbers, would regain the good name it has borne in the past, and prove a most useful bird to the farmer.

Jay.—An almost neutral factor.

Magpie.—Beneficial to the farmer.

Jackdaw.—The good which it does far outweighs the harm.

Rook.—Not particularly beneficial; but its usefulness might be considerably increased were it less numerous.

Lark.—Does more good than harm.

Barn Owl.—A most valuable bird to the agriculturist and perfectly harmless otherwise.

Brown Owl.—Deserves all protection.

Kestrel.—The benefits this bird confers on agriculture far outweigh the harm that it occasionally does to young game.

Sparrowhawk.—Mr. Collinge shows that this bird is useful apart from its fondness for game and poultry, but for the latter reason does not advocate any protection.

Wood Pigeon.—No quarter should be shown to this bird.

One remembers, however, that in a discussion at the British Association Meeting at Dundee last year it was pointed out that when the corn eaten by this bird after the harvest had been gathered in was not counted in, the balance — which, according to the calculations of a careful observer was previously against it—was turned in its favour.

The Stock Dove.—Condemned by Mr. Collinge.

Plover.—It would be difficult to exaggerate the value of this bird to the agriculturalist.

These extracts will show Mr. Collinge's well-considered opinions, but we would urge all those who are interested in birds, from whatever point of view, to get Mr. Collinge's book and study all the interesting details and information contained therein.

W. M. W

PHYSIOLOGY.

Anaphylaxis.—By CHARLES RICHET (Paris). Translated by J. MURRAY BLIGH, M.D., with Preface by T. R. BRADSHAW, M.D., F.R.C.P. 266 pages (including Bibliography). 7-in. × 5-in.

(Constable & Co. Price 3/6 net.)

It it only eleven years since that strange and interesting condition known as Anaphylaxis was first discovered and described by the author of the monograph before us. Already an enormous literature on the subject has grown up, but Professor Richet, the pioneer, is still the greatest master of his subject, as every page of this interesting book testifies.

Anaphylaxis may be described as "the modification of the cells of an organism by the injection of a dissimilar albuminoid substance, so that they seem to reäct with greater intensity on the repetition of the injection," and is of great importance in these days of serum treatment for diphtheria, cellulitis, and other conditions. If, as was described in a recent number of this Journal, after an interval of from a few weeks to two or three years, a second injection of the serum of the same animal is administered, serious symptoms of poisoning often rapidly develop, and in some cases prove fatal. It is also probable that those curious cases in which ordinary articles of diet such as eggs, pork, strawberries, asparagus, shellfish, and so on, in some people give rise to symptoms of poisoning, are to be explained in somewhat the same manner.

The book is clearly and ably written, and should prove of the greatest possible value to those working at this subject. A very complete Bibliography is included.

S. H.

RADIOACTIVITY.

Beyond the Atom. By John Cox, M.A. 151 pages. 13 figures. $6\frac{1}{2}$-in. × $4\frac{3}{4}$-in.

(The Cambridge University Press. Price 1/- net.)

This volume, No. 65 of the "Cambridge Manuals," contains an interesting and succinct account of the modern science of radioactivity and the theory of the disintegration of the atom, which may justly be regarded as the central doctrine of this science. Except for the occasional use of an unexplained technical term or two (*e.g.*, "Faraday tube of force"), the book is well adapted to the needs of general readers. Mr. Cox clearly indicates the broad lines of evidence for the disintegration theory and its advantages over the "helide" hypothesis, which in the light of so much evidence can now hardly be regarded as in any sense tenable. As Mr. Cox says, "the chemist . . . has been compelled to look 'beyond the atom,' and in the words of Blake—

'To see a world in a grain of sand
And heaven in a flower;
To grasp infinity in the palm of the hand,
And eternity in an hour.'"

There is a statement on page 46, however, which will certainly prove misleading, as seeming to indicate that the products of radioactive disintegration are not elementary, for which there is, of course, no evidence, and which is not, I think, what Mr. Cox intends to say.

There is an interesting chapter on "The Objective Reality of Molecules." No doubt the Brownian movement, especially in the light of Perrin's wonderful investigation, does endow molecules with more reality than heretofore, and the word "objective" is not out of place. But lest we interpret this term in too metaphysical a sense, we must remember that Berkeley's arguments concerning the nature of the existence of the material world still remain; and in the last analysis it is clear that the world of science is a purely conceptual world—that it is a great hypothesis, a machine, as it were, produced by the mind in order that the mind may deal easily with its sense-impressions. But on the other hand, of course, if this view limits the meaning of "objectivity," it does nothing to invalidate physical science or to deny its truth, pragmatically understood.

H. S. REDGROVE.

ZOÖLOGY.

The British Parasitic Copepoda.—By THOMAS SCOTT, F.L.S., and ANDREW SCOTT, A.L.S. Vol. II. Copepoda Parasitic on Fishes. 72 plates. 9-in. × 6-in.

(Dulau & Co. Price 25/- net.)

In our July number we noticed the text of the latest publication of the Ray Society, dealing with the British Parasitic Copepoda. The present volume, which is issued to subscribers for the year 1913, contains the excellent plates—more than half of them coloured—the majority of which have been drawn by Mr. Andrew Scott from specimens examined by the authors.

W. M. W.

The Wanderings of Animals.—By HANS GADOW, F.R.S. 150 pages. 17 maps. $6\frac{1}{2}$-in. × 5-in.

(The Cambridge University Press. Price 1/- net.)

The distribution of animals is a question which calls up all sorts of interesting matters. On many of these Dr. Gadow is able to touch in the first part of his book, which shows how animals have spread and how long they have taken to do so. Some attractive calculations are incidentally given with regard to the human species. In England the population doubles itself in fifty years, and if this was to go on, a thousand years hence the whole land surface of the globe would not afford sufficient standing room for the sixteen hundred and sixty million millions of people that would then exist. It is absolutely certain that the origin of man dates back into the Pliocene, and if we assume that the human race started as the traditional Adam and Eve pair in that period, the rate of increase necessary to account for the present total population would be so small as to render the calculation quite preposterous. Dr. Gadow gives figures which show that the rate of propagation has been always as large as it is now all over the world.

The second half of the book consists of brief accounts of the distribution of selected groups of animals, and contains a large amount of useful information in a small compass.

W. M. W.

NOTICES.

PLANT PROTECTION.—Arrangements are being made to hold a Conference on this subject in London on September the 19th. Those interested in the subject who would like to attend are invited to communicate with the Editors of "KNOWLEDGE" at 42, Bloomsbury Square, London, W.C.

CLASSES IN PHOTOGRAPHY.—Mr. Edgar Senior's elementary and advanced classes in photography at the Battersea Polytechnic begin again at 7.30 p.m. on September the 30th, and at the South-Western Polytechnic, Manresa Road, Chelsea, on September 22nd.

THE BRITISH ASSOCIATION.—This year's meeting will be held at Birmingham, under the Presidency of Sir Oliver Lodge, who will give his address on the 10th of September. The Railway Companies, on production of a voucher signed by the Secretary of the Association, will grant reduced fares, and Birmingham can now be reached on the new Great Western line in exactly two hours from Paddington. From a time-table sent to us by the Divisional Superintendent, we learn that trains depart at 9.10 and 11.5 a.m., and 1.0, 2.35, 4.0, 6.0, and 8.0 p.m.

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

OCTOBER, 1913.

DARK-GROUND ILLUMINATION AND ULTRA-MICROSCOPIC METHODS IN BOTANY.

By S. REGINALD PRICE, B.A. (CANTAB.)

During the last few years, and more especially since the introduction of the ultra-microscope in the early part of the century by Siedentopf and Zsigmondy, the application of methods of dark-ground illumination to high-power work has received much attention, while many interesting and important observations have been made by the use of the methods. The work which has been done in botanical research is probably comparatively little known, but nevertheless the method seems likely already to become an important one in studying various aspects of the plant cell and also in other directions indicated below. The results, moreover, are of general interest to the biologist as well as to the specialised plant physiologist, and, in view of this, a short account of some of the observations already made may be of sufficient interest to justify this article.

Only a very brief account of methods can be given here, and at the outset it must be emphasised that a distinction must be made between methods of dark-ground illumination and the method of the ultra-microscope. The latter term is best confined to the method devised and used by Siedentopf and Zsigmondy—the illumination of the object (coloured glass, colloidal solutions, and so on) by a lateral beam of light, perpendicular to the optical axis of the microscope.

Dark-ground illuminators are sometimes also called ultra-microscopes, but this terminology should not be used, although it is true that at times they can render *visible*, particles which are below the limits of visibility in direct illumination.

An apparatus for demonstrating ultra-microscopic particles is always a dark-ground illuminator, but the converse does not necessarily hold. Certain forms of sub-stage illuminators are now on the market, which give a very intense concentration of the light in a small area, and these are chiefly used for studying ultra-microscopic particles. Such are the Cardioid condenser of Zeiss and the Ultra-condenser of Leitz. Possibly the term "ultra-microscope" should not be applied to these, if it be desired to keep a special name for Siedentopf and Zsigmondy's apparatus, but Leitz's term "ultra-condenser" would be suitable.

It is important to notice that most of the high-power dark-ground illuminators, do render visible ultra-microscopic particles under certain conditions.

For further particulars the pamphlets of Leitz and Zeiss should be consulted, as well as works on the microscope, which, however, will not include descriptions of some of the later designs of apparatus, although they will deal with the theory of dark-ground illumination in general.

The most general methods in use are as follows:—

(1) Siedentopf and Zsigmondy's Ultra-microscope, which, however, is inconvenient in biological work, although it has been employed at times.

(2) Sub-stage Dark-ground Illuminators.

The simplest type is the central stop in the immersion condenser of high N.A., which, however, is strongly chromatic.

The simpler forms of dark-ground illuminators, such as the paraboloid of Zeiss and reflecting condensers of most optical firms, are primarily designed for fine dark-ground structural work such as the observation of bacteria; but, as mentioned above, with a bright source of light they render visible ultra-microscopic particles.

The ultra-condenser of Leitz, designed by Dr. Jentzsch, and the cardioid condenser of Zeiss, by Dr. Siedentopf, are both primarily designed for ultra-microscopic observations, but are not very suitable for biological work on account of the delicacy of adjustment required.

In most of the dark-ground illuminators the rays fall on the cover-slip at such an angle that total reflection takes place, so that a clear field appears black. When objects are present they shine out brightly by the light which they scatter.

In using immersion objectives, special means must be taken to reduce the aperture—that is, to cut out the peripheral rays by means of a diaphragm. Apochromatic objectives always give the best results, and the illuminators themselves are usually achromatic.

(3) By stopping the objective.

This method was also devised by Dr. Siedentopf. A certain circular area of the centre of the front lens of the objective is blackened at the back. A condenser of low N.A. is used and stopped down till the direct cone of light is just blocked by the blackened area. When objects are introduced into the field they scatter the light. The method is chiefly used for thick preparations, but has the disadvantage of showing strong diffraction rings.

With regard to the illuminant, in most cases the better the light the better are the results. A Nernst lamp gives fairly good results with the paraboloid, for example, but more especially for the dark-ground structural observations. A small arc lamp is better, but best of all is strong sunlight directed on to a large glass globe filled with water, although this light cannot always be switched on when required!

Such is an indication of the methods employed. A short list of literature will be given at the end. The study of living material is usually most instructive, so that in most cases water has to be used as the mounting fluid.

. . . .

A few of the applications of the method in botanical work will now be shortly described. Little will be said of the work included in the first two classes below, as many of the observations are mostly of interest to the specialist alone. The main lines of work may be perhaps classified as follows:—

(*a*) The study of living bacteria, and so on.

(*b*) The study of moving cilia.

(*c*) Observations of the living plant cell.

(*a*) Little will be said here. The method has been useful in studying bacteria in the living state generally, especially when one dimension is sub-microscopic. The presence and movement of the flagella have also been observed in the living state.

(*b*) The method greatly facilitates the study of cilia generally, as these are easier to observe as a bright line against a dark background than in direct illumination.

Ulélah has recently published his results of a series of researches by means of the method; he used, in fact, a Zeiss paraboloid. Motile cells from practically all the great groups were examined—zoöspores of green and brown Algae, spermatozoids of Bryophyta, and so on, as well as many Flagellata. The results are, of course, to be appreciated by the plant physiologist, but generally the work is of interest in showing that the method is capable of profitable application in this direction.

(*c*) It is, however, with regard to the structure of the plant cell that the most important results have been obtained.

The method of illumination employed, demonstrates the presence of structures and particles which cannot be observed in direct illumination, and it also renders much more distinct some particles which on account of their transparency and small size are very difficult of observation in direct illumination.

The greatest difficulty to be encountered in the application of the method to the study of the plant cell is that of choosing and obtaining suitable material which can be examined in the living state. The object must, if possible, be only one cell thick, which at once precludes the use of masses of tissue, or sections of tissue generally. The cell walls must be optically homogeneous, or nearly so, in order to allow of an illumination of the cell contents, and, moreover, the outer wall of the cell must be quite clean. When all these desiderata have been obtained the cell contents may be quite unsuitable—for example, a large peripheral chloroplast scatters most of the light at once, so that no internal cell structure can be seen.

Objects which may furnish suitable material are more especially unicellular organisms, such as unicellular algae, yeasts and so on, filamentous Algae and Fungi—*Spirogyra*, *Mucor*, flat plates of cells—*monostroma*, thin leaves, unicellular or seriate plant hairs, root-hairs, and so on. There is still another point which rapidly becomes evident when observation is begun—the cells must not be too small nor the filament too narrow, or the diffraction images of the edges mask all other effects.

Much of the work in the observation of the living plant cell has been done by N. Gaidukov (see his "Dunkelfeldbeleuchtung" reference at end).

A few general examples of some of the best objects for observation and the appearance they present may be described, and in many cases the first appearance is sufficiently surprising. One of the most suitable objects for observation is the green alga *Spirogyra*. A species with fairly thick filaments and a rather loose spiral chloroplast is best, but a close spiral does not prevent good observation, and, in fact, in some cases may be an advantage (Price, S.R.; see references below). A single filament is mounted in water and covered with a thin cover-slip for observation. Under quite a low power of the microscope of, say, two hundred diameters in good illumination a large number of twinkling points of light with a rapid dancing motion first attract the attention. These are particles which occur in the cell sap and may conveniently be referred to as "sap-particles." They can usually be seen in illumination under high powers, especially with the condenser considerably stopped down. Little attention as yet seems to have been given to these particles, which are apparently widely distributed in plant cells. They seem to increase in number with a lowering of the plant's vitality.

Under high power, say the three-millimetre apochromat of Zeiss, and a six or twelve compensating ocular, much more can be made out. The chloroplast is relatively inconspicuous now, and the protoplast, which lines the wall of the cell and encloses the sap vacuole, is seen to be full of rapidly oscillating and moving particles of a minute size, particles which are not seen in direct illumination. There is some evidence to show that particles of two orders of magnitude are present, the smaller particles being present in the internal and external layers of the protoplast. On focusing in a lower plane—into the vacuole—the sap particles can be seen again, and now they appear rather as minute bubbles of a refracting liquid of a greater order of magnitude than the protoplasmic particles. In a few cases the nucleus can be seen, appearing almost clear and suspended by protoplasmic fibrils in which are moving particles.

The whole appearance is certainly very striking and animated, and gives rather a new impression of the great activity of the living cell.

Incidentally, a dead cell shows none of the protoplasmic movement, and the coagulated protoplast has quite a different appearance.

The staminal hairs of *Tradescantia* have also been observed by Gaidukov and show somewhat the same phenomena. The cell wall is finely striated, however, so that observation is not so easily made. The circulation and streaming of the protoplasm can be well seen.

The latter is also particularly well shown by certain cells in the leaf of *Elodea*, the American water-weed, so common in our waterways. A single leaf is removed and mounted in water. The leaf is only one cell thick at the edge, and, moreover, the chloroplasts are relatively few in these cells. At first only the "sap particles" may be seen, but with careful observation the protoplasm can be observed filled with minute particles, exhibiting a rapid oscillating or Brownian movement. As the leaf warms up the streaming of these particles along the protoplasmic threads and round the cell is clearly seen. After a time a well-marked rotation of the protoplasm is set up, and the minute particles seem to travel along at a great rate. Subsequently enough energy seems to be developed to cause the chloroplasts to move, but these always do so at a slower rate than the small particles.

Somewhat similar phenomena, the Brownian movement of the small particles in the protoplasm, and so on, have been described for many other objects; for example, *Mougeotia* cells, root-hairs of mustard, yeast cells, multicellular hairs from the tomato plant; but, as would be expected, there are differences in detail. Yet other cases seem to show little or no movement of the protoplasmic particles.

The extreme mobility and the great display of activity in some of these plant cells seem at first sight rather surprising and rather militate against some of the older views of the structure of the protoplasm of the living cell. Although the observations yet made are comparatively few—too few to admit of any elaborate theory being postulated—yet some sort of hypothesis is required to explain these phenomena, to be used as a basis for further analysis. The facts as they appear at present seem to agree quite well with the hypothesis that the protoplasm is of the nature of a colloid solution, and in view of recent work on colloids in other directions this view is considerably strengthened. The particles which have been described above are held by Gaidukov to be actual colloid particles, exhibiting the usual Brownian movement when suspended in fluid. The death of the cell results in complete cessation of the movement—the plasma has coagulated. The liquid watery colloidal solution of the living cell is, in the language of the colloid chemist, a hydrosol, and the coagulated mass a hydrogel. The death of the cell is thus a conversion of hydrosol into hydrogel.

The colloid hypothesis has been further elaborated, but this is not the place to enter into a general discussion of its fuller bearings. It may, however, prove to be a firm stepping-stone leading to a true basis of many of the phenomena connected with the living processes of the cell and with the "life" of the "life-substance" protoplasm.

The account which has been given is necessarily very superficial and sketchy, but it may in some degree indicate that the method is really a useful one, and one of which a good deal may be expected. The glamour surrounding new methods often results in a gross over-estimate of their application; but this glamour, let us hope, has partially disappeared in this particular case, although at first it was very decided. Even if it only serves to take us a small step forward in the comprehension of the life of the cell, its continued use will be amply justified.

The following short list of references may be useful to any interested in the subject generally :—

Zeiss. Pamphlets on "Ultra-microscopy" and "Dark-ground Illumination." Parts 1 to 8.

Leitz. Pamphlet, "Reflecting Condensers."

H. Thirkill. "Ultra-microscopy." Science Progress in the 20th Century. 1909–10. Vol. IV. Page 55.

N. Gaidukov. "Dunkelfeldbeleuchtung und Ultramikroskopie in der Biologie und in der Medezin." 1910. G. Fischer, Jena.

A full list of references is given here:—

Úlélah. *Biologisches Centralblatt.* 1911.

Price, S. R. "Observations with Dark-ground Illumination on Plant Cells." *Proc. Camb. Phil. Soc.* Vol. XVI. Part VI. Page 481.

Price, S. R. "The Method of Dark-ground Illumination in Botanical Research. *Sci. Prog.*, Oct., 1913.

Cotton et Mouton. "Les Ultramicroscopes, les Objets Ultramicroscopiques." Masson et Cie, Paris. (Out of print).

Barnard, T. E. "Ultramicroscopic Vision." *Nature.* Vol. LXXIX. 1909. Page 489,

A SOLAR OBSERVATORY IN NEW ZEALAND.

By MARY PROCTOR.

On April 14th, 1912, I left New York for a lecture-tour in Australasia, for the purpose of arousing enthusiasm and raising the necessary funds for the establishment of a solar physics observatory in that part of the world. Exactly a year later, on April 14th, 1913, I met Mr. Thomas Cawthron, a millionaire, of Nelson, New Zealand, who had read about my lectures in which I had pointed out the necessity for such an observatory in the Dominion, and he generously offered to provide sixty thousand dollars to build, equip, and endow an observatory to be erected somewhere in the vicinity of "the sunny city of Nelson." If Nelson lives up to its reputation in this respect, the institution could not be more favourably situated.

The observatory should prove very valuable for supplying data which will be of great use in connection with meteorology, weather forecasting, and other scientific and practical purposes, such as enabling us to trace the possible connection between sun-spots and magnetic storms on the sun and magnetic storms on the earth.

To establish this theory it was necessary that the sun should be observed continuously throughout the twenty-four hours, but unfortunately a gap of one hundred and fifty degrees separated the solar observatory at Mount Wilson, in Southern California, and the one at Kodaikanal, in Southern India. The proposed observatory at Nelson will not only fill in this gap, completing the chain of such observatories round the world, but it will be the only station of this kind south of the Equator. It will also have the additional advantage of providing a good observing station during the months while winter prevails in the northern hemisphere.

Regarding the climatic conditions of Nelson, they compare most favourably with those of Southern California. The annual average of direct sunshine is two thousand five hundred hours, and of rainfall in inches during the past thirty years is 37·88. Praise of Nelson's climate comes from Professor Archibald, the well-known expert meteorologist, as follows:— "I passed through Nelson twenty-two years ago, and I was impressed by the bright character of the sky." The universal opinion of that time was that Nelson was the climatic paradise of New Zealand. Nelson is a very suitable site for the establishment of a solar observatory and the study of solar physics. Considering that we are now finding that there are oscillations of weather distinctly connected with the small as well as the larger periods of solar phenomena, including the magnetism of the sun and the surface spots, there is little doubt that the projected observatory at Nelson will materially aid meteorologists and physicists to solve the remaining problems which confront us. We shall learn how our luminary affects the weather and other conditions of the earth. It will be work, not only valuable to Nelson and New Zealand, but to the wide world. It will be distinctly to the honour of New Zealand to take a prominent part in an investigation which is daily becoming more and more of world-wide interest and importance. Work such as will be done at Nelson will link with similar study by Sir Norman Lockyer at Cambridge, Professor G. E. Hale at Mount Wilson, and Mr. John Evershed at Kodaikanal in Southern India.

The illustrations show the probable site, usually referred to as the Fringe, situated two thousand five hundred feet above sea level; but at the present moment of writing (May 8th) the matter is awaiting the decision of an expert on such matters from England, at the suggestion of Sir Robert S. Ball, of Cambridge University. About eighteen months ago he was invited to come to Australasia to lecture for the purpose of raising funds for the erection of a solar physics observatory, but owing to his advanced age and duties as a professor at the University he was unable to accept. He suggested that I should come in his place, and the generosity of Mr. Thomas Cawthron has enabled me to state that my mission has been accomplished successfully.

[Since the above was written Miss Proctor has received a letter concerning the serious illness of Sir Robert Ball. Consequently the matter now awaits the decision of Professor Newall, to whom the letter was handed.]

From a photograph *by Tyree, Nelson.*

Figure 390.

Mr. Thomas Cawthron, who has offered to establish a Solar Observatory near Nelson, New Zealand.

Figure 391. One half of a panoramic view of the mountains to the South-East of Nelson, New Zealand. Maungatapu Mountain on the left is 3312 feet high.

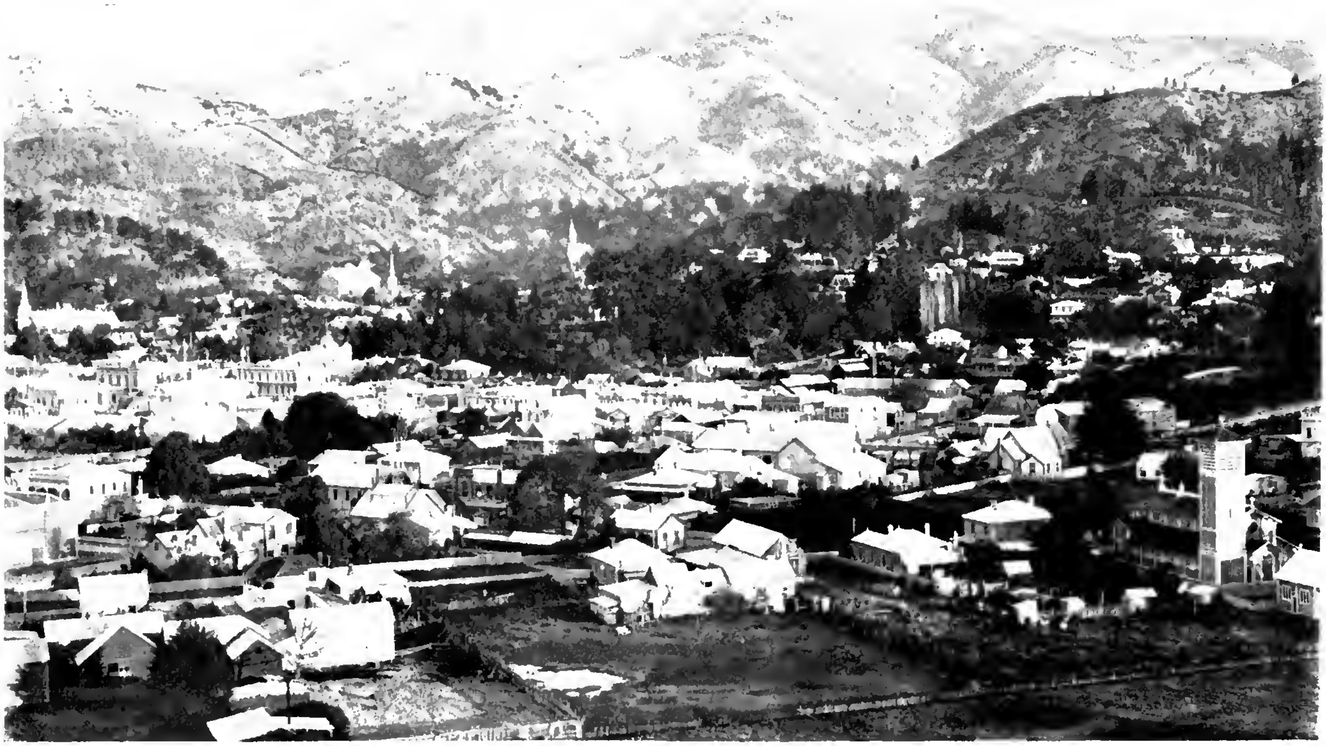


Figure 392. A continuation of the picture seen above. Fringe Hill in the centre is 2580 feet high. On the summit of one of these mountains the Cawthron Solar Observatory will be placed.

From photographs by Tyree Nelson.

THE CHEMISTRY OF THE FOREST.

By P. Q. KEEGAN, LL.D.

By the chemistry of trees is meant the detection by analysis of such separable and distinctive organic and inorganic bodies as are incidental to the vital processes thereof, whether these substances are the direct outcome of the arboreal life energy, or are merely the by- or waste-products of the spent and exhausted activities. The tree, indeed, may be regarded as the outward and visible sign of an inward and wholly invisible force. The capital force is the one called "vital," shrouded in mystery; but chemical forces, aided in some cases by physical forces, are created and set a-going thereby, and are manifested in visible and tangible shape by the inevitable consequences of a production of principles mostly not detectable in the animal or mineral kingdom. It must be admitted, indeed, that several of the most distinctive constituents of the body of the tree, its stem, leaf, and flower, are not the results of any chemical processes known to science, and cannot be artificially reproduced by the most skilful application of the most modern and approved synthetic methods and expedients; that is to say, the chemical origin of what are called the products of vegetable assimilation is a mystery shrouded beneath the inscrutable veil of forest secrecy. With regard to the woodland soil, it may be briefly stated that it contains much humus, *i.e.*, it is highly charged with organic matter, which is the essential condition of the life of certain fungi which assimilate the nitrogen and carbon thereof, and by association with the roots of the tree (mycorhiza), contribute to supply thereto these necessary aliments in the form of ammonia and carbon compounds.

The arborescent forms of the forest flora of the British Islands are not very numerous, but (native and denizen species included) they are sufficiently varied as respects chemical interest and instructiveness. For instance, in the first place, let us study the chemical characteristics of the Gymnosperms, taking as an example that stately and sombre-foliaged occupant of sandy wastes and craggy mounds known as the Scots Pine (*Pinus sylvestris*). Perhaps heretofore we have regarded the leaf as the most vigorously active of the vegetable organs, but here we see that much of the total energy is assigned to the woody tissues. For it is there that the resin, so characteristic of the Coniferae, prevails. Some specially active parent-cells of the heart-wood contain an opaque plasma which divides again and again, and thus forms a group of several daughter-cells, which separate internally (schizogenous), and so leave a hollow space (resin-passage), wherein there flows the product of their spent and exhausted activity (deassimilation), *viz.*, volatile oil and resin. Then, again, the starch and fatty constituents of the wood undergo curious transformations, or rather alternations. During the winter there is no starch whatever in the wood, pith, or bark, the wood at this time bearing much fat-oil which vanishes in April, leaving only a faint residue thereof during the entire summer. Likewise the leaves (really twigs) are free from starch in winter, but about April 1st, whatever the weather may be, and although the chlorophyll therein is oily and inactive, these organs are found crammed with starch, *i.e.*, in circumstances and conditions that in most dicotyledons would assuredly preclude this effect; and the quantity of this starch gradually diminishes, and disappears altogether in mid-October. Coniferous leaves in their most developed condition are always poorer in nitrogenous, carbohydrate, and mineral (ash) constituents than those of deciduous trees, and the ash is also of a somewhat different composition. Hence we learn that our arborescent Gymnosperms (pines and firs) are subject to a fitful periodicity of life-energy interrupted by pretty long periods of repose akin to hibernation, all preordained and operative in the first place in the formed leaves, ere the buds are evolved or the cambium has awakened. A speciality, too, is the strong accumulation of "dry substance" in the tissues under the form of resins, waxes, volatile oils, tannins, tannoids, glucosides, phlobaphenes, and lignin (but not acids), while, on the other hand, the relative amount of starch, fat-oil, carotin, chlorophyll, and albuminoids is comparatively small.

Reviewing now the more familiar field of the Dicotyledons, and in the first place the various species of Elm (*Ulmus campestris*, and so on), we are arrested at once by the presence of a very troublesome constituent known as vegetable mucilage. In the cortex, special sacs or canals evolved from the meristem, and in the leaves cellulose-encased roundish compartments in the epidermises, petioles, and nerves contain mucilage in large quantity. It is a degradation product of cellulose provoked by the great undue pressure of growth: it swells enormously in water, and has an acidic function. Some resin occurs in elm bark and wood parenchyma, but the quantity of tannin is decidedly scanty in all parts of the tree. The leaves contain much carotin, wax, albuminoids, and sugars at all times, and their starch-producing power is extremely vigorous. In fact, the tree is a very distinctive starch-tree, and it retains most of it in winter, little or no oil appearing then in the tissues. The average amount of transpiration is only moderate, its flowers, fruits, and leaves grow rapidly, but are short-lived, as the lavish fortification of its bark, leaves, and even fruits, with lime and silica, attests, and some of its varieties are even capable of forming a primary persistent periderm, albeit only feebly suberified.

Passing on now to those nearly allied, closely related (taxonomically) congeners, the Birch and the Alder, we begin to realise the supreme value of chemical analysis as applied in the world of plants. Both are fat-trees, for in winter the starch vanishes from the pith, wood, and bark, because the leaves produce little starch, and the general reserve thereof is feeble and readily exhausted. So far they agree, but in the Birch the process of deassimilation is not so complete as that in the Alder. In the Birch it is not pushed much beyond the production of waxes, resins, and volatile oils, and hence the tannins, phlobaphenes, pigments, and so on, are comparatively sparse. Hence in the "queen of the woods" we observe a silvery-whitish bark, of ghastly aspect by moonlight, containing some twelve per cent. of a white hydrocarbon (betulin), easily resinifying in the air, but only about five per cent. or less of tannin, and very little hidden phlobaphene. The phellogen that works this effect is stimulated to action by the rapid growth of the very sappy internal tissues. On the other hand, in Alder bark there is found sometimes as much as twenty per cent. of a powerfully astringent tannin, together with some emodin, which is a higher product of deassimilation again. This tannin penetrates freely into the medullary rays, parenchyma, and pith of the wood (birch-wood is almost free from tannin); and although it does not conduce much to lignification, it renders the wood very resistant to the action of water. Birch leaves produce more starch, cellulose, fibre, wax, volatile oil, resin, ash, silica, and soluble salts than Alder leaves do; but these, on the contrary, contain much more nitrogenous matters, and more fat-oil, tannin, pigments, acids, lime, and manganese. Thus we come to perceive that more fundamental differences exist between these two tenants of the forest than what a mere recital of the few and slight specific characters (chaff-like or woody, falling or remaining scales of the seed-bearing catkin, and so on) would in any way fore-shadow or prognosticate.

Certain members of the order Cupuliferae must now claim our attention. As regards the grand old Oak, it may be asserted that no member of the vegetable kingdom has been more exhaustively investigated. All that we need state here, however, is that the amount of starch which it creates and stores up in all its organs is considerably larger and more durable than that of any tree in our sylva. The beautiful Beech exhibits a distinctive variation in this respect, inasmuch as even in January and February its wood is very rich both in oil and starch, every cell in the parenchyma of the outer rings being full of starch (not the case in most starch-trees), and this remains up till April, when the wood is still rich in oil (in fat-trees there is little oil in spring or summer). In the Beech, too, the wood becomes lignified very slowly; the quantity of tannin produced here and elsewhere is relatively small; it lays up a store of starch in the inner rings in a rare manner, and it requires more nitrogen, potash, and lime than many other trees. "The whole tree" says Wicke, "sticks, so to speak, in a siliceous coat of mail, the silica forming a thick solid crust over the whole stem and the young twigs" (the actual white colour of the bark is, however, due to lichens). The pure ash of the bark contains up to ninety per cent. carbonate of lime, indicating an enormous affluence of acids, mainly oxalic. The chief difference between Beech and Oak, as revealed by the chemistry of their leaves, is that the latter is more vivacious than the former: the Oak has much more tannin and carbohydrates, and its protein falls off in greater amount towards autumn, at which time also the quantity of silica in its ash is little over half of what it is in that of the Beech; this latter tree, however, evolves more fat-oil, its ripe nut containing some twenty per cent. thereof, while the acorn produces only about six per cent. at most. This various outcome of these two constituents seems referable to the varying capacity of the two trees to withstand the effects of external conditions of weather, and so on.

We now approach the Ash (*Fraxinus excelsior*) with its smooth bark and knotty protuberances; and it must be confessed that it is difficult to render full justice to its perfection of organisation and to its wonderful wealth of chemical constituents. In fact, we here enter upon a new chapter in the chemistry of the forest. In 1856 Prince Salm-Horstmar discovered in the infusion of the bark a peculiar fluorescence, and in 1857 he isolated and examined the substance causing it and named it *fraxin*. Its dilute aqueous solution with a trace of alkali exhibits by reflected light a strong bluish fluorescence, due to the absorption of certain rays. It is a colourless crystalline glucoside perhaps derived from cinnamene. The tannin of the Ash totally differs from that of any of our native or denizen trees, the Holly excepted. In fact, it is identical with the tannin of coffee, and is accompanied by a tannoid whose dun shades with alkalies produce the blackish Ash leaves in the fall. Ash leaves, indeed, may be ranged among the wonders of British botanical chemistry. They rival the Oak in the manufacture and storage of starch, but far surpass it as respects carbohydrates, such as mannite, inosite, and also malic acid, malates, and mineral matters, but have not so much wax, fat, carotin, tannin, or mucilage. The difference in this case arises from the nature of the protoplasm, or of its behaviour. While, on the one hand, the products of assimilation are only somewhat different, on the other hand the products of deassimilation exhibit a marked variation. Thus, while the tannin of all the trees hitherto considered contains what is called a phloroglucin nucleus, that of the Ash has a quinol nucleus, and, moreover, it is linked on to the derivatives of a hydrocarbon which indicate that a larger number of carbon and hydrogen atoms are relinquished on the disruption of the albuminoid molecule. This means that the process of oxidation in this particular direction is carried in the Ash leaf to a loftier pitch than is the case with regard to the preceding organisms in our review. The Ash is a tree of great soil consumption, and its leaves retain their vitality up to the first frosts, the ash therein amounting to 10·5 per cent. in dry matter with 45·8 per cent. of lime. Curious how it is that this tree sucks up no manganese from the soil, while closely contiguous plants and trees may absorb a great deal.

The lordly Sycamore and some of its allies remain to be considered. The chemistry here is comparatively simple. They are all starch trees, but at the same time are rather oily. Thus there is a lavish plaster of wax on the lower epidermis of the leaves of a Sycamore. Its bark is very poor in tannin, and has no resin apparently, but a saponin-like substance, very much oxalate of calcium, and 9·4 per cent. of ash are found here. Its vital powers awaken early in the year, for concurrently with the regeneration of the starch in spring a quantity of cane-sugar (rising mainly from the roots or base of the trunk) becomes dissolved in the cell sap, which thereby gains sufficient tension to bleed out through the bark if pierced. The adult leaves have no reserve of starch, having no true chromoplasts, but contain much carotin, wax, and albuminoids at all times, also a good deal of tannoid and tannin, only a little sugar or mucilage, but much oxalate of calcium almost from birth, and 11·2 per cent. of ash, which even on 8th August yields 14·9 per cent. silica. The fact that in the leaves the production of starch declines towards the autumn, while the cellulose does not increase, the albuminoids and sugars remain uniform till very late, and there is a heavy fixation of silica and lime in the old tissues, indicate the rapid growth and early decline of vitality of these organs. That well-known ally, the Horse Chestnut, exhibits a similar chemistry, except that its fruit contains starch and saponin, and its bark yields the brilliantly fluorescing aesculin discovered by Canzoneri in 1825. The tannin of these Aceraceae is especially competent to evolve very brilliant crimson tints, as is seen in the American Maples in Autumn, but our species, alas! are precluded from this beauteous display by reason of the sharp weather fangs that cause a premature demise of their external tissues.

By way of summary it may be concluded that starch trees are Elm, Oak, Ash, Sycamore; fat-trees are Birch, Alder, Linden, Scots Pine, Holly. The richest in starch, but having less chlorophyll, are Birch, Ash, Elm, Scots Pine, Oak; poorer in starch, but having more chlorophyll, are Beech, Sycamore, Alder, Poplar, Rowan. As to nitrogen the leaves of Alder, Elm, Beech, Willow, Linden, Sycamore, contain most; while those of Oak, Hazel, Poplar, Ash, have less, as against those of Birch and Scots Pine, which contain the least. Trees rich in waxy and fatty matters are Scots Pine, Sycamore, Beech, Alder, Birch; while Oak, Ash, Elm, Poplar, Holly, produce one half or less thereof. The greatest proportion of lignin or crude fibre is found in Scots Pine, Oak, Sycamore, and rather less in Ash, Elm, Birch, Alder, and Hazel. Alder and Oak produce the most tannin; there is much less in Beech, Elm, and Poplar. The mineral matters of the soil are most strongly absorbed by Elm, Sycamore, and Ash, while the other trees flourish with vigour in most cases on a much sparer diet of that sort.

SAGACITY OF A DOG.

Mr. James Saunders, of Luton, contributes the following to *The Selborne Magazine*:—

"There were two terrier dogs, a black smooth-coated one, and a rather larger white one. The latter was in the water by his own desire, where he was enjoying himself. The black one slipped off the stone coping and had an involuntary bath. He tried to extricate himself by striving with his fore-paws to gain the top of the coping, but the sides of the lake were so perpendicular that his hind feet could get no grip. He partially succeeded several times, but always fell back till he showed evident signs of distress. In the meantime the white dog had left the water by the shallow river bed, and at once went to see what the other dog was doing. He soon realised the gravity of the situation and tried to grab the black dog by the neck. In this he failed several times, but at last got some of his teeth under the other dog's collar and hauled him out instantly."

COSMOLOGICAL HYPOTHESES.*

By R. T. A. INNES.

THE best known and still the most widely accepted cosmological theory is Laplace's nebular hypothesis. This hypothesis was only put forward in a tentative manner by its author, although on several occasions he recurred to the subject. It is proper to note that although it is doubtful if anyone had ever a greater facility for clothing his ideas in mathematical formulas, Laplace used none in explaining the nebular hypothesis. Many cosmogonies have been based on ideas not essentially different from Laplace's—that is, the condensation of a primitive nebula into rings, which later disrupt into planets, whilst the central and final condensation forms the central body or sun of the system. The fission theory of the formation of satellites and double stars from condensing bodies is closely connected with the nebular hypothesis.

Other sets of cosmogonies are indicated under the meteoric or planetesimal hypothesis, and capture theory. Kant's cosmogony was more general in that he postulated neither nebulous matter nor meteors—merely matter. The nebular hypothesis of Laplace, and its modifications by Faye, du Ligondes, Darwin, See, and others, seized on the popular mind because it was not in too marked discord with the theological teachings of the age, " the earth was without form, and void." Genesis i, 2.

By the very mode of its existence the human race can view but a small part of the drama of nature. On the surface of the earth, thanks mainly to the geological record, the mode of the evolution of flora and fauna and the making of rocks is fairly clear. But when we view not the surface of the earth, but bodies outside the earth, the planets, stars and nebulae, our interpretation is not so easy. We cannot even say if the sun, and with it the earth, is growing hotter or colder. We imagine the rhythm of the universe is periodic, but until one period is completed — and this the human race cannot live to see—how can we tell, nay, even guess, the nature of its periodicity! The periodicity may be complicated, is almost certainly more complicated than that of a butterfly which goes through the stages, egg, caterpillar, chrysalis, butterfly, and so on, and what being could by the closest inspection of, say, a millionth of any one of the sub-periods, egg, caterpillar, chrysalis, or butterfly, foretell the other sub-periods! It is probably thus when we attempt to explain the evolution of the stars. When Laplace wrote his nebular hypothesis facts were few, the laws of thermodynamics had not even been formulated, and modern chemistry was in its infancy. Hypotheses without facts are not uncommon; the Greek geniuses loved hypotheses, but seemed to disdain facts, and the effects of their examples are buried deep in the fibres of our mentality. The fundamental assumption of the nebular hypothesis is that a nebula can condense, not only get more dense, but even ultimately form liquids and solids of various atomic weights. This assumption has no foundation in nature, and is so improbable that it should not be accepted without proof. Lockyer's meteoric hypothesis started with a swarm of solid bodies, meteorites, which by their collisions gave rise to a nebula, which then followed the Laplacian theory; but the spectroscopic evidence on which it rested has since been proved to be devoid of foundation.

Although many cosmological hypotheses have been imagined, I wish to show that another can be added to them; its only merit is that it takes into account the few facts of observation which are available to-day. The hypothesis is compounded of the planetesimal hypothesis of Chamberlin and Moulton, and the radiation theory of Arrhenius, with the addition of an explosive element suggested by the mutations of uranium radium-helium.

The primordial stuff out of which the universe is made is in the form of meteors. Aggregations of meteors are caused by collisions and gravitation. These aggregations increase in size forming, firstly, cometary bodies; secondly, planetary bodies; thirdly, sun-type bodies. Growth is continuous in one direction in all these bodies, so that a cometary body by the addition of more meteorites can pass into a planetary body, and a planetary body similarly into a sun-type body, but a sun-type body cannot increase in size indefinitely, as a time comes when it will disrupt with explosive force. A cometary body is a loose aggregation of meteors. A planetary body is a solid body in which the forces of solidification and cohesion are at a maximum. A sun-type body is a liquid body, of which the sun is a prototype. The reverse process cannot take place; thus a sun-type body cannot shed meteorites and so lose matter that it becomes a planetary body, and so on. Under certain circumstances, such as the near presence of a large mass, a cometary aggregation can, however, be dissipated, but this is an indirect effect which does not concern us here. All three classes of bodies can radiate substance in the form of electrons, although at vastly different rates, so that they can pass from the solid or liquid state to the gaseous state, which is and will be called here the stellar state, and from the gaseous or stellar state to the final form, the nebulous state. The stellar state is the first step in the degradation of atomic matter.

It has to be considered how this hypothesis fits

* A paper read to the Science Congress, Lourenco Marques.

facts. Clausius has taught us that the end of the universe as an abode of life or available energy will be reached when entropy becomes a maximum, and that it does tend to such a maximum. This conclusion is not contradicted, it is only enlarged so as to include in the available energy the enormous stores of power contained in every atom. The end of the universe, or at least one sub-period of it, is reached when every atom has disintegrated into its component parts, be they electrons or the elusive nebulium of which nebulae are mainly composed. The older cosmogonists started with nebulium, which in some way could condense into atoms and end with vast cold stars consisting of heterogeneous collections of atoms containing enormous stores of unavailable energy. The present hypothesis reverses the process. We know there are meteorites—numbers flash through our atmosphere and are seen on every clear dark night; a few reach the surface of the earth. Examination and analysis of the meteors which have been found show that in the main these bodies contain all the elements found upon the earth, and that they are compact bodies formed under considerable pressure. How they came into being is quite unknown; to us they must represent an earlier stage or sub-period of the universe akin to the egg or chrysalis stage in the butterfly's period of existence. The earth is increasing its mass by these falls of meteorites, but the increase although constantly in action is very slow. But it is improbable that the planets of the solar system were formed by this process; it is possible that the planets grow by accretion, but their formation was due to explosions of the central mass. As long as matter was considered to be inert, there was no limit to the quantity of it which could be assembled in one mass and held together by the power of the mutual gravitation of its parts. But it is obvious on further thought that a time will come when the gravitational pressure of a mass will break into the atomic structure of its matter and cause explosions. It is by such explosions that planets are thrown off. We can imagine that in the solar system one great explosion threw off all the planets and their satellites, and that some of the satellites are due to sub-explosions at the same epoch, and some due to capture of remnants. In this, the solar-type of explosion, but one seven hundred and thirtieth part of the solar mass was thrown off, but we may expect all types of explosions—thus the original mass might explode into two nearly equal parts, examples of which we see in many double-star systems, or the explosion might be so shattering that the original mass is almost uniformly broken into thousands of fragments forming a star-cluster like ω Centauri or ξ Toucani. Or the mass of a system may so nearly balance the explosive force that explosions are muffled and intermittent; these would give rise to stellar-variability or, in the case of a body like the Sun, act as one of the causes of sunspots. It has been shown that some of the transformations of radium are rhythmic, a fact which suggests that the sunspot period may be due to atomic disintegration.

Here we may remark that it is not impossible that explosive action on the Earth, as shown in volcanic action, is due to the liberation of atomic energy; formerly it was ascribed to the percolation of water into hot strata, but the recent researches of A. Brun have proved that the ejecta of volcanoes are free from either steam or water. A time comes when the central mass of a system becomes fairly quiescent, such as the Sun now is. In this quiescent stage the Sun is a globe of liquid with an enormous radiation of heat and light waves, and emitting electrons; its heat is mainly due to atomic disintegration which will continue as long as any of it remains, or, in other words, as long as it contains atoms of more than gaseous atomic weight. Its end will be approached by its passing into a gaseous or stellar state, which will later devolve into a nebula. There are no dark suns or stars. Continuity requires that the Earth and other planets should be going through a like process, but on a much slower scale owing to their smaller masses, and perhaps, also, to the different proportions of the elements of which their chemical constitutions are built up; one can imagine that whilst, sây, Jupiter is still growing by planetesimal accretion, the Sun's attractive mass may become so small through the emission of electrons that the centre of our system will be transferred, in the course of ages, to the planet Jupiter.

The explosion hypothesis suggests an explanation for the phenomena exhibited by the so-called Novae or new stars; these are small stars which almost instantly increase enormously in luminosity and slowly and somewhat irregularly fade away, often to small nebulae. These may be assumed to be gaseous stars, in which the ratio of their specific heats exceeds one and one-third; they are then essentially unstable, and a time comes when a radical change of state occurs—a sudden blaze up, followed in most cases by a rapid disintegration into the final state of nebulosity, in which entropy has become a maximum and atomic energy a minimum.

The implication of this hypothesis in the glacial epochs of the Earth is simple. A glacial period will come on slowly as the heat of the Sun falls through the rhythmic close of a period of chemical disintegration; the hot period will come on suddenly with a prodigious melting of the waters, a time of maximum temperature following the epoch of greatest cold comparatively closely. If temperature and time were plotted the curve would resemble that of the light of a variable star, as it should, because the cause at work is the same.

If we seem to live in an age of uniformity in temperature conditions, it is perhaps because the race can only flourish under such circumstances; the theory gives no promise of continued uniformity. An explosive disintegration of atomic energy on the Sun may occur at any time. We can only surmise from past conditions on the Earth that at present the Sun is getting colder in preparation or as an antecedent to a further outburst. Here again the behaviour of variable stars is an indication; although some of these stars are remarkably regular in their changes, others are not, and generally the fainter the minimum the more rapid and brighter the following maximum.

In building up the above hypothesis the following facts of observation have been borne in mind:—

1. The mutation of heavy elements, such as uranium (atomic weight 238·5) into helium (atomic weight 4) with an enormous liberation of energy spread over thousands of millions of years.
2. The changing of stars into nebulae of which some four or five cases are known, whereas the reverse process is unknown.
3. Gaseous stars (spectra showing helium and hydrogen, with or without bright lines) are very light, their density not exceeding one-ninth that of the Sun, whilst their gravitative power seems to be "nil." Thus the brilliant close pair α Crucis shows no orbital motion, whilst the essentially wider solar-type star α Centauri is a rapid binary pair. (N.B.—Wider is used in a mathematical sense and includes the effect of surface luminosity; so far as distance alone goes, α Centauri is not so wide as α Crucis.)
4. Nebulous matter is found near most stars of the gaseous types—thus the nebulous regions of Orion are in the midst of helium-type stars; nebulous matter is unknown near solar-type stars.

As, under the explosion hypothesis, the Sun is liquid it cannot maintain its temperature by contraction, because liquids are virtually incompressible, hence Helmholz's theory of the maintenance of solar heat is not applicable. It is further improbable that gaseous or stellar-type masses always contract as they radiate heat; on the contrary, Kelvin's investigations indicate very strongly that such masses of gas may expand. The argument that spiral nebulae are systems in formation, overlooks the palpable fact that these objects are exceedingly faint. Long exposure photographs give very misleading pictures of spiral nebulae. In nearly every case the total brightness is less than any one of its neighbouring small stars. It would be of the same order of reasoning to assert that islands are formed out of wisps of cirrus cloud.

The commonly received view that gaseous stars are hotter than liquid or sun-type stars has perhaps been engendered by the classification really based on the nebular hypothesis, *viz.*, that white stars are the hottest and that sun-type stars already show signs of cooling, but Huggins clearly shows that solar-type stars are the hotter—thus in his "Atlas of Spectra," 1899, page 85, he says:—

"In strong contrast with this falling off in Vega at about λ 3,700 the continuous spectrum of the solar stars, Procyon and notably Capella—that is to say, the narrow bright intervals between the numerous strong dark lines, . . . is obviously far more intense." And it may fairly be asked, if the gaseous or stellar type of star is the hotter, why it should not show metallic lines in its spectrum. The answer, under the new hypothesis, is that such stars no longer contain substances of high atomic weight, as these substances have disintegrated into the simpler gaseous elements.

One cannot imagine the process, in a universe tending to uniformity and to a maximum of entropy, by which a simple gas, such as nebulium is, can be transformed into complex atoms containing enormous stores of energy. The reverse process seems to be a more fitting one; it starts with heterogeneity and finishes with homogeneity. In short, Laplace's nebular hypothesis as a representation of nature is quite untenable, as it is contrary to observation and to known chemical and thermodynamical laws; in spite of this, literally volumes of mathematical deductions (but not by its author) have been drawn from it.

I have added a list of references to various modern authorities whose views have influenced my own; some numerical results have been quoted.

References.

Barnard.—"The Temporary Stars. On the present appearance of some of these bodies." *Astronomische Nachrichten* No. 4655, 1913, May 20th.

Nova Cygni, 1876: Its appearance is distinctly hazy.

Nova Aurigae, 1891: Its image is ill-defined.

Nova Sagittarii, 1898: It is always hazy and ill-defined.

Nova Lacertae, 1910: It presented the appearance of a very small nebula, less than 2-in. in diameter, of a bluish-white colour.

Chamberlin, Moulton and others. "Contributions to Cosmogony and the Fundamental Problems of Geodesy." "The Tidal and Other Problems," 1909.

This is a remarkable work, which is published under cost price by the Carnegie Institution of Washington, but it is so poorly advertised that its circulation is far below its real merits. For this reason, I venture to quote some of the conclusions reached in it.

Chamberlin:—"The application of the most radical and the most rigorous method of estimating the frictional value of the present water-tides . . . seems to show that they have only a negligible influence on the Earth's rotation . . . The tides of the lithosphere are chiefly elastic strains, and have little retardative value . . . The accelerative forces seem to be also negligible . . . There has been no such change in the rate of the Earth's rotation . . . as to require to be seriously considered in the study of the Earth's deformations." (Page 59).

Chamberlin writes (page 23):—"There can be no theoretical doubt that there are tides of the lithosphere."

Since then Professor A. Young's discovery of lunar-tide effects on the Karoo has since been published. ("Tidal Phenomena at Inland Boreholes near Cradock," *Trans. Roy. Soc. of South Africa*, 1913, Vol. III, Part I.)

Moulton:—"In a word, the quantitative results obtained in this paper are on the whole strongly adverse to the theory that the Earth and Moon have developed by fission from an original mass, and that tidal friction has been an important factor in their evolution. Indeed, they are so uniformly contradictory to its implications as to bring it into serious question, if not to compel us to cease to consider it as even a possibility." (Page 133.)

" . . . The hypothesis of Laplace has the support of no observational evidence. On the contrary, there are well-known considerations . . . which compel us to reject it . . ." (page 137). As to the possibility of the fission-theory of the formation of satellites, planets and double-stars, Moulton's conclusions are:—

"(1) We find that the Sun cannot arrive at this critical stage (fission) until its mean density shall have exceeded 307×10^{11} on the water standard. This corresponds to an equatorial diameter of the Sun of about twenty-two miles.

(2) We find that the Sun cannot become so oblate as Saturn is now until its mean density shall have exceeded 148×10^{10} on the water standard. . . . Since even the latter density is impossibly great we conclude that the Sun will never become so oblate as Saturn is now, and that it will always be more stable than Saturn is now.

"(3) We find that Saturn cannot arrive at the critical state at which Jacobian ellipsoids branch until its mean density shall have become twenty-one times that of water. . . We conclude because of the great density demanded that Saturn will never suffer fission." (Page 159.) "Perhaps the hypothesis that stars are simply condensed nebulae, which has been stimulated by a century of belief in the Laplacian theory, should now be accepted with greater reserve than formerly. Up to the present we have made it the basis not only for work in dynamical cosmogony, but also in classifying the stars. It may be the time is ripe for a serious attempt to see if the opposite hypothesis of the disintegration of matter—because of the enormous sub-atomic energies, which perhaps are released in the extremes of temperature and pressure existing in the interior of suns, and of its dispersion in space along coronal streamers or otherwise—cannot be made to satisfy equally well-known phenomena. The existence of such a definitely formulated hypothesis would have a very salutary effect in the interpretation of the results of astronomical observations. We should then more readily reach what is probably a more nearly correct conclusion, *viz.*, that both aggregation and dispersion of matter under certain conditions are important modes of evolution, and that possibly together they lead in some way to approximate cycles of an extent in time and space so far not contemplated." (Page 160.)

Lunn.—"Geophysical Theory Under the Planetesimal Hypothesis."

In this paper, if I grasp aright the meaning, the author shows, by adopting plausible laws of compression and density, that it is only small bodies that can be very dense, which is borne out so far as they go by astronomical observations; thus we have

Type.	Body.	Mass.	Density.
Planetary ...	Meteorite ...	Infinitesimal	3 to 8
,, ...	Mercury ...	1/5000000	1·21
,, ...	Earth ...	1/330000	1·00
Sun or Solar...	Sun ...	1	0·26
Stellar or Gaseous...	Algol* ...	3	0·14
,, ,,	β Lyrae ...	9·6	0·00016

* Uncertain, Stebbins gives Mass 0·55, Density 0·02.

Cox.—"Beyond the Atom," 1913.

"One pound of the emanation would, at its maximum intensity, radiate energy at the rate of about ten thousand horse-power. This large emission of energy from the radio-active bodies throws an interesting light on two questions which have long been the subject of controversy, the age of the Earth and the source of the heat of the Sun." (Page 109.)

Period of fall of Uranium to half-value six thousand million years. (Table, p. 91.)

Kelvin (and Green).—"The Problem of a Spherical Gaseous Nebula." *Trans. R. S. of Edin.*, 1907-8.

"It is scarcely possible to conceive that any fluid composed of the chemical elements known to us, could be gaseous in the Sun's atmosphere at depths exceeding one hundred kilometres." (Page 268.)

Kelvin calls a gas in which a the ratio of the specific heats is greater than $1\frac{1}{3}$ a gas of species P; and it is almost certain that all monatomic gases have $a = 1\frac{2}{3}$.

"We see that the central temperature of a globe of gas P in equilibrium increases through gradual loss of heat by radiation into space. We then see also that the internal energy of a globe of gas P, continuing in a condition of approximate equilibrium while heat is being radiated away across its boundary, would go on increasing, and the work done by mutual gravitation of its parts would go on increasing till the gas in the central regions becomes too dense to obey Boyle's Law." (Page 281.)

In this statement no account is taken of any possible liberation of atomic energy, but, even without this, it is evident that the underlying idea of contraction is at fault, and that a decrease of internal temperature and increase of size could go on together. So far as observation goes, the evidence is in favour of the latter view. Although hardly supplying an exact parallel, it is well known that the gaseous envelopes of comets contract as they approach the Sun.

Newcomb.—"The Stars: A Study of the Universe." 1902.

"A very remarkable case is that of Zeta Orionis. It has a minute companion at a distance of $2''\cdot5$. Were it a model of the Sun, a companion at this apparent distance should perform its revolution in fourteen years, But, as a matter of fact, the motion is so slow that even now, after fifty years of observation, it cannot be determined with any precision. It is probably less than $0''\cdot1$ in a year. The number expressing the comparison of the density and surface brilliancy of this star with those of the Sun is probably less than 0·0001. The general conclusion to be drawn is obvious. The stars in general are not models of our Sun." (Page 200.)

Newcomb.—"Popular Astronomy," 1882.

"Then a mathematical computation of the attractive power exerted by such a system of masses (five hundred million sun-masses) shows that a body falling from an infinite distance to the centre of the system would acquire a velocity of twenty-five miles a second." (Page 501.)

This calculation does not seem to be correct, but it serves to show how impossible it is for the potential energy of a nebula composed of nebulium, helium and hydrogen to be changed by gravitation into the radio-active and other atomic energies of heavy atoms. The velocity with which a small mass falling from rest at an infinite distance would strike the Sun is three hundred and eighty miles a second. This means that a gram falling into the Sun would generate forty-four thousand eight hundred and forty-four calories; this is but one five hundred thousandth of that evolved by radium.

Perry.—"The Life of a Star." *Nature*, 1899, July 13th.

"Assumptions like those of Homar Lane and Ritter may lead to results which are altogether wrong. . . . Homar Lane, Lord Kelvin, Ritter, and all people who have tried to make exact calculations, have assumed that the stuff of which a star is composed behaves as a perfect gas in a state of convective equilibrium. . . . But if we apply our results to the Sun we find that at its centre there is a density thirty-three, that is, fifty per cent. greater than the ordinary density of platinum. It seems to me that speculation on this basis of perfectly gaseous stuff ought to cease when the density of the gas at the centre of the star approaches 0.1 or one-tenth of the density of ordinary water in the laboratory. . . It seems to me that if a mass of this kind of gas (in which γ the ratio of its specific heats$=1\frac{1}{3}$) gravitates by itself from an infinite distance, it retains all its energy. But such gas must surely be imagined to be radiating heat, as it is not at zero temperature. Where can it get such heat? I come to the conclusion that there must be atomic energy available somehow in it. . . I say that no substance for which $\gamma = 1\frac{1}{3}$ can behave as a perfect gas."

Kelvin's remarks on and his endorsement of Professor Perry's conclusions will be found in *Nature*, 1907, February 14th.

Ramsay. "Elements and Electrons, 1912."

"Cordite, the explosive powder used for our artillery, evolves 1,253 calories per gram. . . Radium, 2,800,000,000 calories."

CORRESPONDENCE.

"THE ORIGIN OF LIFE."

To the Editors of "KNOWLEDGE."

SIRS,—I have seen Mr. H. Stanley Redgrove's article in the August number of "KNOWLEDGE" in which he refers to a "nine days' wonder" produced by my experiments on the action of radium salts on sterilised organic media, such as gelatin bouillon used for the cultivation of bacteria. He adds that Mr. Soddy showed the effects were of a purely chemical nature. I was not aware that Mr. Soddy had made any experiments upon the subject; nor do I believe that unlike the effects produced by barium, strontium, and lead salts, the results due to radium are of a purely chemical nature.

The effects are on the whole physical rather than chemical as I have repeatedly pointed out, and as Sir William Ramsay was good enough to explain they might have been expected to be. My own views upon the subject were put forward at length in my article in the *Fortnightly Review*, September, 1905, and in my book on the "Origin of Life" published in 1906, of both of which Mr. Redgrove is apparently unaware. If these experiments remain a nine years' wonder I throe not, but I venture to deny, considering the prolonged discussion to which they have given rise, and are likely yet to give rise to when more fully understood, that they were a nine days' wonder if indeed they can be said to be a wonder at all.

JOHN BUTLER BURKE.

WEYBRIDGE.

BRITISH MEASURES NEARLY HYDROMETRIC.

To the Editors of "KNOWLEDGE."

SIRS,—It is not, perhaps, generally known that our British system of weights and measures is very nearly *hydrometric*, that is, having a simple relation between the measures of length and weight through the medium of *water*. If we suppose that the gallon is reduced by the small amount of three one-thousandth parts, we have the following interesting and useful relation:

Sixty-four cubic feet = four hundred gallons.

We may visualise this by picturing a cube which measures four feet in each direction and therefore contains $4\times4\times4$, or sixty-four cubic feet.

Now by law a gallon of water weighs ten pounds; and to preserve this relation we must suppose the pound to be reduced by the same small amount as the gallon. If this be done, and if for convenience we call our four-foot cube a "vol," we shall have

One vol of water weighs two tons (four thousand pounds).

An easy deduction from this is

One cubic foot of water weighs one thousand ounces

and from this again we have

$\frac{1}{10}$-foot cube of water weighs one ounce.

IMMO S. ALLEN.

LONDON INSTITUTION,
FINSBURY CIRCUS, E.C.

THE HISTORICAL MEDICAL MUSEUM.

In our notices in the August number of "Knowledge" allusion was made to the Historical Medical Museum, organised by Mr. Henry S. Wellcome, and formally opened by Dr. Norman Moore, the President of the Section of the International Medical Congress which dealt with the history of medicine. The idea of forming a museum illustrating the history of the healing art occurred to Mr. Henry S. Wellcome several years ago, and the remarkable collection of rare and curious objects of historical interest connected with surgery, medicine, and the allied sciences brought together from all parts of the world is now housed at 54a, Wigmore Street, London.

Dr. Norman Moore in the course of his opening address said that the Museum, which had been recognised as a part of the History of Medicine Section of the International Medical Congress, formed a most important addition to its studies. He reviewed the formation of earlier museums, all of which are relatively recent creations and usually developments from libraries. In the reign of Elizabeth, John Dee formed one of the first, a collection of mathematical and astronomical instruments and of various curiosities in his library at Mortlake, but the first considerable museum in England was that of John Tradescant, father and son, at Lambeth. The catalogue of the Tradescantian Museum was printed in 1656, and shows that it had fifteen sections, among which were beasts, birds, reptiles, weapons, and many dried plants and fruits; for the Tradescants were primarily gardeners and collectors of herbs. Their museum went to Elias Ashmole, and was re-arranged at Oxford, where most people have seen the unique head and foot of the dodo, the body having been destroyed in one of those periods of darkness to which all universities are liable.

Another great museum was formed in London by James Petiver, an apothecary to the Charterhouse, who was educated at Rugby School and at St. Bartholomew's Hospital. He was a botanist and entomologist, but the many sea captains whom he came to know, brought him every kind of curiosity from all over the world. Sir Hans Sloane bought his collection and others, made a great one of his own, and bequeathed the whole to the nation.

All these early museums were associated with libraries and contained every kind of specimen, and this form the British Museum still retains. The museum of Francis Calceolari, of Verona, is described in a folio of eight hundred pages printed in 1622, and a picture of the museum showed the original form which developed into such a collection as is the British Museum. The specimens were in a well-proportioned room, paved with variegated marble and surrounded by an ornate sort of dresser with drawers and shelves. At one end were books and on the shelves all round were specimens. On one side was a statue of Atlas bearing the world, showing the regions whence the specimens had come, and on the other Minerva, showing that all learning was included in the collection.

The gift of Dr. William Hunter to the University of Glasgow was another museum of this type. It contains pathological, anatomical, and natural history specimens, manuscripts, pictures, early printed books, Greek and other coins.

A more limited kind of museum succeeded these vast collections, of which a type is the collection of anatomical preparations formed by Edmund King, surgeon to St. Bartholomew's, in the seventeenth century. Of these specialised museums the greatest was that of John Hunter, now under the care of the Royal College of Surgeons in Lincoln's Inn Fields.

The museum, which they were there to open was the first established in England to illustrate the history of medicine, and it might justly be regarded as a further step in the establishment of the subject as a regular study.

The origins of medicine might be studied in two directions. In the hall in which they were assembled could be seen two figures which typify these. There was Ixtilton, the Mexican god of healing, his head covered by a grotesque mask, a necklace of the teeth of the sperm whale round his neck, a curious instrument of enchantment in his right hand, seeming to have uttered some strange and terrifying ejaculation as he extended his left hand. Near him was the Apollo Belvedere, the most perfect of the sculptured representations of men; his face showed the highest flights of thought and powers of observation. The figure of Ixtilton suggested charms, amulets, and magical ceremonies. The figures of Apollo and of his son Asklepios suggested observation, experiment, and reasoning.

. . . . .

It is always useful when considering the development of any phase of human activity which began at a time before written records were made, to study what is done at the present day by uncivilised people, and one section of the Historical Medical Museum is devoted to what one might call superstitious medicine, to the fancies and fetishes of savages and the ways and implements of witch doctors. For instance, in the entrance hall we find one of the rough figures from the outside of a village, into which scores of sufferers have driven spikes and nails, indicating the places in which they felt pain

Figure 393. The Barber Surgeon's Shop.

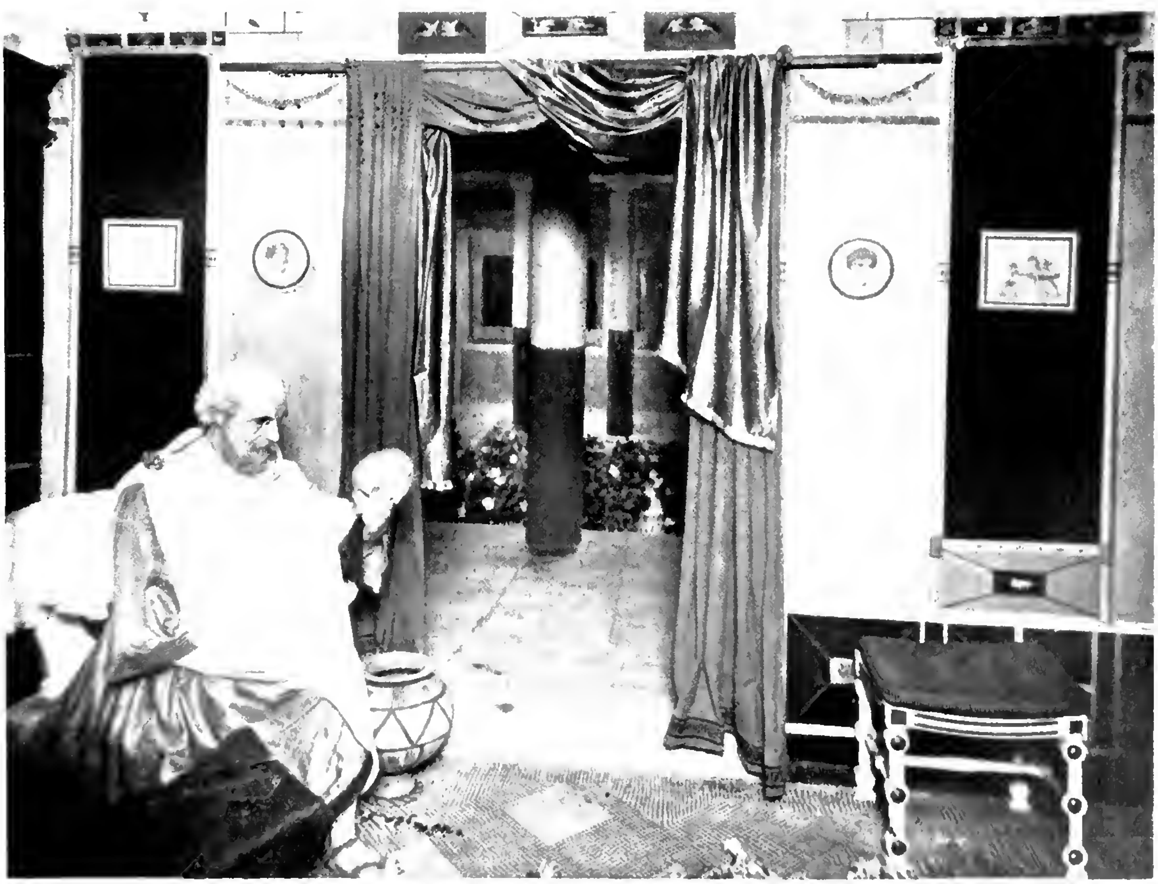


Figure 394. A Roman Surgery in Pompeii.

FIGURE 395. Liebig's Laboratory.

FIGURE 396. An Alchemist's Laboratory.

in their own bodies, and with the belief that by the simple process adopted they would be cured.

Adjacent to this exhibit, and coming like it from tropical countries, we have quite the latest development of modern zoölogical medicine; for arranged under microscopes are slides illustrating the most important Protozoa which cause disease, and on the walls are maps, diagrams, and pictures showing the past history and present knowledge of malaria, yellow fever, sleeping-sickness, and other diseases which make themselves felt in hot climates.

Exceedingly interesting is the series of portraits and relics of Dr. Edward Jenner, the discoverer of vaccination, which are in an alcove of the Gallery of Pictures, and, indeed, not the least remarkable part of the collection is that devoted to celebrated medical men.

Returning to the bacteriological side we are reminded again and again of the great benefits of antiseptic surgery. At the same time there are many pictures of operations performed in ancient days which proved perfectly successful. In this connection it may be mentioned that not a few of the exhibits indicate what operations were like before the introduction of anaesthetics. One peculiar feature of the representations, whether they be of operations, of post mortems, or of birth chambers, is the large audience that has collected together in most of the cases.

As may be expected, a fair amount of space is devoted to surgical instruments and their evolution, but it must not be thought that there is not an immense amount of material of general interest. There is an excellent selection of charms and talismans, including many Egyptian amulets, and a feature which we have chosen to illustrate here by the courtesy of the Museum Committee is the reconstruction of ancient shops and laboratories. On page 375 we show the barber surgeon's shop, the ceiling of which is decorated with bleeding-dishes. Below, on the same page, we reproduce a photograph of a Roman surgery in Pompeii, which has been reconstructed for the Historical Medical Museum, and the furniture and decoration of which have been copied from the originals found in Pompeii and Herculaneum. On page 376 is depicted Liebig's laboratory, and also that of an alchemist.

Other points of special interest on the ground floor are the representation of a lying-in room of the sixteenth century, the chapel showing votive tablets, chiefly from Perugia, which were offerings put up out of gratitude by those who had recovered from accidents or disease during the seventeenth, eighteenth, and nineteenth centuries. We must not forget to mention also a London pharmacy of the eighteenth century. The shop front is the original of that established in 1798 by John Bell, the founder of the Pharmaceutical Society. The room at the back contains the actual fittings from a pharmaceutical laboratory of the eighteenth century which once stood in Russell Street, Covent Garden.

It would be impossible within the limits of a single article to give a really comprehensive account of all that Mr. Henry S. Wellcome and his able assistant, Mr. C. S. Thompson, have got together, but we may mention a few things which have attracted our attention during our visits to which allusion has not yet been made.

Among the very many pictures are representations of Ambroise Paré using the ligature when amputating on the battlefield at the siege of Baravilliers in 1552; of William Gilbert demonstrating the magnet before Queen Elizabeth; of William Harvey explaining his theory of the circulation of the blood to Charles I; and of Leeuwenhoek with his microscope. Elsewhere there is a fine collection of early microscopes, which alone would be worth a visit to the Museum.

A case not mentioned in the catalogue contains the shirt, drawers, and garters worn by Charles I on the scaffold, together with touch-pieces, mostly nobles from the reign of Henry VIII onwards, used in connection with touching for king's evil.

The frieze in the gallery of pictures represents the sculptured reliefs in the birth-house at Luxor illustrating the birth of Amenophis III, 1450 B.C.

In the gallery devoted to books, manuscripts, and diplomas we find a demand from the Rector and Council of the University of Pavia to the Inquisitor of Witches. It appears that the anatomical department of the University was entitled to the body of one malefactor every year, but that they had not had one for six years; and hearing that a woman had been sentenced to be burned alive for witchcraft, the authorities applied to the Inquisitor, requesting him to choose some other method of killing her, so that her body might be useful, not only to the University of Pavia, but to the world at large.

We are shown also the contents of the opium den raided in the east end of London which previously had furnished Charles Dickens with his references to opium smoking in "The Mystery of Edwin Drood." The evolution of the infant's feeding bottle from a cow's horn is illustrated, and there are some interesting models of and original parturition chairs. A Sicilian one of the latter, dating from the eighteenth century, was believed to possess special powers, and was known as "The Miraculous Chair of Palermo." It was in the possession of a famous family of midwives for three generations, and it is estimated to have been used in two thousand cases.

With the instruments of torture we find a number of appliances used for restraining the insane from the fifteenth to the eighteenth century. There are ancient weights and measures, and a collection of curious materials used in medicine. It is understood that the Museum will be made a permanent one, as a great many of the objects belong to Mr. Wellcome or have been presented, while a number of those who have lent specimens will allow them to remain for some time on exhibition. The Museum is not open to the public, but members of learned societies can gain admission.

THE NATURE OF X-RADIATION.

By W. F. D. CHAMBERS, B.A. CANTAB.,

Barrister-at-Law.

(*For Illustrations, see Page 390*).

Is the universe a liquid or "flowing crystal" in process of transformation, with varying acceleration, to the solid or cubic state?*

Daring as such a speculation may appear to-day, its analogies are almost involuntarily suggested by recent developments in optics and crystallography; and speculation (in leisure hours) gives a zest to science.

Even the older physics and astronomy taught us that it was not improbable that the sidereal universe might be tending, under laws of conservation and dissipation, to a uniform diffusion of heat, a *rigor mortis*, in which there should exist no longer the restless surge of potential differences which is responsible for the grand drama of life and evolution.

Coming now to sober facts, it will be familiar to your readers that the X-rays, hitherto supposed to be subject neither to refraction, diffraction, nor deflection by magnetic fields, have at last yielded to the seductions of crystalline substances, as the present writer predicted they would four years ago. From the year 1905 a particulate theory of the aether, or medium supposed to pervade space, has been advocated, and it was proposed that light, in some forms at least, might consist of polar particles, or self-satisfying doublets, which neutralise *inter se* their chemical valencies, and, even in a high degree, their susceptibility to external stress. The X-rays, and at first the alpha particle of helium, emitted by the radium atom undergoing transformation, were supposed to be among these forms. This hypothesis, first published in *The Journal of Downside College*, 1907, was later sketched as a general theory of Energy-Action in the *Scientific Monthly Magazine*. The distinctive geometrical feature of the attempt was the use of Gregory St. Vincent's principle of the quadrature of the hyperbola, which curve in its rectangular form was supposed to furnish a limit to the excursions of light and cathode particles, when the curve is transformed to polar coördinates, and rotation round an axis is supposed added to the motion. Professor Bickerton, quite independently of the writer, has made use of a similar geometric scheme for his Kinetol, *vide* "Birth of Worlds and Systems," 1911, page 17.

Benoist [*Journal de Physique* (3), X, 1901, page 653, and elsewhere] has shown that when X-rays are allowed to fall upon various metallic surfaces after passing through a standardising prism of paraffin, the molecular weights plotted against the absorptions seem to approximate to such a curve, and this law of absorption (which must correspond with a redistribution of material particles) is independent of temperature. Furthermore, there is reason to think that individual series of compounds are susceptible of treatment in the same way, especially as regards their critical changes at high temperatures. We may also recall the fact that in his original experiments on the modifications of light produced by narrow apertures Newton found that the shadows produced by knife-blades placed in the path, approximated to rectangular hyperbolas the more nearly the edges were brought together.

Professor Bragg has given the more complete expression of the doublet theory of X-radiation, and Tutton has dealt with the conception in its wider application in his work on crystals (" International Science Series "), where he illustrates the various internal and external forms which may be produced by " astatic " or moving magnetic fields.

It has also been pointed out that such a theory of the ultimate significance of Mendeléef's famous principle of periodicity would probably lead us to suspect a composite nature of hydrogen, which might be considered as a primary doublet, or perhaps connected with the terrestrially unknown gases coronium and nebulium; and now Sir J. J. Thomson has given grounds for believing in the possibility of some such modification of Prout's hypothesis. Hydrogen, if not composite, is at least capable of some extraordinary action with neon.

It must not, however, be supposed that such speculations are opposed fundamentally to the undulatory theory of light. The discoveries of Perrin in connection with the " Brownian movements " in fluids in no way invalidate tidal theory, though they tend to show that water may be considered from another, and perhaps deeper, point of view than that which treats of the unresolved motion of its particles, or movements *en masse*. The mechanism of ripples or " pulses " in aether may in like manner be shown to be subject to general laws of arithmetical and geometrical progression in the distribution of constituents, and yet this need by no means change the law of averages, the differential equations of the group effects. Similarly we assert nothing of the movements of individual birds in a flight or of bees in a swarm merely because we see numbers of them together moving as if they had no purpose or aim in their random wanderings on behalf of nest or hive. Indeed there are cases where

* Some recent theorists have sought to reduce even colloids to a crystal basis.

such aggregates of moving individuals, *e.g.*, the spiral nebulae, will appear perhaps like a stationary or wavy streak of cloud maintaining a fictitious appearance of rest during long periods; and yet they are in all probability the seat of turbulent centrifugal action the ends of which it will take aeons to discern.

Professor See, of Mare Island, California, in his recent monumental work on the nebular theory, maintains that he has adduced evidence that the older forms of these mysterious germs of worlds approximate to the Archimedean form of spiral, the later tending to the logarithmic. These curves can express respectively arithmetical and geometrical progressions such as Perrin found; and it is noteworthy that upon any such theory of gravitation, as a residual mode of energy, as that of Lorentz a resistance varying in the inverse square must be added. Professor See in a recent letter to the writer suggests that sufficient attention has not yet been given to such attempted correlation; such was also the opinion of Poincaré. It appears not improbable that free electrons passing through atoms, or some stars, such as 1830 ϵ Groombridge, through globular clusters, would do so, not upon long ellipses, but rather on elliptiform helices, their orbital motion being gradually damped while passing through the centre of the cluster. Yet in no science must we be more vigilant against spurious appearances of irregularity or regularity than in optics. In that science a speculative element is positively a saving grace; as Faraday expressed it: "That man only is condemned who cherishes fixity of opinion." Do not the canals of Mars teach us a like lesson, that these questions of law or ultimate expressions of fact are still open to faith in a beneficent and volitional purpose?

In pursuance of such ideas Mr. Rankin and the writer have recently (*Nature*, June 19th and August 21st, 1913) been able to show that X-rays are "diffracted," or at least characterised by contact or close proximity to metals as well as "crystals," and even by substances such as plate glass (see Figure 411), which must be regarded as either structureless or at least in a transitional stage, seeing that it is a super-cooled liquid. Some of these effects have also been obtained through cast, as well as wrought, iron plates (up to one centimetre in thickness), used as obstacles without apertures, showing a geometrical pattern on special rapid plates which can scarcely in all cases be attributed to the mechanical rolling of the metals. It seems not improbable (see Figure 410) that the primary beam of X-rays has undergone some displacement or shift, as though it were subject to some repulsive agency which begins to act perceptibly at short distances, effects which are visible only to the photographic eyes of science. In this experiment a thin lamina of mica was used to cover the aperture in a lead screen, and was placed at an angle of 85° to the rays. The curious bands upon the reflected portion of the beam are still, we believe, unexplained. A series of upwards of two hundred experiments has been made with the object of throwing light upon some of the obscure questions raised by the recent reflection of X-rays. A short résumé only of the results can be given in the present article.

Halos, similar to those of Figures 406 and 407, were obtained both with and without mica, or other crystal used to cover the apertures, which were generally about a quarter of an inch in diameter, in metal screens, lead, iron, brass, and others. One hypothesis of these halos attributes them to atmospheric secondary radiation. They are probably not halation effects, though if this were the case it would be tantamount to a reflection of X-rays from a glass, *i.e.*, a non-crystalline surface, the back of the "special rapid" plate. The term "halo" is carelessly used by photographers, and should we think be confined to appearances such as Figure 406, where the feature is independent of the image of the direct rays; in Figure 407 the white band alone secures the effect from being possibly due to secondary radiations, or some cause not implicating the primary rays. In experiments (see Figure 409) to study the disposition of the reflected spots from mica placed normally to the aperture in an iron screen it was found in several cases that these markings occur at increasing distances from the centre, indicating a spiral sequence; the exterior spots not well seen in the reproduction, appear elongated or drawn out into bands which are not concentric. Figure 408 shows one arm of a bright cross which had appeared on one negative where no mica or crystal had been interposed in the aperture of an iron screen. This cross covered the whole plate, *i.e.*, extended beyond, and was apparently independent of, the image of the aperture, and suggested a possibility that the primary rays might possess some structure or be polarised or quenched in special directions by the use of certain crystals. But in further experiments black bands parallel and normal to the arms of a cross were obtained even with the direct or uninterrupted rays received upon a plate within a wooden box containing an intensifying screen. This raised the question whether these bands might not be purely photographic effects due to some development errors or the mechanical process of plate manufacture, though plates of various makers had been used and all the non-essentials of the experiment repeatedly changed. A crucial trial was therefore devised to determine how far photographic errors could effect the general results, and this showed that the possibility of vibrations at right angles to the plate in process of manufacture causing inequalities of disposition of the sensitive material in process of drying, must be taken into consideration This particular effect could not be due to a primary structure of the X-ray beam, *i.e.*, a structure antecedent to all obstacles, such as metallic crystals, whether in the wires, anti-cathodes, or glass of bulb or plates. The experiment was arranged as follows. Four recording plates, two made by the well-known

Ilford Company, and two by the Imperial Plate Company, of Cricklewood, were placed parallel, one behind the other and a thick lead screen. The plates were normal to the rays, but their edges were at various angles to the horizontal, none of them being the "way" of the plate-process. The distance between the plates was a few centimetres, and that of the first plate to the platinised-nickel anti-cathode of a water-cooled X-ray bulb was fifty centimetres. A constant current of ·7 milliampere was passed through the bulb, and the exposure continued for eleven hours. Dark parallel bands showing a crossed system appeared on all the plates, but these are not, as they should be if one continuous form or structure of radiations had been transmitted through the series, in some one definite relation to the images of three small circular apertures in triangular form which had been made in the lead screen. Similar bands, however, in so many other experiments have been found in a definite quadrilateral pattern that *chance* variations in the plate process or in development can scarcely be the cause, though some *definite* variations causing an inequality of absorbing substance may be. It appears that such causes varying the effect must be considered as one of the inevitable disadvantages of the photographic method, which even in the case of experiments with crystals, giving reflections or spots of variable form, should be checked by such devices as we have used, or even by the ionisation method. Mr. Keene, in a recent letter to *Nature*, seems to suggest the convertibility of the spots and bands by the mechanical structure of rolled metals.

Inference is either direct or indirect. A thoroughly instructive experiment does not allow one to escape its lesson. But there is another kind of inference, less trustworthy, but still necessary, to guide research, which demands theoretical knowledge or ingenious insight into analogy. No doubt one must first adopt the method of frontal attack which leads to the inevitable form of inference, yet afterwards probabilities or speculative suggestions may be tolerable or even useful.

Now, if the X-rays are simply light, the reasons which may compel them to appear different may be: (1) that the velocity is higher; (2) that the mass of the constituent rays or particles may be greater, the total momentum being higher on one or other of these grounds. I prefer to suppose that it is the velocity, considered as a function of the inertia or primary property of resistance, which is greater than that of ordinary light.* It does not appear that experiments have yet rendered untenable this reduction of light and matter to one and the same substantial theory of electrical resistance. If not, it may form a simple aim or guiding hypothesis which, being proven, would constitute an advance towards the simplicity of generalisation. One or two salient facts which tend in support of such a theory may be mentioned here, not because they prove it, but rather that they are steps on the way. Thus the writer found, following Tribe and Leduc, that if a small quantity of potassium ferri-cyanide be compounded with gelatine, and the mass subjected to electric currents of low voltages, coloured rings appear in the gelatine round the electrodes, and these rings are undoubtedly due to the transport of ions from one pole to the other after the chemical dissociation of molecules. In one case a clear-cut impression like a seal or intaglio was obtained round the zinc electrode as though matter had been actually scooped out and transferred to the other pole. Also Scheffer, of Berlin, has recently shown that probably particles of silver bromide in the gelatine of such plates as were used for these X-ray experiments explode and emit daughter particles having filaments connecting them to the parents. It seems reasonable to expect that there should be for freed electrons some lateral principle of limitation of the distribution answering to the vertical geometrical progression discovered by Perrin for the arrangement of small particles in fluids. For instance, he found (*vide* "The Brownian Movement and Molecular Reality," translated by F. Soddy, F.R.S., page 42) that the concentrations of granules were determined in five equidistant planes, the numbers being 100, 116, 146 170, and 200, whereas the numbers 100, 119, 142, 169, and 201, which do not differ from the preceding by more than the limits of an experimental error, are in geometrical progression, the altitudes (represented in Gregory Vincent's construction as areas or volumes) being in arithmetical progression. This is also suggested to the ordinary observer by the form of the smoke from volcanoes in still air, which spreads out into a flat plate bounded on the undersurface by what resembles a hyperbolic curve. Such a principle, if based on numerical experiments such as those of Perrin, with the granules of X-ray plates, might tend in the direction of setting free the logarithmic or hyperbolic curve from the special mode of energy-action we know as gravitation, giving us a counter-principle of levitation or atomic-segregation through the cosmos acting, in general, contrary to weight, which is conformable to much recent research and speculation, including Professor Bickerton's new astronomy.

* This view was first expressed by the writer before Kaufmann and Abraham had given experimental evidence of it for Cathode particles. *Vide* "New Theories in Biology," *Zoological Record*, 1899, where it is called the principle of "Cumulative inertia."

THE FACE OF THE SKY FOR NOVEMBER.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 65.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Uranus. R.A.	Uranus. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Nov. 1	14 24·4	S. 14·3	17 3·0	S. 28·0	15 56·6	S. 23·3	12 53·8	S. 4·0	7 30·1	N. 23·1	18 56·3	S. 23·1	5 5·4	N. 21·1	20 24·9	S. 19·9	8 1·0	N. 20·1
,, 6	14 44·1	15·9	21 39.2	S. 16·9	16 15·7	24·1	13 16·8	6·4	7 35·9	23·1	18 59·8	23·0	5 4·2	21·1	20 25·3	19·9	8 1·0	20·1
,, 11	15 4·2	17·3	1 13·2	N. 10·3	16 26·4	24·1	13 40·1	8·7	7 40·7	23·1	19 3·5	22·9	5 2·8	21·0	20 25·7	19·9	8 0·9	20·1
,, 16	15 24·6	18·7	5 29·7	N. 28·3	16 22·8	23·0	14 3·7	11·0	7 44·3	23·2	19 7·4	22·8	5 1·4	21·0	20 26·3	19·8	8 0·7	20·1
, 21	15 45·4	19·9	10 14·0	N. 12·9	16 2·8	20·6	14 27·7	13·1	7 46·7	23·3	19 11·5	22·7	4 59·8	21·0	20 26·9	19·8	8 0·5	20·1
, 26	16 6·5	S. 20·9	14 35·5	S. 19·4	15 37·2	S. 17·7	14 52·2	S. 15·1	7 47·7	N. 23·5	19 15·7	S. 22·6	4 58·1	N. 20·9	20 27·6	S. 19·8	8 0·3	N. 20·1

TABLE 66.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Mars. P	Mars. B	Mars. L	Mars. T	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
Greenwich Noon.	°	°	°	°	°	°	°	h. m.	°	°	°	°	h. m.	h. m.
Nov. 1	+24·6	+4·3	312·5	+ 5·5	−14·4	+9·4	15·0	10 58 *m*	−6·8	−1·5	304·5	292·4	1 32 *e*	1 53 *e*
,, 6	23·7	3·7	246·6	−17·7	13·6	9·8	328·2	2 10 *e*	7·2	1·4	12·8	322·6	9 30 *e*	1 3 *e*
,, 11	22·6	3·2	180·7	−20·9	13·0	10·0	281·7	5 22 *e*	7·6	1·4	81·2	352·7	7 38 *e*	0 13 *e*
,, 16	21·2	2·6	114·7	− 3·1	12·5	10·1	235·3	8 32 *e*	8·0	1·4	149·4	22·9	5 46 *e*	9 19 *e*
,, 21	19·7	2·0	48·8	+19·4	12·1	10·1	189·3	11 41 *e*	8·4	1·3	217·7	53·0	3 54 *e*	8 29 *e*
,. 26	+18·0	+1·4	342·9	+17·1	−12·0	+10·0	143·5	2 11 *m*	−8·8	−1·3	285·9	83·1	2 2 *e*	7 39 *e*

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Mars, T is the time of passage of Fastigium Aryn across the centre of the disc. In the case of Jupiter, L_1 refers to the equatorial zone; L_2 to the temperate zones; T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

The asterisk indicates the day following that given in the date column.

THE SUN continues his Southward march, but with slackening speed. Sunrise during November changes from 6.53 to 7.44, sunset from 4.35 to 3.53. Its semi-diameter increases from 16′ 9″ to 16′ 15″. Outbreaks of spots in high latitudes should be watched for.

MERCURY is an evening star till 23rd. It reaches greatest elongation (23½° E) on 2nd, but, being South of Sun, is not well placed for observation by Northern observers. Illumination diminishes from ⅜ to Zero, then increases to $\frac{1}{12}$. Semi-diameter increases from 3″ to 5″.

VENUS is a morning star, rising 2 hours before the Sun. Semi-diameter diminishes from 5½″ to 5¼″. At beginning of month $\frac{9}{10}$ of disc is illuminated; at end of month $\frac{18}{20}$. Being North of Sun it is favourably placed for Northern observers.

THE MOON.—First Quarter $5^d\ 6^h\ 34^m$ *e*; Full $13^d\ 11^h\ 11^m$ *e*; Last Quarter $21^d\ 7^h\ 56^m$ *m*. New $28^d\ 1^h\ 41^m$ *m*. Apogee $9^d\ 4^h$ *m*, semi-diameter 14′ 46″. Perigee $25^d\ 6^h$ *m*, semi-diameter 16′ 22″. Maximum Librations, 1^d 7° N, 2^d 7° W, 16^d 7° S., 17^d 5° E, 29^d 7° N, Dec 1^d 6° W. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon (see Table 67).

TABLE 67. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.		h. m.	
Nov. 1 ...	BAC 5838	6·8	4 51 *e*	129°	—	—
,, 5 ...	27 Capricorni	6·1	6 12 *e*	31	7 22 *e*	269°
,, 8 ...	BAC 8129	6·3	3 39 *e*	101	4 31 *e*	195
,, 14 ...	66 Arietis	6·1	6 29 *m*	118	7 11 *m*	223
,, 16 ...	BD+27°880	7·0	—	—	5 31 *e*	248
,, 16 ...	136 Tauri	4·6	6 1 *e*	103	6 49 *e*	242
,, 18 ...	47 Geminorum	5.6	2 8 *m*	79	3 20 *m*	304
,, 18 ...	BAC 2383	6·5	5 38 *m*	27	5 49 *m*	9

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

MARS is a morning Star, in Gemini, semi-diameter 6″, defect of illumination over a second. It passes its stationary point on November 27th, and will reach Opposition early in January, so the season of observation has commenced. The North Pole is now turned towards us.

JUPITER is now very low in the West. Polar semi-diameter, 16″ in mid-November.

TABLE 68.

Day.	West.		East.	Day.	West.		East.
Nov. 1	413	○	2	Nov. 16	24	○	13
,, 2	42	○	13	,, 17	421	○	3
,, 3	4	○	3 2● 1●	,, 18	4	⊙	23
,, 4	41	○	23	,, 19	4	⊙	31
,, 5	423	○	1	,, 20	4321	○	
,, 6	3421	○		,, 21	43	○	21
,, 7	3	○	412	,, 22	431	○	2
,, 8	31	○	24	,, 23	42	○	31
,, 9	2	○	134	,, 24	21	○	43
,, 10	2	○	34 1●	,, 25		○	1243
,, 11	1	○	234	,, 26		○	234 1●
,, 12	2	⊙	14	,, 27	231	○	4
,, 13	321	○	4	,, 28	3	○	14 2●
,, 14	3	○	214	,, 29	31	○	24
,, 15	31	○	42	,, 30	2	○	14 3●

Configuration at 5^h *e* for an inverting telescope.

Satellite phenomena visible at Greenwich, $1^d\ 7^h\ 55^m$ I. Oc. D., $8^h\ 0^m$ II. Tr. I.; $2^d\ 5^h\ 11^m$ I. Tr. I., $6^h\ 21^m$ I. Sh. I., $7^h\ 30^m$ II. Tr. E.; $3^d\ 5^h\ 50^m\ 20^s$ I. Ec. R., $7^h\ 56^m\ 52^s$ II. Ec. R.; $5^d\ 6^h\ 44^m$ III. Sh. E.; $9^d\ 7^h\ 11^m$ I. Tr. I.; $10^d\ 4^h\ 24^m$ I. Oc. D., $5^h\ 31^m$ II. Oc. D.; $11^d\ 5^h\ 5^m$ I. Sh. E.; $12^d\ 5^h\ 5^m$ II. Sh. E., $6^h\ 22^m$ III. Tr. E., $7^h\ 14^m$ III. Sh. I.; $17^d\ 6^h\ 23^m$ I. Oc. D.; $18^d\ 4^h\ 41^m$ I. Sh. I., $6^h\ 0^m$ I. Tr. E., $7^h\ 0^m$ I. Sh. E.; $19^d\ 4^h\ 8^m\ 59^s$ I. Ec. R., $4^h\ 47^m$ I. Sh. I., $5^h\ 42^m$ II. Tr. E.; $23^d\ 4^h\ 48^m\ 38^s$ III. Ec. R.; $24^d\ 5^h\ 6^m\ 16^s$ IV. Ec. D.; $25^d\ 5^h\ 42^m$ I. Tr. I.; $6^h\ 36^m$ I. Sh. I.; $26^d\ 5^h\ 37^m$ II. Tr. I., $6^h\ 3^m\ 52^s$ I. Ec. R., $28^d\ 5^h\ 10^m\ 49^s$ II. Ec. R. All these are in the evening hours, the planet setting before midnight. Attention is called to the double eclipse of 3^d. The eclipses take place to the east of the disc, or to the right in an inverting telescope.

SATURN is a morning star, in Taurus, in a good position for observation. Polar semi-diameter 9½″. P. is $-4°\cdot7$; ring major axis 47½″, minor 21″. The ring is very widely open. It is of interest to examine the exact amount of overlap beyond the planet's pole.

East Elongations of Tethys (every fourth given), $1^d\ 5^h\cdot4m$, $8^d\ 6^h\cdot5e$, $16^d\ 7^h\cdot7m$, $23^d\ 8^h\cdot9e$, Dec. $1^d\ 10^h\cdot1m$; Dione (every third given), $3^d\ 10^h\cdot3m$, $11^d\ 3^h\cdot3e$, $19^d\ 8^h\cdot3e$; $28^d\ 1^h\cdot2m$; Rhea (every second given), $8^d\ 10^h\cdot9e$, $17^d\ 11^h\cdot5e$, $27^d\ 0^h\cdot2m$. For Titan and Iapetus E.W. mean East and West Elongations; I. Inferior (North) Conjunctions, S. Superior (South) ones. Titan, $2^d\ 3^h\cdot7e$ I., $6^d\ 0^h\cdot1e$ W.; $10^d\ 11^h\cdot3m$ S., $14^d\ 1^h\cdot9e$ E., $18^d\ 1^h\cdot6^d e$ I., $22^d\ 9^h\cdot8m$ W., $26^d\ 9^h\cdot0m$ S., $30^d\ 11^h\cdot5m$ E.; Iapetus, $8^d\ 8^h\cdot2m$ W., $27^d\ 2\cdot4^h m$ S.

URANUS is an evening star. Semi-diameter, 1¾″. At 1¾° S. of ρ Capricorni.

NEPTUNE is a morning star, entering Cancer. Stationary at beginning of November.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant.		Remarks.
	R.A.	Dec.	
	°	°	
Nov. 1 ...	43	+ 22	Slow, bright.
,, 2 ..	58	+ 9	Slow, bright.
,, 10-12 ...	133	+ 31	Very swift, streaks.
,, 14-16 ..	150	+ 22	Leonids, swift, streaks.
,, 16-28 ...	154	+ 41	Swift, streaks.
,, 20-23 ..	63	+ 23	Slow, bright.
,, 17-23 ...	25	+ 43	Andromedids, very slow, trains.
,, 25 to Dec. 12	189	+ 73	Rather swift.
,, 30 ...	190	+ 58	Swift, streaks.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 0^h to 4^h, next month 2^h to 6^h, and so on.

TABLE 69. NON-ALGOL STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m.	°		d.	
SS Cassiopeiae	0 5	+51 ·1	8·5 to 11·7	139·6	Sep. 6.
T Ceti	0 17	−20 ·5	5·4 to 6·9	280·6	Oct. 16 (min.)
T Cassiopeiae...	0 19	+55 ·3	6·7 to 12·5	443·0	Oct. 7.
TU Cassiopeiae	0 22	+50 ·8	7.7 to 8·5	59	Oct. 29.
TU Andromedae	0 28	+25 ·5	7·7 to 11	317	Oct. 27.
RX Cephei	0 43	+81 ·5	7·4 to 7·9	130	Oct. 24 (min.)
RV Cassiopeiae	0 48	+46 ·9	8 to 13	327	Oct. 24.
Z Ceti	1 2	− 1 ·9	8·8 to 13·5	184·5	Oct. 6.
S Piscium	1 13	+ 8 ·5	8·2 to 14·7	404·45	Sep. 6
X Cassiopeiae	1 51	+58 ·8	8·4 to 12 2	367·0	Nov. 22.
R Arietis	2 11	+24 ·7	7·5 to 12·7	186·66	Sep. 12.
R Ceti	2 22	− 0 ·6	7·5 to 12·8	166·88	Oct. 20.
U Ceti...	2 30	−13 ·5	6·6 to 12·7	235·2	Dec. 8.
R Trianguli	2 32	+33 9	5·9 to 11·1	265·4	Dec. 27.
Y Persei	3 22	+43 ·9	8·2 to 10·4	254·9	Nov. 2.

β Lyrae minima Nov. $8^d\ 5^h e$, $21^d\ 3^h e$, Period $12^d\ 21\cdot8^h$.

Algol minima Nov. $5^d\ 2^h\ 8^m m$, $7^d\ 10^h\ 57^m e$, $10^d\ 7^h\ 46^m e$, $13^d\ 4^h\ 35^m e$, $28^d\ 0^h\ 40^m\ m$, $30^d\ 9^h\ 29^m e$, Period $2^d\ 20\cdot8^h$.

NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

THE NUMBER OF VISIBLE STARS.—The enquiry as to the number of stars in the entire heavens that can be seen with our best telescopes, or photographed by them, is a very interesting one. Various estimates have been given at different times, some going as high as a thousand millions, but it now appears that this nnmber is greatly in excess of the truth. Naked-eye observers are often surprised on hearing that they can seldom see more than two thousand stars at a time. In the same way, when one has seen some of the rich fields of the sky in a large telescope, with the whole region thickly studded with stellar points, one is apt to make extravagant estimates of the number in the whole sky. Mr. R. H. Tucker has a paper in *Publications of the Astronomical Society of the Pacific* for Angust, in which he gives, by the collation of various authorities, the number which can be seen visually (*i.e.*, down to the 17th magnitude) as forty million, or a thousand to the square degree. This is about the same as the number of inhabitants of Great Britain. He gives the number that can be photographed (*i.e.*, down to the 20th magnitude) as a hundred millions. It is well known that the relative increase in number for each additional magnitude falls off for the fainter stars, indicating either an absorption of light in space or our actual approach to the limits of our system. In any case, the number given must be less than the real number of stars in our system, for there are many stars of small intrinsic luminosity which are faint even when near us, and would be invisible in the more remote parts of the system. Of course, no account can be taken of dark, burnt-out stars, as we have no means of forming an estimate of the number of these. If we suppose the star density to remain constant throughout our system (which is probably not true) and take the number of stars within sixteen light-years as eighteen, then a hundred million stars would fill a sphere of radius three thousand light-years, which is the same value as Newcomb's for the distance of the outer parts of the Galaxy. But the value rests on snch doubtful assumptions that it is only a rough guess.

The same publication contains an article by H. D. Curtis on the unit to be used for stellar distances. He advocates the continuance of the use of the light-year, instead of the astron or parsec, on the grounds that it is more easily grasped by the general reader, and also that it is known to one part in ten thousand, or ten times as accurately as the solar parallax. As regards the first point, I do not think that anyone proposes to drop the ligbt-year for popular purposes; the second does not seem to me to carry much weight, in view of the fact that star-distances can only be found in terms of the sun's distance, and also that no stellar parallax is trustworthy to more than two significant figures. The parsec is advocated because it enables us to pass almost instantaneonsly from parallax to distance, thns saving a large amount of mental arithmetic.

There is one point in his paper which gives some food for thonght: he speaks of the light-year as being six ***trillion*** miles. This is an instance of the American system that calls a thousand millions a billion, a thousand billions a trillion, and so on. The English system makes a million millions a billion, a million billions a trillion, and so on. It has the logical advantage that the bi-, tri-, and so on, express the powers to which a million is raised, whereas the prefixes are meaningless on the American system; moreover, there is the important advantage that fewer new names are introduced in the expression of large numbers. The adoption of a uniform system of arithmetical notation throughout the world seems a more important matter than the question of the relative advantages of the light-year or the parsec.

GIANT AND DWARF STARS.—Professor H. N. Russell gave an interesting address on this subject at the June meeting of the Royal Astronomical Society, and a summary of it appears in the *Observatory* for August. He takes all the stars for which parallaxes worthy of any confidence have been obtained, and classifies them according to intrinsic brightness and spectral type. He concludes that all the intrinsically very faint stars are red, of spectral type K or M, while all the stars of types A, B are much brighter than the sun. There are, however, a number of red stars that are intrinsically very bright, snch as Arcturus, Aldebaran, Antares. The stars of types K, M are either much brighter than the sun or much fainter. Of the dwarf stars of class M not one is visible to the naked eye, although one is the second nearest star in the heavens.

Discussing the masses, he gives reasons for supposing that these differ among themselves much less than the intrinsic brightness, and that the dwarf stars are those of very low surface brightness.

He conjectures that the giant red stars are at an early stage of low temperature, low surface brightness, low density, great surface, and consequently great total light. As each contracted it would grow hotter and whiter, but smaller, so that its total light would not change much. When hottest it would have a spectrum of type A or B; only massive stars would attain the highest temperature, and stars of types A, B are found to be massive in those cases where their mass can be determined. After passing the maximum temperature it would grow smaller, redder, and duller, *i.e.*, it would pass to the class of dwarf stars. According to this view the difference between giants and dwarfs is not one of total mass, but of age and degree of condensation. It is, of course, rather curious that stars in snch different conditions should give the same type of spectrum, *i.e.*, that type M should occur both at the beginning and the end of a star's career; but the evidence seems strong that these M stars do form two different classes.

Professor Russell hopes to publish his researches more fully next year, and we may look forward to their appearance as likely to throw new light on the life-history of the stars.

A NEW COMET.—The second comet of the year was found by Dr. J. Metcalf, on September 2nd, being his third discovery of tbe kind. It was of the tenth magnitude, in Right Ascension $6^h\ 50^m$, North Declination 57°. Daily motion minus $1^m\ 16^s$, North 34′. If an ephemeris for October should be ready in time, it will be given in another column, with "Face of the Sky" for November.

Later.—The comet was nearest to the Sun on July 20th, but approached the Earth in September so as to grow slightly lighter; but it will not be conspicuous. Another faint comet was found by Nenjmin on September 3rd.

BOTANY.

By Professor F. Cavers, D.Sc., F.L.S.

BOTANY AT THE BRITISH ASSOCIATION.—The doings of Section K (Botany) at the Birmingham meeting presented various features of interest. For the first time in the history of the British Association, a lady was chosen as President of a Section, and in her address Miss Ethel Sargant referred in felicitous terms to this innovation as an honour done to herself as a botanist, but also as an act of generosity —greater because done in the face of custom and prejudice.

RECENT RESEARCH ON EMBRYOLOGY OF ANGIOSPERMS.—Miss Sargant, after a tribute to the work and influence of the late Lord Avebury, as a representative of a small but distinguished class of naturalists, to whom she referred as "the salt of the subject, preserving it from the worst effects of a purely professional and academic standard," gave an interesting account of the development of botanical embryology since 1870. As might have been expected from the large share which the President herself has taken in the investigation of seedling structure in Angiosperms and its phylogenetic interpretation, the address was limited to Angiosperm embryology, though this is, of course, in itself a sufficiently wide field. As pointed out by Balfour, embryology ought, strictly speaking, to deal with the growth and structure of organisms during their development within the egg-membranes before they are capable of leading an independent existence, but modern investigators have shown that such a limitation of the science would have a purely artificial character, and the term "embryology" is now employed to cover the anatomy and physiology of the organism during the whole period included between its first coming into being and its attainment of the adult state. The older botanists used the term in the narrower sense, including the study of the embryo-sac and the structures contained in it before the formation of the unfertilised egg-cell as well as the fertilisation of the latter and its subsequent divisions, but they did not proceed beyond the resting stage of the embryo within the ripe seed. Here, as in zoölogy, this division is arbitrary and inconvenient; hence in the following remarks embryology is taken to include every stage in the development of the plant from the first division of the fertilised egg-cell to maturity.

Systematists from Caesalpino onwards have paid much attention to the structure of the seed, and were indeed forced to study the embryo because its characters are often of systematic importance; for instance, the number of cotyledons is the most constant character separating the two great classes of Angiosperms, while the presence or absence of endosperm in the ripe seed, besides being important systematically, determines the function of the cotyledons after germination, and thus influences their structure profoundly. Hence botanists became familiar with the structure of the embryo in the ripe seed before they had traced its origin from the fertilised egg-cell, or followed its development after germination. Since the early history of the embryo was a sealed book to observers without the compound microscope, work on the external morphology of seedlings preceded that on the formation of the embryo. In the school of seedling descriptive work the greatest name is that of Thilo Irmisch (1815–1879), whose work was neglected by the succeeding generation owing to the rapid development of microscopic botany, starting from Hanstein's classic work (1870) on the divisions of the fertilised egg-cell, which laid the foundation of botanical embryology in the narrower sense—the study of the embryo from origin to germination. The period in the plant's history beginning with the first division of the fertilised egg (a natural epoch, since a new generation dates from it) and ending with the formation of the ripe seed (a true physiological epoch, since it corresponds with a complete change in the conditions of life) would seem very well defined; but experience has shown that here, as in zoölogy, embryologists lose more than they gain by dividing the subject in this way—one group of investigators beginning their work where the others end theirs—and that this division is neither so simple nor so natural as it appears at first sight. It is not simple because the embryo is not always completely dormant during the interval between the formation of the ripe seed and the first steps in germination. In most Monocotyledons and many Dicotyledons the embryo is an almost undifferentiated mass of meristem when the seed first ripens, and becomes differentiated internally and externally by degrees during the interval before germination: this is often called the maturation of the seed, and it is quite distinct from its ripening. Maturation is a process characteristic of the seeds of geophilous plants (plants with bulbs, corms, rhizomes and other perennating underground organs) which commonly lie in the ground for a year at least before germination; the embryo of such plants is not comparable morphologically with that in the seed of an annual which may have ripened at the same time, since the embryo of the annual has root, stem, and leaves besides its cotyledons, and is ready to germinate immediately on the return of spring. Hence the morphologist must continue his study of the geophilous embryo throughout the maturation period if he is to compare it with that of the annual; even then he will find it less advanced than the annual embryo though both be examined as they break out of the seed, for the geophyte may, perhaps, be four or five years before it flowers, while the annual has to complete its whole life-cycle in a single season. The division of the subject into two parts, the first ending with the embryo in the ripe seed, is also an unnatural one, even if the time of maturation be included in that first period; for the structure of the embryo cannot be completely understood by reference to its past alone. The observer must expect adaptive characters of three kinds:—(1) those imposed on the embryo in the past by its development within the embryo-sac while it is still parasitic on the parent plant; (2) certain adaptations to the process of germination itself; (3) characters which will be useful after germination. Before the utility of these characters can be fully understood the development of the seedling must be followed for some time. In short, the structure of the embryo is dependent upon its future as well as on its past, and a division of the subject which excludes that future is, as Balfour says, purely artificial.

The work done in recent years on the anatomy of the seedling has therefore not only completed Irmisch's work on its external morphology, but has also thrown light on the problems of early embryology, attacked by Hanstein and his immediate followers. These problems are of two kinds, relating to the internal anatomy or the external morphology of the embryo. Hanstein himself was chiefly interested in the former, and his work disposed once for all of the possibility that the embryo of Angiosperms might possess an apical cell in the earlier stages of its growth as a reminiscence of its cryptogamic ancestry. One general result of work on the embryo since Hanstein's time has been to discredit phylogenetic theories based on its early history; indeed, it was hardly to be expected that a small mass of meristem, developing within a confined space and feeding parasitically on the tissues of the mother-plant, should preserve ancestral features. Still, Hanstein and his successors did good service in elucidating the growth of the pro-embryo from the fertilised egg-cell; its division into suspensor and embryo; the general development of both, and the appearance of external and internal differentiation in the embryo before germination.

While some of Hanstein's general conclusions as to internal anatomy have become the common property of text-books, for instance, the early differentiation of the dermatogen and its subsequent development into the epidermal system, he was less successful in demonstrating the initial independence of plerome and periblem, and their relation to the vascular system of the mature stem. The early differentiation of plerome and periblem from the inner tissues of the embryonic axis and their continued formation at the growing-points of root and shoot are processes which demand the most careful investigation on account of their bearing on the stelar hypothesis.

(To be continued.)

CHEMISTRY.

By C. Ainsworth Mitchell, B.A. (Oxon.), F.I.C.

TESTING THE VITALITY OF SEEDS.—An ingenious method of ascertaining whether a seed is living has been devised by Mr. S. Tashiro, and an outline of his communication on this subject to the Eighth International Congress of Applied Chemistry is given in the *Analyst* (1913, XXXVIII, 370). The method depends upon the fact that so long as a seed is alive it liberates carbon dioxide. This gas can be detected and estimated by means of a special apparatus which is so sensitive that it can measure as little as one ten-millionth part of a gramme. It was found with the aid of this apparatus that when a living seed was crushed or bruised its activity was stimulated, and that it then emitted a much greater quantity of carbon dioxide.

DUST EXPLOSIONS.—Interesting experiments have been made by Mr. W. R. Lang (*Proc. Chem. Soc.*, 1913, No. 168, 1911) to test the liability to explosion of finely divided starch and coal dust when mixed with air. The fine powder was allowed to fall into the upper end of a vertical glass cylinder about seven feet long by four inches in diameter. Through the sides of this open glass chamber, about half-way down, were fused two wires connected with an induction coil, so that a spark could be passed through the mixture. When this was done the dust, whether of coal, starch or lycopodium, ignited explosively; the combustion spread throughout the length of the tube, and flames issued from each open end. Analogous results were produced by applying a light to the end of the tube.

Microscopic measurements of the particles of different kinds of dust used in the experiments were made, and the average results calculated into the total areas of the substances per one hundred grammes. In this way the following results were obtained:—

Substance.	Mean diameter of particles in millimetres.	Total surface area for 100 grammes of substance.
		Square Metres.
Lycopodium powder ...	0·028	20·92
Maize starch	0·0122	32·78
Coal dust (*a*) medium ...	0·012	33·33
,, ,, (*b*) fine ...	0·0016	250·00
"Pyrophoric carbon" ...	0·00125	332·00
"Pyrophoric iron" ...	0·0054	15·08

GEOGRAPHY.

By A. Stevens, M.A., B.Sc.

A PHYSIOGRAPHICAL STUDY IN NEW ZEALAND. —In the September *Geographical Journal* there is an account of the physiography of the middle Clarence valley, New Zealand, by Mr. C. A. Cotton. The Clarence River rises near Mount Franklin, in North Canterbury, and after flowing in a southerly direction for some forty miles, turns sharply towards the north-west, flows for fifty miles between the Seaward and (Inland) Kaikoura Ranges, and is again sharply deflected to the south. The paper in question discusses the portion of the course which lies between the Kaikouras.

The geology of the country has not been fully worked out, and, as so frequently happens in New Zealand, presents some difficult and disputed questions. Generally it may be stated that the underlying older rocks are of about Carboniferous age. They are much contorted, and the system of folding has not been described. These rocks have been extensively denuded, and probably were cut down so as to present a surface of low relief. Newer deposits, of age ranging from Cretaceous to Pliocene, covered them; on a basal conglomerate rested soft mudstones, and the sequence passed up, through resistent beds of limestone and flint and soft marls, to a top layer of hard conglomerate. Earth-movements on a large scale have affected the area and produced two huge anticlines, or probably anticlinoria, separated by an asymmetrical syncline, the north-west limb of which gave way, and is represented by a reversed fault of enormous and undetermined throw. The anticlines build the Kaikoura Ranges, while the syncline has been occupied by the Clarence River, which in its middle course is therefore a consequent stream.

In the cycle of denudation which ensued, the covering of newer rocks was removed from the mountains by the streams of the Clarence system, a flat floor of mudstone being left in the valley. This lies closer to the north-west side of the valley, where it is faced by the scarp of the limestone, and the want of symmetry of the valley is a direct consequence of the asymmetry of the syncline. A subordinate uplift following rejuvenated the stream, already at base level, and it proceeded to cut a gorge in the valley floor. The courses of rivers further to the north and to the south are transverse to the middle Clarence, and consequently to the axis of the mountains, and these, Mr. Cotton considers, are antecedents, whose courses were determined by a simple regional uplift earlier than the folding. By the latter movement the Clarence alone was diverted, and only in its middle course, where the rise of the land reached its maximum. The lower Clarence follows the course of an antecedent stream. The valley slopes and floor of the middle Clarence are trenched by streams antecedent, consequent, and subsequent, some graded, some still cutting. The limestone ridge is dissected by superposed consequents from the Kaikoura Range which often join twos or threes just before clearing the ridge, and so cut out pyramidal hills of limestone rather lower than the adjacent part of the scarp. The fault-plane gives rise in places to noticeable topographical features. It facets spurs from the Kaikouras (long spurs from the Seaward Kaikouras are also faceted—but by the stream), while in the lower part of the valley it is marked by a bench, some twenty feet wide, which represents an earthquake fissure. Evidences of glaciation are wanting in the area, though it has been held that the valley is deeply ice-worn. Mr. Cotton believes that glaciers have always been absent, as they are now, for the steepness of the slopes prevents the accumulation of reservoirs of snow.

OCEANOGRAPHY OF THE MEDITERRANEAN.—An article in *Nature*, for September 4th, draws attention to the report of the Danish Oceanographical Expeditions of 1908–10, to the Mediterranean and the adjacent seas. It is found that the Mediterranean is divided into two basins by a submarine ridge four hundred metres below sea-level at the deepest points, which continues the line of Italy and Sicily to the north coast of Africa. Of these basins the western is, for the most part, two thousand to three thousand metres deep, the eastern generally deeper, soundings of more than four thousand metres having been made. The main interest centres in the movements of the water. The rainfall balances less than one quarter of the loss by evaporation, and the water-level is maintained by an inward current from the Atlantic which runs from one to three knots. As a direct consequence the pressure inside is increased, and a stream sets out towards the ocean at a speed which varies between one half and five knots. Although the temperature is uniformly so high as thirteen degrees at the depth of one thousand metres, the unusual salinity, due to excessive evaporation, raises the density of the water so much that the outgoing current is a deep one. These currents are, of course, affected by the tides, and the warm outward current is made by the rotation of the earth to swing to the north and east in the lower strata of the Atlantic. This may explain the occasional high salinity in enclosed seas on the British coasts. Again, the high precipitation in the area which feeds the Black Sea and the Sea of Marmora makes these waters remarkably poor in salts, and conditions exactly opposite obtain. But the threshold of the Black Sea is so shallow that the deeper layers of the water are stagnant, and the dissolved gas is hydrogen sulphide; hence only some forms of bacteria people the sea. The water-circulation within the Mediterranean is complex and incompletely described. It varies at different depths and in different areas.

STUDIES IN GLACIERS.—From data, more or less complete, covering a period of some dozen years, one might conclude that at present there is a general tendency to retreat of the ice-fronts of the glaciers of the world. From several parts reports come in of the extension of the length of glaciers, but the figures require careful scrutiny (Hans Hess, *Petermanns Mitteilungen*, April), and when circumstances more or less incidental are considered and the size and importance of the various ice-streams taken into account, the impression is produced that a longer period of study is necessary, and in most cases more detailed records are required. Those who make general statements covering the phenomena of the whole globe raise not unfounded suspicions that they are looking too keenly for unreasonable uniformity.

In Switzerland, if we eliminate small cirque-glaciers, which are usually in a state of oscillation, only the Lower Grindelwald glacier and the small glacier of the Sex Rouge show continued advance (*Annales de Géographie*, July, and so on). In Scandinavia in several important instances advances up to one hundred and sixty metres are recorded; but, on the whole, the glaciers are in a state of oscillation, and no general statement is justified. In Asia, New Zealand, and South America definite information is wanting, but elsewhere it is stated there is a general tendency to regression. In Alaska, however, certain of the main glaciers have pushed forward their ice-fronts, that of La Pérouse, for example, having gained four hundred metres. This growth followed upon earth tremors recorded in 1899, and has been correlated with them. Hess prefers to connect the advance with the abundant snowfalls of the end of the nineteenth century.

Joseph Vallot (*Comptes Rendus*, CLVI, May, 1913,) gives a record of temperature observations in glaciers at high altitudes (four thousand metres) made during 1898, 1900, 1911. A diurnal variation up to 13° (centigrade) is observable to a depth of ·7 metre. Down to 7·5 metres the temperature falls rapidly, and below that it varies between −12° and −13°, remaining stationary at −12·8° below fifteen metres. At the depth of about one metre, it may be concluded, diurnal temperature variation ceases, and the limit of the seasonal variation is 7·5 metres. The grain of the ice grows from ·5 millimetre to 1·2 millimetres in diameter, apparently without fusion, and the ice is impermeable. Hence neither infiltration of water nor temperature variation, which ceases at a relatively insignificant depth, can be an important factor in producing the flow of glaciers.

GEOLOGY.

By G. W. Tyrrell, A.R.C.Sc., F.G.S.

GARNET AS A GEOLOGICAL BAROMETER.—The petrological investigation of a peculiar manganiferous igneous rock (kodurite) discovered by Dr. L. L. Fermor, of the Geological Survey of India, in connection with his recent survey of the manganiferous deposits of the Indian Empire, has led to certain conclusions as to the mode of formation of garnet (*Records, Geological Survey of India*, Vol. XLIII, Part 1, 1913). Typical kodurite is a plutonic rock consisting of orthoclase, spandite (manganese garnet), and apatite. Associated with kodurite is a garnet (spandite) rock. In attempting to classify these rocks Dr. Fermor calculated their analyses into the norm or standard mineral composition of the American Quantitative Classification. The norm of kodurite contained orthoclase, leucite, anorthite, hedenbergite, wollastonite, tephroite, magnetite, ilmenite, and apatite; whilst that of the garnet rock was expressed as a mixture of anorthite, hedenbergite, akermanite, fayalite, tephroite, and magnetite. A comparison of the specific gravity of the mode (actual mineral composition) with that of the norm (standard mineral composition) showed that the kodurite occupied ten per cent., and the spandite rock twenty per cent., less room when crystallised as the mode than as the norm. This indicated at once that the crystallisation of kodurite and spandite rock was conditioned by high pressure, necessitating a decrease in volume as compared with the conditions of pressure under which the norms might have crystallised from the respective magmas.

If this be the true interpretation, garnet may be regarded as a geological barometer, indicating especially high pressure during its formation. Confirmation is found in the fact that garnet is an abundant constituent of all the various rocks associated with the kodurite series. Further speculation on these lines suggested that eclogite is the high-pressure form of gabbro, and consideration of the chemical analyses and the specific gravities of these rocks supported this view. Since the plutonic rocks, formed at great depths under pressure, are typically non-garnetiferous, Dr. Fermor postulates the existence below the plutonic zone of a shell characterised by garnets wherever the necessary sesquioxide radicle is present. For this shell is suggested the term ***infra-plutonic***. Other minerals, notably diamond, the high-pressure form of carbon, may also be characteristic of the infra-plutonic zone, and Dr. Fermor makes the interesting suggestion that the diamond pipes of Kimberley, in which eclogites and garnets are found, may be directly connected with the infra-plutonic zone.

PRESERVATION OF PLANT-FOSSILS IN LAVA.—Some interesting examples of tree-moulds in lava are described by F. A. Perrett (*American Journal of Science*, Vol. XXXVI, August, 1913) from Kilauea. The basalt lava from this great crater has sometimes invaded a forest of trees and then flowed away, leaving an investment or casing of lava upon a tree-trunk up to a height corresponding with the greatest depth of the lava stream at that point. These are known as the ***salient*** or ***projecting*** types of tree-mould, and stand above the surrounding plain as a monument to the original tree, which, if not destroyed at once by the basalt-flood, soon dies and rots away.

In the ***sunken*** or ***ground*** type of tree-mould the lava has invaded low ground, and has come to a standstill among the trees. The latter, of which no trace now remains, have left an impression of their forms down to the minutest detail upon the lasting stone. These casts are found on the sides of cylindrical openings, from three to five metres deep, in the lava-plains. An excellent illustration in the paper shows the faithfulness of these impressions of the rugged bark of the trees upon the plastic lava. It is a matter for comment that the trees were not destroyed by their "baptism of fire," long before such impressions could be taken. If, however, the resinous varieties be excepted, large tree-trunks, massive and full of moisture, will resist carbonisation at least long enough for a skin of cold, solid basalt to form in contact with them, and thus provide a nearly non-conducting layer.

Similar plant-remains preserved in lava have been described by Solórzano and Hobson from Mexico, where fragments of maize were found in basaltic scoriae; and by H. M. Cadell, who has described a lycopod stem, twelve inches long, embedded in olivine-basalt lava from the Bo'ness Coalfield. Phenomena identical with those described by Perrett were observed by F. A. Fouqué on Etna, where the lava of the 1865 eruption flowed through a wood of lofty trees.

SAPPHIRE IN MULL.—Clear blue corundum has been found by the Geological Survey in two localities to the west of Carsaig, Mull. The mineral occurs in tabular hexagonal plates, which are, however, too small and irregular to have any gem value. In each case the crystals are found in igneous rocks which have involved xenolithic masses of sedimentary material. In one locality large xenolithic blocks of baked sandstone and shale are involved in an igneous matrix which is probably intrusive, and which encloses numerous little sapphires. In the second locality the sapphires are found in an irregular composite sill consisting partly of andesitic felsite and partly of trachytic granophyre or syenite. This intrusion is also full of xenolithic material, including baked shale. The sapphires are found both in the latter and in the igneous matrix.

METEOROLOGY.

By William Marriott, F.R.Met.Soc.

BEN NEVIS OBSERVATORY.—It is announced that a tourist hotel is being built on the top of Ben Nevis on the site of the former Meteorological Observatory. This hotel will probably be the terminus of the four and a half miles railway which it is proposed to construct when funds are assured and sanction obtained to proceed.

It will, no doubt, be remembered that the Ben Nevis

Observatory was closed at the end of September, 1904, owing to the lack of financial support. This observatory, which is four thousand four hundred and four feet above sea-level, on the highest spot in the British Isles, was established by the Scottish Meteorological Society in 1883, and observations were taken every hour, day and night, without a break, frequently under very difficult conditions, for a period of nearly twenty-one years. During the months of February and March it was not uncommon for south-easterly gales to blow for three or four days continuously at the rate of one hundred miles an hour. On these occasions the observers had to go out roped together or to crawl along the surface, otherwise they would have been blown away by the wind. At other times the rain would freeze as it fell, and so everything became coated with ice, which continued to increase in thickness almost indefinitely. During summer, or when the temperature was above the freezing-point, the fog soaked everything exposed to it, and so all the instruments outside the observatory streamed with moisture, even though no rain was actually falling; while in winter, or when the temperature was below freezing-point, the effect of the fog was to cover everything with long feathery masses of rime or crystalline specks of snow. These continued to grow to great lengths on the windward side until they broke off by their own weight. In these circumstances it was impossible to use self-recording instruments, and so the observers had to take observations every hour, day and night.

The average temperature, rainfall, amount of cloud, and hours of sunshine are as follows:—

Table 70.

Month.	Temperature.	Rainfall. Inches.	Cloud.	Sunshine. Hours.
January ...	24·0°	18·33	8·8	22·4
February ...	23·8	13·55	8·3	42·3
March... ...	24·0	15·25	8·4	54·7
April	27·6	8·48	8·0	80·4
May	33·0	7·90	7·8	116·3
June	39·7	7·54	7·7	127·0
July	41·1	10·80	8·6	84·9
August ...	40·4	13·34	8·8	58·1
September ...	38·0	15·74	8·3	62·2
October ...	31·4	15·42	8·5	41·8
November ...	28·9	15·36	8·5	27·9
December ...	25·2	19·07	8·7	18·0
Year	31·4	160·77	8·4	736·0

As temperature decreases approximately at the rate of 1° F. every one hundred feet, the temperature at the summit is usually about 15° lower than at Fort William; consequently the snow on the top of the mountain remains unmelted for the greater part of the year.

BRITISH RAINFALL, 1912.—The publication of the annual volumes of *British Rainfall* is always looked forward to not only by meteorologists but also by engineers and surveyors, and others who have any interest in rainfall statistics. The volume for last year, 1912, has recently been issued, and this includes the records of rainfall from more than five thousand observers in Great Britain and Ireland. The records confirm the popular opinion that the year 1912 was a very wet one, as will be seen from Table 71.

The greatest amounts of rainfall recorded in the year were 205·17 inches at Crib Goch, on Snowdon, and 196·43 inches at the Stye in Cumberland. The lowest amount was 19·24 inches at Stifford, in Essex. It appears that the summer of 1912 in England and Wales was wetter than any other summer during the past fifty years, although the rainfall of the summer of 1879 was nearly similar.

April, May, and September were the generally dry months, and March, June, August, and December the wet months.

Table 71.

	Rainfall for 1912.	Difference from Average.
England ...	39·31 in.	+ 7·25 in. or 23 per cent.
Wales	56·19 „	+ 9·01 „ „ 19 „ „
Isle of Man ...	41·85 „	+ 0·22 „ „ 1 „ „
Scotland ...	41·77 „	+ 4·70 „ „ 11 „ „
Ireland	44·06 „	+ 3·43 „ „ 8 „ „

The most remarkable feature of the year was the unprecedented rainstorm of August 25th–26th, in East Anglia, when more than six inches fell over an area of four hundred and forty-six square miles, and more than seven inches over an area of two hundred and forty-one square miles, while more than eight inches fell between Norwich and Brundall. Serious floods resulted from this extraordinary rainfall: the flood at Norwich was fifteen inches higher than the previous highest one in 1614.

Dr. H. R. Mill, the director of the British Rainfall Organisation, has been obliged, acting under medical advice, to take a long and complete rest. We trust that this cessation from work will restore him to health. During his absence the work of the organisation will be carried on under the joint direction of Mr. R. C. Mossman and Mr. C. Salter.

AEROPLANES AND WEATHER.—The recent attempt of Mr. Hawker to win the *Daily Mail* prize of £5,000 in the waterplane race round Great Britain reminds me of a letter I received a year ago from a correspondent, who attributed all the bad weather to the action of aeroplanes. The letter was as follows:

"Sir,—Has it not occurred to you and others that the bad weather, and consequent likelihood of famine for us all, is due to this interference with Nature's laws? This foolish so-called 'flying' is cutting up the atmosphere. It is well known that heavy firing of guns brings down rain by concussion, and it stands to reason that great steel propellers, slashing the air for great distances, is bound to cause violent disturbance of the weather. Wherever there is 'flying,' there come storms of wind and torrents of rain, and bitter cold as by an electric fan. So do stop this rubbish lest we all starve."

The writer of the above evidently has a very decided prejudice and hatred against flying machines, and also is ready to attribute good or bad weather to unknown influences. One often hears many other people give expression to somewhat similar opinions as to the weather, although it is very doubtful if they really *think* anything about the matter. A few years ago very decided opinions were expressed by many people who asserted that the wireless installations erected at certain places round the coast had quite altered our weather. Up to the present, however, the ordinary meteorological observations have not shown that any perceptible effect has been produced by these things on the weather.

The cheap newspaper press is also much given to the use of terms and adjectives about passing events—even about the weather—which are great exaggerations and often incomprehensible. Anything that in the slightest degree interferes with pleasure, sport, or comfort is at once described in terms of execration. As an instance of this the following example may be given. Thursday, August 28th, was very fine and bright, but the next day, Friday, was misty, damp, and close, with a slight thunderstorm and little rain between 10 and 11 a.m. On Saturday morning a placard of one of the London daily papers was wholly taken up in large type with the words "Grumpiest Day of the Year." It is difficult to understand what the editor meant by such an expression. He could hardly have realised that a few hundredths of an inch of rain are quite insignificant compared to the eight inches which fell in Norfolk only twelve months previously, as mentioned in the preceding note.

MICROSCOPY.

By F.R.M.S.

AN IMPROVEMENT IN THE HAND MAGNIFIER.—Mr. W. G. Williams, of the Swansea Field Naturalists' Society, has sent a sketch of a very simple way of using a magnifier so as to have one hand free. Usually the magnifier is held in one hand, and the specimen in the other, and if it is desired to arrange the specimen or refer to a book, the magnifier has to be set down, and the observation begun again. It will be seen by reference to the drawing that hole A (see Figure 397) is made of sufficient size for the frame of the magnifier to rest on the top of the third finger of the left hand, the specimen under examination is held between the thumb and first finger, and the right hand is free to do dissecting or for other purposes (see Figure 398). The improvement costs nothing.

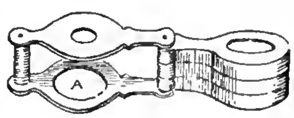


Figure 397.

TERMITES.—A short time ago a friend living in the Orange Free State sent me some specimens of the Termites (usually miscalled White Ants) found in that district, which are apparently quite as mischievous to woodwork there as their relatives in India and elsewhere, and in general appearance they do not greatly differ.

Figure 398.

The Royal Cell containing the Queen was dug up from about four and a half feet below the surface of the ground; it was oven-shaped and measured five inches in length by two and a quarter inches in width, with a height in the centre of one inch. It was perforated by numerous small holes giving access to the workers and soldiers, but, of course, useless as a means of exit for the Queen, whose distended abdomen measured three inches in length and was three quarters of an inch in diameter at its widest part. The workers measured ·175 inches, were pale yellow in colour and without eyes, for which they had no need, since they carry on their operations in darkness, their home duties being mainly to feed the Queen and to remove the eggs as laid. Each bore a pair of moniliform antennae of fifteen joints, and in addition to the usual mouth organs was armed with a pair of strong mandibles eminently adapted for the destruction of wood. The soldiers were considerably larger in size, measuring ·3 inches, of which the head alone was rather more than one third; they were dark red in colour and in addition to antennae resembling those of the workers, were furnished with a pair of formidable mandibles worked by muscles of great power. On carefully comparing these mandibles with available figures, and particularly with those of *Termes bellicosus* at the Natural History Museum, I found that they differed materially in shape, and regarding this as indicating a different species I did my best to identify it. In this, however, the Museum experts were unable to help me, and a reference to the learned Professor who is regarded as the greatest European authority on the subject only resulted in his opinion that though it appeared to be a new species he would not definitely commit himself on the matter from the drawings and specimens submitted. I therefore give drawings of the mandibles of these soldiers (see Figure 399) and also of those of the nearest form met with, *T. bellicosus* (see Figure 400), thinking that the comparison may be of interest to some of our readers. R. T. L.

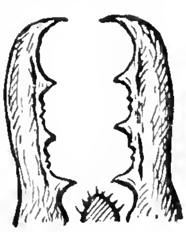


Figure 399.
Mandibles of a Soldier Termite.

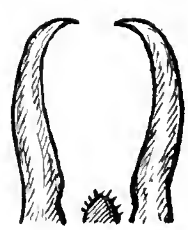


Figure 400.
Mandibles of *Termes bellicosus.*

NEW METHOD OF RADIO-MICROGRAPHY BY P. GOBY.—A new and very attractive branch of science has lately been opened up owing to the researches of a French savant, and workers in various fields will now have a new resource at their disposal, this being known as radio-micrography, as it is the application of the well-known principles of radiography by the use of the X-rays to microscopic research. While there has been a great improvement made in the methods and instruments used for radiography of large specimens of ordinary size, and remarkable results in the way of radiographs are now obtained with such apparatus, we are not aware that the structure of microscopic specimens has been as yet revealed, so that the apparatus invented by M. Pierre Goby, of Grasse, and the radiographs which he secures by the use of the rays, will be of interest to all naturalists. By observing the views of the different specimens which we present in Figures 401–405 on page 389, it will be seen at once that the method is likely to be a valuable auxiliary in all kinds of research work, and the interior structure of the specimens can in most cases be shown up very clearly, as, for instance, in the case of microscopic shells, diatoms, and the like. Not only can the method be used for what may be termed strictly microscopic specimens, but it can also serve for enlarged radiographs of very small animal specimens, where an ordinary radiograph would be too small to give the required details.

In the account of his new method, which M. Goby has kindly given to us, he states that in both these cases the results are obtained by the use of a special X-ray apparatus of his design, and he expects to make public the details of the device at a not very distant date. Meanwhile he has given us some radio-micrographs, as they must no doubt be called, and they speak for themselves. The details which he thus obtains are difficult and in a great number of cases impossible to obtain with the usual method of sections prepared for microscopic use. From the start, he commenced to apply his researches in the field of palaeontology as well as in conchology, and finds that the protozoa in general, as well as foraminifera of all species and other analagous microscopic specimens, can be observed in their most minute details in the interior of their structure, and to show what can be done by the new method we may state that he was able to detect the presence of different species in cases where ordinary examination would lead one to suppose that only one species was present. In all the sands which contain microscopic specimens of different kinds such as have not been examined, the use of a fine pinch of sand allows of discovering new species and to make a very exact determination of their nature. The specimens which are illustrated here (see Figures 401 to 405) are magnified from twenty to twenty-five diameters. One of them shows a pinch of sand from the south of France (see Figure 404), containing a number of different forms.

Not less interesting is the application of the radiographic method to very small animal specimens, and this allows us to observe the gradual formation of the bones from the birth of the animal to its full age. Not only can the details of the bone structure be followed very clearly, but the method allows of noticing the special features of the skin in many cases and different anomalies—this with great precision in the details.

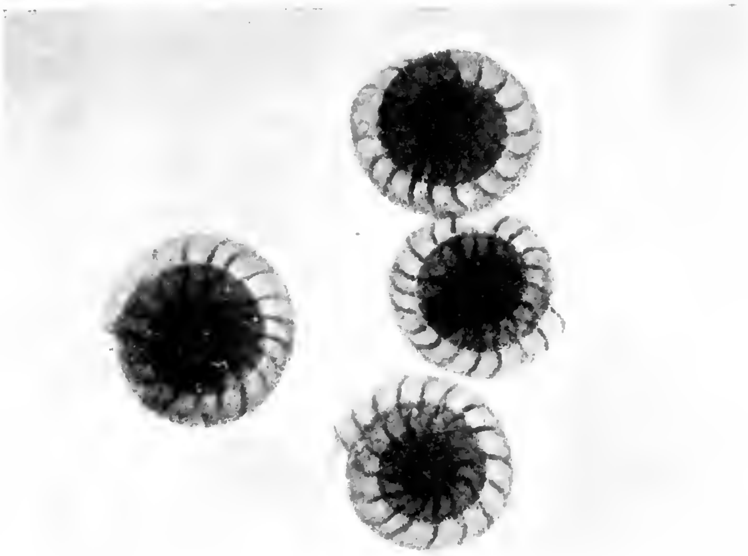


FIGURE 401. Nummulites.
Magnified 25 diameters.

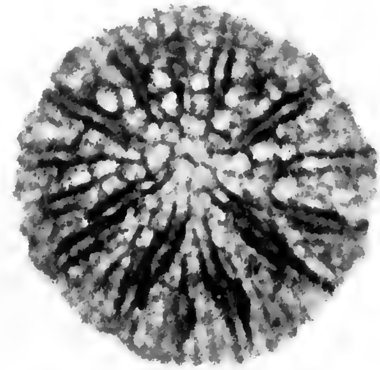


FIGURE 403. An Orbitolite.
Magnified 25 diameters.

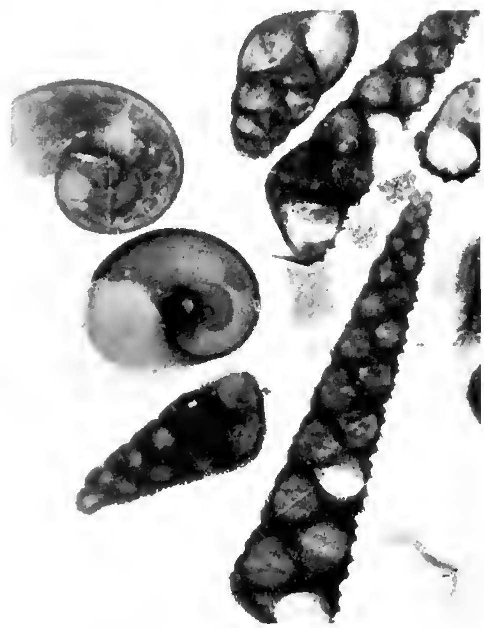


FIGURE 404. A pinch of sand from the South of France. Magnified 20 diameters.

FIGURE 402. Fore and hind limbs of *Seps*.

FIGURE 405. *Seps tridactylus*.

Figure 406. Halo obtained with X-rays without crystal.

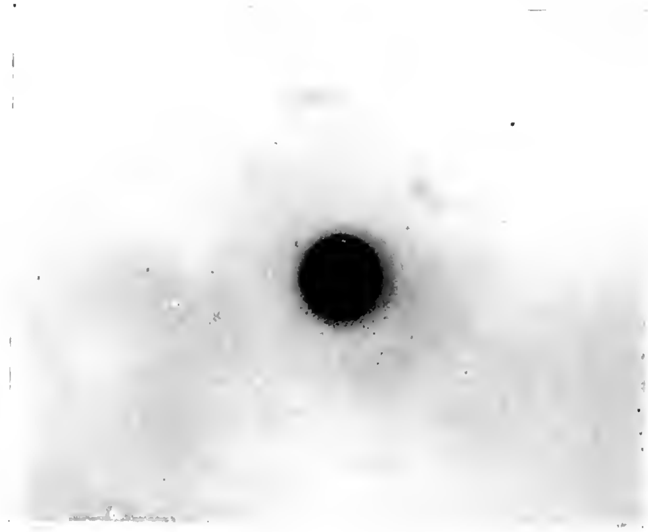


Figure 409. Spots from mica normal to rays.

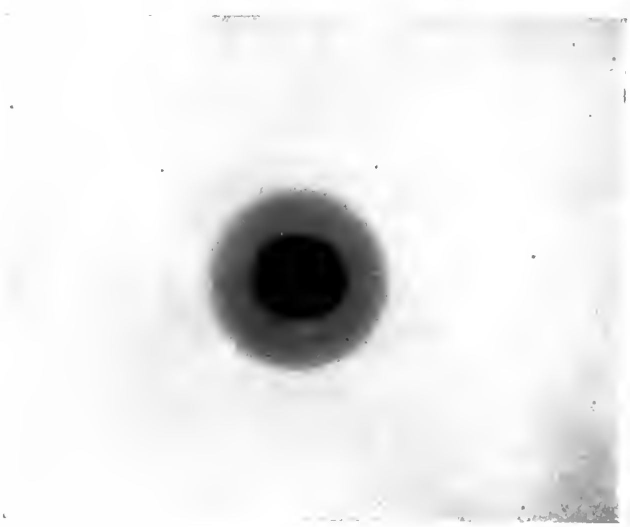


Figure 407. Halo from metals without crystals.

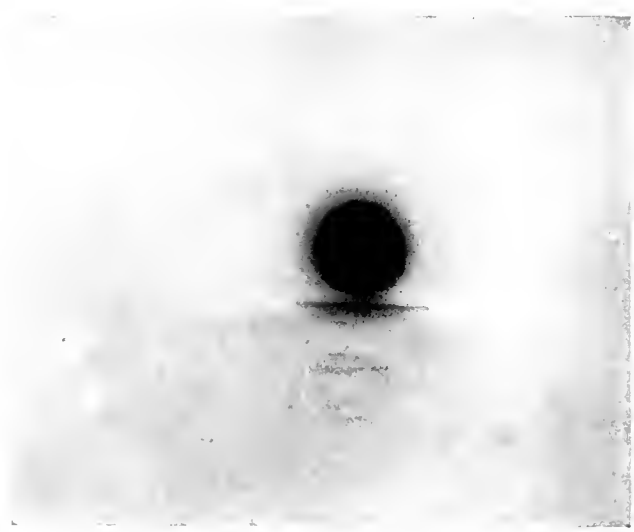


Figure 410. Reflection from mica at angle 85° showing bands on the reflection and intermediate band.

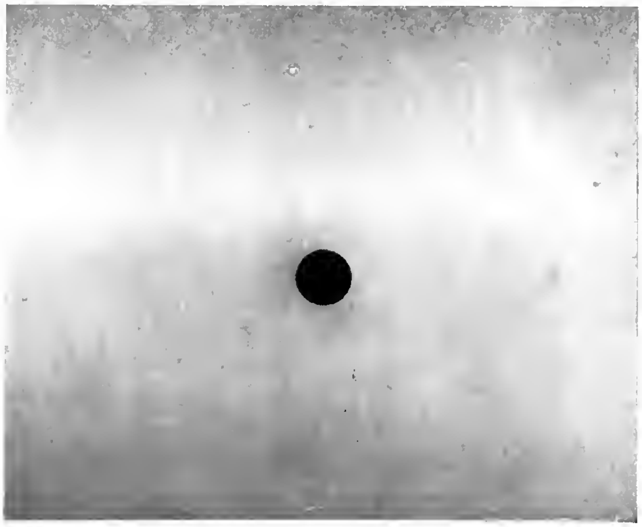


Figure 408. No crystal used. Showing a broad white band across plate; also black bands.

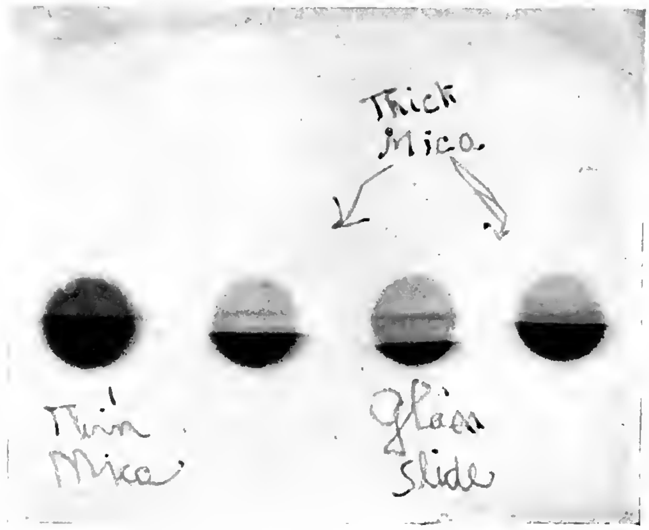


Figure 411. Shows peripheral effects with mica across aperture in metal screen.

As will be observed in some of the illustrations, the flesh parts and even the details of the muscles are apparent and are clearly represented. It would be too long to enumerate the applications which the new field of radio-micrography is likely to obtain in the near future, but in furnishing the present radiographs M. Goby is confident that scientific men will find it valuable for different kinds of research work, and no doubt it will be taken up in various quarters.

FRANCIS P. MANN.

Since the above was received M. Goby has described his apparatus, and the following description is taken from a translation of the contribution to *Comptes Rendus*, CLVI., pages 686–688, which appears in the current number of *The Journal of the Royal Microscopical Society*, from which we have copied the diagrams shown in Figures 412 and 413.

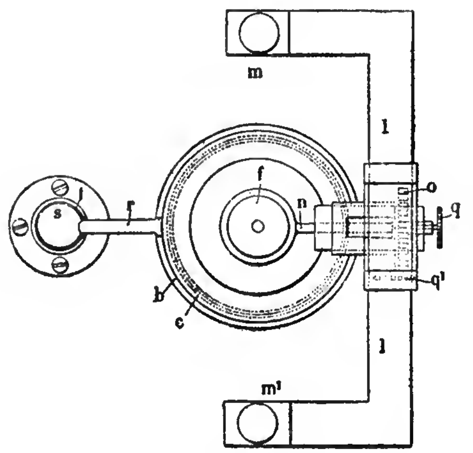


FIGURE 412.

The difficulty of obtaining by the Röntgen rays the requisite clearness of detail has been overcome by means of the apparatus shown in Figure 413, which is carried on the telescopic pillar *u v*, the movable joint *s* of which allows it to be pivoted in a horizontal position.

Two large metal cylinders a^1, a^2, the one sliding within the other, form a photographic camera body, the length of which can be varied as wanted. The top of this body *c* is provided with a socket c^1 through which slides the axial metal tube *d*, which is destined for suppression of the secondary or superfluous rays, and for the transmission of the cluster of active rays, which the thick leaden diaphragm *f* of very small diameter allows to pass, whilst a disc *g* opaque to the luminous rays alone, shuts off other light which might affect the photographic plate.

At the other extremity of the tube *d* an "incidence indicator" or device for enabling the incidence of the rays to be regulated is adapted, which consists essentially of a very narrow metallic tube *i*, supported by two discs h^1, h^2, permeable to the X-rays. Normally to this is placed a small fluorescent screen *j*, which can be examined through a darkened glass disc *k*, destined to protect the eye of the operator, when the apparatus is put in a horizontal position. By means of the mechanism o, *p*, *q*, the focus tube carrier *l* can be adjusted in two directions, and all that is necessary is to adjust the special Röntgen tubes held by the isolating clamps *m*, m^1, so that the small luminous spot is seen in the centre of the screen surrounded by a dark circle, thus indicating that the central ray of the cluster is following a path axial to the tube itself. One can now regulate the desired sizes of the radiographic field indicated by the extent of the illuminated zone of the screen, by sliding the tube *d* nearer or farther away from the source of radiation. After once centring the focus-tube by means of the incidence indicator, this does not need to be repeated, the indicator being then slipped out of the tube *d* and laid aside.

All that now has to be done is, in the light of an ordinary dark room, to place a small photographic plate, square by preference and of very fine grain, on the centre of the leaden disc *b*, which forms the base of the camera, and which is marked with a diametrical cross for purposes of registration. The small object to be radiographed is placed in direct contact with the sensitised surface of the plate without the interposition of black paper. It only remains to pull down the cylindrical camera body into its grove and to allow the appropriate rays of a Röntgen tube, with a very small anti-cathode, to act for a convenient time in order to obtain, thanks to the normality of the incident rays and to the suppression of the paper envelope, the great clearness of detail which allows of the radio-micrographs being enlarged to a considerable size.

PHOTOGRAPHY.

By EDGAR SENIOR.

FAULTY PERSPECTIVE SEEN IN MANY PHOTOGRAPHS.—Anyone who has compared a photograph with the scene that it was intended to represent must have noticed on many occasions the great amount of difference existing between the two with regard to the relative size of the objects depicted when the photograph has been taken with a short-focus lens. We have an example before us as we write, taken with a lens of this kind, in which the size of the objects in the foreground is out of all proportion to those at a distance, and this is by no means an isolated example, but is quite a common effect obtained by the use of wide-angle or short-focus lenses; and although wide-angle lenses are useful at times, such as when working in confined situations, there is the attendant disadvantage that objects situated in the foreground are made to appear too large compared with those at a distance. In considering the cause of this phenomenon, we must remember that the eye when looking steadily at an object forms an image upon the retina which embraces an angle of not more than 60°; therefore, in order that a photograph may convey a correct idea of the relative size of the objects represented when it is viewed at a distance of ten or twelve inches, the angle included in the picture should not be greater than that of the angle it subtends for vision, which is from 55° to 60°; since if more is included in the photograph than this, the images of objects in the foreground will appear too large in comparison with those at a distance. To render it obvious that distortion of this nature is not really due to any fault of the lens, it is only necessary to view the photograph at a distance equal to the focus of the lens with which it was taken for the distortion to disappear, or, better still, to enlarge the picture, as then it would be viewed at a correspondingly greater distance. The conditions under which a photograph will give a true representation of natural objects have received considerable attention from Dr. Alexander Gleichen, and in a paper translated by Dr. Lindsay Johnson, M.A., F.R.P.S., and published in *The Photographic Journal*, the author appears to consider that the aperture of the lens should not in any case be larger in diameter than the pupil of the eye (about eight millimetres), and that the focus of the lens employed should not be less than ten inches (the normal distance of distinct vision), or if the focus is less than this the picture must be afterwards enlarged as many times as the focus is less. Now, in using a ten-inch

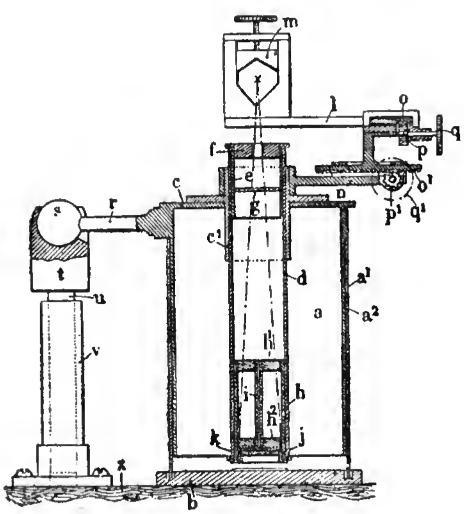


FIGURE 413.

focus ens with an aperture of eight millimetres ($\frac{5}{16}$) in diameter, it is evident that the rapidity of the lens would be equal to F/32, and this would be far too small for many purposes. But as the size of the aperture is limited to $\frac{5}{16}$ of an inch in diameter, the only alternative is to use a shorter focus lens, and so gain rapidity in that manner. Suppose, then, that we wish to obtain a rapidity equal to an aperture of F/6·4; then as the rapidity of lenses varies inversely as the square of their focal lengths and the square of the diameter of their apertures, the desired end would be gained by reducing the focal length of the lens in the same proportion as the diameter of the aperture would otherwise have to be increased, which in this case is five times; therefore, instead of using a ten-inch focus lens, one of two-inch focus would have to be employed; and as $2 \div \frac{5}{16} = 6 \cdot 4$ we should gain the rapidity while the size of the aperture itself remained unaltered. At the same time the photograph would require to be subsequently enlarged five times in order to be seen in correct perspective when viewed at a distance of ten inches. If the degree of enlargement to be finally obtained has been previously decided upon, then the focal length of the lens necessary for use in taking the original photograph "in order that the required conditions may be fulfilled" can be found from the following equation:

$$F = \frac{v}{m}$$

where F = the focal length of lens required, v = the distance of distinct vision (ten inches), and m = the number of times the picture is to be afterwards enlarged. Thus suppose that the photograph is to be enlarged twice; then

$$F = \frac{10}{2} = 5 \text{ inches},$$

and as the diameter of the aperture is to be $\frac{5}{16}$-inch then $5 \div \frac{5}{16} = 16$, and the intensity ratio would be F/16. By transposing the above equation we are also able to obtain the distance from which the enlargement should be viewed.

$$v = F\,(m).$$

Thus suppose that a picture taken with the five-inch focus lens is subsequently enlarged twelve times; then $v = 5\,(12) = 60$ inches, and the enlargement when viewed from a distance of five feet should appear true to nature.

A SIMPLE FORM OF LENS SHADE.—It is obvious that any light which reaches the plate, apart from that which is actually employed in the formation of the image, must of necessity have an adverse effect upon it; and it is often found when using a lens larger than is necessary to cover the plate that the extra light which enters the camera, not being entirely absorbed by the dead black with which its interior is coated, causes a certain amount of haze or mistiness to appear over the entire image, which destroys somewhat the brilliancy of the picture. An effect of this kind is particularly noticeable when working in an unusually bright light, such as that obtained by the seashore, when something that will reduce this excess of light becomes desirable. Adjustable hoods have been recommended for attaching to the lens, but these are difficult to manage, and whatever is employed, if it act in such a manner that it only allows the lens just to illuminate the plate that is in use, then the rising front is rendered useless, as it is necessary for the circle of illumination to be considerably larger than that required to include the plate to enable this adjunct to a camera to be employed at all. The writer some years ago made some experiments in bright light by the seashore, to determine as far as possible the value of lens shades, using a stand camera so that the various effects could be studied visually as well as photographically, and the improvement that resulted in both cases when a thin piece of wood made to extend some four or five inches beyond the lens, and jointed so that it could be depressed to any extent short of intercepting the rays of light, was at once apparent. A shade of this description was made that could be detached instantly from the camera when not required, and as it folded up it was easily carried in the pocket. Such an arrangement, however, appears to be simply a modification of one used many years ago by the late Mr. William England, and which is described as a double-hinged mahogany flap which could be bent down over the lens; and from the very fact that it was found valuable by this gentleman in taking the very fine photographs which he produced should be an extra recommendation in its favour. Then in the case of telephotography a shade in the form of a hood becomes an absolute necessity for obtaining brilliant pictures, since the amount of light which is actually employed in the formation of the image is small compared with that which enters the positive lens; hence light traps in the form of diaphragms inside the lens tube and special care in the selection of a dead black and other devices are found inadequate when dealing with an amount of stray light which is many times greater than that used in taking the photograph. On this account a tube or hood attached to the front of the lens, and adjustable in length so that it can be altered to suit various angles or magnifications, as suggested by Captain Owen Wheeler, F.R.P.S., must be employed in cases of high magnification in order to obtain the most brilliant images.

ZOÖLOGY.

By Professor J. Arthur Thomson, M.A., LL.D.

NEST MADE BY ORANG UTAN.—A recent issue (Part I, 1913) of *The Proceedings of the Zoölogical Society of London*, contains an interesting photograph, by Mr. Seth-Smith, of the nest made in a tree near the Apes' House by the large Sumatran Orang-Utan (*Simia satyrus*) which escaped from its cage in November, 1912. It may be recalled that a careful description has been given by Moebius of the nests which the Orang makes in the woods. A nest is made every night or every second night. It may be a yard and a half long by four-fifths of a yard broad. It consists of two dozen or so branches, with loose leaves above them. It is simply a temporary bed and not, as some have asserted, either a hut or a nursery.

A REMARKABLE FISH.—Messrs. Holt and Byrne have described from the south-west coast of Ireland a new deep-water fish (*Lamprotoxus flagellibarba*) with several remarkable features. The only specimen obtained had a body about seven inches long, without including caudal fin and lower jaw. It bore a filamentous barbel many times longer than the body. The colour of the scaleless skin was velvety black, and the barbel was grey. A purplish-grey cord-like band of luminous tissue, partially embedded in the skin, formed a closed loop on the anterior part of each side of the body. There was also a large photophore behind and slightly below the eye, occluded by skin save for a narrow slit. Very small photophores, hardly visible externally, were present in lateral and marginal series.

HERMAPHRODITE BEES.—In a hive in the Caucasus, G. Kojewnikov found hermaphrodite bees. There were also normal workers and drones from the same queen-mother. The hermaphrodites looked like workers with the heads of drones, but there was an intimate mixture of characters. One of the mandibles was a drone's, the other a worker's; the eyes were drone's eyes, the thorax was a worker's thorax. The sting was very variable. An interesting point is that while some of the hermaphrodites had an ovary on one side and a testis on the other, others had two ovaries or two testes. Yet those which were unequivocally females or males as regards the essential organs of generation were, nevertheless, hermaphrodites in skeletal parts. This seems to show that in this case the nature of the reproductive organs does not influence the development of the external sex characters.

COMMENSALISM OF ANTS AND CATERPILLARS.—Towards a hundred cases are known of caterpillars (Lycaenidae and Erycinidae) living in commensalism with ants. M. Charles Oberthür has recently called attention to two species in Brittany—*Lycaena argiades* and *L. baton*—which appear to illustrate this kind of association. Harold

Powell reports the same in regard to *L. baetica*, *L. bellargus* and *L. iolas*. An ant removed from its companion caterpillar (*L. baetica*) is restless and disturbed. In the case of *L. bellargus* the ant rides on the caterpillar and caresses it. Oberthür also refers to an Australian form which lives in the nests of green ants. When the imago hatches out it is covered with very deciduous white scales which fall like a shower of confetti when it takes to wing from among its quondam companions. There seems no doubt that this association of ants and caterpillars will reward further investigation.

LAND CRAYFISHES OF AUSTRALIA.—Very little is known of the habits of these interesting animals (species of *Engaeus*) which have left the aquatic habitat of their race and become burrowers in damp ground. The burrows are sometimes near the bank of a stream, but very frequently far removed from any water in the middle of the forest in some damp situation. There is water at the bottom of the burrow. Messrs. G. W. Smith and E. H. J. Schuster, in a recent study of the species of *Engaeus*, call attention to the great depth of the carapace, its arched roof-like shape, the reduced abdomen, the small eyes, and the tendency to reduction in the size of the gills. An unusually strong hairiness of the mouth-parts and neighbouring regions is probably correlated with the necessity of filtering the water in the burrows, which is usually very muddy. There are not a few minor losses or suppressions, *e.g.*, the loss of a flagellum on the antennule and the reduction of the antennary scale, and the authors suggest that the underground burrowing habit which removes the crayfishes from active competition with other aquatic forms has permitted degenerative changes which have no special adaptive significance.

The young are brought into the world and tended by the female parent in the same way as in the ordinary crayfish, being carried about attached to the swimmerets. As the animals keep to their burrows during the day, very little is known as to their feeding habits. "It is probable that they are mainly carnivorous in diet, as the remains of earthworms, insect larvae, and probably land crustacea have been found in their stomachs. . . . . The evergreen beech forests in Western Tasmania support a very rich terrestrial fauna of land amphipods (*Talitrus*) which swarm under the fallen beech leaves and timber, and numerous myriopods and insect larvae occur as well, affording abundant food in exactly the situations which *Engaeus* chooses for its burrows."

SPECIFICITY.—We have repeatedly referred in these Notes to the existence of minute peculiarities of structure which distinguish species, sometimes more convincingly and reliably than do larger and more obvious features. A fish may be known by a single scale or a bird by a single feather; and the cells lining the windpipe of a horse are readily distinguished from those of the dog which barks at the horse's feet. All flesh is not the same flesh, and nothing is more specific than the blood. On a larger scale are peculiarities of structure which run through a series of related forms. A good example is furnished by Mr. Edwin S. Goodrich in his study of the structure of bone in fishes. Ganoid scales are of two kinds, which differ fundamentally in structure and mode of growth—Cosmoid and true Ganoid. The latter are again divisible into Palaeoniscoid and Lepidosteoid. The Lepidosteoid scale is easily distinguishable by the presence of a system of delicate tubules running through and at right angles to the bony layers. The same peculiar tubules occur in the skull plates and other dermal plates of all the recent and extinct Lepidosteoids and Amioids that have been examined, with a single possible exception (probably a primitive form). The minute peculiarity is quite distinctive. Mr. Goodrich has more recently discovered that the Lepidosteoid structure is exhibited not by the dermal bones only, but by the whole endoskeleton as well. "The skull-bones, the ribs, even the vertebral centra, are all provided with the characteristic tubules traversing the bony lamellae, just as in the scales. It follows that, from the examination of the minutest fragment of the skeleton of a living or extinct species of fish, we can decide whether or not it belongs to the Amioidei and Lepidosteoidei, or to some other group. The histological structure of the bone, may therefore be of the greatest practical value for the identification of fragmentary specimens. It may also prove of great importance in the interpretation of phylogeny." This is a fine instance of a minute detail of structure holding good as an index of relationship.

AFRICAN ELEMENT IN FRESHWATER FAUNA OF BRITISH INDIA.—At the Zoölogical Congress at Monaco Dr. Nelson Annandale directed attention to the affinity, more close in some cases than in others, which can be demonstrated between the freshwater fauna of India and that of Tropical Africa. In some instances this affinity also extends to South or Central America. The African element in the Indian fauna was also compared with what we know to exist in the fauna of the Jordan system. In the latter a large contingent of the fish-fauna is pure African, but many of the lower aquatic invertebrates resemble African forms much less closely than do the Indian representatives of the groups. An explanation may be found, on the one hand, in the more recent date of the geographical connection between what is now the valley of the Jordan and the river-systems of Africa; and, on the other hand, in the fact that existing conditions of climate and chemical composition of the water are more similar in Tropical Africa and India than they are in the former and Palestine.

GALL-PRODUCTION.—Every contribution to the study of galls is welcome; for while great progress has been made towards understanding them the uncertainties remain very conspicuous. How far does the mechanical irritation produced by the parasite count as a stimulus? Or is it wholly chemical? To what extent do bacteria and other fungi play a part in stimulation? How far is the gall that is formed in response to the stimulus a quite new sort of growth? How is it that the same plant may produce several different galls in response to the stimulus of not distantly related hosts? How far can it be held that the host derives benefit from the gall because it thus restricts the sphere of the parasite's operations? How far, on the other hand, is the plant playing into the hands of its parasite by forming the gall?

In a recent elaborate study of Canadian galls Mr. A. Cosens maintains that the gall-producing stimulus renders the protoplasm of the host more active and awakens in it dormant characteristics, but does not endow it with power to produce entirely new structures. The idea that the gall-producing stimulus must be applied directly to the cambium is not true in all cases, for any actively growing tissue will respond to the gall-stimulus. Moreover the effect of the stimulus is operative on tissue at a considerable distance from the centre of application. There is no doubt that ferments secreted by the gall-producer (Cynipidae) count for much. They may pre-digest food for the larval gall-insect and may indirectly stimulate cell-proliferation.

PERIWINKLES AND THE TIDE.—It has been noticed that periwinkles (*Littorina littorea*) shift their position on the rocks in correspondence with the tidal changes. It has even been maintained that this tendency to periodic movement is so engrained in the periwinkle's constitution that it takes place apart from any tides. Recent experiments by Haseman do not confirm the last statement. It seems, moreover, that the oscillatory movements in normal conditions are not exhibited by periwinkles on horizontal flat surfaces between tide-marks or when they are below the low-tide mark. What seems to remain secure is that periwinkles on the vertical surfaces of rocks between tide-marks exhibit up and down movements which correspond with the movements of the tides.

MORE ABOUT BLACK TERMITES.—Professor Bugnion has told us something more about *Eutermes monoceros*, the Black Termite of Ceylon. In their nocturnal excursions to the trees—some of which were fifteen to twenty yards distant—they usually managed to keep to the same paths. As they are blind, they must feel or smell their way. Minute black specks probably excrementitious, are often to be seen marking the path. An interesting observation refers to a case where the path followed went up four posts and down the other side instead of keeping along the level ground!

At critical places, or when danger threatens, the soldiers form a double file guarding the march of the workers, and they all face outwards. From an ampulla in their head they squirt out viscous fluid in the face of offensive true ants like *Oecophylla*. The nocturnal expeditions have the object of collecting lichens, débris of leaves, and apparently some black material from the humus.

HABITS OF THE AGAMA.—Dr. W. A. Lamborn gives an interesting account of the habits of the common West African lizard, *Agama colonorum*. There seems to be a great disparity in the numbers of the sexes, and each male is attended by several females, sometimes six or seven, who behave with remarkable subservience towards their lord and master. "The male's responsibilities seem to be in excess of his capacities, so that the females are forced to resort to various artifices to secure their share of his attentions." The males are exceedingly combative, and the intrusion of one into another's preserves usually leads to a battle. "The tail is the offensive weapon, and to bring it into action the males take up a position parallel to each other, but head to tail. Each seeks to overcome the other, not by a number of strokes, but by a single well-directed blow." The female lays the eggs, in a cluster of three or four, in a burrow in the ground, and covers them with earth. The lizards are usually insectivorous, but will eat lettuce, tomatoes, and the like, in the dry season. Their voracity is remarkable. On one occasion Dr. Lamborn dropped no fewer than eighteen butterflies before a male Agama, and all were consumed in ten minutes.

IN VERY DEEP WATERS.—Professor Louis Roule has recently described a new abyssal fish, ***Grimaldichthys profundissimus***, gen. et sp. nov., which was dredged by His Serene Highness the Prince of Monaco from a depth of 6,035 metres to the south-west of the Azores. One of the features of this new form is that all the rays of the pectoral fin are free and filamentous. The rather dangerous title ***profundissimus*** indicates that up to date the depth inhabited by this fish is greater than that recorded for any other.

HATCHING OF CROCODILES' EGGS.—Many years ago (1899) Dr. Voeltzkow noticed that unhatched crocodiles (*Crocodilus madagascariensis*) utter a cry from within the egg—a cry that can be heard even when the eggs are covered, as in nature, by one to two yards of sand. The sounds are produced with the mouth closed, as we produce hiccough sounds. Dr. Voeltzkow writes:—"This crying of the young can be induced by walking heavily past the receptacle containing the eggs (a box in the study), by knocking against it, by taking an egg in the hand and turning it; in fact, any shock causes the young one to lift up its voice in the egg. As the female visits the nest almost daily in order to convince herself of its orderly condition, her passage from the water to the nest and back shakes the ground and induces the production of sound by those young ones which are sufficiently developed. Thereupon the old one scrapes the sand out of the pit and presently the young emerge." Dr. W. A. Lamborn has recently made similar observations in regard to ***Crocodilus niloticus*** at Lagos. Croaking noises were heard from below a dry path, and when he dug down he found thirteen eggs, all chipped save a bad one, at a depth of about eighteen inches. All the young crocodiles hatched out within half an hour of being dug up.

SOLAR DISTURBANCES DURING AUGUST, 1913.

By FRANK C. DENNETT.

AUGUST has been marked by a continued absence of activity on the Solar disc. On two days only (11th and 28th) tiny spotlets or pores were visible, on eight others (10, 14, 16–19, 27 and 29) faculae were seen, and on the remaining twenty-one days the sun appeared free from disturbance, unless exception be taken to a greyish patch some thirty hours past the central meridian, in north latitude, seen on the 24th. The longtitude of the central meridian at noon on August 1st was 87° 10′.

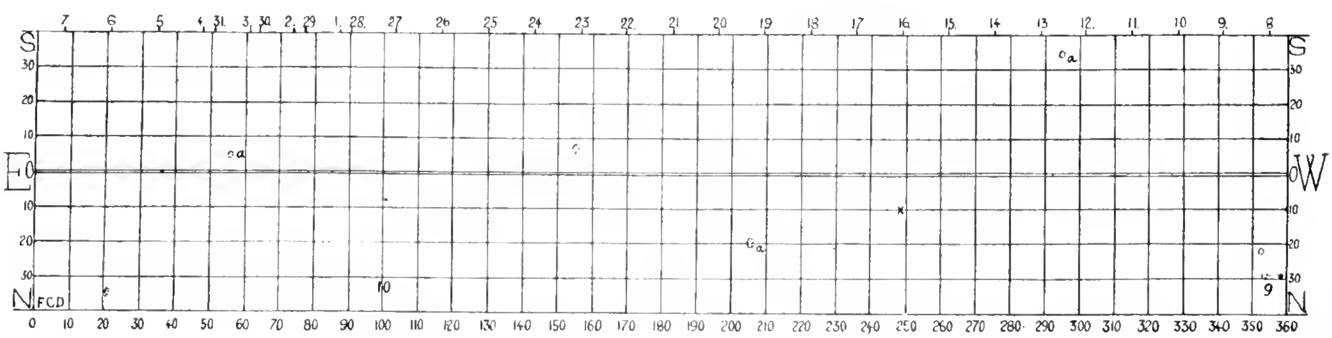
By some strange mishap the spot groups and faculae for July have not reproduced on the diagram in the September number of KNOWLEDGE; they have therefore been inserted in our present chart, the faculae being distinguished by the letter *a*.

On August 11th a tiny pore was visible, amid faculae, advancing from the north-eastern limb; it was too minute for measurement, but was approximately in the position marked by a cross in longitude 248°, N. latitude 10°. Only seen on one day.

On the 28th a minute pore with faculae was seen some 40° round the eastern limb—approximately in longitude 40°—cloud intervened before exact measurements could be made. Faculae were visible on the 10th some 35° from the south-western limb. On the 14th a small double facula, situated just south of the area of Group No. 9, closing up to the western limb. On the 16th a small bright cloud seen less than 20° from the North Pole, some three days past the meridian. On the 17th and two following days a facula seen some 8° S. latitude, in longitude 155°. On the 27th a tiny facula was almost on the meridian about 18° from the South pole; also a brilliant knot in N. latitude 34°, longitude 21°; this remained visible on the two following days.

Our chart is constructed from the combined observations of Messrs. J. McHarg, E. E. Peacock, and F. C. Dennett.

DAY OF AUGUST, 1913.



By the courtesy of *Country Life, Ltd.*

FIGURE 414.

Male Peregrine Falcon or Tiercel.

(From "The Peregrine Falcon at the Eyrie.")

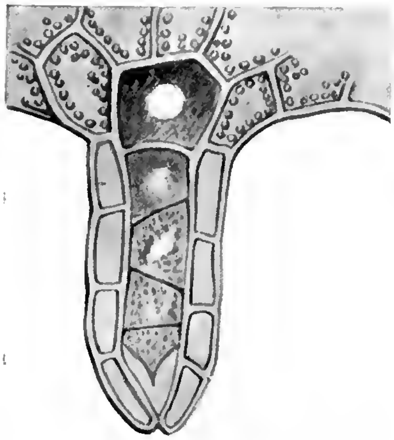


Figure 415.
An Archegonium of a fern.

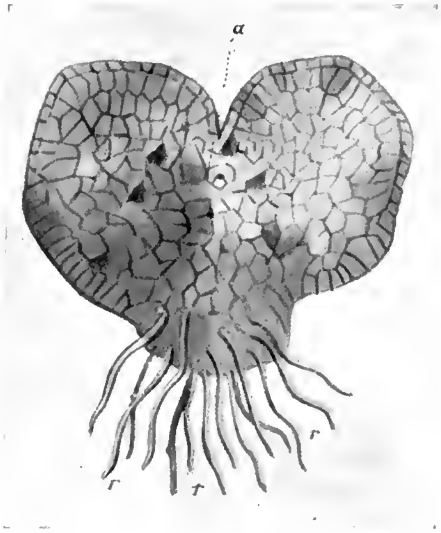


Figure 416.
A Prothallium of a fern.

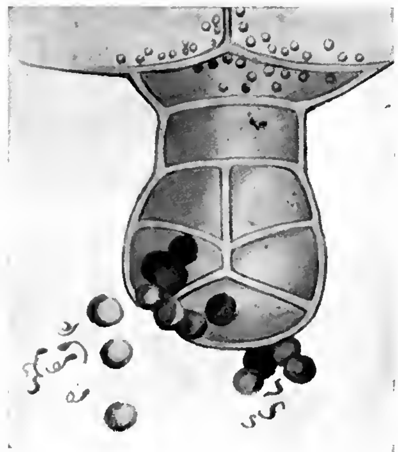


Figure 417.
An Antheridium of a fern.

Figure 418. The Sparassis (*Sparassis crispa*).

A fungus (one-half natural size) covered with twisted, thin, brittle lobes of a creamy white tint, found only in pine-woods, and considered to be one of the most desirable of the esculent species.

(From "Hutchinson's Popular Botany," by the courtesy of Messrs. Hutchinson & Co.)

REVIEWS.

BIOLOGY.

La Biologie Synthétique.—By PROFESSOR STÉPHANE LEDUC. 217 pages. 118 figures. 9-in. × 5¾-in.

(Paris: A. Poinat. Price 6 francs.)

This is a sequel to the author's *Théorie Physico-Chimique de la Vie et Générations Spontanées*, translated by Dr. Deane Butcher and published under the title of *The Mechanism of Life* (Rebman, 1911). Professor Leduc points out that hitherto life has only been studied analytically; that is to say, living organisms have been investigated by studying in detail each separate part. He suggests that it is time the synthetic method be applied in biology, since many of the phenomena associated with living organisms are exhibited (or, perhaps one would say, simulated) separately in the inorganic world. The book is highly suggestive, and the proposed synthetic method of dealing with biological problems ought to prove of great value. The book is marred, however, by a tendency to materialistic metaphysics—a domain which in reality lies outside of pure science. What Professor Leduc terms "physicisme" and "mysticisme" are complementary rather than antagonistic. Philosophy completes the work of science. The latter is concerned with the correlation of phenomena; the former seeks their source. The latter may adopt a mechanistic theory of life; the former must transcend this.

H. S. REDGROVE.

BOTANY.

Hutchinson's Popular Botany.—By A. E. KNIGHT and EDWARD STEP, F.L.S. Vols. I and II. 588 pages. 721 figures. 18 coloured plates. 10-in. × 7-in.

(Hutchinson & Co. Price 7/6 each Vol. net.)

There was a time, and that not very long ago, when the study of Botany meant to a very large extent the mere collecting and naming of flowering plants. Hutchinson's "Popular Botany" shows well how things have changed. The inside of plants to many has become more interesting than specific differences. The way in which the various parts do their work and still more recently the interrelation between plants which form communities and the connection between plants and animals have attracted wide attention. All these topics as well as those groups of plants which do not bear flowers are considered and illustrated in "Popular Botany" by a wealth of photographs and careful drawings, the latter by Mr. A. E. Knight and the former, in many cases, by Mr. Edward Step. There are also eighteen coloured plates. The first volume contains chapters dealing with the cell, with tissues, with physiological processes, with structure, and lastly with the leaf in relation to environment. In the second volume the last-mentioned topic is completed, floral forms and their relations to insects are discussed at length, and the reproduction of flowering plants and lower forms is described and illustrated. Examples of the pictures, which are a great feature of the book, we are permitted to give on Page 396.

W. M. W.

CHEMISTRY.

Mineral and Aërated Waters.—By C. AINSWORTH MITCHELL. 227 pages. 114 illustrations. 8¾-in. × 5½-in.

(Constable & Co. Price 8/6 net.)

From very early times the waters of certain springs and wells were supposed to have medicinal properties which were generally considered to be supernatural or miraculous. As the chemists of the eighteenth and early nineteenth centuries acquired a knowledge of the constituents to which the therapeutic effects were due, it was natural that attempts to prepare them artificially should be made. In this book the author gives a short account of spas, wells, and natural mineral waters, and then traces historically the development of aërated water manufacture from Bergmann's primitive efforts to the complicated methods of the present time. The latter involve not only the use of liquid carbon dioxide and elaborate machinery for aëration, but also ingenious mechanical methods of purification and bottling.

An excellent description of these processes, accompanied by many valuable diagrams and photographs, occupies a great part of the book. The chapter on the bacteriological and chemical examination of the manufactured products is interesting, but we think that, in view of the fact that the amount of lead in citric and tartaric acids has not reached the minimum suggested by analysts, some of the common tests for this metal might have been included. The work of Bardet has shown lately that though lead, tin and silver are generally constituents of well waters, they are only present in spectroscopic amounts, so that the acids and essences—which, by the way, are scarcely mentioned in the book—are probably the only sources of impurities. The bibliography might have included, with advantage, such works as Raspe's "Heilquellen Analysen" and the "Deutsches Bäderbuch."

These omissions however, do not detract from the merits of an excellent book, which is not only extremely interesting to the general reader, but should prove most useful to the manufacturer.

A. S. Jr.

Treatise on General and Industrial Organic Chemistry.—By Dr. E. Molinari. Translated from the Italian by T. H. Pope, B.Sc., F.I.C. 770 pages. 506 illustrations.

(J. & A. Churchill. Price 24/- net.)

This volume is practically a continuation of the author's work on Industrial Inorganic Chemistry which was recently reviewed in these columns, and deals with the subject upon similar lines. The first part gives a general outline of the physical and chemical methods of examining and identifying organic compounds, and includes sections upon elementary analysis, determination of molecular weights, and the relationship between physical properties and chemical constitution. Part II gives an account of methane and its derivatives, and includes hydrocarbons, fats, alcohols, and sugars; while Part III. deals with cyclic compounds, including aromatic hydrocarbons, phenols, colouring matters, proteins, glucosides and so on. In the case of each group of compounds, a general outline is given of the characteristics of the principal individuals, and this is followed by an account of industrial methods of preparing those of technical importance. For example, twenty pages are devoted to the description of the manufacture and purification of illuminating gas, and a similar space to petroleum and its products.

The author's aim appears to have been not so much to give exact details of experimental work as to enable the reader to follow the principles upon which the industrial processes are based.

Dealing with such a wide range of subjects, it was obviously impossible for one man to be thoroughly conversant with them all, and in certain places this want of first-hand knowledge is manifest. Taken as a whole, however, and judged by those sections with which the reviewer is most familiar, the book may be recommended as accurate and up-to-date. Here and there small errors and inaccuracies may be noted. For example, it is not correct to state that "in comparison with all other fats, butter contains a large quantity of volatile acids soluble in water." Possibly, however, it is the translation that is at fault here, and the reading should be "a larger quantity than any other fat." The slip on page 281 where it is stated that "the most favourable temperature is 30 per cent." makes the passage meaningless. If "30° C." is meant, the statement is not borne out by the facts.

The book is profusely illustrated, but it is to be regretted that worn electros have been used for many of the illustrations.

In the future edition, which is sure to be needed before long, it would be advisable to replace many of these blocks by fresh drawings. The work deserves it.

C. A. M.

GEOLOGY.

Volcanoes, their Structure and Significance.—By Professor T. G. Bonney, Sc.D., LL.D., F.R.S. Third Edition. 379 pages. 16 plates. 21 illustrations. $8\frac{1}{2}$-in. × 6-in.

(John Murray. Price 6/- net.)

Since the second edition of this work much has been added to our knowledge of vulcanicity by the great eruptions of the Soufrière and Mont Pelée, and by those in Guatemala and Savaii. The first-named, however, was treated in an appendix to the second edition, but in this book it assumes its proper place in the text as, in at least one feature, a new type of vulcanicity. The book is divided into six chapters, each elaborating one aspect of volcanoes, their life history, products, dissection, geological history in Britain, distribution, and origin. The book is written in a picturesque and vigorous style, well adapted to sustain the interest of the general reader for whom it is intended. A disarming preface wards off undue criticism. We may perhaps observe that while the simplified petrographical nomenclature adopted may be very comforting to both author and reader there is no such simplicity in the rocks themselves; and although the author animadverts on the great number of new names, the majority of them are absolutely necessary if any serious comparative work in petrology is to be done. Professor Bonney also favours the older view that there were two periods of eruption in the famous old volcano of Arthur's Seat, Edinburgh; but the recent detailed mapping of the Scottish Geological Survey is decisive in favour of Professor Judd's view that it is the product of one continuous volcanic episode. The book concludes with an admirable chapter on the various theories advanced to account for volcanoes, in which we should have liked to have seen some reference to Daly's recent fine work on the mechanism of volcanic action.

G. W. T.

Submerged Forests.—By Clement Reid, F.R.S. (Cambridge Manuals). 129 pages. 5 figures. $6\frac{1}{2}$-in. × 5-in.

(The Cambridge University Press. Price 1/-)

At many places around the English coast black peaty earth, with tree-stumps and other plant-remains, is exposed between tide-marks. Several layers of this material, the lowest generally at a depth of sixty feet below sea-level, are often found in dock excavations. These submerged forests, although, as explained by the author, muddy subjects to dabble in, are replete with scientific interest, and their exposition has given rise to a most interesting little volume. Submerged forests and their correlatives, raised beaches, give the clues to the most recent vicissitudes in the relative levels of land and sea. According to the author's estimate the submerged forests indicate a recent subsidence of nearly ninety feet of the land with respect to the sea. The newest of these deposits belongs to the age of polished stone, and the earliest also probably comes within the Neolithic period. In Mr. Reid's opinion the earth-movements ceased about three thousand five hundred years ago, and began about one thousand five hundred years earlier. These estimates, as we are carefully told, are not to be taken as exact, since they are based on somewhat uncertain factors.

Most of the book is occupied with the description of the submerged forests seen on the English coasts. Amongst the interesting subjects dealt with, the Dogger Bank, and the question as to the mode and date of the severance of Britain from the Continent, are the most likely to appeal to the general reader. The author is to be congratulated on this fine exposition of what, at first sight, appears to be an unpromising and difficult subject.

G. W. T.

HISTORY.

Ancient Greece.—By H. B. Cotterill, M.A. 498 pages. 12 plates. 4 maps. 141 illustrations. $8\frac{1}{2}$-in. × $5\frac{1}{2}$-in.

(George Harrap & Co. Price 7/6 net.)

In an agreeable and compendious volume Mr. Cotterell has furnished a popular history of Ancient Greece from the earliest times about which anything is known down to the life of Alexander the Great. He has interwoven with it some account of Greek philosophy, literature, and art, and added copious illustrations of sculpture, vases, ancient sites, and famous men. The book will be a boon to the general reader, who, with no knowledge of the Greek language and no inclination for laborious study, would gladly acquaint himself with the meaning and the place in history of all that is most beautiful and expressive in art. The book, in fact, supplies a want that must often have been felt by intelligent people with small leisure. Mr. Cotterill sketches briefly the results of recent discoveries throwing light on Aegean civilisation, and shows how the early history of Greece was connected with that of Crete and Egypt; facts made additionally clear by a useful chronological table, which provides an approximate idea of their contemporary histories. In later times that most tragic and graphic chapter in Greek history, the Sicilian expedition, is illustrated by quotations from Thucydides; the march of the ten thousand from Xenophon. Mr. Cotterill writes with a keen appreciation of what he describes and the illustrations, to which allusion has already been made, have been judiciously selected and well reproduced. Even coins have received attention in this pleasant and useful book.

E. S. G.

PHYSIOLOGY.

Laws of Sexual Philosophy.—By J. L. Chundra. 208 pages. Frontispiece. $7\frac{1}{4}$-in. × 5-in.

(Calcutta: The Author. Price 4/- net.)

Dr. Chundra is Professor of Medicine in the National College of Calcutta, and his book is designed for students of gynaecology and obstetrics. The volume contains much that is of physiological and medical interest. Among other points it discusses the theories which have been brought forward and the experimental investigations, for instance of Professor Schenck, with regard to the determination of sex. The chapter entitled "The Laws of Genius," in which the question of influence transmitted by parents to their children is discussed, will hardly at the present time obtain serious consideration.

W. M. W.

POLITICAL ECONOMY.

The Fate of Empires. Being an Inquiry into the Stability of Civilisation.—By Arthur John Hubbard, M.D. (Dunelm.) 220 pages. 3 figures. $8\frac{3}{4}$-in. × $5\frac{3}{4}$-in.

(Longmans, Green & Co. Price 6/6 net.)

Dr. Hubbard has an interesting thesis to maintain. He attempts to discover those forces which make for the growth and decay of civilisation and of which history gives us only the resultant. Of the latter he holds there are two, namely, those due respectively from the social stress (*i.e.*, the competition of one's fellows) and the racial stress (*i.e.*, the trials and troubles of parenthood). Every stage in the history of organic advance, he argues, will be found to be governed by a new method or idea whereby life can be maintained on a high scale. Each new method is superimposed upon the old, which is utilised, not discarded, by the new. These methods are as follows:—(1) Reflex Action; (2) Instinct; (3) Reason; (4) Religious motive. Instinct sacrifices the individual to the race; Reason, which results in Socialism, Dr. Hubbard maintains, sacrifices the race to society, whose interests under such a régime are identical with those of the individual. In support of this he contends that Socialism appears simultaneously with a fall in the birth-rate. The method of religious motive, he contends, alone reconciles the interests of individual, society, and race by raising conduct from geocentric to cosmocentric significance.

I am inclined to think that Dr. Hubbard has fallen into the error of identifying reason with selfishness. Pure reason is motiveless; it is an organon which any desire may utilise to gain its ends; and for this reason Dr. Hubbard's enumeration of the methods of organic progress seems hardly satisfactory. Nor is there any reason why Socialism should result in a falling birth-rate; the instinct to propagate one's species (to look at the question from a purely selfish standpoint) is, on the whole, sufficiently strong to counteract the desire for ease and comfort; and whilst one can thoroughly agree with Dr. Hubbard's appreciation of the method of religious motive it is difficult to see how any system of political economy could be constructed on this basis. The State can compel its members to obey laws constructed by the aid of reason for their own benefit; it cannot compel them to be religious, though much can be done by means of education. The theoretical portion of Dr. Hubbard's book is followed by an historical section in which his views are illustrated by reference mainly to the Roman and Chinese civilisations. The account of the latter is particularly interesting and suggestive.

H. S. REDGROVE.

SPORT.

The Tarn—the Lake.—By C. J. HOLMES. 48 pages. $8\frac{1}{2}$-in.$\times 5\frac{1}{2}$-in.

(Philip Lee Warner. Price 2/6 net.)

"The Tarn—the Lake" appears to be a prettily written and imaginative treatise on fishing, but after the first two chapters Mr. Holmes switches the giddy and bewildered reader on to the Italian Renaissance, and proceeds to discourse on "Shoes and Ships and Sealing-wax." Not that his observations on these and kindred subjects are wholly lacking in suggestiveness, but it is such a far cry from reminiscences of his youthful experiences with minnows, and he takes so much for granted, and he asks so many questions and never waits for an answer. But eventually he deduces to his own satisfaction the conclusion that degeneracy overtakes men and fish alike, when all the natural incentives to healthy exertion are too carefully removed.

E. S. G.

ZOÖLOGY.

An Introduction to Zoölogy.—By Rosalie Lulham, B.Sc. 457 pages. 6 plates. 328 figures. $7\frac{1}{2}$-in.$\times$5-in.

(Macmillan & Co. Price 7/6.)

Miss Lulham has such a reputation in connection with Nature Study work that one would expect any book that she might write to be interesting and original. We are not disappointed with the present volume, and it is evident that much of the information included is culled from the writer's own observations. If the classifications given are not always those which have been based on recent researches it may be that the author has in mind those who wish to classify things more particularly in the field. For instance, the dragon flies with no complete metamorphoses are still placed in the order Neuroptera with such forms as the lace-wing fly, where there is a resting stage. The reason suggested can, however, hardly explain why the Testacellidae, which contains the worm-eating slugs, the most highly modified of all land mollusca, is not put at the head of the Stylommatophora, and from the description also it is not evident that forms with well-developed shells are placed in the family. Any little points of this kind are, however, over and again made up for by the practical notes given at the end of each chapter, and we may mention specially those on ants and the keeping of ants' nests. There are also many useful hints and references given of the greatest value to young students. In fact, the book is intended to take the place of ordinary notes for those whose teachers spend most of the time at their disposal, as should be done, in practical work.

W. M. W.

The Peregrine Falcon at the Eyrie.—By FRANCIS HEATHERLEY, F.R.C.S. 78 pages. 30 illustrations. 11-in. by 8-in.

("Country Life." Price 5/- net.)

Mr. Francis Heatherley is a bird-lover with a knowledge of photography who during three seasons has carefully watched the eyrie of the peregrine falcon, and the book under consideration contains the records of his own and his friends' observations. The author says that what little experience he has had of the official ornithologist makes him anxious not to be confounded with the latter, as the present mania for bird and egg collecting is deplorable, considering the difficulties it places in the way of study when so much remains to be learnt of the habits of living birds. Mr. Heatherley has also no exaggerated veneration for the printed word which he too often finds is copied from one text-book to another in default of original observations, and in the case of the peregrines, his only working hypothesis was that the falcon is bigger than the tiercel.

Among the chief points of interest brought out are the time of incubation and the way in which, after a few days, the falcon handed over to her mate the actual work of feeding the young and looking after them while she spent her time in hunting and bringing the quarry to him. On one occasion the hen bird absented herself for a considerable time, and Mr. Heatherley is doubtful whether she did this voluntarily, owing to the constant presence of strangers, or whether she had been shot, and the tiercel managed to secure the services of another falcon. It would be interesting to know whether, if he had been left to himself, the male bird would in the end have been driven to hunt to appease his hunger, and that he would afterwards have fed the young. It appears that the prey that was brought to the nest for the latter was plucked or not according to the time which the falcon had at her disposal. What she brought for the tiercel's own consumption was usually skinned. The young ones paid more attention to the warning note of their father than that of their mother, and it is curious that when they began to take their food with less alacrity the tiercel encouraged them by giving a sharp yap.

Mr. Heatherley has come to the conclusion that the difference in size between the nestlings is a sexual one, and not dependent upon the fact that incubation starts with the first laid egg. Mr. C. J. King, who visited the eyrie in 1913, found that of the three eggs one was larger than the others and weighed fifty-eight grains more, while the difference between the two small eggs was not more than a grain. Of the peregrine language the author only learnt three phrases, but he says that the use of a hiding contrivance greatly enlarges one's appreciation of bird language—a rich field for investigation. "In raising himself from the wild, man has cut himself off from much knowledge of the ways of his poor relations, knowledge some of which even our immediate ancestors retained; for instance, the use of the great grey shike as sentinel by the Dutch trappers of passage hawks, a use of a bird's characteristic implying an intimate knowledge few museum authorities would care to claim. Modern bird-photography and nature study are, however, again lifting the veil."

In concluding his very original and interesting book, which we recommend most heartily to all lovers of birds, Mr. Heatherley gives some details with regard to his photographic work. He uses a lens with a fifteen-inch focus because he sees no sense in going to the trouble of getting the camera within six feet of a shy bird and then being content with an image the size of a postage stamp. With Kearton, he believes in developing some, at any rate, of his exposures at the end of the day. He has three shutters to his camera: (1) a time and instantaneous one fastened on to the front, (2) a silent studio shutter which he can fix on by taking out the back of the camera, and (3) the most expensive and the least useful—a focal plane shutter at the back. He uses a blackened brass cylindrical hood to screw on the lens in front so as to project two or three inches, which proves useful against sun and rain. He finds a rücksack the most convenient means for transporting apparatus, and the safest, because a heavy bag swung over the shoulder is likely to suddenly shift when you are in some awkward situation and shake your nerve, if it does nothing worse.

By the courtesy of the publishers we are able to reproduce on page 395 one of the many excellent photographs with which the book is illustrated.

W. M. W.

A Dictionary of English and Folk-Names of British Birds.—By H. Kirke Swann. 266 pages. $8\frac{3}{4}$-in. $\times$ $5\frac{3}{4}$-in. (Witherby & Co. Price 10/- net.)

In this list the accepted English names of British birds are printed in capitals throughout, and under the principal headings there is given much folk-lore and many legends with regard to the more familiar species. Some of the stories are very curious; for instance, the popular belief about the song-thrush is to the effect that the bird acquires new legs and casts the old ones when about ten years old. Another notion, which comes from the Border, with regard to the pied wagtail is that it ought always to wag its tail *nine* times on alighting and before beginning to run about or feed, and should the number be less or more it is very unlucky for the person who is counting. More important from an ornithological point of view is the fact that Mr. Swann gives a reference to the first usage of the various names. Altogether there are nearly five thousand names of all kinds gleaned from literature, from county lists, from several languages and many dialects, and it is obvious that to bring them together, quite apart from the many interesting details that have been added, must have entailed a prodigious amount of work. The time is gone by when the labours of the compiler were not properly recognised, and the value of Mr. Swann's book to all writers upon and students of birds will be acknowledged as very great.

W. M. W.

NOTICES.

ALEXANDER AGASSIZ.—Messrs. Constable will publish almost immediately the "Life and Letters of Alexander Agassiz," edited by his son.

THE FOX.—Mr. J. C. Tregarthen's "Life Story of a Fox," which has gained the admiration of many nature-lovers by the accuracy of its observation and its charming style, is shortly to be issued in a cheaper form by Messrs. A. & C. Black.

THE CENTURY MAGAZINE.—In the issue of this magazine for September, Mr. Robert Sterling Yard, the new editor, reviews the aims of the magazine in the past, and sets forth what they will be in the future. We wish him every success.

UNKNOWN SOUTH AMERICA.—Mr. A. Henry Savage-Landor has been for the past seven months hard at work on his new book, "Across Unknown South America," describing his remarkable journey across that beautiful and virgin continent. The book is now completed and will be published shortly, in two volumes, by Messrs. Hodder & Stoughton.

A NEW NATURAL HISTORY.—For many years Messrs. Cassell have specialised in Nature-study volumes, and the latest addition to their series of books upon this subject will be "Cassell's Natural History," which will deal with all the latest discoveries in Nature Science, and contain photographs taken direct from Nature in natural colours, as well as an abundance of other photographs.

THE NEW ENCYCLOPAEDIA.—Messrs. T. C. and E. C. Jack announce the publication of a new encyclopaedia. The work will be original throughout, and owing to the way in which the matter is condensed and the illustrations treated, the one thousand six hundred pages will contain as much information as is usually put into six large volumes. All the entries are thoroughly up to the latest date, and science is a strong feature of the work. Struck by the inconvenience to the reader of having from a dozen to twenty volumes to choose from, and the consequent confusion and irritation, the publishers have put the whole into one good-sized volume. A large edition has been printed, and the work will be issued at a popular price.

MACMILLAN'S NEW BOOKS.—From the classified list of announcements of new books which Messrs. Macmillan and Company have issued, we find quite a number dealing with anthropology and archaeology. Among these are the two parts of "The Golden Bough," which will complete the third edition of Professor Frazer's great work. In "Marriage Ceremonies in Morocco" Professor Westermarck repairs the omission of which he says he was guilty when he wrote "The History of Human Marriage" more than twenty years ago. We notice also that the first volume of an English edition of Windelband and Ruge's "Encyclopaedia of the Philosophical Sciences" is being brought out under the editorship of Sir Henry Jones. There are besides a number of scientific books which should be of interest to our readers.

BIRKBECK COLLEGE.—We have received the Calendar of the Birkbeck College for 1913-14. Founded by Dr. George Birkbeck in 1823, this institution has played a very great part in the education of the Metropolis, and is now conducted in relation with the University of London. Classes are held both in the day and evening; thirty-two members of the staff are recognised teachers of the University.

The courses of study provide for Degrees in the Faculties of Arts, Science, Laws, and Economics.

In Science there is a very extended curriculum for Chemistry, Physics, Mathematics, Botany, Zoölogy, and Geology. The laboratories are well equipped with modern apparatus and appliances, and research work is carried on in all the departments.

The 91st Session of the College commenced on Monday, 29th September, when the Opening Address was given in the Theatre, at 7 p.m., by Sir Francis Darwin, F.R.S., LL.D., D.Sc.

ARTIFICIAL FERTILISATION.—Dr. Jacques Loeb, head of the department of Experimental Biology in the Rockefeller Institute for Medical Research, has written a companion work to his "Mechanistic Conception of Life," which attracted much attention on its publication last year, entitled "Artificial Parthenogenesis and Fertilisation." It will be issued during the autumn by the Cambridge University Press, as British agents for the University of Chicago Press. The subject of the book is an analysis of the mechanism by which the male sex cell, the spermatozoön, causes the animal egg to develop. The author has gained a world-wide reputation for his achievements in artificial fertilisation, and this work penetrates, in great measure, the mystery which surrounds the term "life" to the extent of showing how the action of well-known chemical and physical agencies may be substituted for that of the mysterious complex called the "living spermatozoön."

ELEMENTARY STUDIES IN ASTROSPECTRA.—In November, Professor Bickerton will commence in "Knowledge" a series of articles on stellar spectroscopy for beginners. These articles although intended for persons having no knowledge of spectrum analysis, will by simple basic steps lead the student to the solution of problems that eminent astronomers admit themselves unable to explain. They may therefore be useful to all interested in stellar spectra or in the making and reading of even complex spectrograms. By the term "spectrogram" is generally understood a photograph of a celestial object taken by means of a telescope or camera armed with a prism or diffraction grating.

Professor Bickerton has been for many years in New Zealand, where he held a chair in experimental science for over a quarter of a century. The Chairman of the Board of Governors of his College, writing in the New Zealand *Spectator*, of which he is editor, says:—"Professor Bickerton is a man of intellectual power, a most picturesque writer, and above all one who can invest scientific subjects with a literary charm that makes them intensely interesting to the lay mind."

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

NOVEMBER, 1913.

THE ESTABLISHMENT OF A RACE OF WHITE CANARIES.

By MAUD S. MARTIN.

SOME white canaries were exhibited before the Linnean Society, in the year 1912, and the following is an account of how the race was obtained, by Mrs. Martin, who bred them. Professor Arthur Dendy, F.R.S., who introduced the exhibit, has kindly written the following lines by way of preface to the article.

Last year I had the pleasure of meeting Dr. Palmer, of New Zealand, who had brought over to England a considerable number of white canaries bred by Mrs. Martin. At my suggestion Dr. Palmer exhibited a pair of these very beautiful birds at a meeting of the Linnean Society, where they aroused great interest, and in response to a request for further information as to how they had been obtained, Mrs. Martin has very kindly written the following account, which I feel sure will be welcomed by readers of "KNOWLEDGE." "Mendelism" is so much to the front nowadays that it is hardly necessary to point out the great interest of Mrs. Martin's observations. They afford an excellent illustration of the wonderful power which the scientific study of heredity has placed at the disposal of those who wish to produce new and permanent varieties of plants or animals. White canaries have, it is true, occasionally been obtained as sports by previous breeders, but I believe I am right in saying that no one has hitherto succeeded in establishing a pure white breed. That this has now been accomplished by an amateur, working alone in New Zealand, and without any special scientific training, shows how much may be expected in the future from the application of Mendelian principles. Thanks to such writers as Professor Bateson and Professor Punnett—to mention only two of the best known workers in this field—a knowledge of these principles is now widely disseminated, and Mrs. Martin's work illustrates very clearly how easily and successfully such knowledge can be put to practical use.

Mrs. Martin is, of course, responsible not only for the results obtained, but also for the form in which those results are set forth; but in justice to her it should be stated that, being in New Zealand, she has had no opportunity either of consulting with specialists in the subject or of revising the proofs of her paper.

A. D.

During the season of 1908–9, a pure white hen canary (having a grey tick on the left cheek) was hatched in Martinborough, Wellington, New Zealand, being a sport from ordinary buff parents—its mother being a buff hen with a black cap, and its father a buff cock with a green crest and green wing mark. In the same nest as the white sport were three other birds, all buffs, more or less marked with green. All the birds in this aviary were very much in-bred, and many of them were very pale in colour, being a creamy white in the nest feathers, but moulting brighter. One very pale cock bird (with a grey tick of the left cheek) was mate to most of the hens both young and old.

The parent birds escaped after rearing their brood.

The white sport hen was bred by Miss Lee, of Martinborough, and I purchased it from her, as I intended, if possible, to produce from it a race of white canaries breeding true to colour. To attain this end I determined to experiment on Mendel's lines and bought as a mate for the white sport a buff cock, quite unrelated to her. From the mating of this pair in 1909–10, I reared three buff cocks and three buff hens (see Tables 72 and 73). No "whites" appeared, which is, of course, what I expected. The white sport hen died before the next season, so I was unable to use her again, and was left with her young ones (three buff cocks and three buff hens) to carry on the experiment. Some of them were clear and some variegated.

These three buff cocks and three buff hens I mated together in 1910–11 and obtained from them forty-eight buff chicks and eighteen white ones, proving their hybrid character (see Tables 72 and 74). Nine of the "whites" were reared, six cocks and three hens, and I kept five buff hens to breed with the following year. The buff cocks I did not use for breeding as I had not white hens enough to spare to test them with to see if they carried white blood. Also there would certainly be some dominants in them and I did not want to increase my breeding operations or to multiply the buff birds—for which reason I did not use the buff hybrid cocks of the first generation again, but used only the white cocks as mates for all the hens the following year.

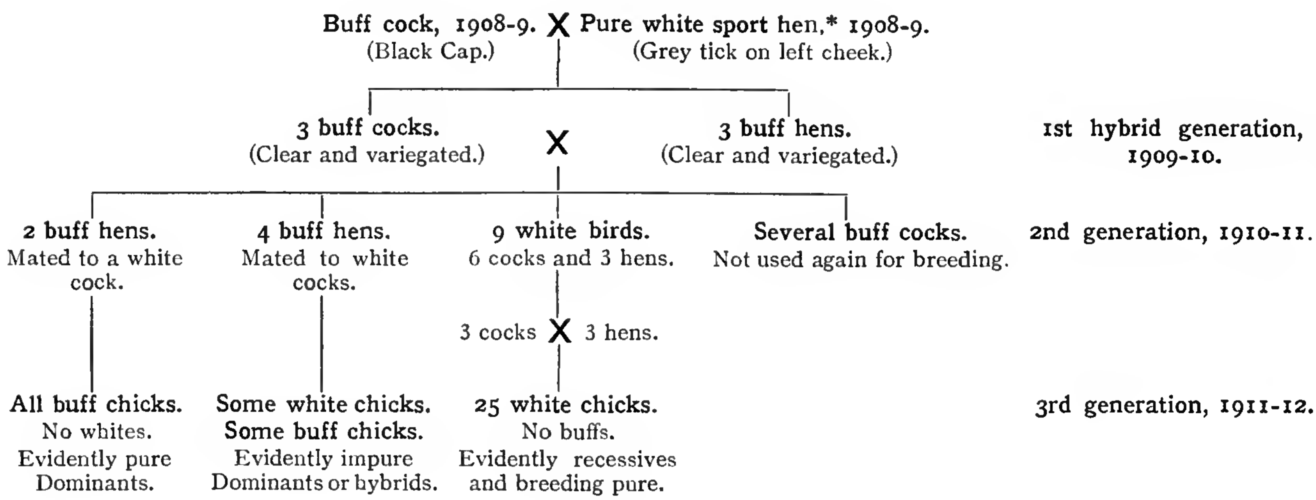
The three buff hens of 1909–10 (first hybrid generation) I mated in 1911–12 to their sons the white cocks of 1910–11 (second generation) and from them I obtained fourteen buff chicks and twenty-six white chicks (see Table 75).

The three white hens (1910–11, second generation) I mated to white cocks (1910–11, second generation) in 1911–12, and from them I obtained twenty-five white chicks, no buff ones appearing in the nests at all, apparently proving their recessive character (see Table 76). The six buff hens (1910–11, second generation, I mated to white cocks (1910–11, second generation) in 1911–12. Two of them gave me only buff birds, no white ones appearing in the nests at all, which looked as though they were dominants, (see Table 77), the other four hens having sixteen buff chicks and twenty-seven white ones, evidently being hybrids, or impure dominants (see Table 78).

The details of each nest are made out in the accompanying tables. The eggs were carefully numbered and the young had numbered rings on their legs, so that there should be no mistaking the birds belonging to each pair.

The white chickens are easily distinguished directly they are hatched, as their skin is a pale bright pink, quite unlike the ordinary yellow appearance of a common hatching. Very often (but not always) the hybrid chicks have a pinkish-yellowish body when first hatched, but this soon turns yellow, and is never the bright light pink of the white chick. Also the hybrid chicks are generally (but not always) very pale in the nest feathers, quite a creamy white, but becoming brighter yellow later, although many remain very pale, but not all of them. It was on account of these two peculiarities of the hybrid birds that I mated the two buff hens (see Table 79) to the white cocks, as I suspected that they would have

Table 72.



* Note.—The white sport was bred from ordinary variegated buff parents and very much in-bred. One pale buff cock, in particular, appeared several times as father in previous generations, the white hen being his granddaughter on both sides.

young white ones, which they both did have. Hen I. (1907–8) I hatched in my own aviary, and she was almost white in the nest feathers and always continued very pale, and when mated to a goldfinch gave me pied mules. Hen II. (1909–10) had peculiarly pinkish-yellowish chicks, so I suspected her too of carrying white blood, and in 1910–11 mated her to a first hybrid generation buff cock, from which mating I got only one pale hen. The following year (1911–12) I mated both mother and daughter to a white cock (1910–11, second generation), and got white chicks from both of them. The daughter is the hen in Pair IV. in Table 78.

I have other pale hens (older) related to the white sport (but not descended from her), as Miss Lee and I have for many years exchanged birds from our aviaries. These hens I intend this year to mate with white cocks, to prove if they are hybrids or not, as I fancy some of them carry white blood too. (Miss Lee, I think, must have many birds capable of producing white chicks—as her birds are mostly very pale—but she does not I think care to experiment systematically.)

TABLE 73.

RESULTS OF MATING BUFF COCK, 1908–9, TO WHITE SPORT HEN, 1908–9.

Unrelated.

Pair.	Buff Chicks.	White Chicks.	Remarks.
Original. 4 broods.	2 2 3 2	0 0 0 0	The young ones in the third nest died.
	9 six survived.		1st Hybrid Generation, 1909–10.

TABLE 74.

RESULTS OF MATING 3 BUFF COCKS AND 3 BUFF HENS, 1909–10.

1st Hybrid Generation from Buff Cock and White Hen Sport, the Hens being the Sisters of the Cocks.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 6 broods.	3 3 2 4 3 3	0 1 1 1 1 0	
II. 6 broods.	4 4 1 4 3 3	1 0 1 1 1 2	
III. 7 broods.	1 3 4 1 2 0 0	0 1 0 3 1 1 2	
	48	18	2nd Generation from White Hen, 1910–11.

TABLE 75.

RESULTS OF MATING 3 BUFF HENS, 1909–10, OF THE 1ST HYBRID GENERATION TO 3 WHITE COCKS OF THE 2ND GENERATION, THE HENS BEING THE MOTHERS OF THE COCKS.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 5 broods.	2 1 0 0 2	2 2 3 1 0	
II. 5 broods.	1 0 4 0 1	1 4 2 0 3	
III. 4 broods.	0 0 2 1	3 1 1 3	
	14	26	

TABLE 76.

RESULTS OF MATING 3 WHITE COCKS AND 3 WHITE HENS, 1910–11, 2ND GENERATION FROM WHITE HEN.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 3 broods.	0 0 0	2 4 4	The first hen died half-way through the season. All the birds were white, as was expected and hoped for. It appears that white colouration is recessive according to Mendel's law.
II. 4 broods.	0 0 0 0	0 5 2 0	
III. 4 broods.	0 0 0 0	3 2 0 3	
	0	25	3rd Generation from White Hen.

TABLE 77.

RESULTS OF MATING 2 BUFF HENS, 1910–11, AND WHITE COCKS, 1910–11, ALL SECOND GENERATION FROM WHITE HEN SPORT.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 4 broods.	3 4 2 3	0 0 0 0	Apparently these two hens were dominants, as they gave no white chicks in any nest.
II. 3 broods.	3 3 4	0 0 0	
	22	0	3rd Generation, 1911–12.

TABLE 78.

RESULTS OF MATING 4 BUFF HENS, 1910–11, AND WHITE COCKS, 1910–11, ALL SECOND GENERATION FROM WHITE HEN SPORT EXCEPT THE HEN IN PAIR IV.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 3 broods.	0 3 2	3 2 2	Apparently these 4 hens were impure dominants, as they gave white chicks as well as buffs. The hen of the 4th pair was descended from the White Sport Hen on the father's side only, though related on the mother's.
II. 3 broods.	3 1 1	0 3 1	
III. 3 broods.	1 2 1	3 2 2	
IV. 3 broods.	0 1 1	4 2 3	
	16	27	3rd Generation, 1911–12.

TABLE 79.

RESULTS OF MATING 2 BUFF HENS (CLOSELY RELATED TO THE WHITE SPORT, ONE BEING ONE YEAR OLDER AND ONE BEING ONE YEAR YOUNGER, BUT NOT DIRECTLY DESCENDED FROM HER, BOTH HAVING ANCESTORS IN COMMON AND BOTH BEING DESCENDED FROM THE PALE BUFF COCK MENTIONED IN THE NOTE (TABLE 72), TO WHITE COCKS, 1910–11.

Pair.	Buff Chicks.	White Chicks.	Remarks.
I. 2 broods.	0 0	1 1	Other nests of the hen in Pair I came to nothing. The hen in Pair II was the mother by a buff cock (1st Hybrid Generation) of the hen in Pair IV. in Table 78.
II. 3 broods.	3 1 3	2 1 1	
	7	6	

NOTE.—I mated these two buff hens to white cocks as I knew they were both related to the White Sport, and I thought, for several reasons, that they might carry white blood. Evidently, the white blood must have been in the strain several years before the White Sport was hatched. No more whites have appeared in that aviary, but they have not tried for them systematically. I have other old hens related to the White Sport, which I am mating this year to White Cocks, to see if perhaps they will prove to be hybrid from their breeding results.

TABLE 80.

RESULTS OF MATING JONQUE CINNAMON HEN AND WHITE COCK.

Unrelated.

Pair.	Description of young birds.	
I. 3 broods.	1 jonque green hen. 1 buff green cock. 1 clear buff hen. 1 buff green hen. 2 clear buff cocks. 1 yellow bird (died young). 3 green birds. 2 yellow birds (died young).	No whites appeared, as was expected. The buffs are exceptionally pale coloured.

All my birds (and also Miss Lee's) are buff, being bred from buff cocks and buff hens, except the progeny from the jonque cinnamon hen (see Table 80) from which bird I have one jonque green hen, to be mated this year (with the other young of the cinnamon hen) with a white cock. This cinnamon I bought, and it is quite unrelated to my other stock. The clear buff hen in the cinnamon's first nest was extremely pale (quite white in patches) in its nest feathers, and has remained extremely pale, as have also the two young clear buff cocks in her second nest; they are quite as pale as any of my buff birds bred from clear buff hens and white cocks, and much paler than many of them. This is remarkable as the basis of cinnamon colouring is green.

All my white birds have black eyes, not pink as one might imagine they would have, and they are very strong and hardy, being bred and reared out of doors and living in an open out-door aviary all the year round.

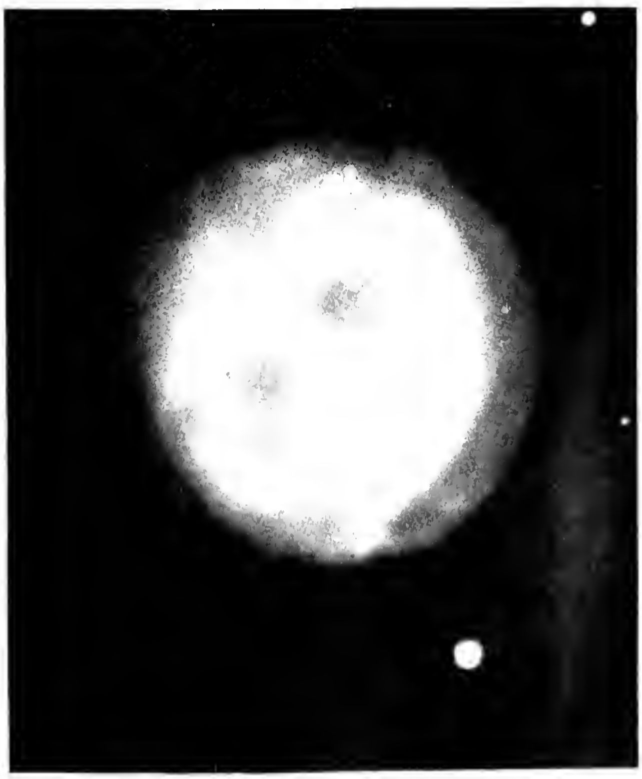
In their case their white plumage does not seem to make them delicate.

Altogether I think the experiment has been most successful, as I have established my race of white canaries breeding true to colour, and apparently the colours yellow and white obey the Mendelian laws, producing dominants, impure dominants (or hybrids) and recessives.

From a photograph by De la Baume Pluvinel *Alcala de Chisvert, Spain, August 30th, 1905.*

FIGURE 419. Prominences that can be seen by means of an ordinary telescope only during an eclipse, but which are shown at all times when a telescope is armed with prisms of wide dispersion.

* Horizontal Refractor and Coelostat. *Ap.* 0,153m. (6") *F.L.* 11,880m. (38' 11¾".) *Exp.* 2 secs.

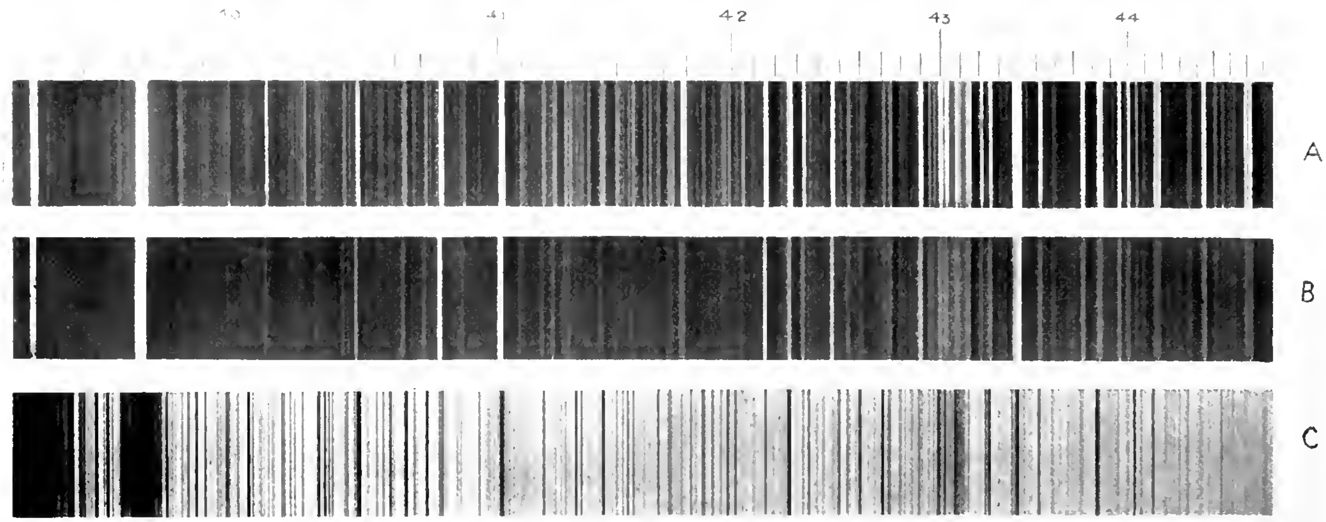


From a photograph by G. W. Ritchey, Mount Wilson Observatory, February 9th, 1910.

FIGURE 420. Owl Nebula in Ursa Major (N.G.C. 3587) showing the central star, the bilateral symmetry, and the concentric appearance that would occasionally be a late stage in the third body produced by a graze of suns.

From a photograph by G. W. Ritchey, Mount Wilson Observatory, July 2nd 4th, 1910.

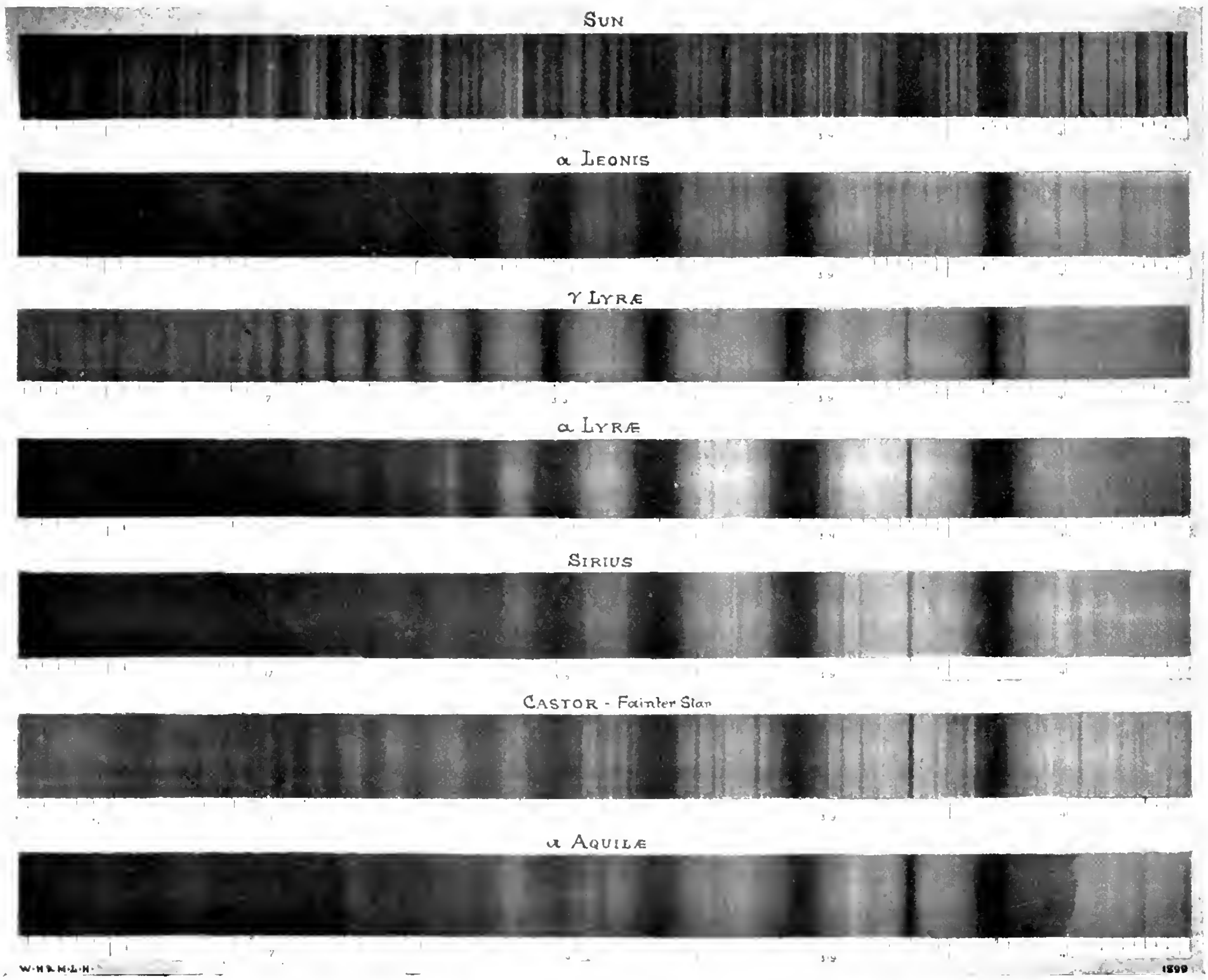
FIGURE 421. The Nebula in Cygnus (N.G.C. 6992), showing details brought out by the camera which are too faint directly to affect the human eye.



From spectrograms taken with a 2-prism flint spectroscope *by E. H. Hills, Pulgaon, India, January 22nd 1898.*

FIGURE 422. A* and B†, spectra showing the flame bands of the reversing layer of the Sun seen during an eclipse. C, the dark lines of the ordinary spectrum when the Sun shines through glowing metallic vapours.

* At point of second contact. † At point of third contact.



From spectrograms by *William Huggins, Tulse Hill.*

FIGURE 423. Spectra of pre-solar stars (compared with the Sun) showing the many dark bands of hydrogen, all of which become bright bands at a certain stage in the life-history of novae.

STELLAR SPECTROSCOPY FOR BEGINNERS.

By PROFESSOR A. W. BICKERTON, A.R.S.M.

I. INTRODUCTORY HISTORIC SKETCH.

THE arming of the telescope with the prism and photographic plate has produced another bound forward in astronomical discoveries as great as that made three hundred years ago, when Galileo armed the eye with his wonderful optic tube. The telescope extended our knowledge into such abysses of space that the millions of miles to the distant Sun became almost too short a unit with which to measure them. It showed us that the filmy light of the Galaxy was a seed-bed of millions of suns, as Democritus so clearly described it two thousand years before. Some of these suns proved to be so vast as altogether to dwarf our majestic orb. The telescope showed us also that the distant inhabitants of space possess as great a diversity of structure as immensity of mass.

The cipher messages unfolded by the prism were to reveal the most unexpected truths: these rainbow-tinted strips of light we call spectra, told us, not merely the structure, but also the chemical composition of the many members of those distant regions.

The year 1642, when Galileo died, was that in which Newton was born. Amid his many wondrous discoveries of appliance and of principle it had been the especial privilege of Galileo to apply the telescope to the reaping of a rich and varied celestial harvest. Newton continued to garner this wonderful harvest, but he also sowed the seed of another crop of results scarcely to be begun to be reaped before two and a half centuries had elapsed. This fertile experiment of Newton's was to place a prism of glass in a beam of sunlight that streamed through a hole in the shutters of a window; thus he analysed and decomposed the light into its constituents. It was a wonderful but crude experiment, for the lovely strip of light he so produced was what we call an impure spectrum. Newton never much improved on his beautiful basic experiment; it did not occur to him to use a narrow slit instead of a round hole, to prevent his colours from overlapping, and so render his tints pure. It was reserved for Wollaston and Fraunhofer to do that, and so discover that the spectrum of the Sun (as Newton called the coloured strip of light) was broken up by black bands. Wollaston saw these bands, but thought too little of them to take much trouble to perfect his experiments. Not so Fraunhofer: he carefully plotted them, and named them with the letters of the alphabet to distinguish them, and so we still call these revealing ciphers Fraunhofer lines. By-and-by it was found that the light of burning metals gave coloured lines instead of a rainbow-tinted strip, and soon, in the hands of Bunsen and Kirchhoff, this furnished a means of detecting the chemical elements: an instrument was constructed to do this which was called the spectroscope, and spectrum analysis was born.

SPECTRUM ANALYSIS.

It had long been known that the colour of these flames was characteristic of many elements, and these varied colours were used to give beauty to fireworks and as aids in chemical analysis. If we examine a set piece in a pyrotechnic display with a spectroscope, the instrument spreads each colour out into a series of separate lines of light. The yellow in a firework display is caused by sodium, and this element gives a brilliant yellow band. If an exceedingly narrow slit be used in a good spectroscope, the band separates into two parts, and if the light be passed through several prisms, the two constituents may be obtained at quite a distance from one another. Kirchhoff noticed that the exact position of these two bright yellow sodium bands was occupied by two black bands in the spectrum of sunlight. He afterwards discovered that the characteristic bright line of other glowing metals corresponded with other sets of black lines in the solar spectrum. Further experiments showed that the bright bands given by a soda flame became reversed when the electric light was allowed to shine through it. The continuous spectrum produced by the electric arc was crossed with black lines when it shone through the yellow flame. The whole mystery of the Fraunhofer lines was cleared up, the sun was a blazing ball of fire shining through an atmosphere of flaming metals; hence we had the basic discovery that in the radiant beams coming from the Sun we were able to read its composition and character (see Figure 422). With added refinements, the same method was applied to the suns that shine at night; the songs of the singing atoms were read, and told us the story of the stars. A great principle had been revealed to man: the same elements that have been used to build this Earth go to make up the structure of the heavens. Gradually, as revelation after revelation has come to us, we realise that "all are but parts of one stupendous whole," that Nature is a complex unity; and the latest revelation of all that the stars are telling us in the cipher messages is that the scheme of creation is a cyclic system infinite and immortal.

The Physics of the Stars.

The principle of isochromatic reversal was not merely to tell the chemistry of the heavens, but, joined to another fact called Doppler's principle, was to unfold all kinds of physical facts and astronomic wonders.

Doppler's Principle.

The express that took me to the British Association Meeting at Birmingham passed another express that had its steam whistle in full blast. As the train approached the note was ghastly in the high pitch of its shriek; suddenly, as the engine passed, the note dropped enormously, to be followed instantly by a low-pitched groan. I had often noticed the pitch of an insect's hum drop as it passed me, and, standing on a railway bridge, had heard the note of a steam whistle change as it passed under the bridge. But the passing of those two swift expresses gave me an illustration of Doppler's principle that I have never heard equalled before.

Each vibration produced by the approaching whistle was made in a position nearer to us than the former impulse, so they were closed up and became shorter; a shorter wave produces a higher pitch, and so the whistle shrieked; when the train had passed, and was going away, each vibration originated at a more distant point and the waves were lengthened, the note consequently dropped, and the high shriek became a low groan.

The same principle applies to colour: the slow waves of light are red, the swift ones violet, the other tints have intermediate velocities. Suns, when very close to one another, have been pulled by mutual gravitation, so that they may have speeds of hundreds of miles a second; the pitch of the definite waves produced by each kind of their singing atoms have the pitch of their definite waves of light altered, and they become shorter as the suns approach, and longer as they recede.

Hence a pair of suns that in our most powerful telescopes appear to be a single point of light may, under the spectroscope, give us a spectrum in which a characteristic line of hydrogen may appear double, and each line be displaced from the normal position. In such a double star the sun approaching us will give us lines displaced towards the violet, and the sun receding a line displaced towards the red end of the spectrum. Thus the spectroscope reveals the motion as well as the composition of heavenly bodies.

If the pair of suns graze, a third body is struck off, like the spark from flint and steel. In the case of the exploding third star, produced in this way by grazing suns, the quickly expanding and ensphering shell of hydrogen that would be produced, as described in "Knowledge" in September 1911, would be made up of atoms moving in all directions away from the nucleus of the exploding sun, and hence in all directions to our line of sight (see Figure 420). The atoms moving towards us would give lines displaced towards the violet, and those away from us towards the red. Intermediate directions would have resolved velocities that would fill the space between these. The single line of light that would be produced were the hydrogen at rest, would broaden into blaze bands, occasionally showing an opposite speed on the two edges of each band of thousands of miles a second. In the special case of Nova Persei, the displacement in each direction was fully a thousand miles a second. This is perhaps the most interesting historic example of the physical reading of stellar spectroscopy. The details of these two wonderful principles of reversal of light and change of speed will be given in detail in the succeeding articles. Figure 423 shows the dark bands of hydrogen as seen in ordinary stars.

The Astronomy of the Invisible.

This principle of relative motion of lines reveals the existence of dead suns by their influence on luminous stars; the spectra of some stars are seen to have their bands moving periodically backwards and forwards on the spectrum. Such a pair of stars are one class of what are known as spectroscopic binaries, so called because it is only in the spectroscope that the fact that they are double stars is revealed. Because in addition, as in the case of Algol the Demon Star, the dark star sometimes eclipses the bright one, we are able to deduce their orbits, and thus weigh and measure these two properties of the two constituents.

Solar Eclipses.

When the Moon exactly covers the face of the Sun, as it did for a second or so last year, if we arm the telescope with a prism, a series of images of the circular rim of light is produced. There is a different ring for each special note of the vibratory atoms of the various metals. We thus get a most singular spectrum covered with rings of light, instead of straight lines; some of the rings overlap one another and some stand clear. Probably it is not more than once in a century that the disc of the Moon and the Sun thus exactly overlap and leave the reversing layer to be seen all round. There is only one small spot on all the Earth (and that not precisely known) where it can be seen. Its duration is something like a second. Yet the photograph of this rare and elusive phenomenon was actually taken last year in Portugal by James H. Worthington. It will be published in the next number of "Knowledge." The same principle is used during ordinary eclipses to photograph the great crimson hydrogen flames and the metallic outbursts that spring from the Sun (see Figure 419).

By means of the same method of placing a large prism in the path of the rays gathered by the telescope it is possible to so dilute the ordinary white solar light that the monochromatic light of the hydrogen flame may be seen when there is no eclipse. By making an extremely long spectrum the ordinary sunlight is so spread out as to be insignificant, whilst the red monochromatic light of the flames retains its intensity, and thus we are enabled to see these red flames during ordinary sunlight.

THE PHOTOGRAPHIC FILM.

Another principle adds greatly both to the power of the ordinary telescope and particularly when the optic tube is armed with a prism. It is the application of photography to astronomy. One wonderful effect is obtained by photography; the human eye soon tires, whereas the photographic film will continue to add to its effects for hours or even days, and thus filmy masses of light that would for ever have remained undetected imprint their message on the sensitive plate until, as in the case of the nebulae of the Pleiades, details of structure are shown connecting up the whole of this beautiful cluster of stars, yet with the ordinary telescope, used by the naked eye, the stars seem to stand out on an almost absolutely dark background. An example still more remarkable of the minuteness of its detail is given in Figure 421. Another effect of photography is that the film may be left exposed, or exposed automatically, so as to record effects when no one is near. Perhaps the most wonderful of all the applications of photo-spectroscopy is the work done in Harvard Observatory and its branches, of the wholesale automatic photography of the spectrograms of large numbers of stars, taken all at once.

THE IMPORTANCE OF THEORY.

Years ago Newcomb feared that the science of astronomy would be buried beneath the tremendous mass of uncorrelated facts that were then accumulated; yet in spite of this the whole endeavour of astronomy, until quite recently, has been merely further accumulations. This state of things is passing; endeavours to correlate astronomical phenomena are being made by able men, both in the New World and the Old. And although these endeavours have not hitherto been eminently successful, nor much accepted save by their respective propounders, yet the attempts are promising symptoms of the times. There is a distinct advance on the part of astronomers in their willingness to receive the assistance of workers in other branches of science. Physicists and chemists are allowed to read papers before astronomical societies. On the other hand the learned societies representing experimental science now make room for cosmic generalisations. At the British Association Meeting joint conferences of many sections were held.

All this is very hopeful, for nothing causes science to spring forward by such leaps and bounds as great generalisations. Although they are thus the milestones in human progress, generalisations have generally been neglected for something like half a century. We are not without examples of disastrous neglect in the present age of science. The broadening outlook gives us at present a better prospect and supplies a probability that research will be no longer mere vicious specialisation, but each expert will do his work with definite purpose and in correlation with the sum of knowledge.

Amid all the tremendous rush of present discovery there is no branch of knowledge that is correlated so widely in all directions as spectroscopy, and no scientific worker should be ignorant of its basic principles.

CORRESPONDENCE.

RAY FLORETS IN THE DISC OF *CHRYSANTHEMUM*.

To the Editors of "KNOWLEDGE."

SIRS,—I enclose you a photograph of a specimen of the common Marguerite (see Figure 505, page 431) in which two strap florets have been produced in the centre of the group of tubular ones; the two strap florets were surrounded at their bases by a small involucre. I have not seen a flower like this before, and thought the reproduction of the photograph might be of interest to readers of "KNOWLEDGE."

NEWCASTLE-ON-TYNE. JOHN HUME.

AUSTRALITES.

To the Editors of "KNOWLEDGE."

SIRS,—The short account given by Mr. G. W. Tyrrell (page 308) on the subject of "Australites" (which formed the subject of a memoir by Mr. E. J. Dunn, of Victoria, Australia) has interested me very much.

In the year 1909 it fell to my lot to make a journey from the coast of Vera Cruz up to near Mexico City on horseback, accompanied by another geologist. The trip took four days, and we rose close on seven thousand feet.

On the second day out, my companion who had done the same journey previously, said to me, "To-morrow we shall pass beds of sand and sheets of basalt, and I want you to give me your unbiased opinion about the relative geological positions of the sands and basalt, *i.e.*, whether the sands lie above the basalts or *vice versa*."

The third day brought us to the sands, and on seeing a pure white silvery sand I at once said, "Why, that is not sand, it is volcanic ash," and you can imagine my astonishment when, on examining the sand with my pocket lens, I found that a large percentage of the grains consisted of perfect little bubbles.

No doubt the greater part of the remaining grains would be "Australites," but this I did not know at the time.

I think that the conditions in Mexico prove conclusively volcanic origin, for amongst the sand were later on discovered pieces of fibrous pumice and a large amount of dark green obsidian.

The obsidian, by the way, gave the source from which the supply was obtained to make the numerous arrow-heads and long flat needle-shaped spears frequently picked up in the coastal regions.

I hope that the above will prove of interest to your readers.

F. W. MOON (A.M.I.C.E., F.G.S.).

TANDJONG POERA, SUMATRA.

THE STORY OF THE CHIN.

By LOUIS ROBINSON, M.D.

THE human lower jawbone differs in a very essential manner from those found among the rest of the Primates—and all other vertebrates—in having its lower anterior border bent downwards and forwards

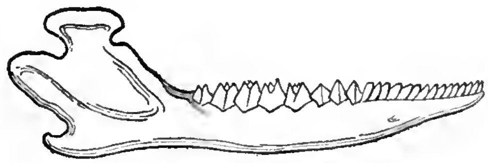


FIGURE 424. *Amphitherium oweni* (Stonesfield State).

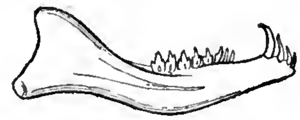


FIGURE 425. Dromatherium (Upper Trias, N. Carolina).

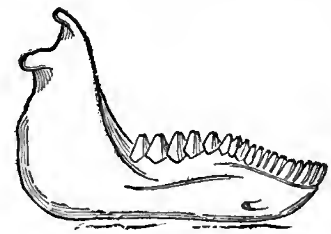


FIGURE 426.—Arsinotherium (Eocene).

so as to form a chin. Recent discoveries of the remains of early men, such as the Heidelberg and Piltdown jaws, have informed us that this distinctive shape of the inferior maxilla has increased in a marked degree since the lower stages of man's existence (see Figures 500 to 504).

I propose to discuss in the present article some of the causes which appear to be responsible for this curious deviation from type. That these causes were evolutionary factors of considerable potency becomes fairly evident when we examine further into the facts. The general type of the mandible among terrestrial vertebrates has been curiously uniform from the very earliest times, as may be seen in the illustrations of mesozoic and eocene jaws (see Figures 424 to 426). It is, we may say, fixed or stereotyped to a remarkable degree. This makes the search for evolutionary forces which have so changed it in our own species all the more interesting.

FIGURE 427. Pariasaurus.

FIGURE 428. Inostransevia.

There are certain apparent chins found among other vertebrates, a few typical instances of which, with their probable evolutionary causes, it may be interesting to discuss briefly.

The elephant (see Figure 431) has a kind of chin, and among older writers in the pre-evolutionary days this fact was adduced as showing its superiority to other quadrupeds. But we now know that the elephant's chin is a mere degenerate remnant of the long lower jaw of his ancestors, the tetrabelodon (see Figure 429) and the mastodon (see Figure 430). In the illustrations to which reference is made the process of its downward evolution is plainly shown.

Another interesting example is found in the dugong and its relations (see Figures 482 to 484). Here a little search into palaeontology shows that this apparent chin is not, like the elephant's, a relic of decayed functions, but that it has, like that of man, increased and improved with the ages. As seen in the illustrations the dugong's collateral ancestor, the halitherium, and its big extinct relative, known as Steller's sea-cow (*Rhytina gigas*), had "chins" also, but in a less marked form. As a matter of fact the downward prolongation of the mandible in these animals is not a chin comparable with our own at all, but is merely a kind of bony rostrum on which the dugong and its relations wear their horny false teeth. This structure, with its curious change of

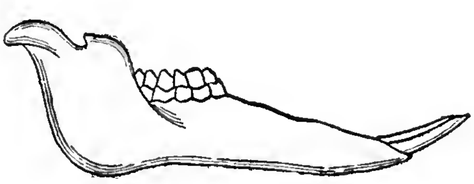


FIGURE 429. Tetrabelodon.

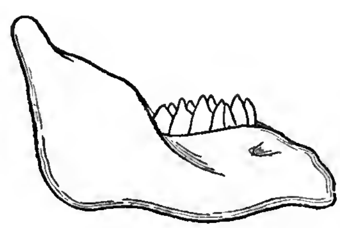


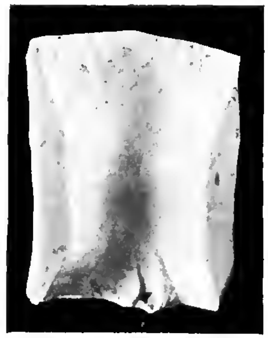
FIGURE 430. Mastodon.

FIGURE 431. *Elephas primigenius.*

angle, is more comparable to the bony support of the flamingo's bill than to a human chin. A very curious fact is that we appear to find the nearest resemblance in the whole animal world, whether

432. Fossil Lemur.

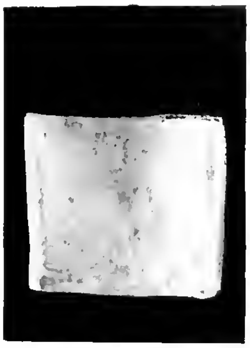
433. Macaque monkey.



434. Chimpanzee (young male.)

435. Siamang gibbon.

436. The Naulette jaw (Spy type.)

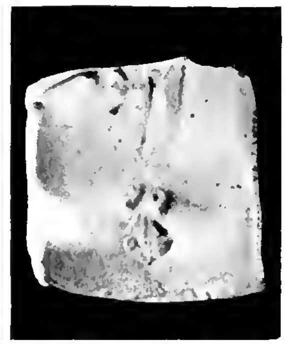


437. Akka Pigmy, from Central Africa.

438. Bushman.

439. Hottentot.

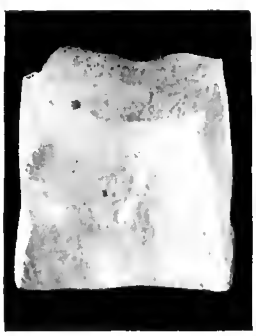
440. Deaf Mute (French).



441. An ordinary European type.

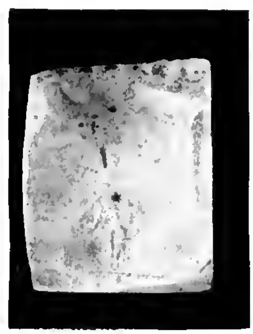
FIGURES 432–441 show the progressive stages from the beginning of the Genial Pit in the Lemur to the fully developed Genial Tubercles in modern civilised man.

442. Hottentot.



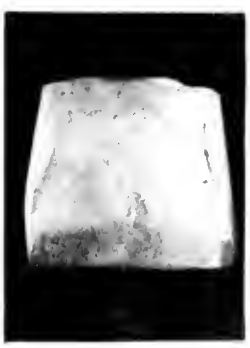
443. Hottentot.

444. Bushman.



445. Hottentot.

446. Bushman.



447. Hottentot.

448. Bushman.

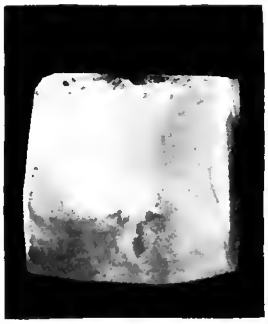
449. Andaman Islander (Negrito).

450. Veddah (Ceylon).

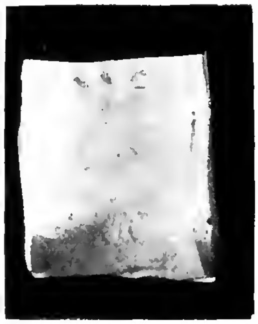
451. Low type (West Africa.)

FIGURES 442–451 show the imperfect development of Genial Tubercle and the persistence of the "Simian Pit" among certain low races with only imperfect articulate speech.

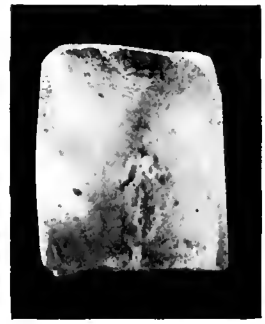
CASTS OF THE INSIDES OF LOWER JAWS.


452. Bushman with tubercles.


453. European Child (six years old).


454. European Child (fourteen years old).


455. European Child (sixteen years old).


456. Ancient Egyptian.

FIGURES 452–456 show the development of the tubercles in young Europeans compared with those well developed in savage and civilised people.


457. Fuegian.


458. Aino.


459. Bushman.


460. Hottentot.


461. Bengali.


462. Tasmanian.


463. Australian.

FIGURES 457–463 afford a study of the remarkable variety of the tubercles in different races.


464. The prehistoric Heidelberg jaw.


465. O'Brien, the Irish giant.

FIGURES 464–466 show the contrast between the prehistoric type and the well-developed modern type.


466. Maori.


467. Japanese.

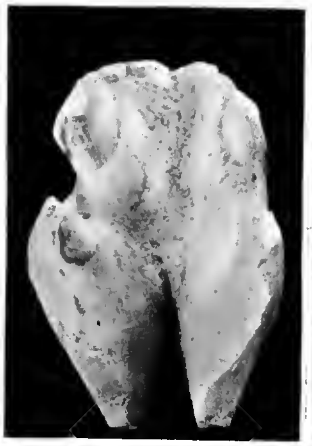

468. Tartar.

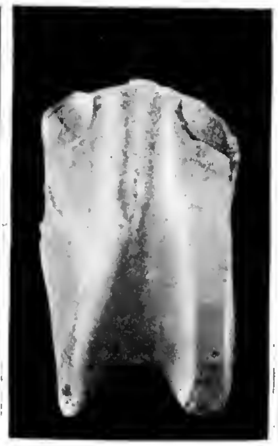

469. Malay.


470. Chinese.

FIGURES 467–470 show the general similarity in races that are somewhat akin in blood and language.

CASTS OF THE INSIDES OF LOWER JAWS.


471. Wolf.


472. Leopard.


473. Chaema Baboon.


474. Anubis Baboon.

FIGURES 471–474 show the marked contrast on the inner side of the jaw between the dog-like apes and the Canidae and Felidae.

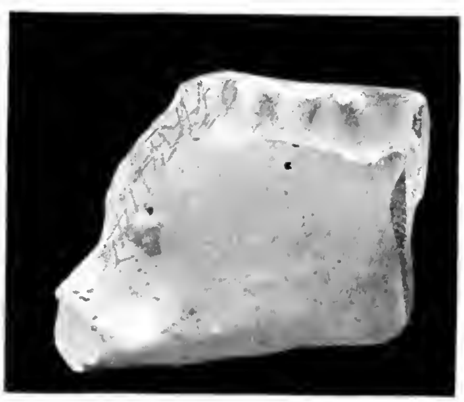

475. Lemur.

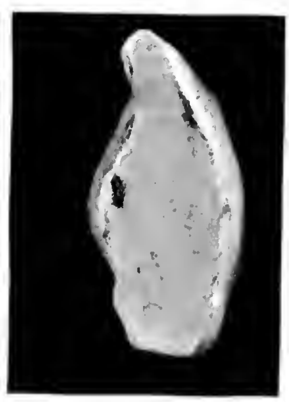

476. Howler Monkey.

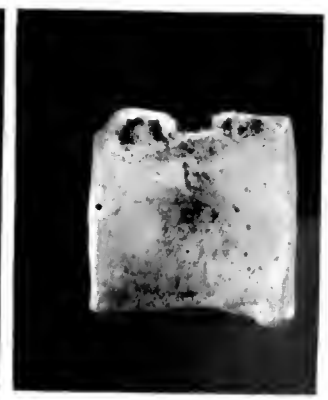

477. Proboscis Monkey.


478. Chimpanzee with exceptional pit.

FIGURES 475–478 form an extremely heterogeneous group.


479. The Piltdown jaw.


480. Profile section of the Heidelberg jaw.


481. Central African Pigmy.

FIGURES 479–481 show prehistoric jaws compared with a low type of modern savage.

CASTS OF THE INSIDES OF LOWER JAWS.

Figure 482. Halitherium.

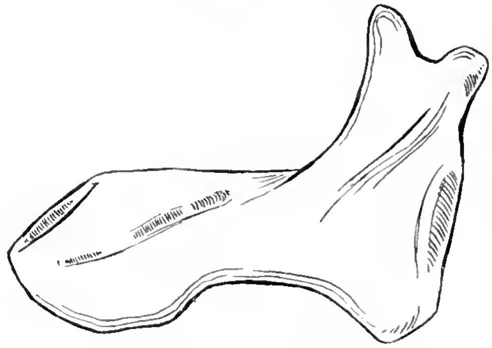


Figure 483. Steller's Sea Cow.

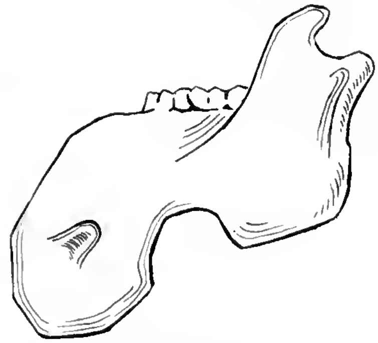


Figure 484. Dugong.

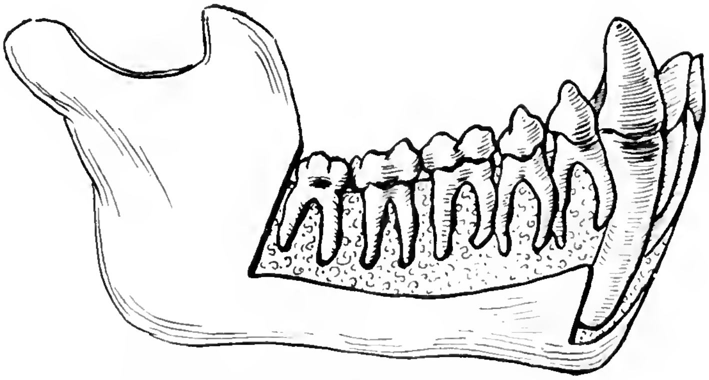


Figure 485. The Jawbone of a Chimpanzee,
showing roots of teeth and the stout buttressed socket of the canine filling the side of the "Chin."

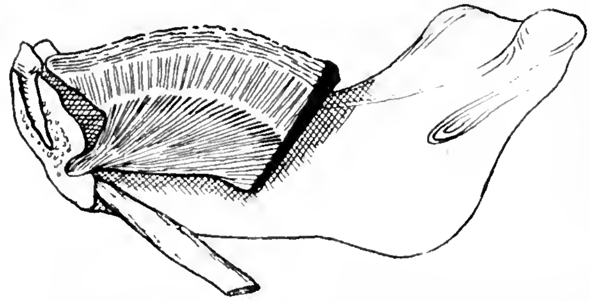


Figure 486. The lower Jaw and Tongue of a Macaque,
from a drawing of a dissection by the Author, showing the deep pit for the origin of the *genio-glossus* muscle.

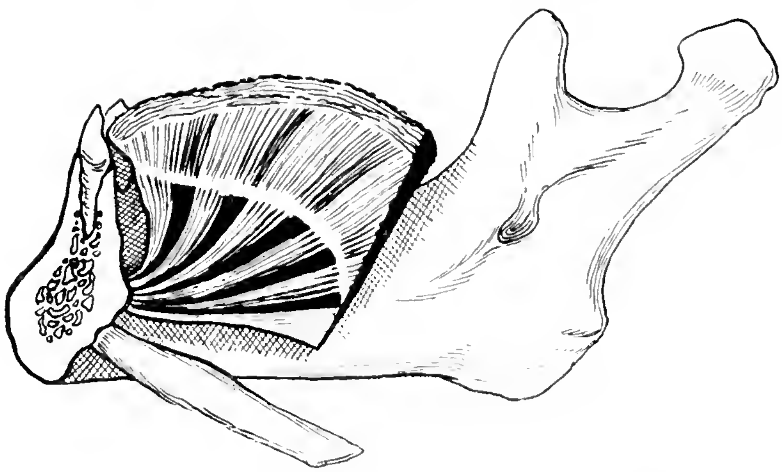


Figure 487. Human Jawbone with part of the Tongue,
drawing showing the spreading *fasciculi* of the *genio-glossus* muscle, and their origin from the upper genial tubercle.

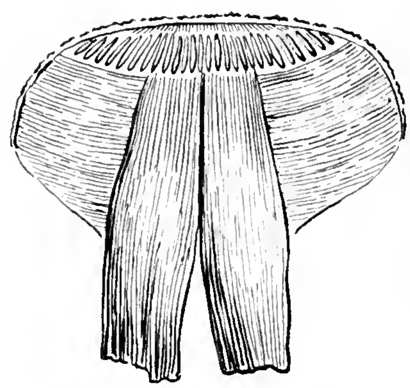
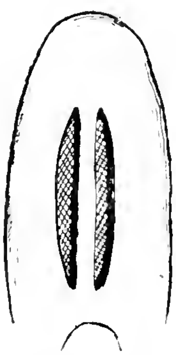
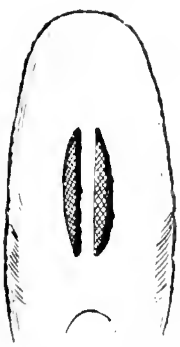


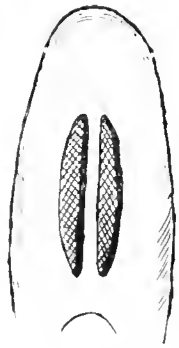
Figure 488. Transverse section through the Tongue,
diagram showing *genio-glossus* muscle penetrating the intrinsic muscles. After Quain.



489. Siamang.

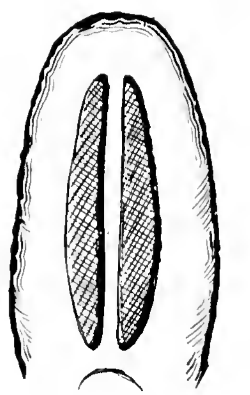


490. Orang.



491. Chimpanzee.

492. Dog.



493. Man.

494. Pig.

Figures 489 to 494 show the under surface of the tongue and the proportions of the *genio-glossus* muscle.

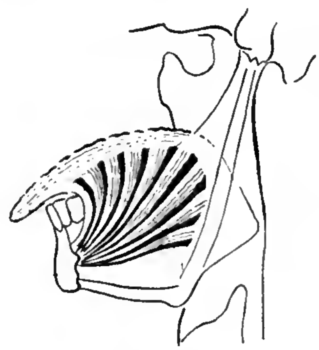


Figure 495.
Diagram of the *genio-glossus* muscle at rest.

ancient or modern, to our own mandible in a group of some of the earliest reptiles that have yet been discovered. In the Figures 427 and 428 of those strange thero-morphs, Pariasaurus and Inostransevia, unearthed by Professor Amalitzky in the Permian strata on the shores of the northern Dwina, we see an extraordinary chin which resembles our own in several striking anatomical particulars.

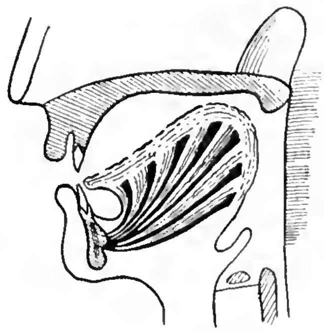


Figure 496.
Diagram of the *genio-glossus* muscle in pronouncing the sound "Oo."

How such a resemblance comes to exist I do not even venture to guess; but most assuredly Nature's moulding forces, which so shaped the mandibles of these ancient reptiles, were totally different from those cerebral activities largely responsible for the chin of civilised man. We say so more confidently because casts of their skull-cavities show that they had no brains to speak of, the whole cerebral chamber being of about the same calibre as the tunnel for the spinal marrow.

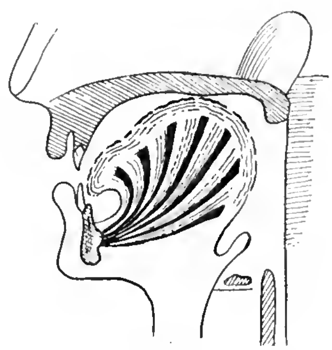


Figure 497.
Diagram of the *genio-glossus* muscle in pronouncing the letter "K."

When the writer discussed this subject before the British Association at Birmingham, and there suggested that the needs of the mechanism for articulate speech would probably account for the essential changes in man's lower jaw, it was pointed out by Professor Elliot Smith that man's face differs from those of his nearest congeners in many other particulars quite as remarkable as these. I hope some day to show that most of these other changes have been profoundly influenced, if not actually caused, by structural necessities demanded by articulate speech. To attempt to do so now would take me beyond the scope of the present subject, and I shall therefore confine my attention merely to the changes that have taken place in the mandible.

In the many endeavours that have been made to explain the why and wherefore of the chin, the argument as to its being due to sexual selection deserves most notice. It has been rightly said that the chin is essential to the beauty of the human countenance, and therefore in a choice of mates, those deficient in this direction would be losers in life's race. Arguments from aesthetics are very difficult to handle, because of the extraordinary differences in the standards of beauty, not only among different species of the lower animals, but among different nearly related races of men. Who can doubt that among the anthropoid apes there is a type of apish beauty (including the retreating lower jaw) which satisfies the most critical and exacting simian taste in choosing a mate? We need not do more than allude to the peculiar aesthetic standards obviously existing a little lower down the scale among the baboons, drills, and mandrils.

A chin is now unquestionably a *sine qua non* of human beauty. But how did it become so? When did the simian ideal cease to flutter the hearts of our primitive ancestors?

Do we not find that almost all the adorable features which have this disturbing and fateful influence nowadays are based upon and are the sign of some intrinsic quality contributing to racial efficiency which lies behind mere appearance? The lower races are continually, to the great embarrassment of sundry Colonial Governments, desirous of mating with a superior race differing from them in physique and in colour. There can be no question that if the colonists in such cases were not the superior race this evidence of the working of sexual selection would not appear. It would seem, therefore, that the primitive man who was *manly* and, amongst other manly attributes, had a chin, scored all along the evolutionary line in mating contests over the primitive man who was apelike. The individual or the race which does not recognise the upward stream of tendency in such particulars by instinct alone cannot be found upon the surface of this planet.

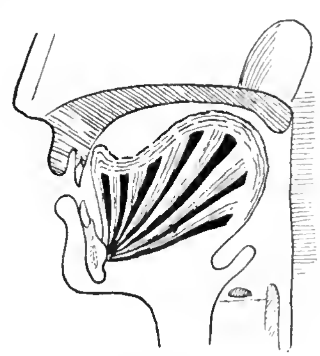


Figure 498.
Diagram of the *genio-glossus* muscle in pronouncing the letter "T."

One argument against the sufficiency of sexual selection in producing a chin, is the well-known fact that man in the early stages of his existence muffled up his lower jaw with a beard, which is, almost without doubt, of purely ornamental value. Hence it would seem that the

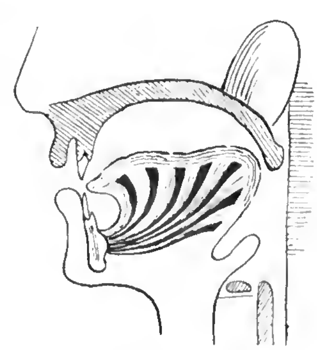


Figure 499.
Diagram of the *genio-glossus* muscle in pronouncing the sound "Ah."

chin *per se* as a sexual ornament was a failure. Women, it is true, have not adopted this form of hirsute decoration; but I doubt if this goes far in helping the aesthetic argument, since, according to the ideals generally current, a big jaw and formidable chin are nowhere considered an excellent thing in woman. I think we shall find that before aesthetics came greatly into play, more prosaic evolutionary forces had already exerted pressure upon the lower jawbone, and had begun to mould it into the general shape in which we find it now.

A glance at the drawing of the mandible of a chimpanzee (see Figure 485) with the roots of the teeth exposed shows the real status of the chin in the anthropoids. It is mainly formed by two thick bony buttresses supporting the sockets of the lower canine teeth. This apparently was the real physical beginning of the bony chin, or rather was, as it were, the gross concrete foundation upon which evolutionary forces of another kind have based the modern structure.

It is a most remarkable and suggestive fact that after man (or the *infra-man*) had lost his huge lower canines, this abundance of bony tissue in the lower edge of the mandible did not disappear, but became more marked as an anatomical feature (see Figure 487). From analogy with the elephant, such a degeneration should have taken place at once. That this did not happen is a proof that the part more than justified its continued existence by performing some function of vital importance to the species.

Sir E. Ray Lankester, in one of his delightful scientific *causeries*, has pointed out that man's chin consists of something more than a bony prominence on the jaw. There is a distinct fleshy pad upon its outer surface, which materially influences its outline and which consists of fatty tissue bound up in little cushion-like compartments almost exactly comparable to the pads on our fingers and toes. Although the aesthetic and sex influences may be apparent here rather more than in the bony mandible itself—for who can gainsay the charm of a softly rounded chin?—the probable origin of this cushion-like covering is to be found in the fact that the protruding chin needed a pad for exactly the same reason as do a cricketer's shins. It was into a world full of brutal tumult and hard knocks that the nascent chin first made its appearance! In the prize-ring to-day it is a well-known fact that a blow on the chin is the most rapid way of putting your opponent *hors de combat*; and, moreover, it has become apparent that the nearer the exponent of "the noble art" is in structure to a chimpanzee or gorilla the better chance will he have of wearing the glorious "Champion Belt of all the World." If we look at the bony structure of the chin in some of the prehistoric jaws, we find it of astonishing strength, being stout and buttressed as if to stand terrific violence. This is remarkably shown in Emil Selenka's admirable monograph on primitive jaws, published by Kreidel, of Wiesbaden, in 1903. From the above facts it seems reasonable to infer that man acquired such advantages as a chin can give *at his peril*; and here, again, it is suggested that some evolutionary need, of exceptional potency, moulded man's jawbone into its modern shape.

It is when we turn a human mandible round and look at it from the inside, and observe the surface beneath the central incisor teeth, that we begin to get hints as to the actual functions of the chin and the causes which have led to our deviation from ancestral type. About half-way between the rim of the central tooth-sockets and the lower edge there

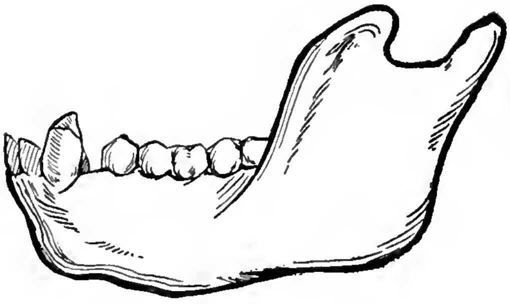


FIGURE 500. Chimpanzee.

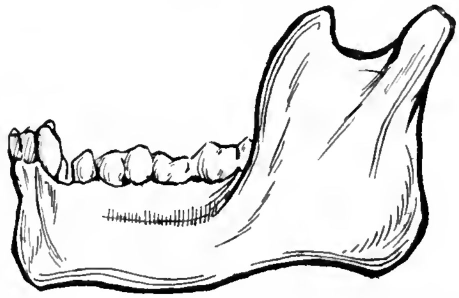


FIGURE 501. Siamang.

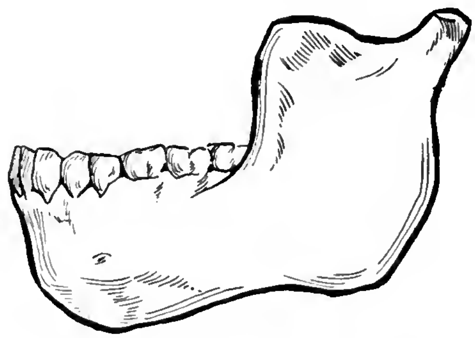


FIGURE 502. Heidelberg.

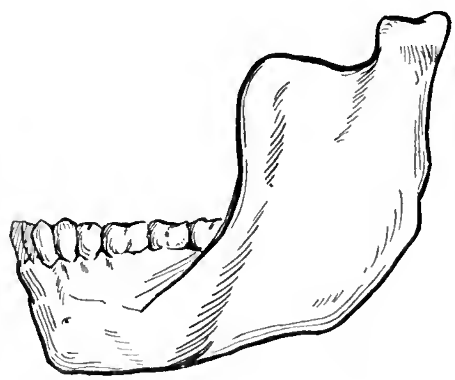


FIGURE 503. Neander type.

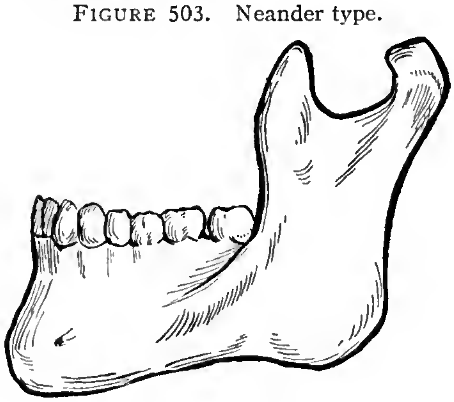


FIGURE 504. Modern man.

are to be found in practically all European and in most other jawbones two bony prominences known as the genial tubercles (see Figure 441). Below them are two somewhat similar prominences, generally much smaller (which often appear as faint convergent ridges), which are also known to anatomists as genial tubercles; but these, I think, we need not consider of any importance in the present argument. They are to be found, not only in the lowest savages and in prehistoric men, but also in a large number of the apes and other vertebrates; indeed, I have detected apparent traces of them in those strange Permian reptiles of incalculable antiquity to which allusion was made above. They are the points of attachment for a little muscle which appears to be equally developed in man and in many of the lower creatures. It is known as the *genio-hyoideus*, and has no connection with the tongue.

A close examination of the larger bony prominences, or the genial tubercles proper, reveals some very interesting and remarkable facts, especially when we employ comparative methods. To these are attached the tendon of the fanlike *genio-glossus* muscle which spreads out beneath the whole lower surface of the central region of the tongue, and penetrates through the intrinsic muscles almost to the upper surface (see Figures 487 and 488). Now if we examine any of the current books on anatomy, little or no suggestion is found that the functions of the *genio-glossus* muscle have to do with articulate speech. Let us leave the mandible for a while and confine our attention to the structure and functions of this muscle, and I think it will soon become evident that it has more to do with the oral (as distinct from the laryngeal) machinery of articulate speech than any other structure.

In the diagrams (see Figures 489 to 494), which show the under surface of the tongue of man and other creatures more or less related to him, it is seen how remarkably this muscle has become developed since we became human. The functions accorded to it in our standard works of anatomy would apply to the needs of the dog and the pig equally to those of man; yet we see that in these animals it is a mere feeble slip of flesh which can exercise but little influence.

I have dissected it in a good many apes, among which animals it evidently had somewhat important duties quite apart from vocal production; in fact, I doubt whether in any other creature except in man we should find the tongue interfering in any way whatever in the sounds which issue from the larynx. The muscle is not only much smaller in apes than in man, but it is much more homogeneous and compact (see Figure 486); while, so far as I have been able to observe, the method of innervation shows an even greater difference than is seen in the structure of the muscle itself. To put the matter very briefly, in man the *genio-glossus* has become a series of a large number of independent muscular strips which are, to all intents and purposes, separate muscles, each with its little fibre of the hypoglossal nerve entering it in such a way as not to hamper its free movement, while in the apes it is apparently a single muscle, or a closely united group, acting *en bloc*.

It must be remembered that the adoption of an exceedingly important new method of expression and communication such as human articulate speech would require widespread and most elaborate changes in the structures which it brought into play. It is not possible on the present occasion to go into the marvellously intricate cerebral, nervous, and muscular machinery, with its innumerable bonds of coördination required for ordinary speech; but a little search into the matter will show anyone that we are here in contact with one of the most incredible marvels in Nature. Most wonderful of all, the whole mechanism is, from an evolutionary standpoint, *quite new*—a product of merely the later fragment of a brief geological period!

When we consider the number of movements, following one another in continually varying order, required for articulate speech, it is obvious that only machinery which is able to act with every mechanical advantage and with a minimum of friction, can accomplish such a task with precision. Public speakers frequently talk at the rate of one hundred and fifty words a minute, while it seems possible to articulate quite clearly and correctly when speaking at the rate of one hundred and eighty words a minute. If we analyse the action of the tongue when speaking at the rate of one hundred and fifty words a minute, we find that there must be at least five hundred different movements or adjustments. This gives eight or nine in every second! Such movements, it must be remembered, do not follow one another regularly in mechanical rotation like the piston-beats of a multiple-cylindered engine, but are continually varying their order. What wonder is it that coördination sometimes breaks down, with the result of a stutter or a stammer?

Now a brief examination of the intrinsic muscles of the tongue, *i.e.*, those that begin and end in the tongue itself like the distal muscles of an elephant's trunk, will show how totally inadequate these would be to produce any such result; but immediately one takes careful note of the mode of action of the *genio-glossus* muscle the solution of the tongue's incredible agility becomes possible.

It is seen in the accompanying diagrams (see Figures 495 to 499) that the several bundles, or *fasciculi*, of the muscle are able to act more or less at right angles to the main plane of the tongue without anything to hamper them. For each flash-like movement of the tongue away from the palate all that is demanded is an instantaneous shortening of one or other of these independent strips. For instance, in pronouncing the letter T we place the tip of the tongue against the palate close to the upper incisor teeth (see Figure 498), and then snatch it away with great rapidity. The placing it there is probably the work of the intrinsic muscle called the superior longitudinal lingual, but the more critical action of withdrawing it at the proper moment is due to the front fibres of the *genio-glossus, which become taut and braced for instantaneous action as soon as the tongue-tip is pressed against the palate.*

In Figure 497 it is seen that in the hard G or K exactly the same thing takes place with the central *fasciculi* of the muscle. A like action comes in with sounds involving L, N, R, D, J, Q; while in S, X, and all other consonants where the nice adjustment of the distance of the tongue from the palate is a matter of moment the *genio-glossus* muscle is capable—and appears to be the only structure capable—of exercising a quick and exact control. The same applies to the vowels, as is well shown in the accompanying diagrams after Von Meyer's drawings. Von Meyer, however, has not shown the *genio-glossus* muscle in action as it is shown here, and indeed, strangely enough, does not give it a word of mention as a factor in articulate speech.

It is worth while to take note of the fact that practically all the speech-movements of the tongue take place in the neighbourhood of its central line, and that the sides play a very subordinate part. Hence the other extrinsic muscles, such as the *hyo-glossus* and *stylo-glossus* can have little or no part in articulation (see Figure 488).

Now let us return to our inferior maxilla and examine the attachments and relations of the *genio-glossus.* It is obvious that for quick, precise movements, such as those demanded by articulate speech, it must be unhampered and have plenty of room to act. An examination of the arrangements for the play of the muscle in different animals is exceedingly instructive. In the dog, and indeed the majority of the mammalia, the tongue lies flat upon the lower jawbone leaving practically no room for any muscular machinery. If, however, a photograph of a plaster cast of the inner surface of the wolf's jaw (see Figure 471) is compared with that of the baboon (see Figures 473 and 474), which outwardly resembles it, a remarkable difference of shape is evident.

In all the monkeys—and even lower down the scale among the lemurs—we find that Nature has made provision for working room for the *genio-glossus* muscle by excavating a kind of pit on the inner surface of the mandible beneath the tongue. This pit has been noticed by various comparative anatomists, but I had never seen any explanation of the reason why it exists, nor was I aware of its function, until a series of dissections of monkeys' jaws showed in every case the tiny tendon of the *genio-glossus* coming from the lower surface of the deepest part of the pit (see Figures 433 and 486). The more doglike the jaw is, as in the baboons—the more, in fact, it corresponds in general outline with the prevalent type of the mandible among lower vertebrates—the deeper is this pit. As soon, however, as the mandible begins in some degree to resemble our own, as in some chimpanzees and gibbons, and the whole lower surface becomes tilted forwards, the pit seems to be no longer needed, and becomes shallower. One may as well remark in passing that it is of course obvious that originally the *genio-glossus* muscle had nothing whatever to do with articulate speech. The need it met in the economy of lemurs and apes was probably that of giving increased mobility to the tongue for sorting food already in the mouth. This is plainly seen when we give a monkey a nut and see him crack it and turn it about with his tongue, selecting the kernel and rejecting every fragment of shell. This ability common among all the Primates to sort food with the tongue, and with its aid to eschew unacceptable morsels, is strikingly absent in the case of most animals. Anyone can assure himself of this on seeing a dog try to get rid of some small unpalatable object. Animals such as cattle, and especially camels and giraffes, which are liable to get dangerous thorns into their mouths, depend upon a most elaborate arrangement of the long papillae lining their cheeks, so that by a simple backward and forward movement of the tongue such things are at length extruded.

There seems little doubt but that it is this sorting machinery of the tongue in the lower Primates which has been seized upon and greatly elaborated for the new and wondrous mechanism of articulate speech.

Before going further it may be as well to clear up another point which seems to have puzzled some of my audience when I was lecturing at Birmingham. The question was asked me, "How is a parrot able to talk if he has no chin?" An equally pertinent question would be, "How is a phonograph able to talk when it possesses no chin?" A parrot has deep down behind its breastbone a marvellously elaborate and versatile sound-producing apparatus, almost as different from any possessed by ourselves as is the mechanism of a phonograph. When man began to speak, he had to make use of raw material, *which was there already,* to build up his talking machinery. That the parrot and the phonograph can speak, merely proves that there are other ways of doing it; but the only question which we here have to discuss is how man did it himself with such means as were at his disposal.

When we come to examine the difference between prehistoric man and modern savages we find the same order of structural change in the mandible still going on, tending to the greater efficiency of the *genio-glossus* muscle for speaking purposes. When this fanlike group of muscular fibres came out of a deep pit, such as is seen in the illustration of the jaws of the lower monkeys, the fibres were obviously hampered by being bunched and huddled together (see Figure 486). As the jaw became tilted forward, giving more engine room beneath the tongue, the need for the pit became less, and it becomes shallower and shallower until we find it a mere depression, as in the Siamang gibbon (see Figure 435). These changes are plainly shown in the series of plaster casts of which photographs are reproduced in Figures 432 to 441. First of all is a fossil lemur, in which the jaw still retains its generalised character, but is beginning to show depressions as the genial pit makes its appearance; then one has apes like the baboons, macaques, or colobus monkeys with an exceedingly deep pit or depression. Next come anthropoids, in which the lower edge of the jaw is already being dropped into something resembling a chin, and the depression at once becomes less apparent. Next are some jawbones of prehistoric man, namely, the Heidelberg and the Naulette jaws, in which the depression is still plainly seen and is scarcely less marked than in the gibbon.

It will be seen that the Heidelberg jaw shows on its surface a tubercle; indeed, I understand that one of the descriptions of it published soon after it was found stated that it did not differ from modern jaws in this respect (see Figure 464). A brief comparison with the other casts, however, will make it plain that the tubercle here seen is too low down to be that for the *genio-glossus*, and is plainly the one for the *genio-hyoid* muscle mentioned in the earlier part of this article, which has nothing whatever to do with the tongue. This tubercle is quite common among the apes.

When we come to the Pygmies and Bushmen we find in the majority of jaws the remains of this pit or a mere flat surface; but in some African dwarf races, and among the Hottentots, Veddahs, and Andamanese, two little prominences are seen beginning to grow at the lower edge of the pit (see Figures 442 to 452). These tubercles, as we pass to higher and more civilised races, become more and more prominent, until we get the European type familiar to all students of anatomy.

Now the bearing of these changes on the functions of the *genio-glossus* muscle is fairly evident. First of all, it needed a deep pit in the lower apes to get room to work at all. Then the depth of the pit became unnecessary through the tilting of the lower surface of the mandible; and by means of this change the muscle was obviously given greater freedom for action. Then we get a nearly flat surface; and finally a prominence appears, enabling the separate *fasciculi* of the muscle to spread from the very point of origin and so act independently without hampering their neighbours (see Figures 441, 455, 461, and 465).

We are thus able to follow the whole course of the history of the *genio-glossus* muscle from fossil lemurs to modern men, and a very remarkable history it is, difficult, I believe, to parallel in any other structure of the body which we may pick out for the purpose. We found it in the lower apes, in which it first appears as an important factor in tongue movements, coming out of a hole in the lower jaw, and we take leave of it mounted upon a pinnacle quite as high as the pit was deep (see Figures 486 and 487). This is as if an organism commenced its career in the uttermost depths of the sea, and attained its full development at the top of Mount Everest! The muscle might stand above all things else in our bodies as a symbol and sign of our upward progress. For I think it cannot be denied that its development marched *pari passu* with the development of intellectual capacities and the increasing need of a means of clear expression.

When speech began, as distinct from mere animal stereotyped cries and other noises, it is, of course, impossible to say. For the speech of certain low savages, consisting of grunts, guttural sounds, and clicks, it is fairly obvious that few tongue movements are necessary: but wherever languages have become more elaborate—and many of them in different parts of the world appear to have had an independent origin from more brute-like utterances—we find that the *genio-glossus* muscle comes more and more into play, as is evidenced by its tubercles of attachment and by the forward tilt of the chin to give elbow room among all the higher races.

The speech of monkeys is, of course, a myth, and most of our anthropoid friends are curiously silent beings. The two exceptions appear to be the chimpanzee, which is described by travellers as shouting and calling in varied tones in the forest, and certain gibbons, which appear to come nearer to us in the variety of articulate utterances than any other of the Primates. From the series of plaster casts shown in the plates, and in many others that are in my possession, it seems to become evident that, speaking generally, the genial tubercles may be taken as some index of social and intellectual development. They are not, of course, strictly necessary for speech, but it is clear, both from anatomical and general reasons, that they greatly facilitate speech.

It is interesting to watch their development in the normal human subject (see Figures 453 to 455), and I have several casts which illustrate this fairly clearly. In all young children they are absent, and up to the age of fourteen years they make but a small show; in fact, the jaw of a child of fourteen years almost exactly resembles in this respect that of a Bushman or Pygmy; between fourteen and seventeen, however, they appear to obtain their full development. How far that development is dependent upon the use of the muscle it is difficult to say; my own belief is that, like many of the roughnesses and ridges upon our bones, they are very largely the product of vigorous muscular action, *i.e.*, Nature has met the obvious need of the muscle by altering the bone in a certain specific direction.

For many years I have been endeavouring to get evidence as to the presence or absence of the tubercles in deaf mutes. Such as I have, so far as it goes, seems to show that in adults who have never acquired articulate speech they are quite absent (see Figure 440). In the one specimen I have from a deaf mute, the bone almost exactly resembles that of a Bushman, or a child of fourteen.

A glance over the peculiarities of the tubercles in the accompanying plates shows how extraordinarily variable they are in different individuals and in different races (see Figures 457 and 458), but before any safe generalised conclusions are drawn from these diversities one ought to have many thousands before one for comparison. It seems to me quite probable that this would prove a fruitful line of research for anyone with leisure and opportunity to follow up; for, when we consider the distinct anatomical problems involved in the pronouncing of different languages it seems not improbable that definite structural peculiarities might become apparent in accordance with the "tongue" spoken. We know that it is practically impossible for Europeans to acquire the elaborate tongue and throat movements of not a few barbarous languages, and it would be extraordinary indeed if this wide diversity in muscular function did not leave some trace which the methods of the anatomist might reveal.

In Figure 465 is reproduced a photograph of a cast from part of the jawbone of O'Brien, the Irish giant, the capture of whose body gave John Hunter so much trouble. I placed it there, because it shows the typical arrangement of the genial tubercles in a very marked manner. It also tells us something else, which I think is not a little instructive. There can be no question that the Irish speak our language with much greater correctness and precision than the average Anglo-Saxon, and further investigations seemed to show that in Irish jaws there was a fuller development of the genial tubercles than in those found in English museums. On following the same line of research a little further it became apparent that a greater symmetry and uniformity of the development of the genial tubercles was to be found in French and Italian jaws than in English. This seems to be a matter well worth following up.

A few other suggestive points come out from a further examination of the plaster casts, reproduced in the plates, which have no very direct bearing upon our present enquiry. One, for instance, is the obvious kinship between certain American monkeys and the lemurs, as evidenced by the duplicated pit (see Figures 475 and 476). In nearly all the Old World apes of which I have specimens, the two cavities appear in close proximity or merged into one, but in the American monkeys and the Madagascar lemurs they are generally separated by a marked interval. The lower jaw in certain highly specialised apes, such as the howler and proboscis monkeys, appears very difficult to interpret. Here again a more extended collection, giving opportunities for exact comparative methods, would be certain to throw a good deal of light on what is at present a subject which seems to have been very little studied.

Apart from these by-products of the enquiry I think it will be acknowledged that many of the facts put forward in this article go far in justifying my suggestion that the chin, which is so marked a characteristic of the modern human mandible, may be considered part of the necessary mechanism of articulate speech.

Note: *The illustrations in the above article are by Mènie Gowland.*

REPORTS.

THE YORKSHIRE NATURALISTS' UNION.—By the unanimous vote of the council of the Yorkshire Naturalists' Union the President for the next year will be Mr. T. Sheppard, F.G.S., of Hull. The Yorkshire Naturalists' Union is one of the most successful associations of its kind in Great Britain, and has published many important monographs on the flora and fauna of the county, and also issues *The Naturalist*, which is one of the oldest scientific monthly magazines in the country. The Union has a membership of nearly four thousand, and about forty important natural history societies are affiliated with it. Until recently Mr. Sheppard was the Honorary Secretary, and took a leading part in the editing and publishing of its important monographs, and there is no doubt that it is largely due to his efforts that the Union owes its present influential position. Mr. Sheppard is well known from the excellent work he has done in connection with the three municipal museums at Hull. He is the author of numerous books and monographs, as well as of the remarkable series of Hull Museum Publications, close upon a hundred of which have been published during the past fourteen years. He has already filled the presidential chairs of the Yorkshire Numismatic Society, the Hull Geological Society, the Hull Literary Club, the Hull Scientific Club, and the Hull Shakespeare and Playgoers' Society.

CAN LEAD BE TURNED INTO GOLD? — At a meeting of the Alchemical Society on Friday night, October 10th, Professor John Ferguson, M.A., LL.D., and so on (of Glasgow University), delivered an interesting address on English Alchemical Literature, in the course of which he said the English literature on the subject was not very bulky although it might be precious. Other chemical and technical processes had very extensive literature in which the various discoveries were traced. So far as he knew there was no gold made by alchemists in existence at the present time. When they saw a gold medal they knew it was gold, but there was no proof that gold was ever made from mercury, lead, or any other metal. Even if a piece of gold was produced which was alleged to have been made by an alchemist, they had no knowledge at present as to how it was done. He had never come across an old book or manuscript on alchemy which ever explained the method by which base metals could be transmuted into gold. There were many manuscripts extant at the British Museum and the Oxford Library bearing on the subject, and in them one could find enough material to occupy his whole attention for many years.

He did not propose to deal with the manuscripts because of their great abundance and also because of their inaccessibility, but would confine his remarks to books printed in the English language on the subject. There were many books in Latin whose authors are Englishmen, but he had not time to deal with them. The earliest printed book on alchemy was published somewhere about the year 1474 or 1480. Probably it had been taken from a manuscript, and so far as he knew it was the only book on the subject printed in the fifteenth century. A number of books were printed in the sixteenth century, and still more in the seventeenth century, but after that the number declined, and during the eighteenth century and nineteenth century most of the books dealing with the subject were reprints. The lecturer then dealt in great detail with the various authors, most of whom claimed to have discovered the secret powder for transmuting base metals into gold. There was a wide field for research work among the manuscripts at the British Museum and the Oxford Library. Whether any of those manuscripts contained the precious secret he did not know, but he hoped that now he had called attention to the literature on that subject it would lead others to investigate the matter, which was a very interesting one.

THE NOMENCLATURE OF VARIABLE STARS.

By F. A BELLAMY, M.A., F.R.A.S.

THE present state of chaos in the nomenclature used for variable stars—and it is daily increasing—calls for careful consideration by astronomers to remove some of the present anomalies, and, in view of the immense increase in the number of known variable stars—which will be still further increased by photographic means—to establish some definite, convenient, intelligible, and permanent notation.

The beginning of astronomical observations of the variability in the light of stars may be placed in the year 1572 with the discovery of the star which is usually known as Tycho Brahé's *Nova* in the constellation of Cassiopeia, or sometimes as B Cassiopeiae. In the next hundred years three more such stars (*Novae*) were discovered in 1600, 1604, and 1670, and are known as P Cygni, a star in Serpentis, and 11 Vulpeculae. Until about one hundred years ago not many observations of the variability in the light of stars, or of *Novae*, are recorded. Systematic and careful estimations of the magnitudes of certain stars were made about seventy-five years ago, chiefly by Schmidt (of Athens), Argelander (of Bonn), Heis, and, later, by Hind, Pogson and J. Baxendell in this country: their observations soon proved the degree of variation of light in a number of stars they had kept under frequent observation; and, incidentally, these observers—to be more precise Argelander and Pogson—laid the basis of the scale for accurate stellar magnitudes, and afforded us both the means of determining relative magnitudes and of carrying on a magnitude scale with a definite light-ratio. One may say quite fairly that for the last seventy years all visual estimations of stellar magnitudes have been made on this basis (Argelander and Pogson) without change, and Pogson's value of the light-ratio, or difference in the star's light from one magnitude to the next, of 2·512, or logarithm 0·400, has since been universally adopted, though Professor E. C. Pickering's latest photometric work indicates a slightly different value; also he proves that Argelander's magnitudes of the fainter stars observed, 8·0 to 9·5 magnitude, require diminishing by some tenths of a magnitude: this is probably due to the small size of Argelander's telescope, which is still *in situ* at Bonn as when last used by Argelander and Schönfeld. This by way of a parenthesis to indicate the origin of accurate stellar magnitudes; for, without a uniform basis, the observations upon variable stars for the determination of their periods would be useless.

Returning to the definite subject of this note, the first catalogue of variable stars appears to have been that formed and published by Argelander in 1844, and was published in Schumacher's "Jahrbuch," on page 214. This catalogue contained eighteen stars only, and all were well situated for observation in what is now the German Empire: it may be of interest to give them.

FIRST CATALOGUE OF VARIABLE STARS.

o Ceti, β Persei, χ Cygni, R Hydrae, R Leonis, η Aquilae, β Lyrae, δ Cephei, α Herculis, R Coronae Borealis, R Scuti, R Virginis, R Aquarii, R Serpentis, S Serpentis, α Cassiopeiae, α Orionis, α Hydrae.

The capital letters have been added to some of these stars. The stars, when read horizontally, are in the order of discovery; *Novae* were omitted by Argelander; they are mostly bright stars, and ten of these have the old Greek notation, which remains in variable star nomenclature as for all other astronomical purposes. Of the other eight, seven have the prefix R, and one the letter S. As some of the capital letters beginning at A had already been used by Bayer, about two hundred years earlier, Argelander formed the scheme of applying the letters of the alphabet, beginning at R, to the stars shown to be variable, other than those already designated with Greek or other letters. So soon as enough variable stars had been discovered to require the letter *Z*, the sequence was to be continued with the duplication or combination of letters; thus after *Z* the next in the series would be R R to R *Z*, S S to S *Z*, and so on to *Z Z*. The necessary complement of these prefixes was the name of the constellation; so the full designation for a variable star might be R Andromedae, R R Aquarii, or *Z Z* Cygni. This form of nomenclature was sufficient for forty-five variable stars in each constellation. Until a few years ago the discovery of new variable stars depended upon visual work, and this nomenclature sufficed for all needs. With the greater application, or rather a closer examination, of the many thousands of photographs that have been taken at Harvard College and other observatories (mainly at Harvard), the number of new variable stars is being increased by hundreds a year; the result is that the method of Argelander has broken down—at least for certain constellations.

In 1909 the number of variable stars was more than forty-five (= *Z Z*) for the constellation of Cygnus. Recourse was then had to the dual use of the letters beginning with A A—single letters could not be used, for, as I have pointed out, many single capital letters were already in use for non-variable stars. The continuance of this notation, it is intended, shall run on after *Z Z*, with the letters A A, A B, A C, and so on, prefixed to the name of the constellation. If this part of the dual notation be not continued beyond A Q, B Q, and so on, there will be provision for one hundred and thirty-six additional variable stars in each constellation. If it be continued, as is being done in Hartwig's Ast. Gesell. annual catalogues, from A A to A *Z*, as far as Q Q to Q *Z* (always omitting J), then there will be provision for two hundred and eighty stars, besides the fifty-four from R to *Z Z* for each constellation.

In 1909 there were eighty-six constellations in which one or more variable stars had been discovered. The state of this lettered nomenclature in 1909 was that in the constellation of Scutum there were nine lettered variable stars and thirty-one waiting for letters, in Sagittarius twenty-seven lettered stars and seventy-four waiting, in Scorpio twenty-five lettered stars and eighty-four waiting, and in Orion there were nine lettered stars and one hundred and twenty-five waiting for letters of identification. In 1912 the constellations of Cygnus, Scorpio, Sagittarius, Centaurus, Carina, Aquarius, Aquila, Hercules, Andromeda, and Draco had almost exhausted the R to *Z Z* section of the alphabet; in fact, A K was reached for Scorpio, A O for Sagittarius, while for Cygnus the alphabet with dual notation had been passed through once, and A *Z* reached. For Scorpio there were thirty-nine more lettered variable stars than in 1909, and yet there were forty-five more already discovered and waiting for letters. At the rate at which variable stars are being photographically discovered it will require but two or three years, perhaps, for the whole alphabet to be used up in the dual form. To continue to ring the changes with triples would be cumbersome. The single or double letter form with the figure 3 as an index might be convenient, both for manuscript use and print, as R^3, S^3Z, or A^3Q; but any extension of the scheme by mere variation of printers' type—as has been suggested—would be extremely inconvenient, and a source of many errors.

We shall now return to the historical side of the subject and resume the thread of Argelander's Catalogue of 18 variable stars published in 1844.

Though the lettered nomenclature had been in use for some years, Argelander had given no very definite account of the scheme until that which appeared in the *Astronomische Nachrichten*, No. 959, 1855, May 3rd; this explanation may be given best in his own words:—

"Mit *R* bezeichne ich den Stern in der Jungfrau, dessen periodische Veränderlichkeit Harding im Jahre 1809 entdeckt hat, und dessen Position für 1855 ist: $12^h\ 31^m\ 9^s + 7°\ 47'\cdot 3$. Dass ich einen nicht bei *Bayer* vorkommenden Stern mit einem Buchstaben bezeichne, wird mir hoffentlich nicht verdacht werden. Die veränderlichen Stern haben bei ihrer Merkwürdigkeit wohl ein Anrecht auf eine solche Auszeichnung, die zur Bequemlichkeit der Nachweisung bei so oft erwähnten Sternen fast unentbehrlich ist. Um aber eine Verwechselung mit den *Bayer*'schen Buchstaben möglichst zu vermeiden, habe ich die letzten des Alphabets gewählt, und sie dem grossen Alphabete entnommen. Nur im Hercules gehen die lateinischen Buchstaben bei *Bayer* bis *z*, im Stier bis *t*, in der Jungfrau bis *q*, im Löwen, Orion und Schwan bis *p*; im letztern Sternbilde ist dies ein grosser Buchstabe. *Bayer* kennt sonst für seine Bezeichnungen in den Sternbildern von den grossen Buchstaben nur das *A*; die andern grossen Buchstaben, die auf seinen Charten vorkommen, weisen entweder auf hellere Sterne benachbarter Sternbilder hin oder auf ausgezeichnete Puncte der Himmelskugel. Nur bei dem bekannten neuen Sterne vom Jahre 1600 macht er eine Ausnahme, indem er ihn mit P bezeichnet; er sagt: 'P tertii fulgens stella, anno MDC primum conspecta et observata, omnium ferme tacito consensu pro novo phaenomene recepta, eundem adhuc hodie retinet situm e.q.s.' Ich könnte somit *Bayer* als meiner Vorgänger bei dieser Auszeichnung der veränderlichen Sterne citiren; indess glaube ich, dass dieser Astronom daran nicht gedacht hat, sondern den Stern in seiner vor 1600 schon fertigen Charte, vielleicht erst auf der Kupferplatte, nachgetragen, und desshalb die Ordnung nicht unterbrechen wollte; er hätte ihn sonst nach seiner Methode mit γ, γ mit δ bezeichnen müssen, u-s-w, also wären alle folgenden Sterne geändert worden."

The nomenclature proposed and used by Argelander was generally adopted. Here is an example by Dr. R. Luther (Bilk) in *Ast. Nach.* No. 996 (1855, November 29th): "welcher nach dem Argeland'schen Vorschlage (in No. 959 der *Ast. Nach.*) T Piscium bezeichnet werden möge."

Argelander's Catalogue was followed by Norman Pogson's pioneer work at the Radcliffe Observatory, and he published a catalogue of 53 stars in 1854, using Argelander's notation; G. F. Chambers, who is still living, published a list of 123 variable stars in the *Astronomical Register*, II, 194, in 1864, August; this was reprinted in the *Astronomische Nachrichten* in Band LXIII, page 117; a revised form also appeared in the *Monthly Notices of the Royal Astronomical Society* vol. XXV, page 208 (1865, May), and in later years catalogues of 235 variable stars, 126 probably variable, and 500 red or orange stars in his *Handbook of Astronomy*. In these catalogues he was helped by J. Baxendell, G. Knott, F. Brodie, and J. E. Gore. In 1865 and 1875 Schönfeld published catalogues. The number then given was 143 stars: to this number 48 variable and 77 suspected variable stars were added at Harvard Observatory in 1883, and further lists were published from Harvard in the *Proceedings of the American Academy of Sciences*, vols. XIX–XXII. In 1888 an Index to observations of variable star (published) observations was given in the *Annals of the Astronomical Observatory of Harvard College*, vol. XVIII, No. VIII: in this 225 stars are given and the records of 125,720 observations made from 1838–1888 are indicated.

Chandler published in *The Astronomical Journal*, vol. VIII, 81 (1888), a catalogue of 225 variable stars, with their elements, and a great deal of other information; a second edition, containing 260 stars, was published in *The Astronomical Journal*, vol. XIII, page 89 (1893); and a third and last edition, recording 393 stars, was published in *The Astronomical Journal*, vol. XVI, page 145 (1896). Soon after this Roberts published a catalogue of 94 stars south of —23° Dec., a portion of the sky previously much neglected.

Chandler adopted an entirely new notation in his three catalogues; we give the reasons for the method in his own words:—

"The number of a star, upon a system of ordinal notation designed to remedy the inconveniences attending the usual current numbers . . . . if the numbers of any one list are retained, the interpolated stars require a suffix letter, resulting in a hybrid notation which is exceedingly objectionable, and which sooner or later has to be reformed; when the whole process of degeneration, with its awkwardness and confusion, begins anew. It seems certainly better to adopt a system which attaches a permanent numeral to each star, and which permits interpolation to a practically unlimited extent. I would accordingly suggest that the numbers for variable star catalogues be *one tenth of the right ascension, expressed in seconds of time, for the equinox 1900·0.*"

This method limits us to 8640 variable stars in the whole sky unless we adopt the "hybrid notation" disparagingly referred to in the above quotation.

The publication known as the *Vierteljahrschrift der Astronomischen Gesellschaft* has contained, since 1870, a list of variable stars with ephemerides. The work was edited or compiled formerly by Winnecke, Schönfeld, and at present by Hartwig. Up to 1889 it contained stars to 2° south of the equator; from 1889–1895 stars as far south as — 30° Dec. were included; from 1895–1902 the catalogues were extended to — 35° Dec., and after that variable stars in the whole sky were included; the catalogue of 1906 contained information for 709 stars similar to that in Chandler's catalogues. The number in the catalogue for 1913 is 962 stars north of — 23° Dec. and 417 stars south of that. During the year 1912 148 new variable stars were discovered, 109 from photographs and 39 visually; since 1900 about 80 per centum were found by ladies, chiefly from Harvard and Arequipa photographs. The non-continuance of the preparation for further editions of Chandler's catalogue resulted in more attention being given to variable star work at the Harvard Observatory. For some years Professor W. M. Reed had been forming a bibliography of variable stars, on cards, giving the details for separate stars, and in 1897 this extensive record had needed 15,000 cards; then it was continued upon similar lines by Miss Cannon, who added 20,000 cards; and the results of Professor Reed and Miss Cannon's work formed volume XLVIII, No. III (published in 1903), and was called the Provisional Catalogue of 1,227 stars, and is usually considered to be the first catalogue of variable stars independently formed at the Harvard Observatory. A supplement was published in *The Harvard Circular*, No. 77, and a further supplement is in *Harvard Annals*, volume LIII, No. VII. The continuation of this work at Harvard with still greater vigour, aided by an exhaustive and comparative examination of portions of the Harvard extensive series of photographs, revealed a large number of new variable stars, and a new catalogue was required. The volume LV, under the joint editors, Miss A. J. Cannon and Professor E. C. Pickering, was published in 1907 to 1909 to replace the former first and provisional catalogue, and it extends to 291 pages, entirely devoted to variable star work. This second catalogue contains 1,957 stars, with a supplementary list in Table IX (page 272). On page 103 of volume LV begins a list of 167 observers and observatories which have contributed the observations included.

The variable stars discovered in the globular clusters are included in this number 1,957, but not those 1,791 variable stars already discovered in the Magellanic clouds. To December, 1906 only, there were 3,748 variable stars to be dealt with: of these, 2,909 have been discovered at the Harvard Observatory, mainly from photographs taken there and at Arequipa; 514 of these 2,909 stars were found by S. I. Bailey in southern globular clusters, 221 more were detected by Mrs. Fleming from an examination of third-type spectra (photographs taken for the Henry Draper Memorial), and Miss H. S. Leavitt has discovered 2,110 of the total 2,909 stars; they were mainly in the Magellanic clouds.

The Harvard Observatory publications and work upon variable stars really mark the introduction of an entirely new system, and this brings us to the third form of nomenclature. The great accession to the number of variable stars in recent years, largely owing to the extensive use to which the photographic gelatine plate has been put, caused Professor E. C. Pickering to form some easy, permanent, and inexhaustible method of nomenclature for variable stars, and one that would at the same time afford some other information than a mere name.

The scheme which he first adopted in the Harvard Provisional Catalogue was numerical in form, yet not a mere number, but figures which also give the position of the star in the sky with sufficient accuracy to enable an observer to remember or ascertain from an abbreviated or compact list—without the necessity of consulting a large catalogue—whether the star is suitably situated for observation. The form of designation which was adopted for the Harvard Provisional Catalogue is retained in the second catalogue of variable stars in Vol. LV. The method has been found of great convenience in actual practice. It is in constant and daily use at that observatory, and the six figures, to be read as three pairs, are quite readily retained in the mind for all stars frequently observed, and the accuracy indicated by the figures is sufficient to enable the observer to set the 6-in. telescope and identify the variable star field readily.

The plan is to give the hours and minutes of the star's R.A. for 1900, omitting *all* seconds (*not* the nearest minute) and the degrees of declination, omitting all minutes; when there are several variable stars with the same hours and minutes and the same degree, as sometimes occurs in clusters, then a small letter is added beginning with a, b, c, and so on; in no case yet, we think, has more than a single letter been required. Though the method is really independent of the constellations it is better to give them; the designation almost always indicates the constellation. The most unsatisfactory point in the scheme appears to be the dual character for the northern and southern stars; if the constellation be given as well as the number all would be clear for stars in those constellations beyond fifteen degrees from the equator. But for those, as Cetus, Orion, Aquila, and so on, which embrace stars on both sides of the equator some additional and distinctive notation must be introduced, and Professor Pickering continues his custom—as in all his photometric and other work—of designating all negative quantities in print in italic type. In a bad light, or when using a catalogue quickly, one is apt to overlook the italic type, this is the chief objection to the method; but the introduction of a minus sign would give emphasis to the star being in the southern hemisphere.

Had north polar distance (N.P.D.) been adopted instead of declination this difficulty would have been overcome; but N.P.D. is very seldom used in practice, and not many instruments are so graduated.

Let us see how the second Harvard Catalogue looks. This is a portion of one page:—

Designation.	Name.	D.M.	R.A. 1900.		Dec. 1900.	
			h.	m.	°	′
181912	— Scuti ...	5045	18	19·9	−12	45
182109	— Scuti ...	4376	18	21·1	− 9	15
182158	R Z Draconis...	...	18	21·8	+58	50
182513	X Scuti ...	5014	18	25·7	−13	11
183149	S V Draconis...	R	18	31·2	+49	18
183146	— Lyrae ...	...	18	31·6	+46	3
183107	— Scuti ...	4633	18	31·7	− 7	41
183208	Y Scuti ...	4663	18	32·6	− 8	27
183342	— Cor. Aust.	13498	18	33·6	−42	20
183647	— Telescopii	12488	18	36·5	−47	21
183604	— Scuti ...	4553	18	36·7	− 4	13
183606	— Ophiuchi...	...	18	36·8	+ 6	20

Two-thirds of these had no letters in 1907.

It will be appropriate to make a quotation here from *The Annals of the Harvard Observatory*, vol. LV:—

"The number of variable stars has now become so large that it is necessary to have some convenient means of referring to them and of locating them. The numbers given by the editor of the *Astronomische Nachrichten*, while very useful for certain purposes, are not convenient as permanent reference numbers for the stars. In reading an article which merely gives, for instance, 21, 1909 Andromedae, one is at a loss to recall just where the object is, or whether it is suitably placed for observation. For this purpose a list must be consulted to find the position of the object. On the other hand the designations used here serve to locate the star. They give the hour and minute of right ascension and the degree of declination. This is often all that is needed. An observer can at once make up his mind whether the object can be observed at present or at a later time. The objection has been raised that six figures cannot readily be remembered. On the contrary, it is found here that they cling to the memory with remarkable tenacity if constantly used in connection with each variable. An observer here,* by whom these [numerical] designations are used daily, recently made a test. He wrote down the names of 367 variable stars. For 260 of these stars he supplied from memory the designations correct in all six figures."

This quotation introduces the fourth form of nomenclature now current. It is convenient as a temporary expedient, but we think it should be abandoned as being cumbersome and overlapping. The *Astronomische Nachrichten* notes the discovery of variable stars, and each year the series begins with No. 1 (with the constellation added); so, unless one is careful to add the year, confusion will soon arise. From this temporary method of nomenclature the star is advanced to the lettered form, but that may not be until some years have elapsed and the star has been proved to be variable.

The application of letters to the variable stars is years in arrear; the general result is that we have four forms of nomenclature for variable stars in current use.

There is yet a fifth method. Each year, as already mentioned, there is a catalogue of variable stars edited by Hartwig, and published in the *Vierteljahrschrift der Ast. Gesell.*; the stars (in the list for 1913) are numbered from No. 1 to 962 in order of R.A. for epoch 1855·0, and include only the stars to −23° declination; those south of −23° begin at No. 1001 to 1417, but in order of R.A. for 1875·0! At the end of these annual catalogues there is an alphabetical arrangement of the constellations with the appropriated letters, to which is added the number in the catalogue. So, as new stars are added each year, the catalogue number for, say, R Aurigae will differ almost every year. As only about 1,400 variable stars are given in Hartwig's catalogue for 1913, and 3,748 are given in the Harvard Second Catalogue to the end of 1906, it is presumed that when the number 999 is reached the next thousand will have to be skipped and continue the northern list at 2,000: this is encouraging confusion. The epoch for the Harvard Catalogue is the same convenient date as for the International Astrographic Survey, 1900; and it would save much time and be of the greatest advantage to practical astronomy in all its branches, if all positions of stars, whether approximate or accurate, were always given for this epoch (1900·0) for the next thirty or forty years, when 1950·0 might be adopted until the year 2000.

Those interested in variable star work have therefore at least five forms of nomenclature and three different epochs to amuse themselves with, besides variations for north and south stars. In view of the fact that continued rapid accessions of new

* The Observatory of Harvard College.

variable stars are being made to the total, now well over 4,000, and that only 1,400 of these have lettered names, it would greatly benefit astronomy and be to the credit of astronomers if some international consensus of opinion were obtained, and a definite and, as far as possible, a permanent scheme were evolved from the present confusion.

In Chambers's "Handbook of Astronomy," Vol. III, page 271, we read: "Argelander's very crude and unsatisfactory nomenclature (*Astr. Nachr.*, XL, 959, 1855, May 3) has been followed, but at no very distant period it will have to give place to something more artistic." And he wrote as long ago as in 1865: "The time seems arriving when it will be imperatively necessary to adopt a new nomenclature for variable stars. The present system, besides being inartistic, is gradually, and not very slowly either, drawing to a natural termination."

This period has undoubtedly arrived, and, whether or not Professor E. C. Pickering's scheme is more artistic, it is certainly very convenient, of great utility, capable of indefinite expansion, and with some modifications, might very well hold the field.

To show how compact and convenient Professor Pickering's method is we shall conclude this article by giving a sample of the form in which Professor Pickering has arranged a table for all the variable stars with letters (to 1907). The whole catalogue of lettered stars can be given on four or five pages. Here is a sample (see Table 81).

The first star R Andromedae has R.A. 0^h 18^m and Dec. + 38°; RT Andromedae has a note; SR, TR, TS are not used, only letters in *direct* sequence; thus, for Cygnus, there are no stars for XR to XW, YR to YZ, or ZR to ZY. All the stars under Antlia have south declinations, also most of those under Aquarius. There seems no valid reason why letters and Professor Pickering's notation should not be applied immediately a discovery—with sufficient verification—in the star's light is announced; we should get rid of the second, fourth, and fifth variations in nomenclature and two different epochs. Even if the star should eventually prove to be non-variable no harm would be done; in 1920, 1930, 1940, or even every five years from 1915, the catalogues could be swept clean of those spurious variable stars and the letters appropriated for others. The order of the letters is no longer coïncident with the order of discovery, and no chronological significance would be disturbed.

TABLE 81. INDEX TO DESIGNATIONS OF VARIABLE STARS.

Constellation.		R.	S.	T.	U.	V.	W.	X.	Y.	Z.
Andromedae	...	001838	003740	001726	010940	004435	021143*a*	001046	013338	232848
,,	R	004533	235048	*r*	013238	020448	004132	005840	231539	230552
,,	S	...	230752	233335	235943	235939	001828	012746	000843	225442
,,	T	...	...	230845	002725	225342	...	...	...	...
Antliae...	...	*100537*	*092728*	*092936*	*103039*	...	...	...	...	...
Aquarii	...	*233815*	*225120*	*204405*	*215717*	204102	*204104*	*221321*	*203905*	*234716*
,,	R	*210903*	*210504*	*221722*	*231917*	*210000*	211800	...	...	...
Cygni	...	193449	200357	204334	201647	203847	213244	203935	204834	195849
,,	R	204244	200938	194048	213753	213937	202539	200747	200635	204846
,,	S	...	213843	202954	194029	200647	200346	201130	194232	202946
,,	T	...	...	193732	194348	203046	210129	205642	192928	191350
,,	U	...	...	...	213542	192843	201942	205030*a*	205230	215543
,,	V	...	...	...	...	210245	201134	205339	210039	214742
,,	W	...	...	...	...	...	200041	201437*b*	214443	204938
,,	X	...	...	...	...	...	...	200158	194541	193056
,,	Y	...	...	...	...	...	...	...	211841	205840
,,	Z	...	...	...	...	...	...	...	...	202046

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

YERKES PARALLAX DETERMINATIONS.—The *Astrophysical Journal* for July contains a further series of parallax determinations by Messrs. Slocum and Mitchell. Only four stars on the present list have parallaxes notably exceeding their probable errors, and three of these are faint. μ Orionis has a parallax of ·″036; Groningen VII, number 20 (RA 16^h 21^m, N. 48°·6), whose magnitude is only 10·7, has a P.M. of 1″·22 and parallax ·″125; an anonymous star, RA 17^h 33^m, N. 18°·6, magnitude 9·1, has parallax ·″108, PM 1·″36. Curiously enough, there are two other ninth-magnitude stars close to it which also have large, though not identical, P.M.'s, but their parallaxes are insensible. The remaining parallax is an 11·3 magnitude star near 17 Lyrae, whose P.M. is 1·″75, parallax ·″124; its intrinsic lustre must be extremely small; if its surface were of the same brightness as our Sun's its size would be comparable with Jupiter's.

WESTPHAL'S COMET.—This comet, which appeared in 1852, has now been detected on its return by M. Delavan at the La Plata Observatory, Argentine Republic, of which Professor Hussey is Director. It was seen at Greenwich on September 30th, when it was of eighth magnitude and about 3′ in diameter, with distinct central condensation. On November 1st its place will be roughly R.A. 20^h 38^m, N. 24° 50′; November 11th R.A. 20^h 33^m, N. 31° 7′. The following are the elements: Perihelion Passage, 1913, November 26·1, Omega 57¼°, Node 346¾°, Inclination 40° 57′, Perihelion Distance 1·25, Period 61·12 years. The perihelion passage is about a month later than the time that would give the best display. In 1852 it was on October 12th, or a fortnight before the time of best display. It is fortunate that the conditions should be good at two consecutive returns. There is little doubt that the comet will be faintly visible to the naked eye at the time of perihelion; it will doubtless be visible in a binocular throughout November.

This is the fourth member of the Neptune comet family to be observed at a second return. The others were Halley, Olbers, Pons-Brooks. There are two others, seen in 1846 and 1847, whose returns are expected about 1921 and 1927. Westphal's has much the shortest period of the family. Its aphelion distance is thirty, exactly Neptune's distance, but there is not a close approach to Neptune's orbit, owing to the large inclination. The time of perihelion is five months earlier than that predicted as the most probable by Hnatek and Viljev. This illustrates the difficulty of accurate prediction in a period of this length.

THE PLANETARY DISTANCES.—I lately received from Professor Lowell an interesting essay on the planetary distances and their bearing on the question of the manner of development of the system. He points out how often the periods of two adjacent planets approximate closely to some simple ratio. Thus:—

Mercury to Venus } Jupiter to Saturn }	... ... = $\frac{2}{5}$	
Venus to Earth	... ... = $\frac{3}{5}$	($\frac{8}{13}$ closer)
Earth to Mars	... ... = $\frac{1}{2}$	($\frac{8}{15}$ closer)
Saturn to Uranus	... ... = $\frac{1}{3}$	
Uranus to Neptune	... ... = $\frac{1}{2}$	

He suggests that there is not only a coincidence but a law here, and that "each planet has formed the next in order at exactly one of these commensurable points, at the same time displacing it slightly Sunward."

He points out that the action of an outer planet on an inner practically diminishes the Sun's mass and increases the period, while the action of an inner one on an outer increases the Sun's mass and diminishes the period, the second case being the more effective. Thus a planet once formed tends to draw neighbouring particles to itself by bringing their periods into conformity with its own.

He then proceeds to consider the effect of commensurability of motion, showing that there is a tendency for particles to swing about the commensurate position; he suggests that in time this leads to the building-up of a planet at this position. The planets would thus have been formed from the inside outwards, "each acting as a sort of elder sister in bringing up the next." Jupiter is supposed to have been formed antecedently to the commencement of this action, and Saturn, Uranus, and Neptune to have been formed outside in succession, each being drawn slightly Sunward from the point of exact commensurability. Thus is explained the youthful appearance and small density of Uranus and Neptune. Had they started at the same time as Jupiter, their small size would lead us to expect further development and greater density. Saturn, on this view, is the youngest planet as regards stage of development reached, which accords well with the very small density and the presence of the ring.

The four inner planets are supposed to have been formed in a similar manner. The present condition of Mars is quite consistent with an origin later than that of the Earth; for in spite of its small size it has evidently not yet reached its "dead" stage. Professor Lowell points out that though there are gaps in the minor planets at the distances corresponding with periods one-half, two-fifths, and one-third of Jupiter's, yet the great bulk of them is concentrated near these points. He suggests that we see here the same congestion of matter as caused planetary aggregation elsewhere, but in this case it proved abortive.

The paper is an interesting attempt to give a physical explanation of the existing planetary distances. He ventures to predict the distance 47·5 (period 328 years) for the planet outside Neptune. From the analogy of the satellite system he thinks it likely that it would have a large eccentricity and inclination. This would make its discovery more difficult, as a much wider zone would have to be swept.

BOTANY.

By PROFESSOR F. CAVERS, D.SC., F.L.S

RECENT RESEARCH ON EMBRYOLOGY OF ANGIOSPERMS.—*(Continued from page 384)*.

Schoute's work on the exact relationship of plerome and periblem at the growing-point to the central cylinder and cortex as differentiated in the older regions of the same axis, whether stem or root, is very important. He accepts Van Tieghem's definition of the stele as the solid cylinder of root or stem enclosed within the endodermis. The endodermis itself is considered as belonging to the cortex because in the root its cells are opposite the radial files of the inner cortex, and indeed form the inmost rank of these files; this is assumed to indicate a common origin by repeated tangential division. The cells of the pericycle, the outermost layer of the stele, alternate with those of the endodermis. As a rule there is no corresponding radial arrangement in the cortical tissue of the stem, but where such exists (as in the stem of Hippuris) the endodermis is again included in it and terminates it. Schoute in 1903 got precise results in species of Hyacinthus, Helianthus, and Linum, in the roots of which the periblem passed into the cortex, its inner layer becoming the endodermis, and the plerome gave rise to the stele only; but owing to difficulties arising chiefly from the insertion of leaves close up to the stem apex and displacements in the original stem structure owing to this habit, Schoute found definite results only in Hippuris, where the plerome gave rise not only to the stele but also to the endodermis and to the two or three inner layers of cortex immediately beyond it. If Schoute's results are well founded the limit between plerome and periblem does not correspond with that between stele and cortex in the stem of Hippuris, and doubt is also thrown on the assumption made by all previous observers that rows of cortical cells arranged in radial files must be of common origin.

The stelar hypothesis is essentially an assertion of the real homology between the vascular systems of stem and root throughout all vascular plants. No difficulty arises so long as we are dealing with roots only, or with the stems of those vascular Cryptogams in which the vascular system is a closed cylinder without gaps at the insertion of the leaf-traces: in such plants the vascular cylinder is as well defined as in all roots and can be described in the same terms. But the case is quite different in the stems of Phanerogams, where apparently the primary vascular cylinder is a system built up of leaf-traces embedded in a parenchymatous matrix. The early anatomists were faced at once by this problem in its crudest form, for they began with the primary structure of the dicotyledonous stem, and that of the root was not clearly understood until many years later; since they attempted to interpret it by reference to the skeleton of the stem and in the same terms; though there is nothing in the anatomy of the root to correspond with the leaf-trace, and the leaf-trace is the vascular unit of stem structure in all Phanerogams. Even when the facts of root structure were accurately known, the conception of the leaf-trace bundle as the structural unit continued to be a stumbling-block. Modern anatomy dates from 1871, when Van Tieghem published the first of his series of memoirs in which the axial core of the root was treated as equivalent to the whole system of leaf-traces in the stem; a conception which gained ground from the first, and was popularised by the happy choice of the term "stele" in 1886. From that time the stelar hypothesis has replaced all other schemes of vascular anatomy; the advance then made on all previous generalisations has been shown by the new impulse given to research and the comparative simplicity introduced into text-book anatomy, though equal simplicity cannot be claimed for the technical language of research in this subject. It is generally accepted that the central cylinder of the root in Phanerogams is far more closely comparable to the leaf-trace cylinder of the stem than to any one of the traces within it, yet when the comparison becomes detailed difficulties arise. For instance, where there is a pith in the root it certainly forms part of the stele, which is a solid cylinder sharply defined by the specialised endodermis around it; but the leaf-traces in the young stem surround a massive cylinder of parenchyma exactly resembling the parenchyma of the cortex with which it is in apparent connection through the gaps between the leaf-traces. Even the secondary formations in the stem do not completely divide one system from the other; when a specialised endodermis is present it is not so clearly defined as in the root; in many cases it is not present, and in a few instances there is an endodermis around each leaf-trace. However, the stele in the stem of Phanerogams is not necessarily a morphological fiction, because in many stems its precise limits cannot be determined, for morphology is not merely descriptive. If we suppose that the stem stele in remote ancestors of the Phanerogams was as well defined as that of the root, and clearly comparable to it, we may attach a real morphological meaning to the term when applied to modern Phanerogams, provided we can show cause to believe that what we call the stele in their stems represents the ancestral stele. Its tissues will then have a history distinct from those of the cortex, though not clearly separated from them. The burden of proof, however, lies with those who assert that an apparently continuous and uniform tissue can be separated into two parts of distinct origin.

The evidence advanced is of two kinds—one founded on the comparative anatomy of stems and the other on the history of the tissues of the individual plant. Schoute has collected evidence to show that in the stems of Angiosperms a specialised layer is commonly distinguished from adjacent tissues either by the peculiar thickening characteristic of the endodermis in the root, or by the presence of starch in its cells. He shows that such a sheath surrounds the vascular cylinder in a very large proportion of Dicotyledons and in a majority of the Monocotyledons, while among Gymnosperms it occurs but rarely; and since the Angiosperms in which this bundle-sheath is obscure or wanting are commonly closely related to species in which it is perfectly well-defined he concludes that its absence in such cases must be attributed to reduction. Allowing that such a layer is as general among Angiosperms as Schoute believes, doubt may still exist as to its homology with the endodermis of the root, which is defined, not only by its thickened walls, but also by the fact that the cells form the inmost rank of the series of radial files distinguishing the inner cortex, while in the stem the inner cortex cells are very rarely arranged radially.

As regards the second class of evidence, that drawn from the history of the tissues in the individual plant, we have already seen that the differentiation of plerome from periblem is far less definite at the growing-point of the stem than at the root apex, and doubts have even been thrown on the identity of plerome and periblem with stele and cortex respectively. But we must now follow the development of the tissues of the embryo into those of the seedling. The normal seedling of all Phanerogams consists at first of cotyledons, hypocotyl, and root, the plumular bud being still rudimentary. The primary root lies usually in a straight line with the primary stem or hypocotyl. The hypocotyl is commonly the first part of the embryo to lengthen, and then its xylem is lignified a little earlier than that of the root or even of the cotyledon; but when, as in many Monocotyledons, the base of the cotyledon lengthens first, lignification begins in that region and advances through the hypocotyl to the primary root. The investigation of the anatomy of the seedling at this epoch becomes extremely important when the vascular system of the root is compared with that of the stem, for in the seedling we have a complete and simple vascular skeleton which at one end belongs to the primary root of the plant and at the other to its primary stem; hence there must be an intermediate region in which stem structure passes into root structure, and the method of transition should at least suggest, if it does not precisely determine, the relation in which they stand to one another. For this reason great value has been attached by anatomists to the transitional region of the main axis. Van Tieghem showed that there are several types of transition between root and stem, in all of which the xylem and phloëm bundles of the root are continued into the cotyledons or plumule; on their way through the hypocotyl they may divide or be displaced, and the xylem bundles "rotate" (that is, they turn on their axes until the protoxylem is internal), but all the elements present in the root are continued upwards in regular succession and are simply re-arranged in the upper part of the seedling. Hence Van Tieghem considered that the steles of root and stem are completely homologous. Gravis and others, however, consider that there is no morphological continuity in the hypocotyl between the vascular systems of root, stem, and leaf: their traces are merely in contact sufficiently intimate for physiological purposes, but there is no true homology between the central cylinder of the stem and that of the root. The third view is that of Chaveaud, who agrees with Gravis that the presence of external xylem is the rule in the hypocotyl and in the base of the cotyledon, but considers that this external xylem belongs to the primitive structure of hypocotyl and cotyledon as well as to that of the root.

As already stated, the vascular system of seedlings is first differentiated in the hypocotyl, base of cotyledon, and base of primary root. According to Chaveaud, in all these regions the primitive stele is root-like, the xylem alternating with the phloëm and its development being centripetal; but this primitive formation is permanent only in the root and commonly in the lower part of the hypocotyl also—in the upper part of the hypocotyl and in the base of the cotyledons the first xylem elements are fugitive and disappear so early that as a rule they are missed completely by the anatomist, who is apt to prefer well-differentiated material and therefore to choose seedlings which are past their first youth. Chaveaud therefore considers that there is an early phase in the development of the seedling in which the stele of the hypocotyl—at that time the only representative of the stem—is developing on exactly the same lines as the stele of the primary root, and is, in fact, continuous with it. At that epoch each cotyledonary trace is also developing on the same plan: it belongs to the same phase of evolution. In many Dicotyledons the insertion of the cotyledons is the simplest imaginable—the original stele of the hypocotyl divides below the cotyledonary node and one half goes to each cotyledon. Where this formation is clearly developed there cannot be said to be any transition between stem and root structure, since stem stele and root stele are continuous and their steles are developing in the same way, while even the leaf-traces of the first two leaves are on similar lines, and their insertion therefore does not modify the structure of the stele. The structure we associate with the stem of Phanerogams appears as follows. In the transitional region of the hypocotyl the first xylem elements—perhaps only two or three at each pole—alternate with the phloëm groups. The elements next differentiated lie within them, for development is still centripetal, but in two diverging groups. The xylem ray is then shaped like an inverted V. Each arm of the V approaches the adjacent phloëm group as it travels inwards, until the last-formed elements lie on the same radius as the centre of the phloëm group, but well within it. The next elements are differentiated on that radius, but are directed towards the phloëm—development has become centrifugal. These successive xylem formations are termed by Chaveaud the alternate, the intermediate, and the superposed. The alternate elements are fugitive in this transitional region: they commonly disappear as the superposed elements become conspicuous. The intermediate xylem persists; but higher up in the hypocotyl the intermediate elements also disappear as the seedling becomes older. Hence in seedlings of a certain age we have endarch bundles at the top of the hypocotyl, forming a stele of the stem type, and an exarch stele lower down, which passes unchanged into the root, the connection between the two being maintained by the intermediate xylem of the transitional region.

Chaveaud believes the stem cylinder in the upper hypocotyl of a fairly old seedling to be a true stele, but one belonging to a later phase of evolution than that of the root, and not strictly homologous with it in the sense in which the earliest vascular formations in cotyledon and hypocotyl respectively were homologous with each other. He considers that the successive vascular formations — marked by the appearance of alternate, intermediate, and superposed xylem in turn — represent three successive phases of stelar development: the root stele corresponds with the first of these phases only. This implies the hypothesis that at some past period a group of plants in the direct line of descent of Angiosperms possessed a stele resembling that which is now a mere stage in the life of the individual; thus the alternate formation found throughout the very young seedling implies an ancestral group with an exarch stele in stem as well as root, and a leaf-trace of corresponding structure. If this view be adopted, the seedling must, during the period when it consists only of cotyledons, hypocotyl, and primary root, with the plumule present as a mere bud, represent a past period in race history when its ancestors possessed an exarch stele in both stem and root, when the stem stele belonged to the stem only and the insertion of leaf-traces hardly modified its structure, and when it entered the root without change, and therefore no transitional region occupied and puzzled the anatomist of the period! This early stage in the development of the seedling is succeeded by that in which the epicotyl (plumule axis) begins to grow, and as a rule the epicotyl is undoubtedly modern: its vascular skeleton is built up of leaf-traces which are endarch from the first, at the cotyledonary node they are inserted on the vascular cylinder of the hypocotyl which has become endarch at the top. This transition has been effected lower down in the hypocotyl, as described already, by the formation first of intermediate and then of superposed xylem together with the gradual disappearance of the original alternate xylem. Hence the cotyledonary node may be considered to mark the interval between two acts in the drama of evolution—an interval the length of which cannot yet be estimated, but is clearly to be reckoned in geological epochs. The race history of the phanerogamic stem-cylinder is at present unknown; possibly the development of the hypocotyl may give a clue as suggested by Chaveaud, or Jeffrey may be right in deriving the leaf-traces from a simple tubular stele (siphonostele) which has become more and more broken up by the appearance of foliar gaps. Until this point is cleared up the exact relationship of the vascular cylinder of the stem to that of the root will remain obscure; as a matter of convenience the stem cylinder will no doubt be called a stele, even should anatomists acknowledge that it cannot be considered as strictly homologous with the stele of the root, but much confusion of thought would be avoided if the two structures were not treated as strictly comparable.

Apart from the foregoing consideration of modern embryology in relation to a single problem of internal anatomy, namely, the comparison of the vascular system of the stem to that of the root, the evidence of embryology is of great weight in questions of internal morphology and phylogeny. Hanstein's account of the Monocotyledon embyro suggests two distinct problems: (1) whether a terminal member can be considered as a leaf, (2) whether Dicotyledons are derived from a monocotyledonous ancestor, or Monocotyledons from a dicotyledonous form. The most obvious interpretation of Hanstein's observations is that the single cotyledon of Monocotyledons is equivalent to the pair found in Dicotyledons: this would imply that Dicotyledons were derived from an ancestor with one cotyledon, apparently terminal, which gave rise to the existing pair by a process of splitting; but other interpretations are possible, and the terminal hypotheses received a shock when Solms-Laubach discovered that in certain Monocotyledons the single cotyledon is lateral from the first. The comparative antiquity of Monocotyledons and Dicotyledons has been one of the first questions raised by the study of seedling anatomy, and it is remarkable that both the hypotheses founded on work of this kind assert the greater antiquity of the dicotyledonous form; but if the cotyledonary member of Monocotyledons is derived from one or both cotyledons of an ancestral pair, it cannot be considered as terminal. Thus the evidence of seedling anatomy bids fair to settle both these problems, and probably others of the same kind.

Though the progress of botanical embryology has been here treated from the morphological side only, it is clear that every department of botany must deal with the immature plants as well as with the adult form. For instance, the struggle for existence between two species in any particular locality must be profoundly affected by the characters of their seedlings. If one species should gain a decided advantage over the other early in life, the vanquished species may never live to set seed, and may thus disappear from the neighbourhood in the first generation. This is an extreme case to show the importance of considering seedling structure in problems of ecology and distribution. The internal structure of seedlings is certainly a department of vegetable anatomy, just as their adaptation to the conditions of life is a department of vegetable physiology. That the connection between embryology and systematic botany must be equally close seems at first sight to be beyond dispute, but the exact nature of that connection is as yet undetermined. Certain features of the embryo are included among the characters used by systematists, but on the whole, the latter have dealt exclusively with the adult plant, the embryo itself having been treated rather as a portion of the seed than as an individual. We need not be surprised if conclusions drawn from the new embryology—that is, the embryology which includes internal characters as well as external—sometimes appear to conflict with the results of systematic botany, and it does not necessarily follow that embryological evidence is of no systematic value. The fault may lie with the embryologists who, being human, do occasionally misinterpret their facts, or possibly the natural system may need some modification in the light of new knowledge. When both explanations have failed to account for the discrepancy in a number of cases, we may be forced to give up looking for phylogenetic results from embryology.

A summary of various papers read at the Birmingham meeting will be given in these columns next month.

CHEMISTRY.

By C. Ainsworth Mitchell, B.A. (Oxon), F.I.C.

PATHOGENIC ORGANISMS IN RIVER WATER.—Mr. A. C. Houston deals, in the *Ninth Research Report, Metropolitan Water Board*, with the question of the typhoid bacillus and its distribution. In a former *Report*, an outline of which was given in these columns, it was shown that under the ordinary conditions of storage and filtration the sewage micro-organisms in a polluted river water are so diluted that a very large volume of the water must be examined in order to detect a single typhoid bacillus. "Where then," as Mr. Houston asks, "is the typhoid bacillus?" and he supplies the answer in the following words: "The home of the typhoid bacillus is not so much in impure waters, or even in the crude sewage from a large community, as in the 'factories' of disease, as exemplified by the 'carrier' case."

In other words, there may be much less danger in the contamination of water by the sewage of a whole community than in traces of contamination from a single individual who happens to be what is known as a "typhoid carrier." In the case of the ordinary sewage contamination produced by a large town the effect of these unknown typhoid "carriers" is reduced by dilution, so that the water will probably contain only the normal quantity of typhoid bacilli. Incidentally it is pointed out that there is but little risk of typhoid infection from breathing sewer gas, and it is interesting to recall that this confirms the conclusion of a former editor of "Knowledge," Mr. A. C. Ranyard, who, twenty years ago, wrote an article on the subject in this journal.

Mr. Houston also calls attention to the striking differences between the death-rates from typhoid shown by European and American cities. This is illustrated by examples of which the following may be quoted :—

	Population.	Typhoid Death-Rate per 100,000.
Edinburgh	320,000	1·3
Berlin	2,000,000	2·2
London	7,280,000	3·3
Vienna	2,000,000	3·8
Paris	2,750,000	5·6
Boston	670,000	11·3
New York	4,766,883	11·6
Philadelphia	1,549,008	17·5
Washington	331,069	23·2
Minneapolis	301,408	58·7

In Mr. Houston's opinion the excessive prevalence of endemic typhoid fever in American cities is probably due to the "carrier" element, rather than to the consumption of impure water in the ordinary sense; since it can be shown by calculation that an ordinary glass of properly purified water will probably not contain a single typhoid bacillus.

CHEMISTRY AT THE BRITISH ASSOCIATION.—Twenty-seven years had passed since a meeting of the British Association had been held in Birmingham. It was at the former meeting in 1886 that Sir William Crookes suggested that the elements might have been evolved from a hypothetical primordial substance or Urthyl. It was therefore appropriate for the President of the Chemical Section, Dr. Wynne, to review the progress that has been made in this and other directions during the last quarter of a century.

With regard to the brilliant hypothesis of Sir William Crookes, the President pointed out that this common origin of all the elements was now commonly accepted, although "the question whether the term 'transmutation' is verifiable under available conditions is answered differently according to the view we take of the disintegration of radium and kindred phenomena."

The main portion of Dr. Wynne's address, however, was occupied with a discussion of the chemical change known as substitution from the point of view of Werner's conception of valency, according to which an atom may possess both a principal and an auxiliary or residual valency.

The reports of two committees were presented to the section, one dealing with "Dynamic Isomerism" and the other with "The Study of Plant Enzymes." In the latter an outline is given of the evidence in support of the view that the pigments in the sap of plants are produced by the oxidation of a colourless chromogen by means of an oxidising enzyme or oxydase.

Most of the papers read before the section were of a highly technical character, and implied a good knowledge of physical and organic chemistry on the part of the audience.

Of more general interest, however, were the communications upon radio-active elements. The investigations of Mr. Fleck during the last year have shown that of the eleven new radio-active elements studied all, with the exception of Uranium X, are chemically identical with common elements already known, such as lead, thallium, and thorium.

In Mr. Soddy's paper upon "The Radio-Elements and the Periodic Law" the conclusion is drawn that "in that part of the Periodic Table in which the evolution of the elements is still proceeding each place is seen to be occupied, not by one element, but on the average, for the places occupied at all, by no less than four, the atomic weights of which vary over as much as eight units. It is impossible to believe that the same may not be true of the rest of the table, and that each known element may be a group of non-separable elements occupying the same place, the atomic weight not being a real constant, but a mean value, of much less fundamental interest than has hitherto been supposed."

The communications dealing with applied chemistry included one upon "The Effect of Impurities on the Quality of Commercial Copper," by Mr. F. Johnson, and "The Action of an Alkaline Natural Water on Lead," by Messrs. Liverseege and Knapp, an outline of which will be given later.

ENGINEERING AND METALLURGICAL.

By T. STENHOUSE, B.Sc., A.R.S.M., F.I.C.

CORROSION OF CONDENSER TUBES.—The results of a long series of experiments carried out with the object of examining some of the factors which seemed likely to bear upon the nature and speed of corrosion in condenser tubes were communicated to the August meeting of the Institute of Metals by Dr. G. D. Bengough and Mr. R. M. Jones. Tubes of four standard compositions were immersed in stationary sea-water at different temperatures, and similar tubes were used in an experimental condenser plant. The results show that the temperature is a very important factor in determining both the nature of the chemical reäctions between sea-water and brass, and also the speed with which the brass is attacked. Action is much more rapid at higher temperatures and the experiments demonstrate the bad economy of overloading condensers. The authors made direct experiments to test the theory that particles of coke, and so on, deposited in the tubes give rise to local galvanic action, resulting in pittings, but could find no evidence of this action taking place. From their experiments they conclude that selective corrosion, resulting in dezincification and pitting, is an inherent property of the alloys examined. They consider that the Admiralty alloy, copper 70, zinc 29, tin 1, and Muntz's special brass, copper 70, zinc 28, lead 2, are more suitable for condenser tubes than plain brass composed of copper 70, zinc 30, and they recommend the extended use of electro-chemical protection.

THE CRITICAL POINTS OF STEEL.—A method of determining the critical points Ar 1 and Ac 1 without the use of a pyrometer is described by Dr. J. E. Stead in a paper read before the Iron and Steel Institute at the September meeting. Two bars of the steel are supported, without touching each other, in a short length of porcelain tube, which is then inserted in the side of a muffle furnace. The bars are allowed to remain until the temperature conditions become constant, the inner ends of the bars being at a temperature of about 1000° C., and the outer ends below 700° C. One bar is then withdrawn for about 15 mm., and the heating continued for about fifteen minutes more. Thin wires of pure silver, aluminium, zinc, and so on, are then inserted in the space between the bars, and the points on the bars where the wires just melt are ascertained. A scale can thus be plotted showing the temperature at each point along the bars. The bars are then withdrawn, quenched, cleaned, and etched, whereby the line of demarcation between the hard and soft portions becomes clearly visible. A reference to the scale gives the temperatures which the bars had at these planes when in the furnace. The withdrawn bar gives the Ar 1 point, and the other bar the Ac 1 point. The results obtained in this way are stated to be within 3° C. of the truth.

GEOGRAPHY.

By A. STEVENS, M.A., B.Sc.

THE DISTRIBUTION OF MAN.—The Presidential Address of Professor H. N. Dickson to Section E (Geography) of the British Association dealt with the question of the Redistribution of Mankind, and recently there has been published a good deal of matter bearing on the subject. The discussion of the problem is bound up with the discussion of resources, but there are certain questions of resources that are of necessity more or less indefinite and incapable of even probable solution. Such deal with coal supply, in general and in detail, and with the extent, position, and importance of supplies of metalliferous minerals. But a matter which is both fundamental and more definite is the supply of food.

Agriculture has presented to the man of limited capital who has energy and ambition and the desire to be his own master in a new country the most attractive if not the only prospect. The principles underlying his work are these: manual labour, which is scarce and costly, is the minimum; the crop covers a large area, so as to pay in spite of the low yield per acre; the ground opened up in the first year is sown and the three months which elapse before the crop comes to the harvest are occupied entirely in opening up fresh land for the next spring. We find Canadian and United States harvests give as low as twelve to fourteen bushels of wheat per acre, Australian (and Russian) eight to ten, compared with twenty-eight to thirty-two, twenty-seven to thirty-three, thirty to thirty-five for the United Kingdom, Holland, and Belgium respectively (J. F. Unstead, "The Statistical Study of Wheat," *Geographical Journal*, August, September, 1913.)

As the demand for wheat grows, the supply may be increased, either by increasing the amount of land under cultivation or by increasing the yield. In certain parts the amount of suitable land under cultivation has closely approached the limit of the amount available, and in any case there is a very definite and reasonably well-ascertained maximum of such land. In the United States this is already evident in its effects. (The American Transcontinental Excursion, 1912, I, "Economic Aspects," by G. G. Chisholm, *Geographical Journal*, October, 1913.) Intensive cultivation is being more and more widely practised, and from the Western States there is a steady stream of emigration to Canada, where the amount of unoccupied wheat land is greater.

It is on account of the great and rapid development of the means of sea and land transport that certain less crowded regions have been able to act as granaries for the thickly populated industrial areas, and this has led to a type of modern colonisation of a markedly recent and rapid growth. But the countries originally mainly agricultural are filling up with an industrial population as new resources are explored and opened up. The consequence is that home productions are more and more used at home, and the surplus for export diminishes. The mean percentage of the total production of wheat exported from the United States fell from thirty-two for the period 1881-90 to nineteen for 1901-10. Russia shows a corresponding fall from twenty-six to twenty-three; only newer countries—Canada, Australia, the Argentine—show large increases. Generally in a country the obvious resources are the first used and the first to reach maximum development, and among these are agricultural resources. Later developments lead to the growth of an industrial population. The order seems natural and inevitable, and Canada and the United States may be taken as types of the earlier and later stages in the evolution of a country.

Wheat is produced as a rule at a distance, often very great, from the industrial centres in which it is consumed, and the cost of transport forms an important if not large part of the cost of the food. The possibility of local production in any commodity depends on, among other things, the cost of the same commodity when imported, and the cost of the home product is simply the cost of production.* Import and local production tend therefore to a state of conditional equilibrium, and the condition may be represented by the formula due to Professor Dickson (*loc. cit.*), slightly modified:

$$I \rightleftarrows E + T,$$

where I represents cost of local production, E cost of production at a distant place, the cost of transport from which is represented by T. The state of true equilibrium is ideal, and there will always be an excess on one side of the equation representing the merchant's profit, and indicating whether imported goods or local products form the main supply.

Scientific statistical study is extremely important in Economic Geography. It should be more widely cultivated because it gives, as it were, a partial differential equation in which variation is expressed with respect to one variable and variation with respect to a complex of others is implicit, and to which a general solution can be found. The essential is that the study be scientific and rigid. Taking wheat in production and distribution as the variable, the solution gives these final results with regard to the redistribution of man: (*a*) intensive methods of cultivation will be adopted and lead to increase in manual labour, and consequently to increase in density of population in regions mainly agricultural and thinly populated at present; (*b*) cost of food will increase, and this will result in an alteration of equilibrium in remuneration for work of all kinds, and in increase of agriculture in countries now almost wholly industrial; (*c*) agricultural and industrial areas will be more closely intermingled, but there will be no less centralisation than at present, and nodal towns will tend to become huge in size.

GEOLOGY.

By G. W. Tyrrell, A.R.C.Sc., F.G.S.

CALCAREOUS ALGAE AS ROCK-FORMERS.—This interesting but neglected subject was taken up by Professor E. J. Garwood in his Presidential Address to the Geological Section of the British Association. Whilst examining the Lower Carboniferous rocks of the North of England, Professor Garwood was impressed by the abundance of nodular structures at certain horizons, and the large areas over which these structures extended. Examined microscopically the nodules were found to be organic, and to consist largely of the calcareous alga known as *Solenopora*. This was the starting point of an investigation which proved calcareous algae to play a much more important part in the formation of limestone deposits than had hitherto been considered. It was also shown that certain forms became dominant over wide areas at the same geological period, and might be used as proof of the general contemporaneity of two deposits. As an example is cited the abundance of *Solenopora compacta* during Llandeilo-Caradoc times over an area covering the Baltic Provinces, the British Isles, and Canada. The presence of calcareous algae, which flourish best in the clear, shallow waters of bays and lagoons, also furnishes evidence as to the conditions prevailing during the accumulation of the rocks containing their fossil remains.

THE ENRICHMENT OF SULPHIDE ORES.—The principle of the secondary enrichment of sulphide ores, announced almost simultaneously and independently by S. F. Emmons, W. H. Weed, and C. R. Van Hise in 1900, has received much discussion in the intervening thirteen years, and has been made the subject of a bulky Bulletin (No. 529) of the United States Geological Survey, by W. H. Emmons. The principle is simple. Under the influence of atmospheric weathering sulphide ores break down and form soluble salts, chiefly sulphates. When conditions are favourable these acid solutions will be carried downwards, generally along the channels afforded by the fissured zone which contains the ore-body. The unoxidised rocks below the ground-water level are in general alkaline, and acid solutions encountering them in regions where air is excluded will lose acidity, and certain of the metals they contain will be precipitated. Also if the solutions of metallic sulphates encounter sulphides in depth, precipitation of metals may ensue; or there may be an interchange between the metals in solution as sulphates and the metallic sulphides. As a consequence of these reäctions certain parts of the ore-body

* Exception may be taken to the economics of the discussion. In the first place, a (more or less problematical) future position is considered up to and in which the nature of human (European) food continues as at present, and in which the questions of supply and demand are somewhat different. For simplicity the matter is taken as less complex than it really is: supply and demand at a price and changes in mode of living are ignored; the question of whether land is or is not available does not necessarily arise. The whole is to be thought of as giving the "differential equation" of the last paragraph.

Figure 505.
Chrysanthemum leucanthemum
with florets in the disc.
(See Page 409).

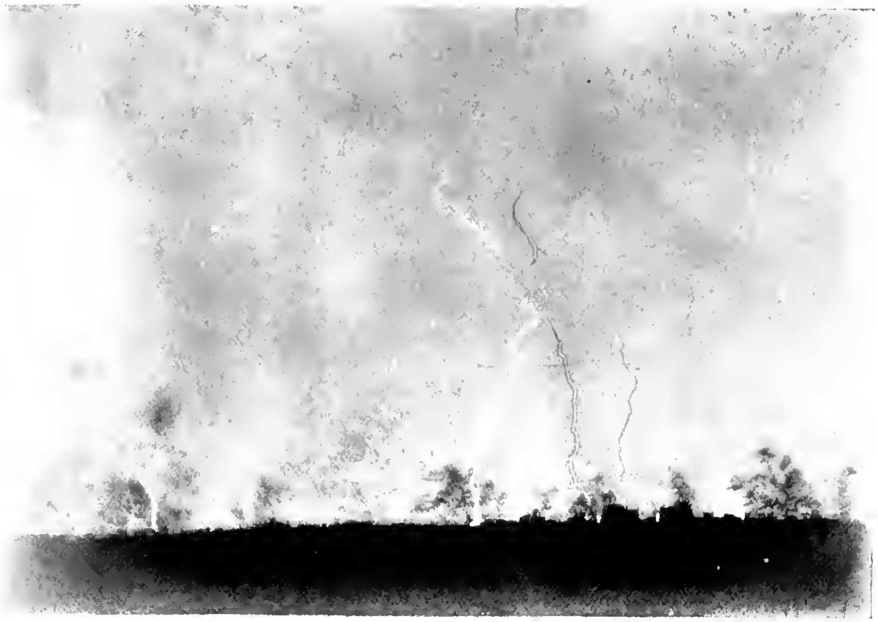


Figure 506. Three lightning flashes giving different images.
(See Page 439).

Figure 507. Lightning flashes taken at Johannesburg.

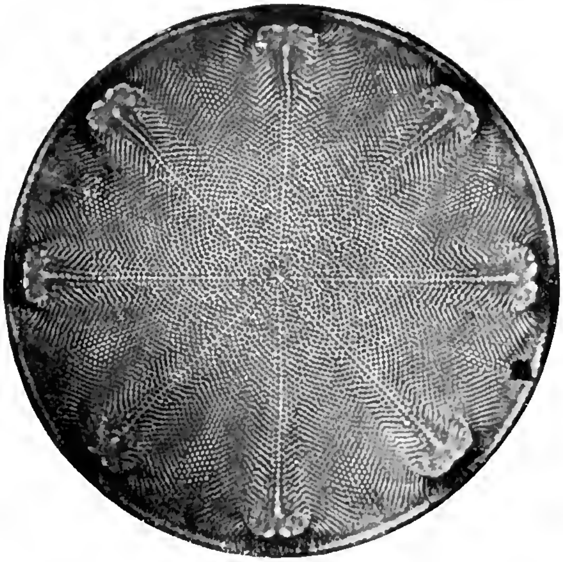


FIGURE 508. *Aulacodiscus kittonii*, eight rays. Objective used; Zeiss's B.B. of 0·30 N.A.; × 375.

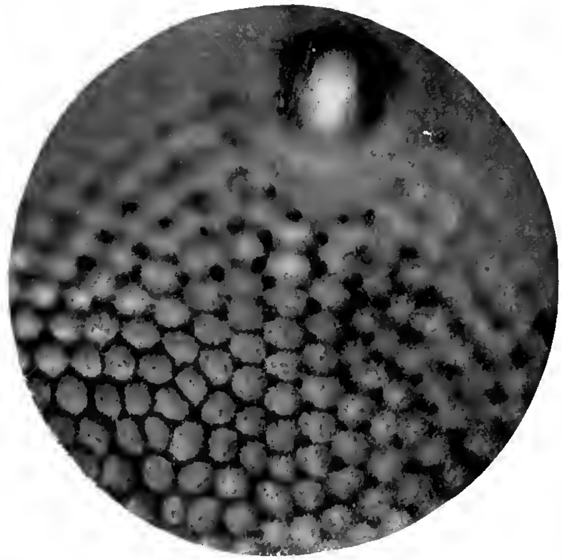


FIGURE 509. *Aulacodiscus sp.?*, a reproduction of Figure 411, Volume XXXV, page 372; × 1,900.

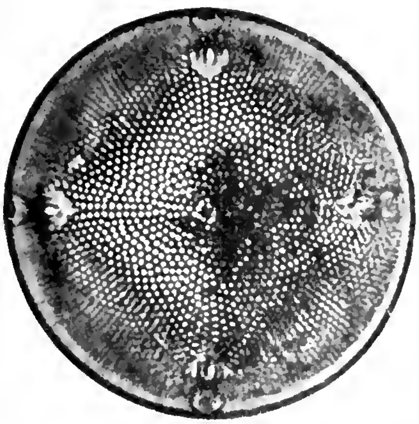


FIGURE 510. *Aulacodiscus sp.?*, from which Figure 509 was taken. Objective used; Zeiss's B.B. of 0·50 N.A.; × 375.

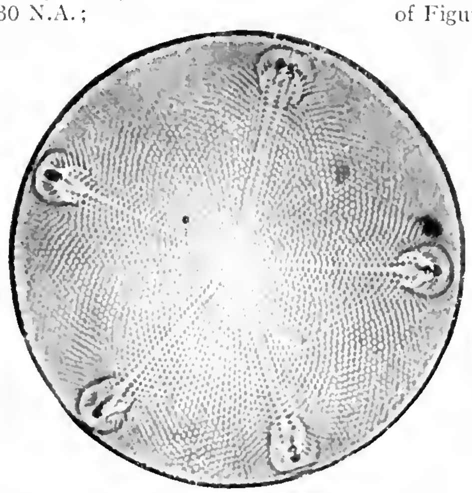


FIGURE 511. *Aulacodiscus kittonii*, from the west coast of Africa. Part of a group of four- and five-rayed forms.

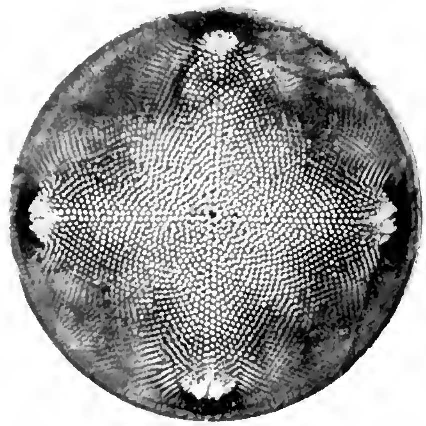


FIGURE 512. *Aulacodiscus kittonii*, four-rayed form. Magnification and objective the same as in Figure 510.

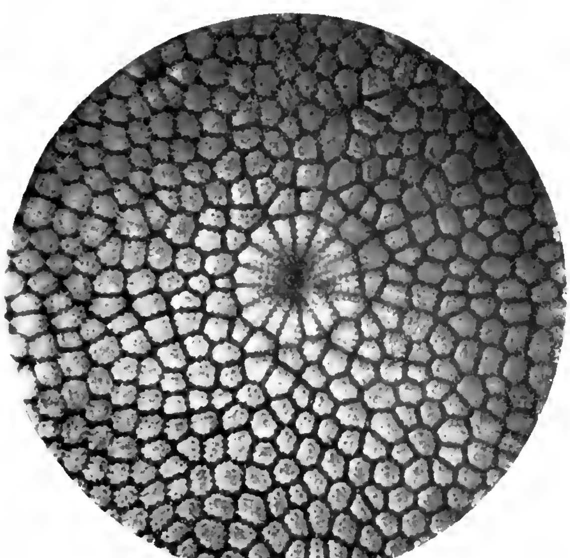


FIGURE 513. *Aulacodiscus kittonii*, centre of the valve, shewn in Figure 508; × 1900, the same lens used as in Figure 514.

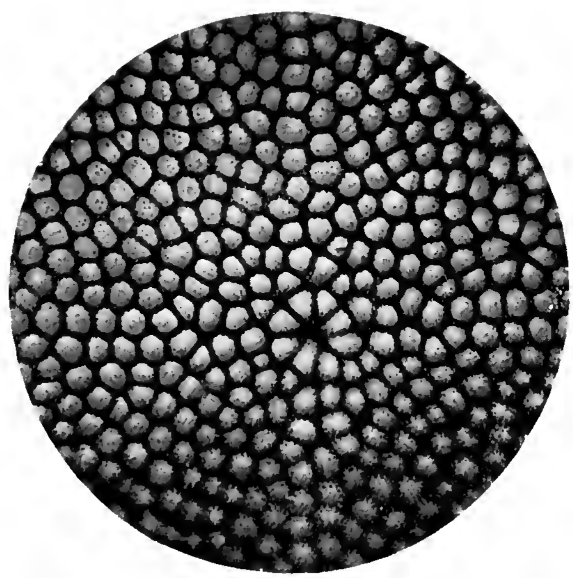


FIGURE 514. *Aulacodiscus kittonii*, centre of the valve, shewn in Figure 512. Objective used; Swift and Son's oil immersion of 1·30 N.A.; × 1,900.

are enriched. The greater part of the metallic contents of the upper portion of the ore-body which is being subjected to denudation is carried down in solution, and enriches the lower portion. Many ore-deposits, especially those of copper, are leached near the surface, and are considerably enriched below the leached zone. At still greater depths the ore becomes of lower grade. The zone of enrichment in a mining region is frequently found to have a clear relation to the surface topography, and especially to the ground-water level. The theory of sulphide enrichment has proved of considerable economic importance, and has been applied to many deposits of the metallic sulphides. The subject is of great interest to chemists as well as to geologists, as is shown by the lengthy chemical discussion in the above-mentioned bulletin.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

FISHERY RESEARCH AND METEOROLOGY.—In the *Annual Report on Sea Fisheries* for 1912, recently issued by the Board of Agriculture and Fisheries, reference is made to the scientific investigations carried out by the Board. It is stated that although hydrographic data have been collected systematically since 1903, it must be admitted that we are still only beginning to arrive at an understanding of the complicated inter-relations of physical conditions and abundance or dearth of fish. In many cases, however, it has already been possible to trace clear indications of a close connection, not only between hydrographical conditions and the movements of fish, but between these conditions and weather. There is a good reason to believe that changes in the ocean circulation, having a direct effect upon the weather, greatly influence the growth of trees, and the relation between atmospheric and hydrographic conditions is not without interest to the fishing community, both because of the effect of weather conditions upon actual fishing operations and because of wind pressure upon the currents of the sea. It is probable that meteorology has not yet been given its proper place among the numerous sciences which may contribute to the proper understanding of the problems connected with fishing.

THUNDERSTORMS IN EGYPT.—Mr. E. W. Bliss in the *Cairo Scientific Journal* for June gives some particulars about thunderstorms in Egypt. A list of all available records of thunderstorms for the forty-five years 1868 to 1912 was recently prepared by the Meteorological Service, and a summary made of the results. For the years 1868 to 1903 the records depend upon the observations made at Abbasia, but after 1903 they include four storms at Alexandria or elsewhere which escaped Cairo. The total number of days during the period on which thunderstorms, whether slight or severe, and also cases where lightning only was observed, was one hundred and eighty. The number of thunderstorms which were accompanied by hail or heavy rain, or did damage to buildings, was twenty-eight. It thus appears that there is an average of rather more than one thunderstorm in two years.

VOLCANIC DUST AND CLIMATIC CHANGES.—Professor W. J. Humphreys, of the United States Weather Bureau, in a paper just published in the *Bulletin of the Mount Weather Observatory*, has dealt with the subject of volcanic dust and other factors in the production of climatic changes and their possible relation to ice ages. Numerous attempts have been made to find a probable cause for the known climatic changes of the distant past, and especially for those profound climate changes that brought about the extensive glaciation that prevailed during the so-called ice ages; but nearly all the older suggestions have been definitely abandoned because they are inadequate to meet the conditions imposed upon them by the results of geological investigations. Professor Humphreys now puts forward the question of volcanic dust in the upper atmosphere as a factor in the production of climatic changes, including, possibly, even those great changes incident to the advance and retreat to maximum and minimum of glaciation. In his discussion of the subject he shows, among many other things, that volcanic dust in the high atmosphere decreases the intensity of solar radiation in the lower atmosphere, and therefore the average temperature of the earth; and this effect has been clearly traced back to 1750, or to the time of the earliest reliable records. It may consequently be said that such a relation between volcanic dust in the upper atmosphere and average temperatures of the lower atmosphere always has obtained, and therefore that volcanic dust must have been a factor, possibly a very important one, in the production of many, perhaps all, past climatic changes, and that through it, at least in part, the world is yet to know many another climatic change in an irregular but well-nigh endless series, usually slight, though always important; but occasionally it may be, as in the past, both profound and disastrous.

DAILY WEATHER MAPS FOR THE NORTHERN HEMISPHERE.—The Meteorological Committee in their Annual Report state that at the beginning of this year Mr. R. F. Stupart, Director of the Meteorological Service of Canada, brought to their notice specimens of the charts of barometric distribution over practically the whole of the Northern Hemisphere, which are prepared daily in Toronto by co-operation with the Weather Bureau of Washington. The charts in question differ from those now prepared in the Meteorological Office, ten days after date, for issue with the *Weekly Weather Report*, by including observations from Alaska. These are not charted on the Canadian Daily Chart, which is used for the compilation of the charts in the weekly report, but it is pointed out that they are of exceptional importance in relation to the general distribution of weather conditions.

The Meteorological Committee are informed that the Russian Government is raising the sum devoted to meteorology to £50,000 a year, with the object, among others, of initiating in the year 1915 a service of strictly simultaneous observations at 6 a.m. and 6 p.m. (Greenwich time) over the whole of the Russian Empire, which extends over nearly 180° of longitude. The extension of the ordinary daily working chart to include practically the whole of the Northern Hemisphere will then be easily realisable. At this moment the cable and wireless companies of the world could exchange information which would give a very fair representation of the weather conditions of the globe to those who are familiar with the average features. The realisation of the project of a "reseau mondial" for the daily weather service is now only a question of international organisation and of money.

MICROSCOPY.

By F.R.M.S.

ANLACODISCUS KITTONII—AN APOLOGY.—As author of the articles in "KNOWLEDGE" on "The True Structure of the Diatom Valve," the writer feels an apology is due from him to the editors and readers of this journal. It is due to them for his own lapse by making a claim which he now finds he cannot support, and begs to tender it accordingly. On page 372, Vol. XXXV, two photo-micrographs were represented by him as the first published of *Anlacodiscus kittonii*, showing the minute details of the structure under an oil-immersion objective of wide aperture. The statement in itself was true enough had the photographs but been of that diatom. Tricked, however, in his memory at the time, he now finds they were not, and his pretension falls to the ground.

The form then given is still probably a variety. It certainly is about the same size, has the same general features, plus the little bosses, but the cellules are much larger; neither does the secondary structure offer much difficulty in seeing or photographing. Such a situation renders the writer's position somewhat ridiculous, as he feels that he is bound to redeem his character somehow, and, after assuming the white sheet, now makes the attempt upon a form there can be no mistaking.

The photo-micrographs of the whole valves, taken for this article, are magnified three hundred and seventy-five times. Looking at the minuteness of the cellules in the two normal forms, even under this magnification, it will be seen at once how difficult is the task of photographing the still more minute secondary structure—six or more faint dots within each cellule. Nothing is more fitted to try the worker's mettle; indeed, one may say from one's experience in diatom structure, nothing else is so fitted. There still remains to try the mettle of the process worker and others in preparing the blocks.

The drawing of the finer structure of this diatom by Messrs. Nelson and Karop, published in *The Journal of the Quekett Club* for 1887, shows a few cellules only. Although professedly drawn to a scale of one thousand two hundred diameters, each cellule appears as of twice the size of those in the present prints, taken at one thousand nine hundred. One can question neither the good faith of the artist nor the real size of the details in the valve, yet the discrepancy can be easily accounted for by supposing that Mr. Karop found them almost impossible to make plain to the eye on so small a scale. This is the difficulty the present writer fears now in his own prints, though trusting to the skill of all connected with the production of "KNOWLEDGE."

In the drawing in question the six or seven dots within each cellule are rendered quite pale, a characteristic feature of this diatom, and one making them so difficult to photograph. The boundaries are formed by a series of similar dots, but black. One does not like to differ from such eminent observers as Messrs. Nelson and Karop, at the same time one cannot help feeling that they are due to interference from the under-structure of hexagons. Something of like appearance occurs in Figure 513 of the present article, yet on using the largest aperture of the substage condenser they disappear and the dotted membrane is seen to be continuous over the whole valve. There would be work for the owners of oil immersions during the winter months to solve this problem and then send the results to "KNOWLEDGE"—with the consent of the editors, of course. The evidence of a continuous membrane is not lacking in some of the coarser discoid forms. We have already seen that in *Triceratium favus* and *Coscinodiscus asteromphalus* there are structureless parts from which the kind of woven material forming the secondary structure springs. In one species of Coscinodiscus, however, from the Nottingham deposit, there is nothing of this; instead a uniform perforated membrane, stuck upon little bosses some distance above the hexagons, spreads over the whole valve.

Coming to the figures now, Figure 510 is of the same valve from which Figure 411 of the last article was taken at one thousand nine hundred diameters. Unfortunately the particulars underneath the print say two thousand seven hundred and fifty, but this is a mistake. In some manner the particulars of four hundred and ten and four hundred and eleven have become transposed. Figure 410 should read two thousand seven hundred and fifty diameters and 411 nineteen hundred. The next, Figure 512, is from an undoubted four-rayed normal form of *A. kittonii*, and it will be seen at once how minute are the cellules as compared with Figure 510. Figure 514, taken at one thousand nine hundred diameters from the centre of the same valve, shows the secondary structure, but so minute as almost to require another lens to see it. In Figure 509 we go back to Figure 411 of volume XXXV in order to compare the size of the cellules with Figure 514. The contrast between the two will then speak for itself.

Figure 508 is from an eight-rayed valve, a very beautiful variety. A photo-micrograph of the same variety of this species appears in the two editions of the Dallinger-Carpenter, taken at two hundred and seventy diameters, by Mr. E. M. Nelson, with an inch objective under dark-ground illumination. Seen on either the first or second plate it looks innocent enough, until one attempts the same performance with an inch objective. Believe one who has tried, and must confess to a dismal failure or failures in consequence. Figure 513 is from the centre of Figure 508, which, with Figure 514, the writer hopes may be taken as a fitting supplement to Mr. Nelson's print. He hopes also that he has now made his *amende honorable*, as really having done what he only boasted of doing before.

The varieties of *A. kittonii* range from three rays to nine. The centre valve in Figure 511 is a five-rayed form, and is curious otherwise as showing that Nature's freaks, such as Two-headed Nightingales and Siamese Twins, are not confined to complex organisms. At the end of each process in the normal form, under high powers, a little bulb of crystal can be seen, in shape like those used to light the carriages in the tube railways. They are just indicated in the print, but at the end of one process two appear in place of the usual one. The specimens in this mount are from the west coast of Africa. Ten in number consist of the four-rayed forms, one of five, yet the secondary structure is so minute as not to offer the slightest signs of resolution under an aperture of 1·30 N.A. Notice also the different shape of the processes from Figures 512 and 508.

PHOTOGRAPHY.

By EDGAR SENIOR.

GLAZING SILVER PRINTS.—When it is desired to impart a high degree of glaze to P.O.P. or bromide prints whcih are made upon a glazed surface paper, the prints after washing should be placed in a solution of some hardening substance, such as ordinary alum, chrome alum, or formalin. Especially in warm weather is this treatment necessary, since the gelatine surface often becomes very soft and liable to adhere to the surface used for squeegeeing upon, whatever precautions may have been taken to avoid it. If alum is employed as the hardening agent a five per cent solution should be employed; formalin, however, is to be preferred in many respects, as alum is not always successful in its action. The strength of the formalin solution should be about one ounce to ten or twenty ounces of water, and the prints should be allowed to remain in for five or ten minutes and then washed in several changes of water. With regard to the materials to be used for squeezing the prints upon, these may be either glass, ferrotype plates, or celluloid, the latter two being the least likely to give trouble from the prints sticking. If glass be used it requires to be very thoroughly cleaned, and must be soaked for some hours in either of the following:—

Nitric acid	5 ounces
Water	20 „

or

Potassium bichromate ...	1 ounce
Water	30 ounces
Sulphuric acid	1 ounce

The bichromate should be dissolved and the solution made perfectly cold before the sulphuric acid is added, this latter being introduced very gradually, stirring well all the time. As this mixture is very corrosive, great care is required in handling it. After the glass plates have been soaked for several hours, they should be well washed in water and allowed to dry, when they are polished with French chalk, this being dusted on to the plate and well rubbed over and finally dusted off again. Or in place of the French chalk a solution of beeswax in benzol or turpentine may be applied with a piece of rag or a tuft of cotton-wool, and the surface afterwards polished with a clean cloth. The following formula will give a good solution for the purpose:—

Beeswax	15 grains
Turpentine	1 ounce

The clean glass, ferrotype plate, or celluloid should have a little of this well rubbed over the surface and then polished off. The material being ready, the prints are taken from the washing water and laid face downwards, and then squeegeed into contact and allowed to become thoroughly dry before any attempt is made to strip them, and on no account must the drying be at all accelerated by heat, or the prints will be difficult to remove from the support. Sometimes difficulty is experienced in getting them off, but this can be prevented by drying the prints first and then rewetting them; and if care be taken to have the surface of the material thoroughly well cleaned and prepared the prints should almost leave by themselves, especially so when ferrotype plates are used.

PHYSICS.

By ALFRED C. EGERTON, B.Sc.

A SENSITIVE PRESSURE GAUGE.—M. Guéritot publishes in the *Comptes Rendus* for June, 1913, an account of a sensitive manoscope which employs thermo-electric junctions to detect very small displacements of air. Two vessels are connected by a tube which is bent in the middle upwards; the tube is heated at the point of the bend electrically, and the heated air remains in the neighbourhood of the bend. On each side of the heated portion of this tube are inserted two junctions of dissimilar metals connected to a galvanometer. Any displacement of the heated air causes a difference of temperature between the two thermal junctions, and consequently an electromotive force is set up which drives a current through a galvanometer. Very small displacements of the heated air can be measured; in fact, variation of atmospheric pressure by one millionth of a millimetre of mercury can be detected.

NEON AND X_3.—Among the most interesting announcements at the Birmingham meeting of the British Association may be mentioned the experiments of F. W. Aston on the separation of neon by diffusion into two constituents possessing atomic weights very nearly the same, confirming in a remarkable way the positive-ray experiments of Sir J. J. Thomson, which showed that neon should contain two substances of very nearly the same atomic weight. The other announcement was by Sir J. J. Thomson about the supposed new gas, X_3. The atoms of a gas of atomic weight 3 had been identified by his positive-ray method. The properties of this gas have been recently studied by Sir J. J. Thomson, and he was able to announce that it behaved as a gas with a molecule consisting of three hydrogen atoms. Thus hydrogen, as well as oxygen, can give rise, under the action of electric discharge, to a molecule consisting of three atoms. The molecule of active nitrogen, discovered by Strutt, on the other hand, is supposed to consist of single atoms.

Section A of the British Association at Birmingham showed great activity, amongst the most interesting of the discussions being that on "Radiation."

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

POISON OF AMPHIBIAN SKIN.—It is well known that the defenceless Amphibians—toads, frogs, newts, salamanders, and the like—are protected by a poisonous secretion formed by skin glands. The phrynin of the toad has been often experimented with, and is a powerful poison. Madame Phisalix has recently found that injections of a modification of Amphibian poison will immunise an animal, *e.g.*, rabbit or guinea-pig, against a strong dose of the same poison. This is what might have been expected from analogous cases. But the further point is of much interest—that animals immunised against Amphibian poison are also immunised against the poison of the viper.

BEHAVIOUR OF FAIRY SHRIMPS.—Professor A. S. Pearse, of the University of Wisconsin, has made an interesting study of the behaviour of *Eubranchipus dadayi*, one of the fairy shrimps. Its movements are exceedingly easy and graceful. The body glides through the water slowly but steadily at the rate of about a foot in ten seconds, with the ventral surface usually uppermost or towards the light. There is considerable dimorphism between the sexes and a difference in colour that is of considerable interest. The males have a delicate, translucent, almost transparent, creamy colour, with reddish tail-pieces, while the females are reddish throughout. The transparency of the males enables them to wander about with comparatively little danger of being seen, and they are thus able to seek out and fertilise the females. On the other hand the coloration of the females makes them inconspicuous as they rest quietly in holes at the bottom of the pool, or await a mate at the surface in the shadow of some floating stick or other shelter. Professor Pearse's point is that "the coloration of each sex is apparently adjusted to its behaviour in such a way that it is well protected." The males have a strong sexual appetite, but as soon as a female has been provided with sperm she resists the advances of males, goes to the bottom of the pond in which she lives, and remains quiescent so that the eggs may descend into the ventral part of her ovisac, undergo fertilisation, and develop.

RACES OF SARDINE.—Louis Fage has made a study of the growth of the Sardine or Pilchard (*Clupea pilchardus*), using the method, now so much employed, of reading the age from the scales and otoliths. As in other cases, the concentric striated zones seen on a scale are interrupted by several clear non-striated zones, the latter indicating periods of rest ("winter rings"). As Hjort has said, "the growth of the scales is so closely bound up with that of the individual that it is possible by simple measurements of the zones of growth on the scale to retrace with real precision the history of the growth of the fish." The results of his measurements lead Fage to conclude that there are two distinct "biological races"—the Mediterranean and the oceanic Sardine. The former grows more slowly, and lags more and more behind as it grows older. He proposes to study the structural differences associated with this different rate of growth.

SIGNALLING AMONG TERMITES.—Professor E. Bugnion, of Lausanne (*MT. Schweiz. Entomolog. Gesellschaft*, XIII, 1913, page 125) communicates some very interesting observations on signalling among Termites. The phenomenon has been previously studied by König, Smeathman, Haviland, Sjöstedt, and Escherich, but Bugnion has gone further. Helped by H. von Buttel-Reepen, he found that the noise is produced by the soldiers, who knock on dry leaves or the like with their mandibles, or with the basal piece of the labium, which is exaggerated and hard. A cobra-like hissing, as it seemed at first, was traced to a colony of *Termes obscuriceps* which had formed its galleries on the big fallen leaves of the Bread Tree (*Artocarpus*). From a colony in Bugnion's office-desk answers used to be got to outside taps. In another experiment a piece of termitary was placed on a big plate and covered with stiff paper; the soldiers collected on the under surface of the paper and answered back to every vibration. The noise differs in different species, but is always due to minute blows on a resonating surface. The result may be a rustling, or a rattling, or a crackling, or otherwise. In the Indian *Termes estherae* Desneux, which turns out to be the same as König's *Hodotermes convulsionarius*, the noise made by the large and aggressive workers when they are disturbed is like the crackling of withered leaves trodden underfoot. There is evidence that the noises or the associated vibrations serve to warn the workers or to reassure and encourage them. There seems little doubt that they are of the nature of signals. That sounds or vibrations are really perceived is made clear by what was seen in the field, by the responses given by the tenants of Bugnion's desk to taps from without, and by the anatomical demonstration of a well-innervated sensory organ, which is probably particularly sensitive to the vibrations of a material like the framework of a leaf or branch, the wooden partitions of the termitary, the dry walls of the fungus-growing labyrinths, and so on. It is too soon to ask how much is auditory and how much finely tactile. The audible signalling is to be distinguished from another kind of signalling—a soundless signalling—which seems to be common among Termites. It is curiously like and unlike military saluting; for it seems that the soldiers salute the workers. So far as we know, both soldiers and workers are sexually immature individuals of both sexes. But this requires looking into. In the soundless signalling the insect stands firmly on its legs, with the head raised and the body slightly oblique, and shakes itself for an instant with a convulsive shiver. This seems to mean something to the passing worker. We cannot get psychologically near enough to say more.

THE FACE OF THE SKY FOR DECEMBER.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 82.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m	°	h. m.	°	h. m.	°	h. m.	°
Dec. 1	16 27·9	S.21·8	19 38·6	S. 25·9	15 24·2	S.16·0	15 17·1	S.17·0	7 47·3	N.23·8	19 20·1	S.22·5	4 56·4	N.20·9	7 59·9	N.20·1
„ 6	16 49·6	22·5	23 34·8	S. 2·4	15 28·4	16·2	15 42·5	18·7	7 45·3	24·1	19 24·6	22·4	4 54·6	20·9	7 59·6	20·2
„ 11	17 11·6	23·0	3 19·9	N.23·0	15 44·9	17·5	16 8·4	20·2	7 41·8	24·5	19 29·1	22·2	4 52·9	20·8	7 59·2	20·2
„ 16	17 33·6	23·3	8 11·9	N.23·9	16 8·5	19·3	16 34·8	21·4	7 36·8	24·9	19 33·8	22·0	4 51·1	20·8	7 58·7	20·2
„ 21	17 55·8	23·4	12 33·1	S. 5·6	16 36·1	21·0	17 1·6	22·3	7 30·5	25·3	19 38·6	21·9	4 49·4	20·7	7 58·2	20·2
„ 26	18 18·0	23·4	17 14·7	S. 28·1	17 6·3	22·5	17 28·7	23·0	7 23·0	25·8	19 43·4	21·7	4 47·8	20·7	7 57·7	20·2
„ 31	18 40·2	S.23·1	21 52·2	S. 15·0	17 38·2	S.23·6	17 56·0	S.23·4	7 14·6	N.26·2	19 48·3	S.21·5	4 46·3	N.20·7	7 57·2	N.20·3

TABLE 83.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Mars. P	Mars. B	Mars. L	Mars. T	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
Greenwich Noon.	°	°	°	°	°	°	°	h. m.	°	°	°	°	h. m.	h. m.
Dec. 1	+16·2	+0·7	277·0	− 8·8	−12·0	+9·7	98·1	5 17 *m*	− 9·3	−1·3	345·2	113·1	10 1 *e*	8 53 *m*
„ 6	14·2	+0·1	211·1	−21·8	12·3	9·3	53·0	8 23 *m*	9·7	1·3	62·4	143·2	10 18 *m*	5 59 *e*
„ 11	12·0	−0·5	145·3	−14·2	12·8	8·7	8·2	11 26 *m*	10·2	1·2	130·6	173·3	8 26 *m*	7 13 *m*
„ 16	9·8	1·2	79·4	+11·5	13·4	8·1	323·7	2 29 *e*	10·6	1·2	198·8	203·4	4 25 *e*	4 19 *e*
„ 21	7·4	1·8	13·5	+21·8	14·3	7·3	279·5	5 30 *e*	−11·1	1·2	267·0	233·4	4 42 *m*	3 30 *e*
„ 26	5·0	2·4	307·7	+ 4·5	15·3	6·4	235·5	8 30 *e*						
„ 31	+ 2·6	−3·0	241·8	−18·4	−16·4	+5·5	191·7	11 30 *e*						

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Mars, T is the time of passage of Fastigium Aryn across the centre of the disc. In the case of Jupiter, L_1 refers to the equatorial zone; L_2 to the temperate zones; T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

The asterisk indicates the day following that given in the date column.

THE SUN reaches its greatest South Declination (Winter Solstice) December $22^d\ 10\frac{1}{2}^h$ *m*. Its semi-diameter increases from 16′ 15″ to 16′ 17½″. Sunrise changes from $7^h\ 46^m$ to $8^h\ 8^m$; sunset from $3^h\ 52^m$ to $3^h\ 58^m$.

MERCURY is an evening star; reaches elongation, 21° W., on 10th, 1½° N. of Venus, $2^d\ 8^h$ *e*. Semi-diameter diminishes from 4″ to 2½″. Fraction of disc illuminated increases from ¼ to $\frac{11}{12}$.

VENUS is a morning star, but getting too near the Sun for convenient observation. Disc practically full. Semi-diameter 5″.

THE MOON.—First Quarter $5^d\ 2^h\ 59^m$ *e*; Full $13^d\ 3^h\ 0^m$ *e*; Last Quarter $20^d\ 4^h\ 16^m$ *e*. New $27^d\ 2^h\ 59^m$ *e*. Apogee $6^d\ 11^h$ *e*. Perigee $21^d\ 2^h$ *e*, semi-diameter 14′ 48″, 16′ 10″ respectively. Maximum Librations, 1^d 6° W, 13^d 5° E, 13^d 6° S., 26^d 6° N, 28^d 5° W. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon. (See Table 85.)

MARS rapidly approaches opposition. Nearest Earth on January 1st, distance 0·622. This is an unfavourable opposition as regards distance, but favourable as regards planet's declination. It will be seen that both hemispheres of Mars are observable, but the Northern one is best placed. The semi-diameter during December increases from 6½″ to 7½″. The unilluminated lune is on the West: its width diminishes from ⅜″ to 0.

JUPITER is an evening star, but almost invisible. Polar semi-diameter, 15½″.

TABLE 84.

Day.	West.		East.		Day.	West.		East.	
Dec. 1	21	○	43		Dec. 13	31	○	24	
„ 2		○	4123		„ 14	32	○	14	
„ 3	4	○	23	1●	„ 15	21	○	34	
„ 4	4231	○			„ 16		○	$^{2}_{1}$34	
„ 5	43	○	1	2●	„ 17	1	○	234	
„ 6	431	○	2		„ 18	23	○	14	
„ 7	423	○	1		„ 19	32	⊙		1●
„ 8	421	○	3		„ 20	341	○	2	
„ 9	4	○	123		„ 21	43	⊙	1	
„ 10	41	○	23		„ 22	421	○	3	
„ 11	23	⊙	4		„ 23	4	○	213	
„ 12	32	○	14		„ 24	41	○	23	

Configuration at 5^h *e* for an inverting telescope.

Satellite phenomena visible at Greenwich, $2^d\ 6^h\ 27^m$ IV. Tr. I.; $3^d\ 4^h\ 54^m$ I. Oc. D.; $4^d\ 4^h\ 32^m$ I. Tr. E.; $5^h\ 20^m$ I. Sh. E.; $11^d\ 4^h\ 15^m$ I. Tr. I., $4^h\ 56^m$ I. Sh. I.; $12^d\ 4^h\ 22^m\ 15^s$ I. Ec. R.; $14^d\ 4^h\ 44^m$ II. Sh. E.; $18^d\ 4^h\ 30^m$ III. Tr. E.; $21^d\ 4^h\ 26^m$ II. Sh. I. These are all in the evening hours. The reappearance from eclipse takes place on the east of the disc, to the right in an inverting telescope.

TABLE 85. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance.		Reappearance.	
			Mean Time.	Angle from N. to E.	Mean Time.	Angle from N. to E.
1913.			h. m.		h. m.	
Dec. 5 ...	b^1 Aquarii	5·4	3 4 *e*	114°	3 44 *e*	176°
,, 8 ...	BD+ 9°142	7·1	5 42 *e*	105	—	—
,, 10 ...	BD+18°347	6·9	4 55 *e*	131	—	—
,, 10 ...	BD+19°432	7·0	9 7 *e*	56	—	—
,, 10 ...	47 Arietis	5·8	11 49 *e*	140	0 15**m*	181
,, 11 ...	9 Tauri	6·7	3 50 *e*	87	—	—
,, 11 ...	16 Tauri	5·4	8 15 *e*	14	9 2 *e*	299
,, 11 ...	17 Tauri	3·8	7 53 *e*	59	9 8 *e*	254
,, 11 ...	20 Tauri	4·1	8 47 *e*	22	9 41 *e*	293
,, 11 ...	23 Tauri	4·3	8 57 *e*	144	9 16 *e*	173
,, 11 ...	24 Tauri	6 8	9 20 *e*	113	..	—
,, 11 ...	BD+23°540	7·0	9 24 *e*	74	—	—
,, 11 ...	η Tauri	3·0	9 29 *e*	121	10 18 *e*	198
,, 11 ...	BAC 1171	6·6	9 59 *e*	82	—	—
,, 13 ...	BAC 1746	6·5	5 56 *e*	80	6 54 *e*	259
,, 14 ...	BAC 1848	5·6	1 19 *m*	99	2 33 *m*	269
,, 14 ...	BAC 1918	6·1	6 11 *m*	128	6 58 *m*	248
,, 14 ...	BD+27°1164	6·9	—	—	6 53 *e*	263
,, 14 ...	BD+27°1194	7·7	—	—	8 42 *e*	194
,, 16 ...	γ Cancri	4·8	9 38 *e*	45	10 11 *e*	343
,, 17 ...	BD+20°2232	6 9	—	—	4 10 *m*	208
,, 17 ...	8 Leonis	5·9	8 57 *e*	76	9 45 *e*	320
,, 20 ...	82 Leonis	6·7	—	—	0 33 *m*	323
,, 20 ...	83 Leonis	6·3	0 20 *m*	122	1 21 *m*	299
,, 20 ...	τ Leonis	5·2	0 55 *m*	121	1 58 *m*	303
,, 21 ...	BAC 4172	6·6	—	—	5 21 *m*	279
,, 22 ...	BD−10°3635	6·9	—	—	5 24 *m*	326
,, 31 ...	ι Aquarii	4·4	5 45 *e*	359	6 24 *e*	291

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

The asterisk indicates the day following that given in the date column. Attention is called to the occultation of the Pleiades, on Dec. 11th, the Moon being 2 days before Full.

SATURN is very well placed for observation, being in opposition on the 7th. Polar semi-diameter 9½″. P. is −4°·4; B−26°·4. Ring major axis 48″, minor 21″. The ring is approaching its maximum opening, and projects beyond the poles of the planet. It is interesting to measure the exact amount of overlap.

East Elongations of Tethys (every fourth given), $1^d\ 10^h{\cdot}1m$, $8^d\ 11^h{\cdot}2e$, $16^d\ 0^h{\cdot}4e$, $24^d\ 1^h{\cdot}5m$, $31^d\ 2^h{\cdot}7e$; Dione (every third given), $6^d\ 6^h{\cdot}2m$, $14^d\ 11^h{\cdot}1m$, $22^d\ 4^h{\cdot}1e$, $30^d\ 9^h{\cdot}1e$; Rhea (every second given), $6^d\ 0^h{\cdot}9m$, $15^d\ 1^h{\cdot}5m$, $24^d\ 2^h{\cdot}2m$. For Titan and Iapetus E.W. mean East and West Elongations; I. Inferior (North) Conjunctions, S. Superior (South) ones. Titan, $2^d\ 11^h{\cdot}8m$ E.; $7^d\ 1^h{\cdot}7m$ I., $12^d\ 9^h{\cdot}8e$ W., $18^d\ 10^h{\cdot}3e$ S., $23^d\ 4^h{\cdot}1e$ E., $28^d\ 6^h{\cdot}2m$ I.; Iapetus, $17^d\ 9^h{\cdot}1m$ E.

URANUS is an evening star, but badly placed.

NEPTUNE is a morning star, in Cancer.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant.		Remarks.
	R.A.	Dec.	
Nov. 25 to Dec. 12	189°	+ 73°	Rather swift.
Dec. 4 ...	162	+ 58	Swift, streaks.
,, 6 ...	80	+ 23	Slow, bright.
,, 8 ...	145	+ 7	Swift, streaks.
,, 8 ..	208	+ 71	Rather swift.
,, 10-12 ...	108	+ 33	Swift, short, conspicuous.
,, 12 ...	119	+ 29	Rather swift.
,, 22 ...	194	+ 67	Swift streaks.
,, 21-22 ...	117	+ 47	Swift.
,, 31 ...	92	+ 57	Slow, bright.

WESTPHAL'S COMET.—The following ephemeris covers the whole time over which the comet is likely to be visible with ordinary telescopes: it is likely to be a faint naked-eye object in November. The ephemeris is for midnight on the dates named.

Date.	R. A.	N. Dec.	Log. Dist. from Sun.	Log Dist. from Earth.
	H. M. S.	° ′		
Oct. 20 ...	20 53 39	17 4	0·1358	9·8141
,, 24 ...	20 47 24	19 53	0·1287	9·8271
,, 28 ...	20 42 27	22 30	0·1225	9·8409
Nov. 1 ...	20 38 30	24 56	0·1169	9·8547
,, 5 ..	20 35 26	27 22	0·1119	9·8682
,, 9 ...	20 33 24	29 40	0·1075	9·8809
,, 13 ...	20 32 8	31 53	0·1038	9·8932
,, 17 ...	20 31 51	34 8	0·1014	9·9050
,, 21 ...	20 32 28	36 20	0·1004	9·9163
,, 25 ...	20 33 54	38 25	0·1000	9·9266
,, 29 ..	20 35 56	40 27	0·1004	9·9361
Dec. 3 ...	20 38 16	42 33	0·1011	9·9444
,, 7 ...	20 41 24	44 41	0·1028	9·9519
,, 11 ...	20 45 52	46 49	0·1062	9·9594
,, 15 ...	20 51 8	49 0	0·1103	9·9662
,, 19 ...	20 57 32	51 9	0·1149	9·9727
,, 23 ...	21 5 4	53 21	0·1206	9·9786
,, 27 ..	21 14 0	55 38	0·1268	9·9847
,, 31 ...	21 24 48	57 50	0·1332	9·9907
Jan. 4 ...	21 37 0	60 17	0·1402	9·9964
,, 8 ...	21 52 8	62 29	0·1483	0.0026
,, 12 ..	22 9 56	64 44	0·1565	0.0087
,, 16 ...	22 31 28	66 59	0·1652	0.0154
,, 20 ...	22 55 16	68 57	0·1740	0.0231
,, 24 ...	23 29 0	70 37	0·1826	0.0315
,, 28 ...	0 5 56	72 12	0·1918	0.0400
Feb. 1 ...	0 48 36	73 14	0·2012	0.0500

The path lies through Vulpecula, Cygnus, Cepheus, and Cassiopeia.

Double Stars and Clusters.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

Variable Stars.—

Table 86. Non-Algol Stars.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m.	°		d.	
R Arietis	2 11	+24 ·7	7·5 to 12·7	186·66	Sep. 12.
R Ceti	2 22	− 0 ·6	7·5 to 12·8	166·88	Oct. 20.
U Ceti...	2 30	−13 ·5	6·6 to 12·7	235·2	Dec. 8.
R Trianguli	2 32	+33 ·9	5·9 to 11·1	265·4	Dec. 27.
Y Persei	3 22	+43 ·9	8·2 to 10·4	254·9	Nov. 2.
R Tauri	4 24	+10 ·0	7·4 to 13·8	325	Dec. 10.
X Camelop.	4 35	+75 ·0	7·5 to 13	141·5	Nov. 18.
T Leporis	5 1	−22 ·0	7·7 to 8·9	366·5	Dec. 6.
S Camelop.	5 32	+68 ·7	7·8 to 10·8	330	Dec. 20.

Principal Minima of β Lyrae Dec. $4^d\ 1^h e$, $17^d\ 11^h m$, $30^d\ 9^h\ m$. Period $12^d\ 21^h\cdot 8$.

Algol minima Dec. $3^d\ 6^h\ 18^m e$, $6^d\ 3^h\ 7^m e$, $15^d\ 5^h\ 34^m m$, $18^d\ 2^h\ 23^m m$, $20^d\ 11^h\ 11^m e$, $23^d\ 8^h\ 0^m e$, $26^d\ 4^h\ 49^m e$. Period $2^d\ 20^h\cdot 8$.

SOLAR DISTURBANCES DURING SEPTEMBER, 1913.

By FRANK C. DENNETT.

September has yielded very little appearance of activity upon the Sun to the ordinary telescopic observer, although to the spectroscopist there does seem to be some increase. No observations were made on two days during the month (1st and 5th), spots were recorded on six days (6th to 10th and 16th), and faculae on nine others (3rd, 14th, and 24th till 30th). On the remaining thirteen days the disc appeared clear. On September 1st the Central Meridian was 37° 27′ at noon.

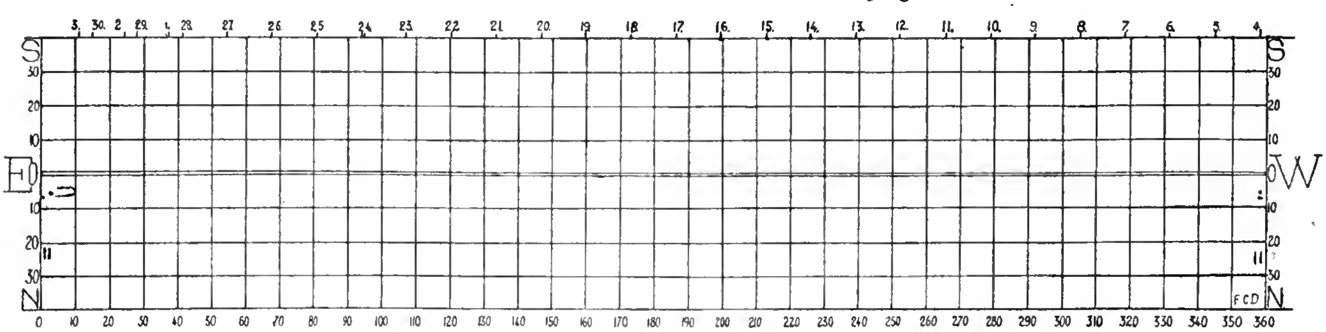
No. 11.—So late as 10 a.m. on September 6th the disc was reported clear, but at 1.20 p.m. a small irregular penumbraless spot was recorded. On the 7th it had four or five smaller companions, some bridged over, hydrogen flocculi were lying about the area, causing displacements of the C-line, first to red and later to violet. On the 8th the leading spot had increased somewhat, and a trailer spot with small companions had developed. Prominences were seen in projection over the group, as well as dark hydrogen flocculi. On the 9th only some members of the leading group visible, edged with brightness, and on the 10th, at 8 a.m., just one pore was left amidst the group of faculae which marked the area; but it was gone by midday. The group reached a length of 45,000 miles on the 8th. The dark line of helium, D_3, was traceable over this disturbance on the 7th, 8th, and 10th.

On the 16th, at 8 a.m., there appeared to be traces of pores on several parts of the disc, the largest being in South latitude some two days past the central meridian, and therefore near longitude 227°.

Faculae were seen near the eastern limb, well to the north, on the 3rd; on the 7th a small facula near longitude 258° and 60° N. latitude; on the 14th several bright flecks appeared scattered over the disc. Faculic flecks were persistently visible in the region within 20° of the north pole, records being made on the 24th and 27th to 30th; a faculic region over, and just ahead of, the area of No. 11, within the eastern limb, seen from the 25th until the 27th.

The observers whose work has contributed to this note have been Messrs. J. McHarg, A. A. Buss, C. Frooms, E. E. Peacock, and the writer.

DAY OF SEPTEMBER, 1913



CORRESPONDENCE.

LIGHTNING FLASHES.

To the Editors of "Knowledge."

Sirs,—During the evening of Tuesday, December 5th, 1911, a most vigorous but short-lived thunderstorm developed some distance to the north-west of Johannesburg. The flashes of lightning, which were principally cloud-earth discharges, were very brilliant, and followed one another at short intervals. I had a whole-plate Sanderson camera practically ready for action, and set this up on the stoep of my house (facing northwards) as quickly as possible. As I had a focal-plane back on the camera, I opened the slit to the width of the plate and decided to expose by withdrawing the slide of the plate-holder, the lens cap not being at hand. Generally in photographing lightning one has to wait for a little time to secure a good flash, but on this occasion there were a number of bright flashes whilst I was in the act of withdrawing the slide. The bright flash to the right of the centre of Figure 507 was the first to occur. At the moment I was not certain whether the flash was too early for me. It was followed almost immediately by the great flash which appears on the left of the picture, and on seeing this I closed the plate-holder at once. The plate was exposed at 7.45 p.m., and was developed at 8.5 p.m. on the same evening. The centre flash is seen to be multiple, showing six or seven discharges. The displacement of the individual flashes is due to the fact that the flash occurred whilst I was withdrawing the plate and the camera was oscillating slightly. The large flash on the left of the picture also shows a similar effect. This flash was much nearer to the camera than the two flashes near the middle of the picture; the latter are beyond a low cloud, whereas the former is in front of this cloud.

The successive strips into which the negative is divided puzzled me whilst the plate was developing, but the explanation soon suggested itself. They represent flashes which occurred during the short interval occupied in opening (and possibly also closing) the plate-holder, which were not in the field of view of the camera, but were near enough to produce a fogging effect. The time taken for the double operation of opening and closing the dark slide I found was nearly three seconds, and in this interval there were at least twelve flashes.

Another plate was exposed at 7.50 p.m. on the same evening, and as the storm was then much more distant the camera was left open for some time. On developing, three small flashes were seen to have impressed themselves (see Figure 506) and, very strangely, they were all photographically different, *i.e.*, one gave a normal image, the second a reversed image, and the third a re-reversed or solarised image.

H. E. WOOD (F.R.Met.S.).

Transvaal Observatory. Johannesburg.

MARS.

To the Editors of "KNOWLEDGE."

SIRS,—In your issue of August, there appeared a letter from M. Antoniadi with reference to a letter of mine which appeared in your June issue. In discussing the questions arising from these letters, I will endeavour as far as possible to dispense with arguments *ad hominem*, and confine myself to arguments ***ad rem***.

M. Antoniadi declares that I misunderstood the purpose of his article in the May issue of your journal ("Considerations on the Physical Appearance of the Planet Mars," pages 193-196). If my interpretation of this article (which is set out in my letter in your issue of June) is incorrect, I had ample excuse for being mistaken. The scorn which in this article M. Antoniadi pours on those who are not of his way of thinking would, I think, justify anyone in supposing that he claimed that his views held the field in science. The motive which led me to criticise M. Antoniadi's article was not an anxiety to contradict, but a desire to point out to the uninitiated reader that his views are by no means universally accepted by men of science.

I am satisfied on the not very important point that there are instances where the canals have been represented out of perspective. Taking into consideration the extreme delicacy of these objects, and indeed they are so delicate as to require the most favourable conditions for observation, and even in the fine air at Flagstaff a disturbed atmosphere at times blurs them out of recognition, it is not surprising that errors of this nature occasionally occur.

M. Antoniadi seems to have altogether failed to understand my meaning when I showed (I hope satisfactorily) that it is not legitimate under any circumstances to represent as indistinct and vague an object which is seen as clear and defined. It is quite possible that if the image of Mars in the telescope could be so enlarged that with perfect definition it appeared the same size as a drawing three inches in diameter held at a distance of one foot, features which under ordinary circumstances appear sharp might appear exceedingly vague and undefined. But, on the other hand, it is also possible that they would appear as sharp and defined as they actually do under ordinary circumstances, with the possible addition of smaller canalian features. This is a question which cannot at present be decided. M. Antoniadi's analogy of a sixpence is a false one. It is true that if a sixpence (or almost any other artificial production) is greatly enlarged its details become vague. This, however, is not true of most objects of nature, in many cases the original details remaining sharp and well defined, and finer features coming into view. If a sixpence were struck of the size of three inches, all the details being perfectly defined, and then reduced to the size of an ordinary sixpence, an enlargement of it to its original size would not show the details vague. It is thus impossible to ascertain without experiment what the appearance of an object will be on enlargement. In recording observations by drawings it is therefore only legitimate to draw exactly what one sees, and it is not legitimate to make a drawing showing what one thinks the planet's appearance would be if it could be seen as large as the drawing. Such a method is drawing beyond one's vision.

Then with regard to photography. In the perception of light and shade contrast the camera is superior to the eye. Hence the great value of the camera in the perception of faint stars and strands of nebulosity and of the light and dark areas of the planet Mars. But it must be admitted that for the perception of fine, sharp detail the camera is not as efficient as the eye. Far more detail has been seen on the moon than has ever been photographed. Poor would be the observer who could see on the moon no more detail than appears on the very finest lunar photographs. In the Martian photographs all the finer detail of the planet's marking is blurred almost out of recognition. It is claimed, however, that canals are indicated even on photographs. It is noticeable that the photograph of Mars given on page 194 in your May issue shows almost as much detail as does M. Antoniadi's drawing of the same region. For light and shade studies of the planet M. Antoniadi's drawings are, undoubtedly, worthy of the highest admiration.

It is useless to go again into a discussion on the advantages of using large and small apertures. It is a matter which must depend on practical experiment. Professor Lowell, after many years' experience with a telescope of the finest make, situated as M. Antoniadi admits in the finest atmospheric conditions, appears to have found that his best results are not obtained when he is using his full aperture of twenty-four inches.

It may be interesting if I make a quotation which refers to Professor Lowell's observations from a book entitled "Is Mars habitable?" by Professor Wallace, F.R.S., who is as much opposed to the theory of the artificiality of the canals as is M. Antoniadi. He writes on page 14 of this book, in reference to one of Professor Lowell's works, "No one can read this book without admiration for the extreme perseverance in long-continued and successful observation the results of which are here recorded, and I myself accept unreservedly the whole series."

I believe that much of the dispute as to the existence or non-existence of the canals as straight lines arises from a confusion between acuteness of vision (or the perception and separation of fine detail), and sensitiveness to impression (or the perception of faint contrasts). The two qualities rarely go together in a high degree though one is often erroneously taken as a guarantee of the existence of the other.

J. E. MAXWELL.

84, DARTMOUTH ROAD, N.W.

REVIEWS.

CHEMISTRY.

Laboratory Text Book of Chemistry.—By V. S. BRYANT, M.A. Part I. 246 pages. 10-in. × $7\frac{1}{2}$-in.

(J. & A. Churchill. Price 4/- net.)

The method upon which this text book is based is excellent, for it aims at suggesting the use of experiment at every stage of its course. From the very first the student is encouraged to test facts and statements for himself, and the danger of his learning the theoretical part of the science by memory is guarded against by the use of supplementary questions, the answers to which will require thought. The present part includes the fundamental principles of chemistry, and the elements, ogygen, hydrogen, and nitrogen, and their chief compounds; and a further section is promised dealing in the same thorough manner with valency, oxides, carbon, and sulphur. Diagrams are provided where necessary, and blank spaces and pages are left for pencilled notes by the teacher or student.

C. A. M.

General Index to "The Chemical News."—Vols. I–C. 712 pages. $10\frac{1}{2}$-in. × $7\frac{1}{4}$-in.

(The Chemical News Office. Price 40/-.)

Not only subscribers to *The Chemical News*, but others who wish to consult its pages, and others again who may now be tempted to seek for information, will appreciate the issue of a general index to Volumes I to C of the periodical in question, which appeared between the years 1860 and 1909. The amount of labour entailed must have been very great. The detail which has been gone into is shown by the fact that subjects and authors are both given, while many of the former are subdivided, and cross-references have been introduced. Although the index contains two thousand one hundred and thirty-six columns, the book is of a convenient size and is only an inch and five-eighths thick. All chemists should show their appreciation of the enterprise of *The Chemical News* by adding this valuable index to their library.

W. M. W.

ENGINEERING.

Continuous Beams in Reinforced Concrete.—By BARNARD GEEN, A.M.I.C.E., M.S.E., M.C.I. 210 pages. 14 illustrations. $11\frac{3}{4}$-in. × $8\frac{3}{4}$-in.

(Chapman & Hall. Price 9/- net.)

Continuity in reinforced concrete structures is at the same time one of the most advantageous features possessed by the material and one of the difficulties that has to be dealt with by the designer. In steel structures continuity of beams can to a great extent be avoided. In reinforced concrete the monolithic nature of the structure makes such an easy solution of the problem impossible. Considerable experimental work has been done on the question of continuity of structures by the French Government Commission and other bodies, but hitherto the literature of the subject has lacked a simple and reliable guide to the stresses to be expected in continuous beams.

Mr. Geen has isolated the question of their determination, and has worked out the bending moment and shear diagrams for two, three, and five spans under five different forms of loading. These diagrams have been combined, so as to give directly the maxima positive and negative shears and bending moments to be provided for in the cases dealt with.

In addition, such closely allied questions as the haunching of beams, the bending stresses in columns due to the continuity of the beams, the effect of subsidence of the supports, and some features of tests of structures are also briefly dealt with by the author.

The book is a useful contribution towards filling a decided blank in the literature of reinforced concrete. The author wisely stops at the determination of the stresses, and does not proceed to discuss the method of determining the sections necessary to resist them. That has been dealt with *ad nauseam* in the literature of the subject.

The scheme of the work is unconventional. Out of a total of two hundred and ten pages only some thirty-seven are occupied by explanatory letterpress, the remainder being devoted to diagrams and tables. The omission of the usual padding and the general clearness and conciseness of the letterpress enhance the value of the work and increase its usefulness as a reference work for practical men.

N. M.

MICROSCOPY.

The Microtomist's Vade-Mecum.—By ARTHUR BOLLES LEE. 7th edition. 526 pages. 9-in. × $5\frac{3}{4}$-in.

(J. & A. Churchill. Price 15/- net.)

Since the first appearance of this book in 1885 no fewer than seven editions have been called for, and no better testimony to its value as a work of reference could be wanted. It is one which every microscopist who does any real work, as well as every biologist who makes researches, must consult again and again. That it has been once more brought up to date is matter for congratulation, and that the new edition should be in the hands of everyone interested is shown by the fact that the index alone gives more than seven hundred new entries.

W. M. W.

ZOÖLOGY.

Notes on the Natural History of Common British Animals and some of their Foreign Relations. Vertebrates.—By KATE M. HALL, F.L.S., F.Z.S. 289 pages. 64 illustrations. $7\frac{1}{2}$-in. × 5-in.

(Adlard & Son. Price 3/6 net.)

Miss Hall's object in writing this book is to give those who are engaged in the busy routine of elementary teaching such information as she thinks would be of great service to them in interesting boys and girls in our common British animals. We think that Miss Hall has most successfully fulfilled her purpose. To get together anything like the amount of material which is here brought into convenient compass, very much reading would have to be done, and it is quite probable, not to say practically certain, that those who lack the Author's training and experience would overlook many of the very interesting points which give the book its charm. It will appeal strongly, not only to the teachers for whom it is meant, but to all those whose tastes lead them to love natural history.

W. M. W.

NOTICES.

LIEBIG'S LABORATORY—A CORRECTION.—Figure 395, which was labelled Liebig's Laboratory, is in reality from a photograph of a Pharmaceutical Laboratory of the eighteenth century, reproduced at the Historical Medical Museum.

CHANGE OF ADDRESS.—Messrs. Wratten & Wainwright, Ltd., have removed from Croydon to Kodak House, Kingsway, W.C. A new factory has been erected for them at Wealdstone, which will enable them to enjoy all the resources of the Kodak plant.

SECOND-HAND APPARATUS.—Mr. Charles Baker's catalogue, No. 53 P, contains a classified list of second-hand photographic apparatus. This is kept separate from other second-hand instruments, of which catalogue No. 54 has just been issued, containing more than two thousand items, all of which are guaranteed to be in perfect working order.

ZOÖLOGICAL BOOKS.—The most recent of Messrs. John Wheldon & Company's catalogues contains nearly twelve hundred entries dealing with the Invertebrata, exclusive of Insects.

Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

DECEMBER, 1913.

STELLAR SPECTROSCOPY FOR BEGINNERS. II.

By PROFESSOR A. W. BICKERTON, A.R.S.M.

Sound and Light.

We speak to one another by means of the vibrations of air; the stars tell us their story by the movements of a medium we call ether, which is perhaps best conceived of as a highly elastic jelly. We cannot see the air, but we can feel it, and when it moves swiftly enough it may knock us down or hurl us over a house. We can neither see nor feel the ether, yet able men tell us we have more proof of the existence of ether than of matter, while some think matter is ether in motion. Air and other matter are made up of little moving particles of extreme minuteness called "atoms."

Atoms.

A popular way of putting the size of atoms is to say that there are more atoms in a drop of water than drops of water in the Atlantic Ocean.

Perhaps the best way of realising some of the properties of atoms is by means of a little instrument Sir William Crookes made and called the sphinthariscope. By means of this pretty toy one can see the effect of swift atoms of helium hitting a surface of sulphide of zinc, each blow producing a flash of light. The point of a needle is coated with a little radium and placed in front of the zinc surface, which thus becomes luminous. Solid radium is for ever breaking up into other elements and becoming a heavy and a light gas, and it takes two thousand years for radium to half become gas. In thus changing, each heavy atom of radium loses a light atom of helium and becomes the atom of another heavy element called "niton," or "radium emanation," which is a gas. The element helium is extremely important in stellar spectroscopy, and we require to know a lot about it; at present we want to form an idea of the minuteness of the atom. The zinc surface, with the radium-coated needle in front, is put at the back of a little brass box with a small convex lens in front. This instrument is called a spinthariscope or scintilliscope. On looking through the lens in a perfectly dark room, each individual atom of helium as it strikes the sensitive surface makes a flash of light. One sees hundreds of such flashes each second. In some spinthariscopes this has been going on for years, and will do so for thousands of years more without much apparent diminution of the number of escaping atoms of helium. Heat or cold makes no apparent difference in the speed of escape of the helium atoms, and no physical or chemical treatment seems either to hurry up or in any way change the rate at which these atoms—the so-called "alpha particles' —leave the radium. Such, then, is the minuteness of the atom.

An atom, although so small, is of wondrous complexity, but for purposes of spectrum analysis we had best think of them as little spherical bells flying about in all directions, ringing for a little time after they hit one another, and, like bells, ringing true to tone. Like other bells also they alter the character of the note according as to how hard and how often they are struck. Heat makes atoms move faster, and so when a gas is heated the particles hit harder, and more overtones are produced. There is a wonderful complexity in these atomic overtones; the atom of iron gives off thousands; some atoms seem to be much less complex. Many atoms seem to be like compound bells, as though made up of many bells of different tones fixed together.

Helium appears to be a very complex atom ; in fact it seems to be an inseparable double atom, each part being groups of bells. In it, however, one characteristic tone rings out so clearly that midst the complexity we can recognise helium by a line of a pure yellow tint.

Colour.

The vibrations of a sheep bell we call sound; those produced by the atoms we call colour ; so it is by colour the stars tell us their story. In the spectrum the pure tints of singing atoms stand apart, each in its proper place and so form the cipher messages that reveal the mystery of the stellar heavens. These ciphers are being gradually deciphered and read by our industrious observers.

But "when the mind is blind the eye does not see." What are wanted are guiding hypotheses, and on all sides workers are awakening to this need. Now their want is felt, the keys to open the doors of the mind to see the richness of the corridors of space and the many mysteries of Creation will surely be forthcoming.

Some of these cosmic keys were found a long time ago, but have only just begun to be used ; yet already they have opened up many rich realms of Nature.

Vibrations.

Sound and light are both examples of propagation of vibrations by wave motions. One gains a good idea of wave motion by watching a field of ripening wheat when moved by the wind. The waves travel the length of the field, yet one knows the individual heads remain each on its own stalk ; each constituent of the wave only oscillates. Ear after ear moves in succession, and so the motion looks to be one of translation.

If a stone be thrown into the middle of a still lake, the disturbance starts a series of waves that travel until they reach the margin of the water. Yet although the waves travel outwards, a cork on the troubled waters merely moves up and down.

The speed of the wave depends on the elasticity and density of the medium ; elasticity increases and density diminishes speed. Elasticity in the air is perhaps best understood by resistance to compression. Make the air in a football hot, and it resists compression more, and is more elastic. The reason is that the particles of air fly faster. The velocity of a sound wave in a gas depends on the speed of the moving molecules of the gas. Thus, at the same temperature, hydrogen particles move four times as fast as oxygen particles. So sound travels four times as fast in hydrogen as it does in oxygen.

A tuning fork strikes a gas particle as a bat does a ball, and it bounces away a minute degree quicker than it came. It hits its next particle more quickly than normal, and so a wave is produced. Sound waves are often many feet in length and travel one thousand one hundred feet a second. Light waves are many thousands to the inch, and travel one hundred and eighty-six thousand miles a second.

A tuning fork may only move one hundredth of an inch. Yet it produces waves of sound that travel thousands of times as fast as its own motion, and the speeds of these waves differ whether they be transmitted by gas, liquid or solid ; for example, if they travel in air, in water, or in glass.

The curious thing is that the wave travels fastest of all in the densest of these three substances. Not, however, because it is dense—density reduces the speed of progression—but because it is more elastic; it recovers from compression more energetically. How are we to explain these phenomena? We may do so as suggested by imagining the tuning fork to be a bat, hitting swift molecular balls thrown by a demon bowler. The bat causes the balls to bound back quicker than they come. In the case of liquids and solids potential energy of molecular and cohesive attraction has been converted into molecular kinetic energy, so the molecules oscillate quicker than in gas. Molecular and cohesive attraction make the liquid and solid more elastic.

Light.

A beam of common white light is one of the most complex things in existence. The waves of sunlight are of many lengths and move in many planes. In this respect the motion of sunlight is more complex than the motion of the air when stirred by an orchestra.

The vibrating particles of air, as the waves come from a musical instrument, move in the line of propagation towards and away from us; not so light. In the ether waves the motion is across the direction from which the light is coming. As the waves enter the eye the motion may be horizontal, or vertical, or in any plane. In common light they move in all planes—in all azimuths, as astronomers say. When they are sorted out so as to move in a single plane we say the light is polarised. An instrument called the polariscope is used to so sort the waves of light. A sound wave cannot be polarised ; its sides do not differ. In plane-polarised common white light the ether moves in one plane only, but its waves are of many lengths. It is the work of the spectroscope to sort the waves into their different lengths. Light consisting of such separate waves moving in one plane is said to be pure monochromatic polarised light. A ray of polarised light of any pure tint is the simplest conception we can have of any beam of light. We picture it best by imagining a tightly stretched skein of silk being jerked, and watching the waves travel along the length of the silk. Let us imagine an atom of sodium to be vibrating, and picture the successive motions in the ether as moved by the yellow beam of light after it has passed through a polariscope. Some transparent crystals have a structure like a gridiron with very close bars. These minerals only allow the vibrations of light to pass in one plane. Such a crystal is a polariscope ; there are many more effective kinds of polariscopes, but the action of these crystals is easy to imagine.

Polariscope phenomena are not often studied in spectroscopy, and will not here be further developed.

REFRACTION OF LIGHT.

A wavy line is a fair representation of a simple ray of light of a pure tint polarised in a plane (see Figure 515). In this each particle has moved on its upright line, and the wave has advanced. A beam of common white light is made up of myriads of such waves of different lengths moving in different planes. It is the duty of the spectroscope to sort and to spread these mixed colours into a long strip in which the waves of different lengths stand out distinctly in the order of their speed or length. This sorting is effected by

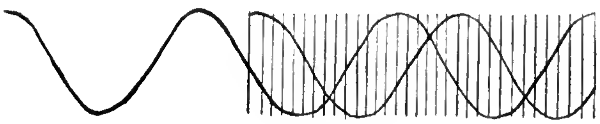


FIGURE 515.

prisms or by a parallel set of very close, fine lines ruled on metal or glass, and called a grating. We will try to understand the action of a prism on a ray of light. As long as a beam of light travels in a

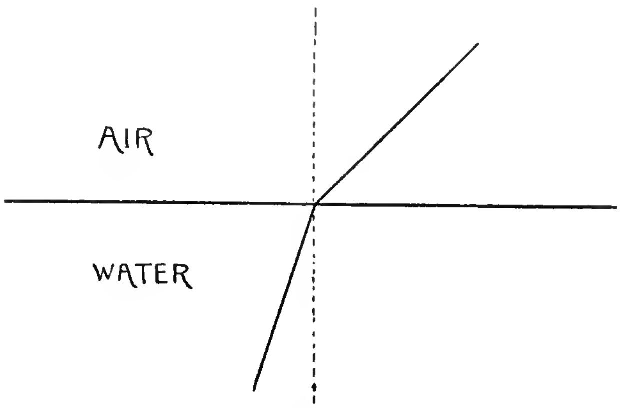


FIGURE 516.

uniform medium, such as still air or still water, it moves straight forward at a uniform speed. In

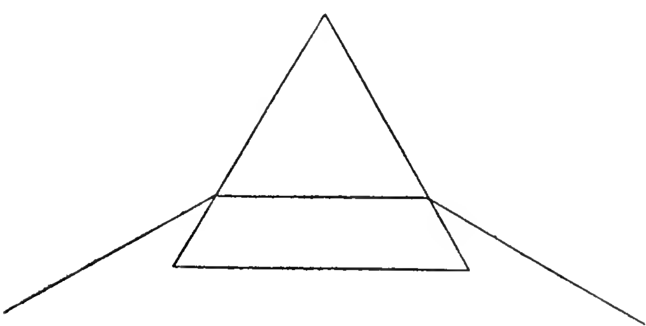


FIGURE 517.

passing from one medium to another a beam of pure light alters speed, and if it falls obliquely on the plane surface of separation it is bent at an angle. If the ray be a pure tint it is bent as in Figure 516. If the pure ray pass through a prism of glass it is bent both on entering and leaving, as in Figure 517.

REFRANGIBILITY OF LIGHT.

A white beam of light may be made up of two pure complementary colours. The best colours to

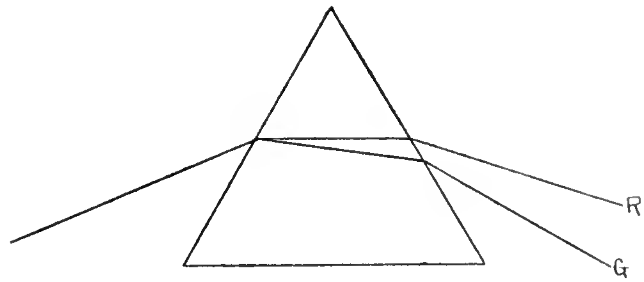


FIGURE 518.

use are green and red. If such a white beam passes through a prism the two colours are differently bent, and so separated as in Figure 518.

The white beam of light from an "Osram" filament lamp has a myriad of different wave-lengths. Those the eye can see, range from about thirty-three

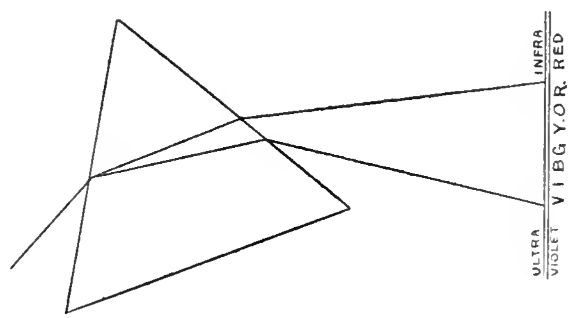


FIGURE 519.

thousand to sixty thousand to the inch. In this case the prism separates them into a rainbow-tinted streak with the red at one end and the violet at the other, in the order shown in Figure 519. The red is

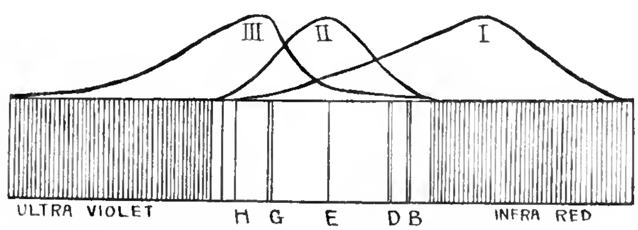


FIGURE 520.

least bent; then in order come orange, yellow, green, blue, indigo, and violet. All the colours shade into one another and there are thousands of tints, each of a different wave-length. In popular lectures, to give an idea of what has happened, I use the simile of a crowd.

SIMILE TO PICTURE A SPECTRUM.

If a strong light shone on a crowd dressed in all the colours of the rainbow, at a distance the crowd would appear to be clothed in white.

Suppose the crowd of many thousands to be made up of individuals of all heights, the tallest about twice as high as the shortest. The tallest are dressed in deep red, then as they are shorter the tint gradually becomes crimson, then passes to scarlet, to orange, to yellow. The individuals of intermediate height are yellow-green, still shorter blue-green, then follow all the tints of blue, of indigo and violet down to the lavender-grey, which some eyes can see and others cannot. Colour-blind men might not be able to see the tall ones. Eyes differ in their power to see the two ends of the spectrum. All the crowd exactly keep up with one another. The tall red fellows stalk along, and the little weak violet ones run to keep up, the size of the stride representing the wave - lengths of various coloured light. Every individual proceeds forward in an exactly straight line. Then they come to the prism; it is a strong turning impulse. Imagine a blast of wind blowing at right angles to the travelling crowd. It turns them all a bit, but the little weak ones, the violet, are turned much more than the strong red, and all the intermediate tints are turned in proportion to their speed of step or their shortness or weakness. All three ideas are important. Then, after passing the impulse of the prism, again they go straight forward. If the crowd be a very narrow one it corresponds with a narrow slit. At once it begins to sort itself into its constituent colours. The crowd broadens as it travels; after a time instead of a mixed crowd its front is a long orderly line of individuals, a rainbow-tinted streak, a spectrum, with the short violet waves running at one end, and the tall red stalking along at the other end. Supposing the individuals of a certain height were truants, there would be a gap, as when the electric arc shines through a sodium flame. Supposing there be many truants of different wave-lengths then there will be many gaps, and we get the analogy of the solar spectrum.

HEAT AND CHEMICAL ACTION.

White solar light is even more complex than the coloured crowd: there are taller fellows than the longest red and shorter than the shortest violet; they are in invisible grey, and the eye cannot see them. The long waves are strong and the short waves tricky. The big slow waves act as robber brigands; they can knock a whole molecule and start it flying. The little waves are weak thieves that cannot deal with a whole molecule, but can steal his atoms.

The invisible ultra-violet waves are better pick-pockets than the strong invisible infra-red. In the solar spectrum the greatest energy is in the heat-waves at and beyond the red end. The chemical or actinic power of the spectrum is near and beyond the violet end. The long waves are heating because they move the whole molecules; the short waves are photographic because photography depends on loosening and breaking up the molecule. The chloride of silver is pulled to pieces and the silver deposited by the quick vibrations of light that are not powerful enough to do much in the way of moving the whole molecule and so heating the compound. The height of the parts of the three curved lines in Figure 520 gives the value in the entire solar spectrum of its three properties; that is, its energy or heat, its light as it affects the eyes, and its actinism or power to pull molecules to pieces. The power to pull to pieces is also feeble energy, so energy is in all parts of the spectrum; but generally the higher the temperature the greater is the ratio of light to heat and the actinic power to the total energy. Generally, also, the higher the temperature, the greater the number and complexity of overtones the atoms produce as they strike one another. Heat being molecular indiscriminate motion, the velocity of molecules increases with the temperature. If a platinum wire be heated by an electric current and used instead of a slit, and looked at with a prism fixed over a hole in a large card with the parallel edges of the prism held parallel to the platinum wire, a good spectrum of the hot wire will be seen. Of course, one does not look directly towards the wire, but in the direction the rays are bent by the prism. When the current is such that the wire is just visible a red mass of light is seen. As the resistance is lessened and the current increases, the wire brightens, and as it does so the red glow spreads to orange, then yellow is added, and other successive colours of the rainbow show themselves. When the platinum is near its fusing point, a magnificently perfect spectrum of great purity is produced. Thus we see the effect of increased temperature in extending the spectrum towards the violet; that is, in increasing the speed of movement of the molecules and consequently lessening the wave-lengths. This is the effect when we heat a solid; because its molecules cannot move freely, it is like a mass of touching bells from which by shaking we can only get a jangle of noise and no music. The tightly fixed atoms of a solid have no room for free motion, so they can only jangle and give waves of every kind.

When a bell rings alone it gives a musical note, and when a vibrating atom is free in a rare gas it gives colours; often of many very pure tints.

The colours in the spectrum of a star tell us its story. The instrument we read the cipher message with is the spectroscope, and the tale it tells us depends on our understanding the laws of light and widely correlated sciences.

(To be continued.)

From a photograph *by J. H. Worthington.*

Figure 521. Flash spectrum obtained near Ovar, Portugal, 1912, April 17th, during a total solar eclipse, with a prismatic camera consisting of a 2·1 inch Achromatic Quartz and Rock-salt lens of 50 inches focus with two 50° Quartz prisms in front of it. Exposure, about ¼-second. The photograph from which this is taken is unique.

(See "Knowledge," November, 1913, page 408.)

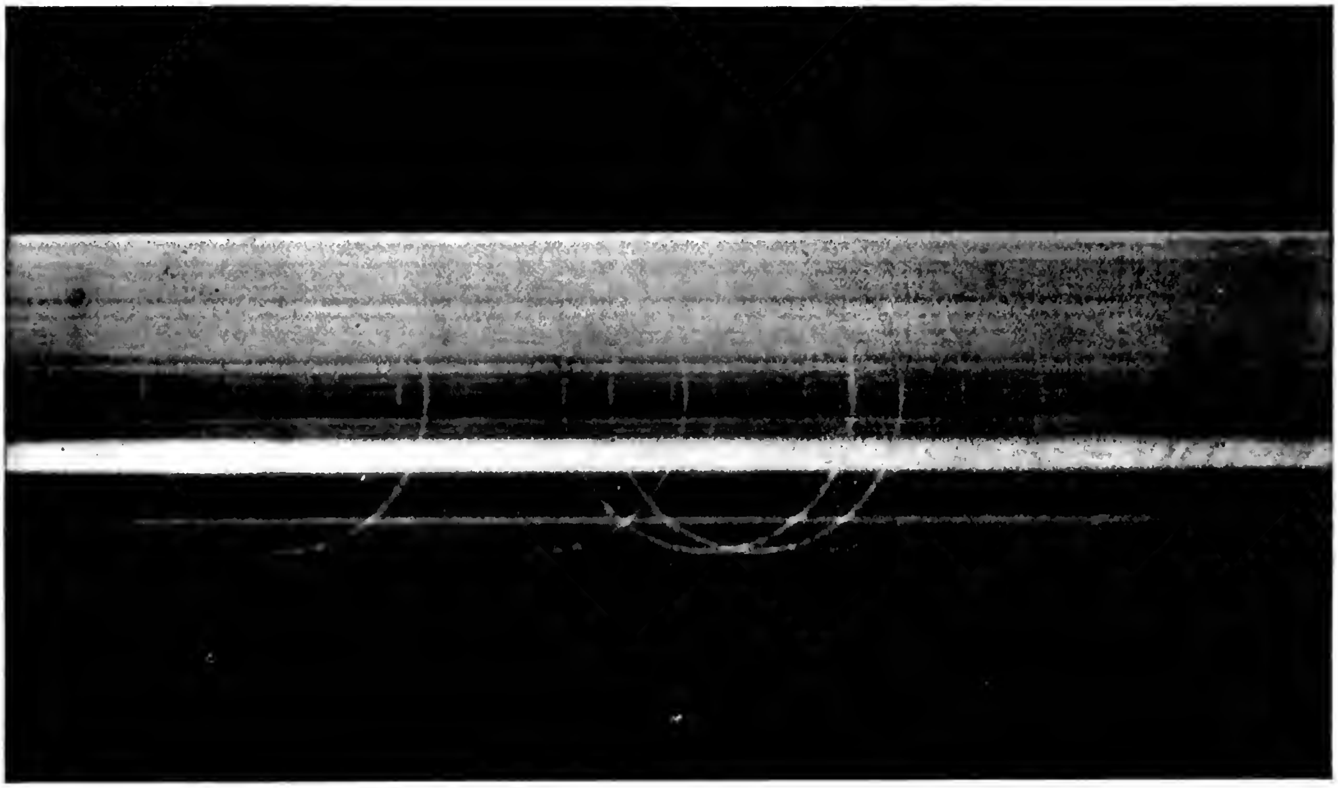
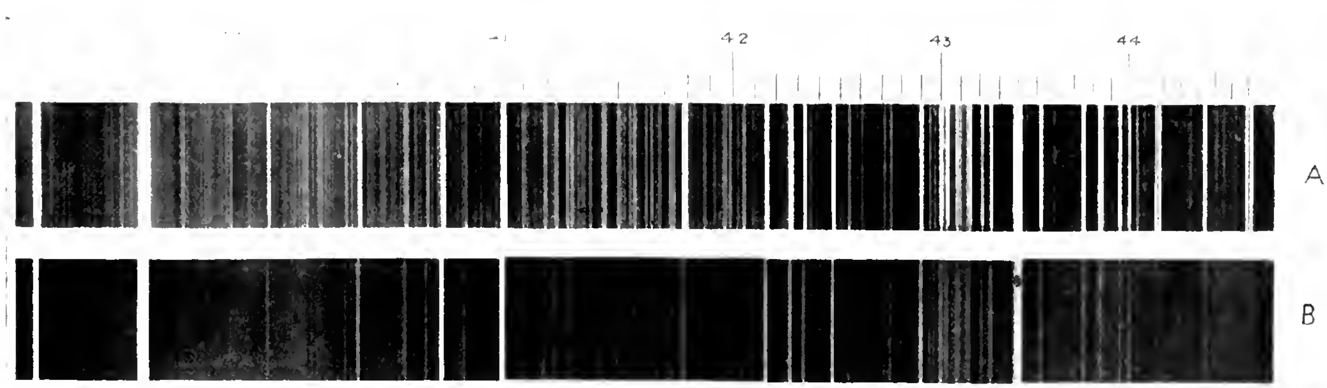


Figure 522. An enlargement of a portion of the flash spectrum shown in Figure 521.



From spectrograms taken with a 2-prism flint spectroscope *by E. H. Hills, Pulgaon, India, January 22nd, 1898.*

Figure 523. A* and B†, spectra showing the flame bands of the reversing layer of the Sun seen during an eclipse. Compare the definition and straightness of the lines in these spectra, photographed through a slit, with the circles in Figures 521 and 522.

* At point of second contact. † At point of third contact.

FIGURE 524. Gannets in the Southern Hemisphere: *Sula capensis* on Bird Island.

FIGURE 525. British Gannets: *Sula bassana* on the Skellig, Ireland.

(From "The Gannet," by J. H. Gurney, by the courtesy of Messrs. Witherby & Co.)

REVIEWS.

AVIATION.

Aviation.—By ALGERNON E. BERRIMAN (late Technical Editor of *Flight*). 360 pages. 32 illustrations. $6\frac{3}{4}$-in. × $5\frac{3}{4}$-in.

(Methuen & Co. Price 10/6 net.)

Mr. Berriman has attempted a Herculean task. He has not only endeavoured to cover the entire ground of a tremendous subject, but he has aimed at producing a book that shall appeal to the whole range of possible readers—from the tyro whose knowledge of flight is limited to a single visit to an aërodrome, to the experienced aviator desirous of understanding the rationale of his movements in the air, or the aëroplane constructor aiming at the perfect machine.

In a measure the author has accomplished the feat. In one sentence he explains that an aëroplane does not flap its wings; in another he becomes severely technical over the differential negative warp. Some really admirable simple examples and experiments, that the schoolboy will delight in, are followed by formulae of Pressure and Resistance Constants. This is well enough, but the reader of the entire volume is left wondering whether the attempt has really been worth while, or whether the schoolboy and the aviator may not both be slightly disappointed.

The only conceivable way in which such a task could be accomplished is in a series of separate articles, and it is of this that the volume with its twenty-four appendices really consists. But the arrangement of these chapters might well have been improved upon. The chronology is intentionally turned upside down, but the result is a loss of sequence and coherence. Many things come over twice; nor does the choice of subjects always seem wise. A description of the various makes of aëroplanes would have been more interesting than the Official Report of the Military Trials of 1912.

Nevertheless the book is inspiring and one to delve into; for it is full of good things. The debt that aviation owes to Sir George Cayley is acknowledged more fully than ever before, and it is pointed out how aëroplane gliders might have been in use centuries before any sort of engine was known. "If the brave spirits of those times had sought to emulate the soaring feats of birds, there is very little doubt but that a man at the present day would be as much at home in the air as he is, for example, in the water."

It may be questioned, by the way, if Mr. Berriman's description of the sensation of flying is the general experience. It is not the writer's, at any rate.

If this book is not wholly satisfying, it is at least brimful of information and interest. It is extremely well illustrated and produced.

G. B.

CHEMISTRY.

Rubber and Rubber Planting.—By R. H. LOCK, D.Sc. 245 pages. 32 illustrations. $7\frac{1}{4}$-in. × $4\frac{3}{4}$-in.

(The Cambridge University Press. Price 5/- net.)

So many industries are now dependent upon a plentiful supply of rubber that a book which describes in a simple manner the nature of indiarubber and the science and practice of planting the trees, should meet with a wide welcome. The authoritative account given by Dr. Lock is not only extremely interesting to read, but should also be of real value to the prospective rubber planter and to those who wish to interpret the prospectus of a rubber company.

Separate chapters are devoted to the physiology of the latex, planting and harvesting operations, and the pests and diseases to which the plant is liable. The book does not profess to deal exhaustively with the chemistry of the subject, but an outline is given at sufficient length for a non-chemical reader, while there is a clear summary of the different processes used in the manufacture of rubber goods.

The description of the industry gains much by the illustrations, which include ten full-page photographs of methods of tapping the rubber, diseased trees, apparatus, and so on, and excellent line drawings, specially made by Mr. Denton Sayers, of the different species of rubber-producing plants.

C. A. M.

Osmotic Pressure.—By A. FINDLAY, D.Sc., F.I.C. 84 pages. 2 illustrations. 9-in. × 6-in.

(Longmans. Green & Co. Price 2/6 net.)

The latest addition to the Monographs on Inorganic and Physical Chemistry is written by the general editor of the series, and deals with the subject of osmosis upon similar lines to those followed in the preceding monographs. Readers of "KNOWLEDGE" will recall the wonderful osmotic forms described by M. Leduc, and his remarkable theories as to the part played by osmotic processes in the development of life. It is another of the points of contact between physics, chemistry, and biology, and biologists in particular will welcome the appearance of a book which can be used as a laboratory companion. The subject is not intended to be exhaustively discussed, for the aim of the monographs in this series is to summarise the present condition of knowledge in each branch and to bring together the results of investigations which are widely scattered in scientific publications all over the world. References to the original papers and a full index increase the value of the book to the practical worker, while the general student of chemistry will here find an excellent outline of this branch of physical chemistry.

C. A. M.

Organic Chemistry for Advanced Students.—By J. B. COHEN, Ph.D., B.Sc., F.R.S. 427 pages. $8\frac{1}{4}$-in. × $5\frac{1}{2}$-in.

(Edward Arnold. Price 16/- net.)

In this work Professor Cohen amplifies and extends the course of lectures which he published six years ago, so as to give, not only a general historical survey of the rise of organic chemistry, but also an account of the recent researches showing the connection between physical properties and chemical structure.

Although full references are given at the foot of each page to the original publications quoted in the text, the book is intended rather to guide the student in the direction he may profitably explore than to serve as a reference handbook.

Starting with an outline of the history down to Kekule's theory, the author proceeds to discuss the valency of carbon, and summarises the facts which tend to prove that, contrary to the belief which was long regarded as almost an axiom, carbon need not necessarily be tetravalent, but may be tervalent or bivalent.

In the following chapters full outlines are given of the nature of organic reäctions, of their dynamics, of the relationship between physical properties and structure, and of colour and structure, and the book concludes with a good index of authors and a subject index. The various theories, which are not infrequently in conflict, are discussed at sufficient length, the arguments for and against them being fairly presented.

It is difficult to overrate the value of this book to the student. Organic chemistry was for far too long a time merely a storehouse of an immense accumulation of facts which were apparently uncorrelated. The aim of each investigator was to prepare a new crystalline compound, and so add another substance to the long list. But now the order underlying all these disconnected facts is gradually being unfolded, and this book of Professor Cohen will help all who seek its aid to grasp the new conceptions which are modifying the whole course of organic chemistry.

C. A. M.

GEOGRAPHY.

Japan's Inheritance (the Country, its People, and their Destiny).—By E. BRUCE MITFORD, F.R.G.S. 384 pages. 12 maps and plans, and 75 illustrations from photographs. 9-in. × 6-in.

(T. Fisher Unwin. Price 10/6.)

More than half the book describes the physical inheritance of Japan, mainly from a geological point-of-view, laying special emphasis on volcanic phenomena; here, as in all parts of the work, the author describes many personal experiences which give the reader a vivid impression of local conditions. Excellent photographs illustrate his descriptions; one longs for a better physical map. He adds a sober account of the present-day state of affairs in the country, warning us that the West and the East have only half learnt each other's lessons, so that there is danger ahead: America has not learnt to treat Orientals with due respect, and Japan, inevitably to be linked with China, has acquired no spiritual foundation to counterbalance its new materialism. Japan has a definite mission to the East, which can only be fulfilled satisfactorily if these defects are remedied. The book is well worth reading.

J. C. C.

The Continent of Europe.—By LIONEL W. LYDE, Professor of Economic Geography in University College, London. 446 pages. Physical maps of each country, and many diagrams. 9-in. × 6-in.

(Macmillan & Co. Price 7/6 net.)

In a closely-written book of over four hundred pages, Professor Lyde gives us a very interesting study of Man in Europe, as influenced by geographical factors such as surface-features and climate, based upon Europe's characteristic peninsular formation. For the sake of this study, he is prepared to accept the tetrahedral theory of the development of world-forms as a convenient working hypothesis; the surface-relief is examined in relation to this and its effect on the movements and habits of Man. His intimate knowledge of economic conditions and their correlation with the various physical controls renders the book worthy of careful study; he makes one realise that in the long run geographical conditions must play the fundamental part in shaping the characters and destinies of countries and their inhabitants. In Europe, especially, human history and sentiment count for so much that he rightly groups his matter around political units rather than "natural regions," and he shows great scientific ingenuity in tracing geographical influences in history. It is a most inspiring book.

J. C. C.

OCEANOGRAPHY.

The Ocean.—By SIR JOHN MURRAY, K.C.B., F.R.S. 256 pages. 12 plates. $6\frac{3}{4}$-in. × $4\frac{1}{4}$-in.

(Williams & Norgate. Price 1/- net.)

It is not easy to do justice to this excellent manual of Oceanography in a short review. From his great knowledge of the subject Sir John Murray has condensed into two hundred and forty-three post octavo pages a very extensive account of the Ocean from almost all points of view. In fact the book is so full of the latest facts and contains so little "padding" that it will serve almost as a textbook or work of reference for *Fachleute*, as well as a manual for the interested amateur. After detailing the methods of research, Sir John Murray passes on to the depth, salinity, and temperature of the Ocean. The difficult problems of "why the sea is salt" and why the percentage of carbonate of lime is so small in the waters of the ocean are explained, though perhaps hardly so fully as might be wished by the unlearned. We have not found reference to the recent suggestion that the sea contains much decomposing organic matter which may be made use of by many organisms hitherto believed to live entirely by the holozoic method of nutrition.

Tides and tidal waves are next touched upon, followed by an account of the difficult question of ocean circulation, the interesting condition of the Black Sea being sufficiently explained in the limited space at the author's disposal, though we think the Gulf Stream hardly receives sufficient attention. Plant and animal life are next dealt with, and the first part of Chapter VIII is perhaps the most interesting and stimulating portion of the book; the latter half is mostly a catalogue. The plates of marine organisms at the end of the book are rather too sketchy to be of much value. We note that Figure 16, Plate VIII is upside down. The nature of the marine deposits is very ably described and the author gives in this connection sundry cogent reasons for disbelief in "Atlantis" and "Gondwanaland." Finally the structure and interrelation of the various geospheres are discussed in a highly interesting manner. We can confidently recommend the book to all those—and they must number not a few—who would learn, from one who is *facile princeps* among living experts, something of the "wonders of the Great Deep."

M. D. H.

ORNITHOLOGY.

The Gannet. — By J. H. GURNEY, F.Z.S. 567 pages. 131 illustrations. 9-in. × 6-in.

(Witherby & Co. Price 27/6 net).

A striking testimony to the interest which is now being taken in British birds is Mr. J. H. Gurney's book on "The Gannet," for he devotes no less than five hundred and sixty pages to his subject. His sub-title is "A Bird with a History," and no one after reading his latest contribution to ornithology can deny that the Solan Goose has a long and interesting story. There was, some years ago, a fear that the Gannet might die out. We are glad to think with Mr. Gurney that its numbers are increasing, and that its fish-eating propensities are overlooked, while the traffic in its feathers is ended and the name Solan Goose is quite forgotten in the "trade." It is to the description of the bird's habits that many no doubt will turn. The fact that the birds show a considerable amount of affection for one another and indulge in caresses after the period of courtship is over, is of interest, as well as the curious way in which the birds gape from time to time, and the number of accidents which are responsible for their deaths. It might be deduced from the facts that the Gannet only lays one egg and takes three years to come to maturity that it is long lived, and a marked bird is said to have reached the age of eighty years. Mr. Gurney's book is really most exhaustive and fascinating, and goes into every kind of detail. On page 446 we are permitted to give two out of the many well-chosen illustrations.

PHYSICS.

Researches in Magneto-Optics.—By P. ZEEMAN, Professor of Experimental Physics in the University of Amsterdam. 219 pages. 74 figures. 9-in. × 6-in.

(Macmillan & Co. Price 6/-.)

The discoverer of the well-known "Zeeman effect" dedicates his monograph to the memory of Michael Faraday. The book itself is not unworthy of such an association. In clearness and completeness of exposition, in true scientific enthusiasm, and in generous recognition of the work done by others, it is a fit successor of the "Experimental Researches." To criticise such a book in a brief notice would be an impertinence, and to deal with it adequately would require more knowledge than the writer of these few lines possesses. He is capable, however, of appreciating the clearness with which the distinction between dispersion and resolving power of a spectroscope is made in the opening chapter. The book is an expansion of Professor Zeeman's lecture given at the Royal Institution in 1906, and has been written specially for Macmillan's series of science monographs. The translation of the Dutch manuscript seems to have been admirably done by Miss J. D. Van der Waals. The last twenty-five pages are filled with the bibliography of the subject. Evidently the book is one which every student of Physics should possess.

W. D. E.

STELLAR PHOTOGRAPHY FOR AMATEURS.

By W. H. STEAVENSON, F.R.A.S.

CONSIDERING the large and important part now played in astronomy by the photographic plate, it is strange that comparatively few amateurs are actively interested in this branch of the science. No doubt most users of telescopes have tried their hand at photography at some time or another, but such attempts are too often limited to the taking of a few snapshots of the sun or moon in the principal focus of the instrument, which is then applied once more to some line of visual work with results that are generally of questionable value. Without wishing for one moment to discourage useful visual work, it is the aim of the writer to show the great possibilities of stellar photography from the point of view of the amateur and to suggest a few branches of astronomical work to which he may profitably apply it.

A few words on the subject of equipment may not be out of place. A common mistake on the part of beginners is to attempt work on too large a scale, using the biggest apertures and longest foci at their command. After what has been done by Roberts, Keeler, and Ritchey, however, it is doubtful whether many amateurs could make any useful advance in the photography of individual clusters and nebulae. It is in small-scale and wide-field work that the average amateur will find it most profitable to engage. The exact size and make of the lenses used must, of course, be largely a matter of individual choice; but whatever choice is made there are at least two qualities which a lens to be used for stellar work should possess, namely, great rapidity and great covering power. Slow lenses may, of course, be used, but the necessary exposures will be so long that it will be hardly worth while to use a lens whose aperture is less than $f5$ or $f6$. Unless expense is no object it is perhaps best not to try to combine extreme rapidity and good covering power in one and the same lens. It is much better, if possible, to have two lenses—a portrait lens for rapid work on small areas and an anastigmat for large fields. The portrait lens should have a working aperture of $f3$ or $f4$, and should be of at least twelve inches focus. Such lenses are often to be picked up quite cheaply in second-hand shops. Their covering power is rather poor, and if the focus is not above twelve inches or so there is no point in using anything larger than a quarter-plate with them. As a rule their limit of fair definition does not extend beyond a circle eight or ten degrees in diameter. The anastigmat should be of about eight inches focus, should work at $f4 \cdot 5$ or $f4 \cdot 8$, and should cover a half-plate sharply at its full aperture. Under such conditions the lens will cover an area in the sky of thirty by forty degrees, or considerably more than four times the area enclosed by the four chief stars of Orion. The portrait-lens and the anastigmat may be used simultaneously, thus acting as mutual checks on each other's work. If they are used separately, the former will obviously be employed for detailed work on small areas, while the latter will be used when it is necessary for any purposes to cover a large region of the sky at once. Of course, for all photographic work necessitating long exposures an equatorial stand is absolutely essential; but it may be a very simple one, and need not even be provided with a clock. The latter adjunct is an obvious advantage as a saver of labour, but, given the requisite patience on the part of the operator, excellent results may easily be obtained with hand driving alone. Unless the telescope is a large one it is best to attach the cameras as counterpoises to the instrument, as this saves unnecessary weight, which is apt to militate against smooth and easy driving. For guiding, the out-of-focus image of a star, bisected by cross-wires in the eyepiece of the telescope, should be used. In order to correct for refraction, a slow motion in declination is essential. Care should be taken to follow accurately to within a few seconds of arc, as even small errors are much more noticeable on photographs than might be expected.

It now only remains to indicate in a general way some of the uses to which such lenses as those mentioned above may be put. First there is the search for variables and *novae*. In this branch of work it is best not to try to cover too much ground at once, but to work systematically on one small region at a time, preferably with the portrait-lens. A small part of the sky, in or near the Milky Way, should be selected and photographed repeatedly with the same instrument at intervals of a few days, the plates being carefully compared by superposition or some other method. For the detection of short-period variables it is best to make several exposures of equal length and at equal intervals on the same night, moving the camera slightly for each exposure. The result will be a number of images of each star, which will be of equal intensity in every case, unless there is in the region a variable undergoing rapid change at the time, in which case it can at once be detected by the inequality of its various images. This method has been used with good results by Professor E. C. Pickering at Harvard.

Another use for the photographic lens is in the search for comets. For this the anastigmat, on account of the large field it covers, is especially suitable. A region of the sky not too far from the sun should be chosen, and the photograph taken as near to the time of sunset or sunrise as the length of the twilight will permit. The writer would particularly recommend this branch of work to observers living in or near the tropics, where the twilight is of short duration. For the actual study of the changes in comets' tails the portrait-lens, on account of its rapidity, is more suitable than the anastigmat, though both may be used.

The visual study of the paths and radiants of meteors may very profitably be supplemented by work with the camera. Owing to the rapidity of their flight, only the brighter meteors will record themselves, but a few definite lines on a measurable plate will be of more value in determining the position of a radiant than any number of loose statements based merely on eye-estimations. Though not strictly speaking "stellar" in character, comets and meteors have been included in this article as being objects which are photographed under essentially the same conditions as the stars themselves.

There are many other ways in which photography can help the amateur astronomer. Its value as a means of map-making is considerable. It is often desirable, for the identification of faint satellites and for other purposes, to have an accurate map of some region which shall show all stars down to a fairly low magnitude. To those who cannot afford to buy the Franklin-Adams charts or the Astrographic Atlas, a home-made map, made in an hour or two with a portrait-lens, will often be very useful.

THE ALCHEMICAL SOCIETY.

AT a meeting of the Alchemical Society held Friday evening, November 14th, a paper was read by Madame Isabelle de Steiger, entitled "The Hermetic Mystery," the chair being occupied by the acting president, Mr. H. Stanley Redgrove, B.Sc., F.C.S.

Madame Isabelle de Steiger's interpretation of the theories and aims of the ancient and mediaeval alchemists differs radically from that accepted by many students of the history of philosophy and science, her views in the main agreeing with those expressed in that well-known but exceedingly rare work, "A Suggestive Enquiry into the Hermetic Mystery and Alchemy."

According to the lecturer, the doctrines underlying Alchemy were the primitive doctrines at the heart of every ancient religion. Alchemy, she maintained, was not concerned with metals but with man, whom the alchemists endeavoured spiritually to perfect through a process analogous to that said to have been discovered by Mesmer. The Alchemists, she said, formed a sort of free secret order, and their writings were cryptogrammatic, being intended to be understood by one another only. They were couched in the language of chemistry to mislead the ignorant, on account of the danger attendant upon any misuse of the processes with which they dealt.

The full text of the lecture has been published in the November number of the Society's Journal.

THE EXHIBITION OF THE NATURE PHOTOGRAPHIC SOCIETY.

SOME three years ago, through the initiative of Mr. Carl Edwards, of Leeds, the Nature Photographic Society came into existence, That there was a place for it soon became evident. A large majority of the leading nature photographers including Messrs. Edward J. Bedford, Richard Kearton, F. Martin Duncan, Oliver G. Pike, and John J. Ward, joined the ranks of the members, and the organisation became a distinct success, while a quarterly journal entitled *The Nature Photographer*, has since appeared regularly. If in the olden times all roads led to Rome, nowadays most things find their way to London, and last year the Annual Meeting of the Nature Photographic Society took place in the metropolis, and what is more, the first exhibition of photographs by members of the Society was held during the months of October and November by the courtesy of the Royal Photographic Society of Great Britain at its house in Russell Square. It may be said at once that an excellent series of pictures was brought together and that Mr. H. Armytage Sanders, who acted as organising secretary of the exhibition, was able to fill all the space which had been kindly placed at his disposal. As the movement in favour of nature photography arose out of the interest which was first of all taken in the hunting of British birds with the camera instead of the gun, it was to be expected that photographs of birds would be well represented. Of them we ought to mention particularly the gannet landing at the nest taken by Mr. Charles Kirk with a "Birdland" Camera, the adjutant bird in two studies of expression by Mr. Edward J. Jacob, who sent also a very beautiful picture of a swan. Many of the movements which are caught by the camera look quite unnatural and are far from being like drawings, so that those who say that nature photographs should always be what is called artistic do not understand their value and are talking rank nonsense. Such past masters in the art of bird photography as Mr. Bedford, Mr. Kearton, Mr. Pike and Mr. Sanders, were also represented, and we are glad to see that Miss Grace Kearton is following in her father's footsteps. Fungi and flowers were fairly well represented; the reproductions of Mr. Essenhigh Corke's colour-photographs were very striking. The president, Mr. Henry Irving, the secretary, Mr. Carl Edwards, as well as Mr. Somerville Hastings, sent pictures of fungi. Mr. Hugh Main illustrated the life-histories of insects and the habits of millipedes: his photographs of the musk beetle we are able to reproduce on page 451.

FIGURE 526.
Larva in stem. Natural size.

FIGURE 529.
Larva, lateral view × 2.

FIGURE 530.
Larva, ventral view × 2.

FIGURE 527.
Pupa, dorsal view × 2.

FIGURE 528.
Pupa, ventral view × 2.

FIGURE 531.
Imago × 2.

From photographs by *Hugh Main.*

The larvae are to be found in the stouter twigs of the willow and are nearly full grown in March or April; they pupate in May, and the beetles emerge in August.

THE MUSK BEETLE (*AROMIA MOSCHATA* LINNÉ.)

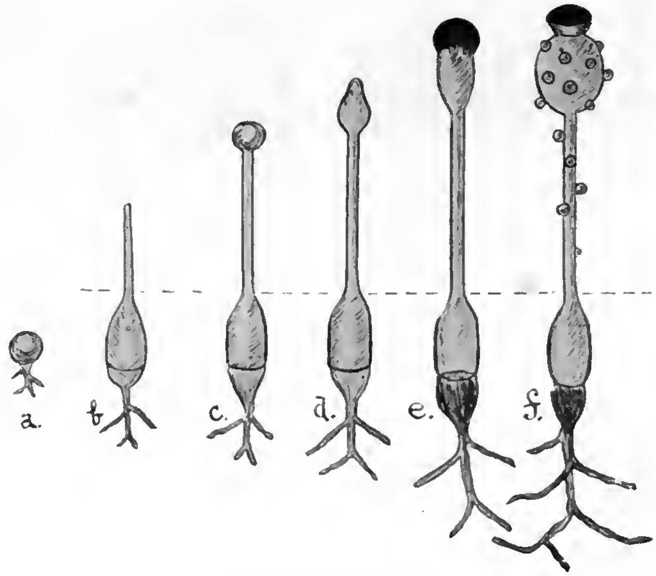


Figure 532.

a. b and c. Early stages of growth when the fungus is still yellow.

d. The fungus filled with a colourless liquid.

e. The partial formation of the sporangium.

f. A mature specimen studded with beads of moisture.

The portion below the dotted line is usually hidden below the surface of the soil.

Figure 533.

The collapse of the tissues after the explosion.

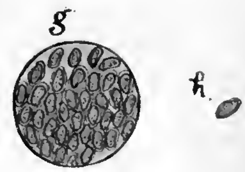


Figure 534.

g. Sporangium, highly magnified, with a number of spores still adhering to the inner surface.

h. A single spore magnified about 800 diameters.

Stages in the life history of *Pilobolus crystallinus*.

(See page 453.)

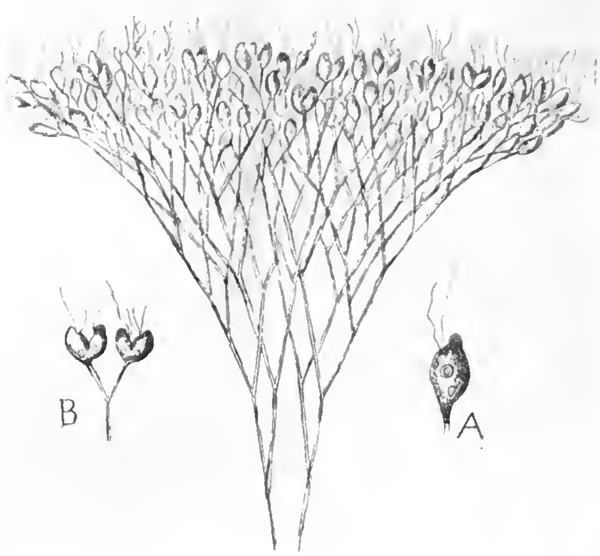


Figure 535.

Dendromonas virgaria Weisse (after Kent).

a. An isolated monad, highly magnified.

b. A colony of two monads in process of longitudinal division.

(See page 466.)

Figure 536.

The partial eclipse of the Sun, 1913, September 29th.

From a photograph taken with a telephoto lens at the Union Observatory, Johannesburg, South Africa, by Mrs. H. E. Wood.

(See page 459.)

AN EXPLOSIVE FUNGUS.

By P. J. ALEXANDER.

AMONG the various kinds of British fungi none, to my mind, are more interesting than those which, when mature, explode like a gun, shooting their spores several feet into the air. Some of these "ball-throwing" fungi belong to the Mucoraceae, a family of the true moulds (Phycomycetae).

The easiest type of this class to find, and the one that presents the greatest facilities for study (as most of its movements can be watched with the naked eye), is *Pilobolus crystallinus*. It may be found in spring, summer, and autumn growing in close clusters on all mammal dung, and especially on that of horses, cows, pigs, and sheep. I have likewise met with it on the droppings of birds. It first came to my notice quite by accident. One day, in my country rambles, I observed some small red pezizas on the sweepings from a sheep pen, and I took some home with me in a tin box that I always carry with me on such occasions. The next morning on going to examine my find I was astounded and delighted to see dense numbers of crystalline bulbs surmounted by a black cap and interspersed with tubes of a beautiful golden colour. I kept the medium on which they were growing moist, and examined the development of this new fungus for ten consecutive days, and I think the results of my observations and study may prove interesting to readers of "KNOWLEDGE."

History.—This fungus was apparently unknown a hundred and fifty years ago—at least we find no mention of it in any literature prior to that date. Scopoli was the first to call attention to it under the synonym of *Mucor obliquus* in 1772; but it was Wiggers who first enabled botanists to recognise this fungus by his description of it published in 1780. It is a curious fact that Tode, whose name is usually connected with this species, did not study it till four years later. We come across it, it is true, in a French work by Léveillé and Durieu de Maisonneuve in 1826; but they did little to elucidate a knowledge of this fungus, as many of their observations were erroneous. F. Cohn noticed it in 1851, and Francis Currey further investigated its formation in 1857. Two years later a Belgian botanist and a native of Louvain published his famous monograph on the subject, showing that he had made a complete analysis of this particular fungus, though still leaving one or two questions unsolved.

Growth.—The first sign of this fungus on the surface of the dung is a tiny golden speck, which, however, soon becomes elongated and shoots up in a golden finger-like tube. About three hours later this tube swells out at the top into a small globe (see Figure 532 *a*, *b*, *c*). Soon after this it loses its colour, the tube and bulb become crystalline, and a black hemispherical cap is formed on the top of the bulb. This cap is the sporangium containing the spores or reproductive bodies. At first it does not seem very distinct from the rest of the bulb (see Figure 532 *e*), but little by little a clear line of demarcation becomes visible (see Figure 532 *f*). The *Pilobolus* is now reaching maturity and ready to discharge its spores. It is filled with a transparent liquid which is slightly acid. Beads of moisture often form along the stem and hang like pearls around the bulb, giving the fully developed fungus a most beautiful and delicate appearance (see Figure 532 *f*). We can even observe with an ordinary lens small worm-like animalcules moving in the swollen bulb. It is now time to collect the spore. The best way to do this is to hold a piece of white paper a few inches over the black capsules. If the light is good the tension soon becomes too great and the caps are blown off with great force. They are sometimes thrown to a height of three feet. Before alighting on the paper they turn a somersault in the air, so as not to strike the surface with their convex side, but fall on the paper like an inverted cup, shutting up the spores inside. This black cap is made of a remarkably tough membrane as we soon discovered in making a microscopic preparation of the same (see Figure 534 *g*, which shows this sporangium, about six hundred times enlarged, full of yellow spores, ellipsoidal in shape). If the fungus is not allowed sufficient light, or if the atmosphere be too warm, instead of projecting the sporangium, the whole fungus withers and topples over (see Figure 533), and soon nothing is seen but a whitish powder left by the dried-up skin of the stem.

The whole plant grows, develops, and dies within twenty-four hours. If left out in the open in its natural surroundings it attains maturity and explodes shortly after sunrise; but if kept in a room where there is little or no sunlight the explosion does not take place until midday or later, and sometimes not at all. This would seem to show that not only elasticity of the tissues but also light is a great factor in causing the projection of the spores, which has been variously attributed by different writers to divers other causes, and erroneously to the tension caused by the liquid in the stem. But if this were the case, then heat would favour the explosion, causing expansion; but experience shows that it is just the contrary which occurs.

The natural size of this little fungus is about three millimetres; hence it will be found rather tiring to examine with the naked eye, but with a good magnifying glass, giving eight or ten diameters, one can study all its movements with ease and comfort.

One must be careful not to confound it with an allied species, *Pilobolus oedipus*, which it closely resembles, and which may be found in the mud and slime of gutters; but in this latter species the spores are globular and of a larger diameter than those of *Pilobolus crystallinus*.

THE DEITIES OF ANCIENT MAORILAND.

By R. W. REID,

New Zealand.

THE perusal of books of travel, and of missionary registers dealing with New Zealand about a hundred years ago, provides the principal information the world possesses concerning the old-time Maoris, their habits and customs, and their religious beliefs. No worthy effort seems to have been made to collate the invaluable accounts of ancient Maoriland scattered through the kind of works mentioned. Here and there, in some old and faded missionary register, scientific facts of the greatest interest and importance are met with; nor are they of less moment because the writers did not always realise their importance, or foresee the avidity with which their somewhat artless contributions would be read by succeeding generations. One has to skim numerous heavy tomes—heavy in more senses than one—to arrive at anything approaching clear conceptions with respect to the religious beliefs—the superstitions, some may designate them—of the Maoris when they were first discovered by Europeans.

The Maoris, like the Greeks, Romans, and other races, had a great variety of gods. Atua was, however, their principal deity. Crozet, in his "Nouveau Voyage à la Mer du Sud," mentions that the Maoris with whom he came in contact had a number of subordinate divinities to whom they were wont to pray for victory over their enemies. A writer (unnamed) in the *Missionary Register* for 1822 gives a description of the Maoris' daily adoration of the sun, moon, and stars. Of the heavenly host the moon, he says, was their favourite. This statement seems to be not fully borne out by the writer; for he observed that when addressing the moon the Maoris employed a mournful song and appeared to be as full of apprehension as of devotion. They presented a totally different demeanour when engaged in their adoration of the sun. Then their arms were extended and partly uplifted, and though their heads were bowed "there was an appearance of much joy in their countenances." The songs sung in their worship, or adoration, of the sun were never solemn, as they were when the moon was addressed, but bright and cheerful. The old Maoris, in addition, held many strange ideas with regard to some of the more conspicuous constellations. Not only were the issues of human affairs influenced, but also the future was indicated by the movements of the stars. The Pleiads, shining in the deep blue of the New Zealand sky, touched the imaginations of the Maoris. Tennyson said the Pleiads

Glitter like a swarm of fire-flies tangled in a silver braid.

But the Maoris discerned there the presence of their kinsmen. The Pleiads, according to Nicholas's "Voyage to New Zealand," they believed to be seven of their departed countrymen fixed in the firmament. One eye only of each of those transported Maoris was visible, and in the form of a star. But it was a common superstition among them—and this fact is frequently mentioned in century-old records—that after death the left eyes of chiefs became stars.

The belief that the stars are the departed heroes of the earth, as readers are aware, is old and widespread. Traces of it can be found in the primitive faiths of nearly every land. A shooting star was regarded as an omen of ill, as generally a warning of the approaching death of a chief; and the Maoris, like the rest of us, have their own man in the moon. He, however, seems to be a kind of deity. He is immortal, and possesses the power of conferring immortality. He loved Rona, a Maori maiden, and, as she loved him in return, she accompanied him to the moon. Different versions of Rona's life after her translation to the night luminary are met with. One is that Rona remained in the moon, and another that she returned to earth to rejoin her Maori lover.

Atua, as stated, was the most powerful god in ancient Maoriland. The word Atua is found in several forms in most of the South Sea dialects, and is thought by some to be allied with the Sanscrit Dewa, the Greek Zeus, and the Latin Deus. This god was deemed by the Maoris to be immortal, omnipresent, invisible, and supreme. Yet, in spite of those mighty attributes, he was believed to be, in disposition, merely a vindictive and malignant demon. The *Missionary Register* for 1823 mentions that when a white clergyman spoke to the Maoris about the infinite goodness of God they bluntly responded with the query: "Are you joking with us?" They believed when anyone became sick, the illness was caused by Atua, in the form of a lizard, having gained admittance into the interior of the ailing person, preying upon his, or her, entrails. Then the *tohungas*, or priests, set to work. *The Proceedings of the Church Missionary Society* for 1819 describes the old Maori mode of frightening, or attempting to frighten, the demon god. The *tohungas*, willingly assisted by the common people, "addressed the most horrid imprecations and curses to the invisible cannibal, in the hope of thereby frightening him away." They imagined that, at other times, Atua amused himself by entangling the fishermen's nets and upsetting their canoes.

In the *Missionary Register* for 1823 is mentioned a circumstance which helps to throw light on the occasional ferocious attacks upon white explorers and others made by the Maoris. Probably the most notable, as it was among the first, of what appear to have been either sudden acts of frenzy or of cold, calculated massacre, was the slaughter of Captain Marion du Fresne at the Bay of Islands in 1772. Captain du Fresne, in command of the ship "Marquis de Castres," and Lieutenant Crozet, commanding the sloop "Mascarin," put into the Bay of Islands to refit. Friendly relations were soon established between the Frenchmen and the Maoris, and for several weeks both races lived together in harmony. "The inhabitants treated us with every show of friendship for thirty-three days," records Crozet in the volume already mentioned, "with the intention of eating us on the thirty-fourth." Whether the massacre was premeditated for a month or more, or was suddenly resorted to in a fit of religious excitement, has never been satisfactorily decided. The fact, however, remains that the Maoris suddenly attacked the party, killing, and afterwards eating, twenty-nine of the number, including du Fresne. Crozet had a narrow escape from the same fate, but he eluded the savages and "lived to tell the tale." The probability is that the murder of du Fresne and his twenty-eight countrymen was due to what in these later days would be designated religious mania. The *Register* says: "The natives have long suspected, ever since white men arrived in their country, that their great god Atua has been very angry with them for having allowed any white men to obtain a footing in their country, a proof of which they think they see in the greater mortality that has recently prevailed among them."

The *Missionary Register* four years later is found discussing these suspicions of the Maoris. It was then apparent that they attributed their losses, sickness, deaths—all their misfortunes—to the God of the Christians. Him they denounced accordingly as being cruel—at all events to others than Christians. The article proceeds: "Sometimes they more rationally assign as the cause of the many deaths the diseases that have been introduced among them by the whites. Until the whites came to their country, they say, young people did not die, but all lived to be so old as to be obliged to creep on their hands and knees." Missionaries and teachers tried to get the Maoris to believe that "the white man's God" and Atua were one and the same. The Rev. Samuel Marsden, New Zealand's first missionary, in one of his letters relates a conversation he had upon this theme with some Maoris, the sons of a chief, who had accompanied him to New South Wales. When he told them that there was but one God, they put the question: "Has the pakeha's [white man's] God given the pakehas any kumeras [sweet potatoes]?" They failed to understand why one God should give the Maoris kumeras and the white man none; and why, also, He should be partial to the whites in the matter of cattle, sheep, and horses and entirely neglect the Maoris so far as these animals were concerned. But the final, and to the Maoris the unanswerable, argument was: "If one God made us both, He would not have committed such a mistake as to give us different colours—make one black, the other white." Mr. Marsden, who, by the way, settled in New Zealand in 1814, asked a Maori what he conceived the Atua to be, and was answered: "The Atua is an immortal shadow."

In "Nicholas's Voyage" appears, on the authority, it is stated, of Nicholas's friend, Duaterra, a lengthy and fairly precise account of the inferior deities of the ancient Maoris. Their number was "very great" and "each has his distinct powers and functions." One minor god "was placed over the elements, another over the fowls and fishes, and so of the rest." Deifications of the different passions and affections also found a place in Maori mythology; a fact which suggests a connection of some kind with the early peoples of Europe and Egypt. It is very remarkable, as Nicholas points out, that the Maoris attributed the creation of man to their three principal deities acting together, "thus exhibiting in their barbarous theology something like a shadow of the Christian Trinity." Still more wonderful was their tradition respecting the creation or formation of the first woman, who, they said, was made of one of the man's ribs. Moreover, the Maori's general term for bone is pronounced something like *hevee*, which certainly seems to be not far removed from the Eve of Biblical narrative.

Chiefs of high standing had, according to Nicholas, their own particular god or gods. When, for instance, the ship "Active" was lying in the river Thames, in the North Island, there was a gale of wind, and this the natives on board attributed to the anger of Hupa's god. Hupa was a chief who lived near the Thames. An elderly native, a man of some note apparently, Koro-Koro by name, informed the master of the ship that, as soon as he got ashore, he would endeavour to prevail upon the chief to propitiate the offended deity. When Mr. Marsden, trying to embarrass the Maoris of Kiapara, asked them if they had ever seen or heard, or had any communication with, the god of that locality—for certain localities had their own particular god—he was bravely informed that the god of the Kiapara had been often heard whistling. Frequently chiefs were called Atuas, or gods, even while they were alive. There was, it will be observed, considerable confusion as to Atua. Atua was the principal god; but the name was thus also applied to men not thought to be specially endowed with supernatural power apparently, but to those who considered themselves as the habitation of deities. An aged chief, Terra by name, who is mentioned in the nineteenth report of the Church Missionary Society, solemnly assured a missionary that the god of thunder resided in his forehead. Not to be eclipsed by this kind of fame his neighbours, Shungie and Okeda, firmly maintained, against all critics and sceptics, that in them lived the gods of the sea.

The dwelling-place of the gods—they, like the Maoris, lived largely in community, it would appear —was always represented as being extremely beautiful. "When the clouds are tinted with bright and lively colours," writes Mr. Kendal, a missionary, "the Atua above, it is supposed, is planting sweet potatoes. At the season when these are planted in the ground the planters dress themselves in their best raiment, and say that, as Atuas on earth, they are imitating the Atua in heaven." Captain Cruise, in his journal, is responsible for the statement that the Maoris he met with a hundred years ago believed that the higher orders among them were immortal, but that when the common people died they perished for ever. The spirit, they explained, left the body the third day after death, till which time it hovered near the corpse, hearing quite well all that was said to it. But they held, further—and here again their beliefs become somewhat complicated and contradictory—that there was a separate immortality for each of the eyes of the dead chief. The left ascended to heaven and became a star, and the other, as a spirit, took flight for the Reinga. The Reinga is, nowadays, sometimes mentioned as the Elysium of the departed, and is also given to the rock on the north shore of New Zealand from which the Maoris believed the spirits leaped into the sea on their way to this Elysium. Little difficulty, apparently, was experienced in passing from the surface of the ocean to the portals of these happy regions. In most mythologies the way to spirit land is usually depicted as being long and painful. Southey, in his "Songs of the American Indians," for example, describes the dread path which has to be trod by the Hurons:

To the country of the dead,
Long and painful is thy way!
O'er rivers wide and deep
Lies the road that must be passed,
By bridges narrow-wall'd,
When scarce the soul can force its way,
While the loose fabric totters under it.

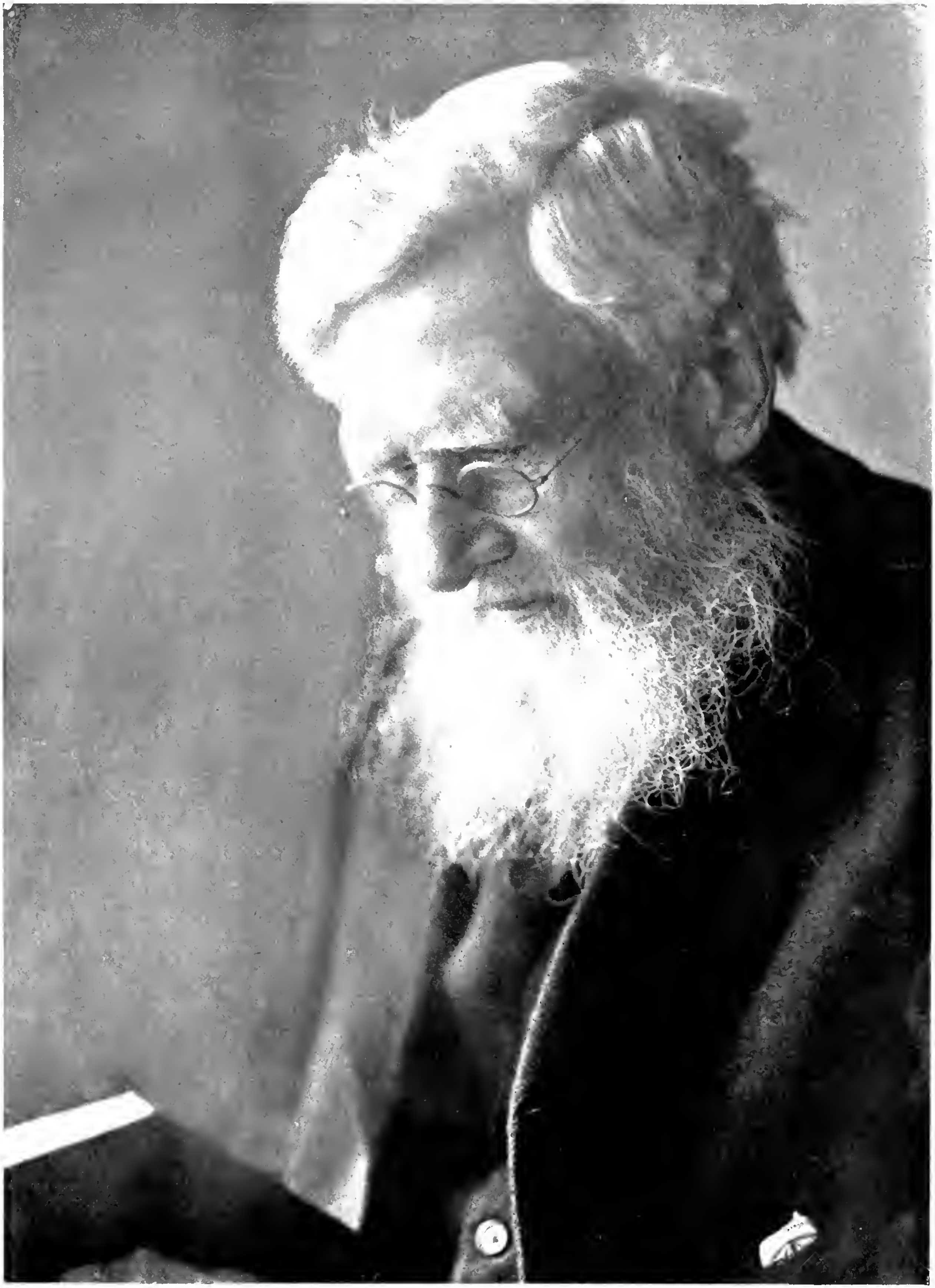
War remained one of the chief employments in the olden-time Maori heaven, though how results were established in the matter of deaths and victories does not appear. A Wesleyan missionary, in *The Missionary Register* for 1826, relates a lively conversation which took place between him and several Maoris on the twin subjects of heaven and hell. He says: "On telling them about the two eternal states, as described in the Scriptures, one of the number, an old chief, began to protest against these things with all the vehemence imaginable, and said he assuredly would not go to heaven, nor would he go to hell to have nothing but fire to eat, but he would go to the Raing or Po, to eat kumeras with his friends who had gone before." Slaves were sacrificed on the death of a chief, so that they might accompany his spirit, or spirits. *The Missionary Register* for 1828 narrates the story of a child having been drowned, when the mother insisted upon a female slave being killed "to be a companion for it on its way to the Reinga." It only remains to add that these old beliefs are not yet wholly extinct in New Zealand. The present-day Maoris will seldom venture far from their homes when the night is dark — spirits are then abroad. Graveyards and the houses of dead chiefs are *tapu*; to desecrate them would bring affliction, possibly death. Still, in the silence of night, when the cry of a belated bird is heard out of the darkness, the Maori will exclaim: "Ah! there goes another spirit to Te Reinga."

THE LATE ALFRED RUSSEL WALLACE.

As our frontispiece to the volume of "Knowledge" for 1912 we gave a portrait of Sir Joseph Hooker, whom science had recently lost, and who in the year 1858, with Sir Charles Lyell, shared the honour of communicating to the Linnean Society the papers relating to the production of varieties, races, and species which contained "the results of the investigations of two indefatigable naturalists, Mr. Charles Darwin and Mr. Alfred Wallace."

Hooker died at the age of ninety-four and now we choose as our frontispiece a portrait of Dr. Alfred Russel Wallace, who has just passed away at the age of ninety. The part which Wallace played in the establishment of the theory of natural selection is too well known to need any comment from us, but we may remind our readers of one or two points in his life. He was born at Usk in Monmouthshire, on January 8th, 1823, and was eight years younger than Darwin. He left Hertford Grammar School in 1836, and helped his brother who was an architect and surveyor. In 1840 he began to take an interest in natural history and travel, and while he was a master at a school in Leicester he met Mr. H. W. Bates and took up with him the study of beetles. It was with Bates that Wallace started off in 1848 to the Amazons, to gather facts towards solving the problem of the origin of species.

In 1852 Wallace, who had left Bates a year or so previously, returned to England, losing all his collections owing to his ship being burnt, and spending ten days in an open boat. He remained in England for a year and a half to publish a book on his travels, after which he went to the Malay Archipelago for nearly eight years. In February, 1858, while he was in the Moluccas, he got the first idea of the survival of the fittest obtaining as did Darwin a suggestion from Malthus's "Essay on Population." The paper arising out of this, Wallace sent to Darwin. It is well known that with regard to some points Wallace differed from Darwin, and he occupied himself in the later years of his life with other matters than those which are purely scientific, but into these we need not here go.



From a photograph *by Hoppé.*

Alfred Russel Wallace, O.M., LL.D., D.C.L., F.R.S.

A portrait taken about 1911.

THE FACE OF THE SKY FOR JANUARY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 87.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Saturn. R.A.	Saturn. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m	°	h. m.	°	h. m.	°
Jan. 1	18 44·6	S. 23·1	22 37·1	S. 9·7	17 44·7	S 23·8	18 1·5	S. 23·5	7 12·9	N. 26·3	4 46·0	N. 20·7	7 57·1	N. 20·3
„ 6	19 6·6	22·6	2 12·0	N. 17·4	18 18·1	24·3	18 28·9	23·5	7 4·1	26·6	4 44·6	20·6	7 56·5	20·3
„ 11	19 28·5	21·9	6 50·7	N. 27·6	18 52·3	24·3	18 56·3	23·2	6 55·5	26·9	4 43·4	20·6	7 55·9	20·3
„ 16	19 50·0	21·0	11 30·9	N. 2·5	19 27·1	23·7	19 23·5	22·7	6 47·4	27·1	4 42·3	20·6	7 55·3	20·4
„ 21	20 11·3	20·0	15 57·2	S. 25·6	20 2·4	22·5	19 50·5	21·8	6 40·3	27·2	4 41·4	20·6	7 54·7	20·4
„ 26	20 32·3	18·9	20 46·5	S. 21·2	20 37·8	20·7	20 17·0	20·7	6 34·4	27·2	4 40·6	20·6	7 54·2	20·4
„ 31	20 53·0	S. 17·5	0 29·3	N. 5·4	21 13·1	S. 18·2	20 43·1	S. 19·3	6 30·0	N. 27·2	4 40·1	N. 20·6	7 53·6	N. 20·4

TABLE 88.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Mars. P	Mars. B	Mars. L	Mars. T
Greenwich Noon.	°	°	°	°	°	°	°	h. m.
Jan. 1	+ 2·1	−3·1	228·6	−20·4	−16·6	+5·3	182·9	0 6 *m**
„ 6	− 0·3	3·7	162·8	−18·5	17·7	4·4	139·2	2 29 *m*
„ 11	2·7	4·2	96·9	+ 4·4	18·8	3·6	95·4	5 29 *m*
„ 16	5·1	4·8	31·1	+21·7	19·8	2·8	51·4	8 29 *m*
„ 21	7·4	5·2	325·3	+11·3	20·7	2·2	7·3	11 30 *m*
„ 26	9·6	5·6	259·4	−14·2	21·4	1·7	322·9	2 32 *e*
„ 31	+11·8	−6·0	193·6	−21·8	−21·9	+1·3	278·3	5 35 *e*

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Mars, T is the time of passage of Fastigium Aryn across the centre of the disc.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

The asterisk indicates the day following that given in the date column.

THE SUN begins its Northward March. Nearest Earth 3^d 9^h *e*. Its semi-diameter diminishes from 16′ 17½″ to 16′ 15½″. Sunrise changes from 8^h 8^m to 7^h 44^m; sunset from 3^h 58^m to 4^h 43^m.

MERCURY is a morning star till 25th, but too near the Sun for convenient observation. Semi-diameter 2½″. Illumination nearly full. In "Face of Sky for December" read "Mercury is a morning Star," not "evening."

VENUS is a morning star, but getting too near the Sun for convenient observation. Disc practically full. Semi-diameter 5″. One degree N. of Mercury, January 14^d 5^h *m*. Superior conjunction, February 11th.

TABLE 89. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1914.			h. m.		h. m.	
Jan. 2	Wash. 1574	7·0	4 50 *e*	13°	—	—°
„ 4	Wash. 56	6·7	8 48 *e*	29	—	—
„ 6	Wash. 149	6·8	8 15 *e*	79	—	—
„ 9	BAC 1648	6·4	10 16 *e*	64	11 27 *e*	291
„ 10	BAC 1746	6·5	5 10 *m*	92	6 0 *m*	277
„ 11	BD+27°1164	6·9	4 57 *m*	90	—	—
„ 12	κ Geminorum	3·6	7 45 *m*	136	8 25 *m*	256
„ 12	BD+23°1913	6·4	5 18 *e*	98	6 12 *e*	280
„ 13	Wash. 635	6·6	—	—	9 14 *e*	210
„ 15	BD+11°2217	7·0	—	—	3 34 *m*	303
„ 15	45 Leonis	5·8	5 0 *m*	174	5 42 *m*	256
„ 15	ρ Leonis	3·8	7 22 *m*	97	8 13 *m*	324
„ 16	BAC 4054	6.4	10 31 *e*	100	11 25 *e*	322
„ 17	Wash. 789	6·9	—	—	6 7 *m*	299
„ 20	BAC 4867	6·4	2 36 *m*	98	3 35 *m*	321
„ 20	BAC 4879	6·1	3 7 *m*	102	4 11 *m*	318
„ 31	62 Piscium	6·1	9 1 *e*	92	9 55 *e*	217
„ 31	δ Piscium	4·6	9 27 *e*	41	10 21 *e*	269

From New to Full the disappearances occur at the Dark Limb, from Full to New the reappearances.

THE MOON.—First Quarter $4^d\ 1^h\ 9^m\ e$; Full $12^d\ 5^h\ 9^m\ m$; Last Quarter $19^d\ 0^h\ 30^m\ m$. New $26^d\ 6^h\ 34^m\ m$. Apogee $3^d\ 9^h\ e$. Perigee $15^d\ 6^h\ e$. Apogee $31^d\ 5^h\ e$, semi-diameter 14′ 48″, 16′ 17″, 14′ 47″ respectively. Maximum Librations, 9^d 6° E, 9^d 7° S, 22^d 7° N, 23^d 5° W. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon. (See Table 89.)

MARS is in opposition $5^d\ 6^h\ e$. Nearest Earth on 1st, distance 0·622. This is an unfavourable opposition as regards distance, but favourable as regards planet's declination. It will be seen that both hemispheres of Mars are observable, but the Northern one is best placed. The semi-diameter during January, diminishes from 7½″ to 6½″. The unilluminated lune is on the East: its width increases from 0 to $\frac{4}{10}$″. The Planet is in Gemini: 2° N. of ε, on 22nd.

JUPITER is invisible, being in conjunction with the Sun on 20th.

SATURN is very well placed for observation, having been in opposition on Dec. 7th. Polar semi-diameter 9½″. P. is −4°·2; B−26°·7. Ring major axis 47″, minor 21″. The ring is approaching its maximum opening, and projects beyond the poles of the planet. It is interesting to measure the exact amount of overlap. The absolute maximum opening will occur on July 1st, but the Planet will then be too near the Sun to see.

East Elongations of Tethys (every fourth given), $2^d\ 0^h{\cdot}0e$, $10^d\ 1^h{\cdot}2m$, $17^d\ 2^h{\cdot}4e$, $25^d\ 3^h{\cdot}6m$; Dione (every third given), $2^d\ 2^h{\cdot}7e$, $10^d\ 7^h{\cdot}8e$, $19^d\ 0^h{\cdot}7m$, $27^d\ 5^h{\cdot}7m$; Rhea (every second given), $2^d\ 2^h{\cdot}8m$, $11^d\ 3^h{\cdot}5m$, $20^d\ 4^h{\cdot}3m$, $29^d\ 5^h{\cdot}0m$. For Titan and Iapetus E.W. mean East and West Elongations; I. Inferior (North) Conjunctions, S. Superior (South) ones. Titan, $5^d\ 6^h{\cdot}2m$ I.; $9^d\ 2^h{\cdot}6m$ W., $13^d\ 1^h{\cdot}9m$ S., $17^d\ 4^h{\cdot}6m$ E., $21^d\ 4^h{\cdot}2m$ I., $25^d\ 0^h{\cdot}6m$ W., $28^d\ 12^h{\cdot}0e$ S; Iapetus, $6^d\ 1^h{\cdot}9e$ I., $25^d\ 1^h{\cdot}4e$ W.

URANUS is invisible, being in conjunction with the Sun on 28th.

NEPTUNE is in opposition on the 17th. Semi-diameter 1″. Possessors of small telescopes may easily recognise it by its motion, if they make a sketch map of the stars in the region, and observe it night by night.

WESTPHAL'S COMET.—See the ephemeris given last month. The R.A. will be some 20″ greater than the ephemeris value, the declination ½° less.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.		Radiant. Dec.	Remarks.
	°		°	
Jan. 2-3 ...	230	+	53	Brilliant shower, swift, long paths.
,, 3 ...	156	+	41	Swift.
,, 11-25 ...	220	+	13	Swift, streaks.
,, 17 ...	295	+	53	Slow, bright.
,, 17-23 ..	159	+	27	Swift.
,, 25 ...	131	+	32	Swift.
,, 29 ...	213	+	52	Very swift.

DOUBLE STARS AND CLUSTERS.—The tables of these given two years ago are again available, and readers are referred to the corresponding month of two years ago.

VARIABLE STARS.—The list will be restricted to two hours of Right Ascension each month. The stars given in recent months continue to be observable.

TABLE 90. NON-ALGOL STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m.	°		d.	
X Aurigae	6 6	+50 ·2	8·1 to 13·0	162·6	Feb. 4.
η Geminorum	6 10	+22 ·5	3·3 to 4·2	233	About January.
V Aurigae	6 18	+47 ·8	8·3 to 11·7	352	Dec. 22.
V Monocerotis	6 18	− 2 ·1	7·7 to 10·2	332	Jan. 7.
V Lyncis	6 22	+61 ·4	8·6 to 9·4	72	Feb. 1.
R Lyncis	6 54	+55 ·5	6·5 to 14·0	379·2	Mar. 27.
S Canis Min....	7 28	+ 8 ·5	7·7 to 12 7	330·3	Dec. 21.
Y Geminorum	7 36	+20 ·7	8·5 to 9·2	286	Jan. 27.
S Geminorum	7 38	+23 ·7	8·3 to 14·5	293·8	Feb. 4.
U Puppis	7 57	−12 ·6	8·5 to 14·5	315	Dec. 16.

Principal Minima of β Lyrae Jan. $12^d\ 7^h\ m$, $25^d\ 5^h\ m$. Period $12^d\ 21^h{\cdot}8$.

Algol minima Jan. $7^d\ 4^h\ 5^m m$, $10^d\ 0^h\ 54^m m$, $12^d\ 9^h\ 42^m e$, $15^d\ 6^h\ 31^m e$, $18^d\ 3^h\ 20^m e$, $30^d\ 2^h\ 36^m m$.

Mira Ceti will reach maximum in March.

CORRESPONDENCE.

THE FLOWERING OF PLANTS IN SOUTH GERMANY IN 1911 AND 1913.

To the Editors of "KNOWLEDGE."

SIRS,—Everyone knows the delights of botanists who, in the month of August, have wandered through the Austrian and Italian Tyrol. Edelweiss and Alpine roses form only a small part of the treasures which they bring away, and they never forget the fragrance of those Alpine meadows where the flowers bloom and the bees fertilise them close under the ice and snow. What is not generally realised is the wealth of the Odenwald and the Schwarzwald especially so far as the fungi are concerned, and these have been particularly abundant in damp years, like 1912 and 1913. Unfortunately the orchards and gardens have neither been so profitable nor so interesting.

So far as the plant-world of South Germany is concerned, the *annus mirabilis* was the year 1911. The vineyards were of more importance than the orchards. The grapes were small but as sweet as sugar, and the tourist now in the neighbourhood of Rüdesheim and Eltville may deem himself fortunate if the kindly host, who has his own vineyard, will supply him with the vintage of 1911. To mix it with Apollinaris, or any natural water, would be a crime.

The Spanish fruiterers, of whom there are many in this part of Germany, had no need to import any fruit except real exotics such as *aubergines* and *pimientos.* Quinces and medlars were relatively extremely abundant. Peaches and apricots were not only thoroughly ripe but also abundant, and consequently so cheap that in some places they were allowed to drop and rot upon the ground. It was worth a walk of many miles out of the tourist's route to see in the neighbourhood of Heilbronn the patient oxen drawing wagon-loads of pumpkins which were like great balls of gold.

In Heidelberg and other towns of Baden it is extremely common to see oleanders and pomegranates in public and private gardens. They are often arranged in rows in front of fashionable hotels, and now and again even in front of a railway station. The blossoms on these were as profuse and as beautiful as those I have seen in the warmest parts of the South of Spain. Autumn blossoms, too, on the magnolias were frequently seen, but this I find is not so rare. What surprised me most was an avenue of horse-chestnuts from which all the leaves had fallen, but the trees were covered with recently opened blossoms. Again and again have I seen horse-chestnuts, from which the leaves had fallen, covered with new leaves, as though it were spring-time; but here were masses of blossom covering trees which were otherwise bare. Is all this a development of buds recently formed, or a development of the dormant buds of a previous year?

This year has been worse than 1912, for the July of that year was a warm month, whereas the heat this year has come much too late. One peculiarity of the Neckar Valley is the occurrence during the first fortnight of August of multitudes of Ephemeridae, which are known there as *August-Fliegen* or *Weisse-Fliegen.* Sometimes these are so abundant as to fill the street lamps, and they are swept from the pavement in barrow-loads, to be used afterwards as bait for fishing in the Neckar. This year the little *white flies* have never been seen. The pomegranates and oleanders have not blossomed, the grapes are not sugar-sweet, and apricots and some other fruits will never ripen. The fruiterers must import what they want from Spain or the South of France, or depend in part upon fruits which have been ripened under glass.

One thing which I have just seen is worth mentioning. Not far from the dusty road which runs parallel to the Neckar between Hirschhorn and Eberbach there is an apple-tree in full blossom. Now what is the cause of that? Certainly not the warmth of the season. It is not the sun which has wooed those blossoms from the buds. What one would like to know is, what buds have been developed, and what will, in all probability, be the history of that tree in the near future?

E. J. DUNGATE.

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Heidelberg.

FRESH WORLDS TO CONQUER.

To the Editors of "Knowledge."

Sirs,—The other day when reading a scientific work (Mr. Soddy's excellent little book on Matter and Energy) I came across the expression, "There is no fear that Science will yet awhile be sighing, like Alexander, for fresh worlds to conquer." I am happy to believe that this is true of Science; but I strongly object to having such a worse than childish aspiration put into the mouth of one of the most highly educated heroes this earth has ever seen. No doubt hundreds have said the same thing before Mr. Soddy, and hundreds will say it again. But no amount of repetition will make the phrase other than what it is, namely, not only false, but the very reverse of what is true, a piece of arrant nonsense and an insult to the memory of a great man, who certainly had his faults, but who never could have accomplished such wonders had his hold on the reality of things been less steadfast and complete. And precisely the fact that so eminent an authority as Mr. Soddy should repeat the absurdity shows that the time for correcting it has arrived.

Alexander did not conquer this world, and was perfectly aware that he had not done so by a long way. It was with bitter grief that he turned back from his Indian expedition in deference to the remonstrances of his army. He must have known, like every other Greek, that the Adriatic limited his power to the West, that Italy, Sicily, and Carthage still remained unsubdued, that his fleets had not doubled the southern cape of Africa, long known to be circumnavigable, nor even sailed to the Pillars of Hercules. And the interesting thing, not merely for his biographers, but for the history of science, is to read the true story which has been converted by an almost inconceivable blunder into the false story commonly circulated.

The true story runs as follows in the version given by Plutarch:

"When Alexander heard from Anaxarchus [a philosopher from Abdêra] that there were an infinity of worlds, he burst into tears, and on being asked what ailed him replied, 'Is it not deplorable that while there are infinite worlds we should not yet have made ourselves masters of this one world?'"

Plutarch tells the story, not where we would expect it, in his Life of Alexander, but in his Moral Anecdotes, though what particular lesson we are expected to draw from it does not appear. Perhaps it was the same as that suggested to Tennyson, when after looking through a telescope at the great star-cluster in Perseus, he observed, "One doesn't think much of the county families after that." Anyhow, the interesting thing to find is that, contemporaneously with the strictly finite world of Aristotle, Alexander's own teacher, revolving concentrically round our Earth, and enclosed by the outermost solid star-sphere, conceived as a single body rotating once in about twenty-four hours, the older and much truer Ionian idea of infinite worlds should still have prevailed.

Thus by a path the reverse of Hamlet's we may follow in imagination the noble dust of Alexander, or at least of Alexander's table-talk, until it mingles with the star-dust of the Milky Way.

ALFRED W. BENN.

THE PARTIAL ECLIPSE OF THE SUN, 1913, SEPTEMBER 29.

To the Editors of "Knowledge."

Sirs,—This phenomenon* was observed at the Union Observatory, Johannesburg. At the time of sunrise a low-lying bank of heavy clouds extended along the Eastern horizon, but the sun began to appear above these clouds six minutes after the calculated time of sunrise. The first appearance of the sun was a very interesting sight. The eclipse was then about at its middle phase and the sun, as it rose above the cloud-bank, was exactly like a lion's claw. When the sun was clear of the clouds it was possible to trace the dark outline of the moon against a slightly lighter background for nearly a minute of arc beyond the sun. This projection of the moon was observed in the neighbourhood of both cusps of the sun. The observation was made with a three-inch refractor through a rather light dark glass. Definition throughout was too poor to enable irregularities on the edge of the moon to be seen. The last contact was observed at $16^h\ 32^m\ 50^s$ Greenwich time.

(Mrs.) H. E. WOOD.

Union Observatory,
Johannesburg,
South Africa.

* See Figure **536**, page 452.

SOLAR DISTURBANCES DURING OCTOBER, 1913.

By FRANK C. DENNETT.

OCTOBER has proved more interesting to the solar observer than any month since December last. Only one day was missed, October the 5th. On seven days (4, 9 to 11, 13, 21, and 30) the disc appeared free from disturbance, and on nine others (1 to 3, 14 to 18, 22 and 23,) only faculae were visible. It is to be remarked that the greater part of the faculae and the whole of the dark spots were displayed in the northern hemisphere. The longitude of the central meridian at noon on October 1st, was 1° 24′.

No. 12.—A pretty group of tiny pores first seen on the 6th, which in the afternoon were ranged like segments of two interlocking eclipses. On the 7th only the rear portion was seen, whilst on the 8th only a grey facula-lipped pore remained which was gone next day. Its maximum length was 35,000 miles.

No. 13.—Two pores, the larger preceding, almost in the centre of the disc, only seen on the 12th.

No. 14.—A small bright facula having two penumbraless pores, one on either side, east and west, seen on the 19th, when the disturbance showed hydrogen flocculi, and the dark D_3 line of helium with the spectroscope. Next day the facula was still traceable with minute pores but they were not seen after.

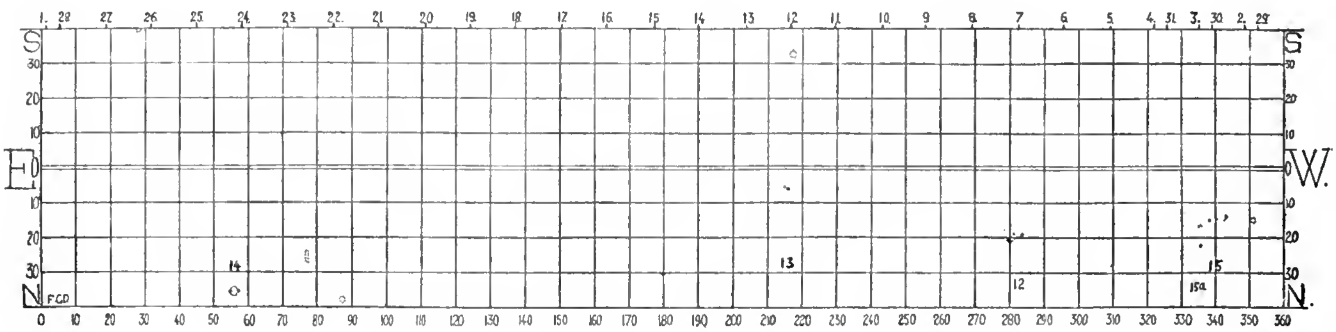
No. 15.—On the 24th a group of pores was visible a little within the north-eastern limb amid brilliant faculae. The components remained small, and were subject to much change until last seen on the 29th. Its greatest length was 72,000 miles.

No. 15A.—On the 31st there was a dark grey "veiled" spotlet a little north of the area which had been occupied by No. 15. It was not, however, seen afterwards.

Faculae like tiny bright granules were visible within a few degrees of the North Pole, on October 1st to 3rd, 6th, 15th, 16th, 24th and 25th. A small one was noted at longitude 28°, S. latitude 40°, on the 3rd. Faculae were also noted near the south-west limb on the 11th, and the north-east on the 14th. On the 16th a faculic knot was at longitude 217°, S. latitude 33°. On the 17th and 18th a faculic knot seen at 87°, 38° N. (near the north-east limb), and a bright streakiness near 77°, 25° N. Traces of the former still showed on the 20th, as well as a pale patch within the eastern limb a little north. Pale faculae a little within the eastern, and nearing the south-western limbs on the 22nd. Also within the north-eastern limb, at 351°, 15° N. on the 23rd and 24th. Within the eastern limb a faculic knot was visible on the 31st.

Our chart is constructed from the combined observations of Messrs. J. McHarg, A. A. Buss, C. Frooms, E. E. Peacock, and the writer.

DAY OF OCTOBER, 1913



NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.SC., F.R.A.S.

DETERMINATION OF RADIAL VELOCITIES OF FAINTER STARS.—It has often been felt that it would be of great importance in advancing our knowledge of the structure of the universe, if spectrograms taken with an objective prism could be used in the determination of radial velocities. The results with the slit spectroscope are splendid in their marvellous accuracy; but owing to the great loss of light at the slit, and the resulting length of exposure, the method is practically limited to the naked-eye stars, or those not much below this limit. When the method of the prism before the object glass, without any slit, is employed, there is no loss of light, consequently much fainter stars can be reached with a moderate exposure; also there are many spectra on each plate, so the work of making a spectroscopic Durchmüsterung is rendered possible. In fact, much progress has been made with this at Harvard, but hitherto attention has been paid merely to the type of spectrum, not to motion in the line of sight. Suggested methods of doing this were given by Professor Pickering and others; these are now discussed by Dr. Schlesinger in *Proc. Amer. Phil. Soc.*, Vol. LII, No. 209. He considers two methods practicable for obtaining fairly accurate results. The first consists in measuring the distance between two known lines in each spectrum. With prismatic spectra the effect of velocity in the line of sight is much greater for the violet end of the spectrum than for the red. Hence stars approaching us have their spectra lengthened, those receding have them shortened. Plates are now available that will photograph the red end of the spectrum with moderate exposures. It is desirable to use a Cooke Triple object-glass, or else to have one specially designed to bring the required regions into focus together. The author also recommends the use of a temperature case surrounding the whole apparatus, as change of temperature affects the sharpness of the spectra. He also advises taking check plates every night on stars whose velocity is already known by the slit method. With these precautions results of considerable accuracy may be expected.

The other practicable method is that of placing a screen of neodymium chloride before the plate. This artificially introduces some absorption lines into the spectrum, one of which, at λ 4272, is stated to be suitable as a comparison line.

He does not recommend this method except for stars of types A and B (Sirius and Orion). In solar and red stars the artificial line is confused with stellar lines.

He gives a third method, but as he considers it less hopeful I do not describe it.

In the case of object-glasses too large to cover by objective prisms, he suggests the use of an auxiliary lens, placed in the cone of rays from the objective, so as to give a smaller pencil of parallel light than that falling on the objective. In this way a smaller prism will suffice, without sacrificing any of the aperture.

It goes without saying that a less degree of accuracy is expected than with the slit method. But what is desired is not so much the exact motion of individual stars as averages for large groups of stars of different types, and distributed over the sky. For this purpose the new methods are full of promise.

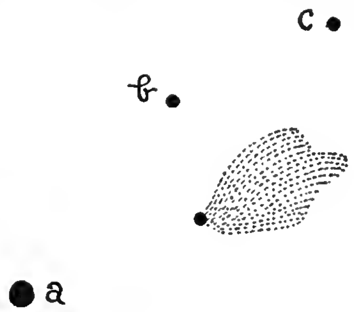


FIGURE 537.

Neujmin's Comet as sketched by Prof. Barnard. 1913, Sept. 9th.

Star a is Nicolaiev 5064, mag. 8.3; b is of mag. 11.7; c, 11.4; comet, 11.5. The distance a-c is 4½′. South is at the top.

COMETS.—In recent years, the autumn has been the great time for comets, and this year has been no exception; four comets, three of them periodic, have been under observation. Westphal's is the most important, from its association with Neptune. It presented an interesting appearance early in October, being easily visible in an opera glass (so that Mrs. F. Wilson found it without knowing of its previous discovery) and having been glimpsed with the unaided eye. However, it did not live up to this early promise. It grew faint and diffused, in spite of its approach to the Sun, and by the end of October was very difficult to see.

On October 22nd it passed within half a degree of Metcalf's comet, and the unusual spectacle was afforded of two comets in the same field. Both were then of the ninth magnitude. As Westphal's is not at perihelion till 3 p.m. on November 26th, it is quite likely that there may be another outburst of activity. This uncertainty about the physical behaviour of comets adds interest to their study. During December Westphal's will be about 40′ south of the ephemeris given last month; the R.A. will be a minute or more in excess of the ephemeris. Corrected elements by Miss Levy: Omega 56° 31′ 36″, Node 346° 47′ 45″, inclination 42° 33′ 7″, Period 61·121 years, Log. q. 0·1012, Log. a. 1·1908.

Neujmin's comet was interesting in two ways; first for its appearance. It was exactly like a small star with a faint nebulous appendage to the south-east. This stellar appearance enabled its position to be fixed with great accuracy. Herr Stracke has computed the following orbit. Perihelion, 1913, Aug. 16·31 Berlin, Omega 346° 7′ 52″, Node 357° 54′ 19″ inclination 14° 52′ 34″, eccentricity ·7786, Period 18·16 years; perihelion distance 1·5300, aphelion distance 12·288.

The comet appears to belong to the group that owns allegiance to Saturn. Two other members of the group are known. One is Tuttle's comet, the other was discovered by Peters in 1846, but has never been seen since. It is to be hoped that the period of the present comet will be accurately determined, to facilitate its recovery at its next return.

A comet discovered by Dr. Zinner at Bamberg, 1913 *e*, is identical with Giacobini's comet, 1900, III, the period being 6·465 years. Perihelion passage is 1913, November 2·30, Omega 171° 32′, Node 193° 0′, inclination 32° 17′ log. q. 9·9961. Owing to its rapid southerly motion it will soon be out of reach of European observers.

THE ANDROMEDA NEBULA.—Lowell Bulletin No. 58, contains an investigation by Mr. V. M. Slipher on the radial velocity of this nebula. It has been known for some years that there were some Fraunhofer lines in its faint continuous spectrum. He secured four plates last autumn and winter with exposures of about seven hours each, and obtains the startling result that the nebula is approaching us at the rate of 297 kilometres per second, the individual values being 284, 296, 308, 301. It is a little difficult to credit that such a vast object as this nebula (certainly several light-years in length) can be moving bodily with such inconceivable speed, and the results will doubtless be discussed by skilled spectroscopists, to see if there is any other explanation of the shifts of the lines. Mr. Slipher notes that the shift in the violet was twice that in the blue, which accords with the supposition that it is due to velocity. If it really has a speed of this order, its distance must be very great, or it would have a sensible proper motion; for the direction of motion is not likely to be exactly radial.

I have lately been examining the photographs of this nebula, and it appears to me that there are far more cases where curves of stars mark out and follow the shape of prominent portions of the nebula than we can reasonably attribute to chance. In my view these stars are actually associated with the nebula. If this assumption is true it is of twofold importance; first, it would dispose of the theory that the nebula is an external galaxy, for these stars are exactly like those forming the background of the sky in ordinary regions, and obviously belonging to our galaxy. Secondly, these stars could be examined for parallax and proper motion much more easily than the nebula itself, since its outlines are vague. The case of the Orion nebula may be recalled; Sir W. Huggins considered it established that the stars forming the Trapezium were actually, not merely optically, associated with the nebula, so that they could be examined for parallax and proper motion, instead of the nebula itself; the soundness of this view is generally admitted.

CAMPBELL'S "STELLAR MOTIONS," AND SIR DAVID GILL'S "HISTORY OF THE CAPE OBSERVATORY."—These two books have lately appeared. The first, which is the "Silliman Lectures, 1910" should be read by all who desire an intimate acquaintance with the marvellous precision of modern spectrographic work, especially as applied to motion in the line of sight, and the countless precautions that are taken to avoid systematic errors in the results. In our own system the method has been applied to various problems: the rotation of the Sun, Venus, and Uranus, and the optical verification of the fact that Saturn's ring is composed of small particles with independent motion. In the stellar heavens the method has given a new determination of the direction and speed of the Sun's motion; it has given great help in forming estimates of the distances of various classes of stars, and in demonstrating the unexpected fact that the speed of a star increases as its spectral type advances. Its application to the study of Algol variables and those of the Beta Lyrae, Cepheid and Geminid types, are also dealt with, and some interesting conclusions are drawn from statistics of spectroscopic doubles.

Sir David Gill gives a *résumé* of the important problems with which the Cape Observatory has been associated. The distances of the Sun, Moon, and Stars, Jupiter's satellites, The Cape Photographic Durchmüsterung, double stars, spectroscopic work, the survey of Africa, are all dealt with. I hope to give some further notes on this book in a future month, but in the meantime I recommend our readers to study it for themselves.

DISTRIBUTION OF CLUSTERS AND NEBULAE.—Dr. Charlier, of Lund, has published some statistics in tabular and graphical form of the distribution of clusters and nebulae in various regions of the sky: they are based on the three catalogues of Dreyer, containing 13,223 objects, of which 769 are clusters. The clusters show an unmistakable tendency to congregate along, or near, the Milky Way. This seems to show that most of the clusters are actually involved in the star-clouds of the Milky Way, and are consequently extremely distant. The individual stars may therefore be very much larger, and the degree of compression very much slighter, than we are apt to imagine from their telescopic aspect.

The nebulae, on the other hand, show a decided avoidance of the Milky Way and an aggregation towards its poles, especially the northern one in Coma Berenices. He has divided the nebulae into various classes according to size, shape, and brightness, but the same general arrangement persists. He has not grouped them according to spectral type (the distinction between "white" and "green" nebulae), though this difference is more significant than the others. It has been suggested that the paucity of nebulae along the galaxy arises from the brightness of the sky background, and the consequent difficulty of detecting faint nebulous objects. However, even the bright nebulae cluster very definitely round the Coma Berenices pole. There is no such marked aggregation of them at the opposite pole.

On the whole it looks as if the Galaxy had some influence on the distribution of nebulae; if so, the greater part of them belong to our own stellar system, and are not external universes. This is also supported by the comparatively small radial velocity indicated by those whose spectra have been carefully observed. We should expect independent universes to have considerable motion relatively to each other, and so to show large radial velocities. Those actually found are of the same order of magnitude as those of the stars.

BOTANY.

By Professor F. Cavers, D.Sc., F.L.S

BOTANY AT THE BRITISH ASSOCIATION (*continued*).—Apart from the Presidential Address given by Miss Sargant, the only notable paper of wide interest was that by Professor Reinke, "On the Nature of Life." The veteran Kiel botanist protested against the view that life can be interpreted merely mechanically, and urged that the greater the progress in experimental physiology, the better we learn to use our knowledge of non-living matter for the explanation of the processes of life, the more we understand that a complete physico-chemical analysis is impossible for any important life process. Behind all the physico-chemical facts ascertained by physiological studies there hides an unknown factor, "an *x* not to be solved by levers and screws and chemical reägents." He maintained that although the laws of energy are valid in the organism as well as in unorganised nature, life being based on transformations of energy or "elementary processes," these processes are not thrown together without order in the living body, but are united by an invisible chain which maintains order among the elementary processes and represents the true difference between life and any event in lifeless nature. This "life principle" is, unlike the single elementary processes, inaccessible to physiological analysis; it is "no force or power, it is a principle of succession, of order, of regulation, of harmony."

An interesting "semi-popular address" was given by Professor W. H. Lang on epiphyllous plants—chiefly algae, lichens, and liverworts—which grow in a non-parasitic manner on the foliage of trees in very damp tropical forests. He pointed out the prevalence in such forms of an efficient means of attachment to the surface of the leaf, and laid stress upon the occurrence of flat disc-like early stages in the germination of the spores of epiphyllous liverworts as an adaptation to this mode of life.

Among various other contributions on the morphology and biology of cryptogams the following may be mentioned. Professor West read two papers dealing with his observations on the genus *Microspora* and on *Zygnema ericetorum*: in the former he pointed out that the isolation of *Microspora* in a special order (Microsporales) of the Green Algae should be given up. Dr. Darbishire described the development of the apothecium in the lichen *Peltigera*, in which male organs (spermatia) are very rare, though fruits are formed abundantly, probably by apogamy; no coiled carpogonia can be made out, but there are deeply staining cells which form part of a connected system of branched hyphae proceeding from medulla to cortex, becoming multinucleate by nuclear divisions in the cells and (after producing functionless trichogynes which force their way through the cortex) giving rise to large cells ("ascogonia") from which the asci derive their paired female nuclei. Miss E. M. Poulton described the structure and life history of an aquatic lichen, *Verrucaria margaracea*. In an interesting paper, illustrated by very fine lantern slides, Professor Buller described the structure of the gills in the toadstool genus *Coprinus*, with special reference to the beautiful adaptations shown by the basidia of varying lengths, bearing the spores at different levels, and thus ensuring the liberation of spores in the most efficient manner. The same genus was dealt with by M. L. Baden, who found that, after encountering great difficulty in germinating the spores of *Coprinus sterquilinus* on ordinary media, vigorous germination occurred in media containing abundant bacteria, leading to the conclusion that in some way the bacteria are of benefit to the spores and to the mycelium formed by their germination—possibly by producing substances which soften the spore coat, or by removing any by-products of the fungus which may hinder germination. The apple-canker fungus, *Nectria ditissima*, was described by S. P. Wiltshire, who found that this fungus, which is a genuine wound parasite, can only attack trees when the injury is deep enough for the fungus to reach the wood, and that in nature the chief means of inoculation are injuries made by frost and by the woolly aphis (*Schizoneura lanigera*), in both cases the bark being burst by the swelling of the various tissues; the reäctions of the host against the disease are the formation of phellogen at the limits of the infected region in the cortex, of abnormal wood similar in structure to the medullary rays, and of wound gum in the wood vessels. Miss M. Hume described the structure of the leptoids, or "sieve-tubes," of the moss genus *Polytrichum*, pointing out that these cells have a nucleus though never containing starch grains or large oil drops like the other living cells of the moss stem. Direct experiments indicate that the conducting function of the leptoids is probably confined to albuminous materials and is not concerned with carbohydrates, the latter being possibly conveyed by the hydroids which probably have not a purely water-conducting function.

Dr. R. R. Gates presented and discussed certain evidences to show that mutation and Mendelian splitting are different processes. Results have been obtained showing that some at least of the mutations of *Oenothera* are not due to recombinations of Mendelian characters, as some writers have assumed, but to irregularities in the reducing nuclear division ("meiosis") which lead to changes in nuclear structure. The cases of *O. lata* and *O. semilata* alone were referred to in this paper, because they offer a means of differentiating between characters which are inherited from the parents and those which arise as a result of unequal or irregular distribution of the chromosomes during meiosis: these mutant forms have fifteen chromosomes instead of fourteen, and the same is true of all individuals possessing the foliage and habit of *lata* or *semilata*, even when these characters are associated with others derived by inheritance from their parental forms. Such cases show definitely that mutation is a process which is independent of the recombinations of characters such as occur in hybrids. The source of the fifteen chromosomes was shown some years ago to lie in occasional irregularities in the distribution of the chromosomes during reduction; two pollen grains of a pollen tetrad receive eight chromosomes, and the other two receive six, and when an egg having seven chromosomes is fertilised by a male cell from a pollen grain with eight, the resulting individual will have fifteen chromosomes and the foliage of *lata* or *semilata*. The extra chromosome, which is a triplicate of a pair already present, is thus associated with the development of certain foliage characters in *Oenothera* in the same way that the accessory chromosome, when present in duplicate, is, in certain insects, associated with the development of female sex characters. This is apparently the first case in plants in which a definite relation has been shown to exist between a chromosome and particular external characters.

Physiology was represented mainly by a joint discussion with the Chemistry Section, which was opened by Professor Moore with an account of various methods of bringing about the synthesis of formaldehyde from carbon dioxide and water by inorganic colloids acting as transformers of light energy; and by a paper in which Mr. W. N. Jones described some recent investigations in pigment (anthocyan) formation.

Ecology was represented by three papers on maritime vegetation. Professor Oliver dealt with the distribution of *Suaeda fruticosa* and its rôle in the stabilising of shingle, pointing out that while all shingle plants to some extent modify or retard the landward movement to which shingle beaches are liable, when very high tides are accompanied by onshore gales, *Suaeda fruticosa*, from its shrubby habit of growth and high capacity of rejuvenescence, is the most effective stabiliser of all British shingle plants. Miss W. H. Wortham described some features of the sand dunes in the south-western corner of Anglesey, with special reference to the succession of the various plant associations; while Mr. P. H. Allen gave a preliminary account of the observations made by a party from the Cambridge University Botany School on the maritime plant associations at Holme, Norfolk, the chief feature of the area being a sandy salt marsh, though there are also sand dunes and shingle banks.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

ACTION OF ALKALINE WATER ON LEAD.—The water consumed in Birmingham, which is mainly derived from Wales, is slightly alkaline, and unless subjected to special treatment has a pronounced action upon bright sheet lead. To obviate risk of danger from this cause a small amount of powdered chalk is added to the water in the Welsh reservoirs. The results of experiments upon this solvent action of the water are described by Messrs. Liverseege and Knapp in a communication to the British Association.

In these experiments, which were continued over a period of five years, it was found that different portions of a lead pipe behaved differently in this respect, and that the resistance offered to the water increased with the lapse of time. New lead pipes were rendered more resistant to the action of the water by treatment with a dilute solution of potassium permanganate. The erosion of sheet lead by the water depended upon the simultaneous action of oxygen, and its degree varied with the distance of the metal from the surface.

Carbon dioxide had but little effect in preventing the action of the water unless present in a quantity exceeding two per cent. by volume. Under those conditions the erosion of the lead was stopped, but the metal was dissolved in appreciable quantities. An addition of lime in proportions within the limits of three to nine parts per one hundred thousand reduced the erosive action, but larger or smaller quantities had little, if any, effect. The best results were obtained by treating the water with not less than four parts of calcium carbonate or not less than two parts of calcium bicarbonate per one hundred thousand.

THE FIXATION OF NITROGEN BY FELSPAR.—A mode of decomposing felspar, and its use in the fixation of atmospheric nitrogen, is described by Mr. W. H. Ross in the *Journ. Ind. Eng. Chem.* (1913, V, 725). If a current of nitrogen be passed over a mixture of felspar and carbon which has been heated to a temperature of 1400° C. only a small proportion of the nitrogen is retained by the ignited mass, but by adding calcium carbonate or lime to the mixture a relatively large amount becomes fixed. In the reäction that takes place the potassium of the felspar is liberated and volatilised, and more nitrogen is fixed than would be required to form a nitride of aluminium. For example, a mixture of two parts of felspar, two parts of carbon, and 4·3 parts of calcium carbonate when ignited at 1400° C. in a current of nitrogen fixed 6·1 per cent. of nitrogen in one hour and 7·4 per cent. in two hours. The fixed nitrogen may be very slowly liberated in the form of ammonia by boiling the product of the reäction with water or with a solution of sodium hydroxide.

THE FORMATION OF ALKALOIDS IN PLANTS.—From the results of experiments upon *Datura* and tobacco plants Messrs. Ciamician and Ravenna (*Chem. Zeit.*, 1913, XXXVII, 1156) have drawn the conclusion that vegetable alkaloids may be formed from amino-acids. For example, green tobacco plants normally contain about 0·15 per cent. of nicotine, but by inoculating them with various organic compounds the proportion of alkaloid could be more than doubled. Thus, after treatment of the plant with pyridine tartrate, the amount of nicotine was raised to 0·22 per cent., while with asparagin it was increased to 0·25 per cent., and with benzoic acid and quinol up to 0·4 per cent. Dextrose also led to an increased production of nicotine, whereas phthalic acid caused the proportion to be less than normal. Analogous results were obtained by treating *Datura* plants with pyridine, piperidine and carbopyrrolic acids, the first of these compounds causing the greatest increase in the alkaloidal production. In the case of both plants there was complete assimilation of the added substances.

ABSORPTION OF OXYGEN BY COAL.—An investigation that has an important bearing upon the spontaneous ignition of coal has been made by Mr. T. F. Winmill (*Times, Eng. Suppl.*, Oct. 1st, 1913). In each series of experiments coal-dust from coal taken from different parts of the Barnsley seam was exposed to the air at a temperature of 30° C. and the rate of oxidation determined. It was found that during the first hour or two the rate of absorption of oxygen was very rapid, and that the quantity absorbed was approximately proportional to the nature and amount of the carbonaceous matter present. As much as a tenth of a cubic centimetre of oxygen was absorbed by one hundred grammes of the coal dust during this initial oxidation, which lasted about forty-eight hours. The speed of absorption then became much slower, but it was possible for the increase of temperature produced during the first stage of oxidation to accelerate the velocity of this second stage to such an extent that, given favourable conditions, there was risk of ignition taking place. The reduction of the proportion of oxygen in the air did not prevent the initial oxidation, while the use of coarser coal-dust having only one four-hundredth of the surface of the fine dust only reduced the speed of oxidation by 28 per cent. A rapid increase in the velocity of the absorption followed each increase of the temperature.

MICRO-ORGANISMS PRODUCING ARSINE.—The conditions under which it is possible for arseniuretted hydrogen (arsine) or similar products to be liberated from compounds of arsenic are matters of considerable importance from the public health point of view. Although wall-papers coloured with an arsenic green are not so common as was once the case, they may still be found, and, when exposed to the air, may yield poisonous volatile compounds. At one time it was commonly believed that cases of poisoning by arsenical wall-papers were due to the dry dust given off from the surface, but in 1908 it was proved by Gosio that the real cause was an organic compound of arsenic produced by the action of certain mould-fungi in the presence of the carbohydrates contained in the paste by which the paper was attached to the wall.

This action is strictly specific, and was shown by Neppe (*Scienza Pratica*, 1908, I, 82) to be a characteristic property of the following moulds, arranged in the order of decreasing activity:—*Penicillium brevicaule*, *Aspergillus clavatus*, *A. fumigatus*, *A. glaucus*, *A. virens*, and *Mucor mucedo*.

A certain degree of moisture is necessary for the action of the mould-fungi, and a temperature of about 25° C. (77° F.) promotes the decomposition, which appears to be a direct vital phenomenon. When the amount of arsenic present exceeds a certain proportion the mould-fungi themselves are poisoned, but they can be gradually rendered immune to larger quantities. The volatile compound set free was found by Neppe to be diethyl-arsine, $HAs(C_2H_5)_2$.

A further investigation of the moulds capable of decomposing arsenical compounds in this way has recently been made by Dr. Husz (*Apoth. Zeit.*, 1913, XXVIII, 605). The behaviour of ninety different mould-fungi was investigated, and it was found that two forms of *Aspergillus* and five forms of *Penicillium* were the chief micro-organisms possessing this property. Among the moulds growing on arsenical paint on the damp walls of a room there was also a variety of *Actinomyces*, which appeared to be of common occurrence. When grown on culture media this mould formed colonies of a chalk-white appearance, owing to the production of spores.

ATOMIC WEIGHT OF CHLORINE.—Two critical studies of the published determinations of the atomic weight of chlorine are given in the *Chem. Zentralblatt* (1913, II, 572). In the first of these by Dr. A. Guye, the collated results obtained by the classic method of precipitating the chlorine with silver give the atomic weight as 35·454, this value being dependent upon the atomic weight of silver, which is taken as 107·87 to 107·88. By the more modern method of calculating the atomic weight from the vapour density, chlorine shows the value 35·461, which corresponds to an atomic weight of 107·89 for silver. The calculations of M. E. Wourtzel are in substantial agreement with those of Dr. Guye. Taking the atomic weight of hydrogen as 1·0076 and that of nitrogen as 14·008, the corresponding atomic weight of chlorine was found to be 35·460.

ENGINEERING AND METALLURGICAL.

By T. STENHOUSE, B.Sc., A.R.S.M., F.I.C.

CORROSION OF CONDENSER TUBES.—Sir Gerald A. Muntz, Bart., and Professor H. C. H. Carpenter, M.A., Ph.D., the Chairman and Hon. Secretary respectively of the Corrosion Committee of the Institute of Metals, have prepared a statement of a further scheme of work planned by the Committee. A short summary of the experimental work already accomplished was given in the last number of "KNOWLEDGE." The new work to be undertaken includes a time-temperature survey of the conditions under which dezincification of condenser tubes can take place, and a more detailed study of the temperatures existing in the experimental condensing plant and other condensers. Special attention will also be directed to the conditions under which electro-chemical protection can be effectively maintained, and in this connection a comparative study of all the principal methods of holding tubes in tube-plates will be carried out. A systematic series of experiments will also be initiated with a set of tubes of a copper-aluminium alloy from which specially interesting results are anticipated. The work will be carried out by Dr. G. D. Bengough, M.A., the Hon. Investigator, the expenses being met by subscriptions to the Corrosion Research Fund of the Institute of Metals. The contributions received to date since the establishment of the fund in January, 1911, amount to nearly £800.

BRITISH ASSOCIATION—SECTION G.—The report of the Committee to Section G of the British Association, on "Certain of the more complex stress distributions in Engineering Materials," gives a review, with bibliography, of the literature dealing with combined and alternating stresses. In notes contributed by Dr. F. Rogers, the usual causes of the failure of metals under alternating stress are summarised in the three main classes:—(*a*) *Flaws*, including pipes, fissures, blow-holes, impurity, and non-metallic enclosures. (*b*) *Faulty original heat-treatment* of pure metal. This includes as a special case, strains set up in manufacture, and overwork in the working processes. (*c*) *Under-estimation of stresses* to be expected, on the part of the designer. This includes as a special case insufficient allowance for the effect of repetition of a stress which would be harmless if applied once or steadily maintained.

The Heat Treatment of steel, as affecting endurance, may conveniently be considered in three main classes:—(1) *Over-heating*, which must be distinguished from "burning," in general, diminishes the endurance under alternating stress. (2) *Reheating through the critical range* is, in general, capable *per se* of bringing the endurance to a normal high value. (3) *The speed of cooling through the critical range* has in any event a most profound influence upon the endurance under alternating stress. Generally speaking, it appears that the more rapid this cooling the greater is this endurance.

GEOGRAPHY.

By A. STEVENS, M.A., B.Sc.

FIORDS.—The work on the Nature and Origin of Fiords, just published by Mr. Murray for Professor J. W. Gregory, will arouse much interest. Fiords have generally been ascribed to glacial action, but Professor Gregory advances reason for believing that they are the result of earth-movements and faulting, and succeeds at least in discrediting the glacial hypothesis. First of all, it is not true that fiords occur only in glaciated regions, for typical fiords occur in the unglaciated areas of Dalmatia and the North Island of New Zealand. Then it is certain that at least the Scottish fiords are pre-Glacial in age, and the direction of glaciation is often transverse to the line of the fiords, as is shown remarkably in the Shetland Isles, where the ice movement was from east to west, while the inlets are strikingly arranged in a north and south direction. Taking the Scottish lochs for example, they are seen to follow four well-marked sets of lines, trending north-east, north-west, east, and north. Fissure-systems running in these directions are frequent and typical in Scotland. Of these the first is the most striking, and the Caledonian Canal with its line of lochs, and the persistence of the line in the northern shore of the Cromarty Firth and the coast of Sutherland and Caithness, is the most remarkable example. This system is dependent on the well-known Great Glen fault. In the north-west system the branch of Loch Awe, for instance, runs in the Pass of Brander, which is also a fault valley. Then the arrangement of fiords is not that which a glacier system would produce. There is no hint of radiating from central high land that would inevitably be seen in features due to ice, and side fiords join a main fiord of one system from directions that associate them with other systems. It is not only in Scotland that the fiords are associated with the ascertained crack-systems of the country. The phenomenon is seen in Spitzbergen, Dalmatia, and in the other regions described. The distribution of fiords is significant and correlated with the different types of movement characteristic of polar and equatorial regions. They occur mainly on western coasts where the piling up of elevations of the earth's crust is greatest, and just beyond which has taken place extensive foundering; and this distribution is dependent on the rotation of the earth. The crack-systems are associated with the foundering of the ocean-beds. Two fiord belts exist, the northern nearer the pole than the southern, on account of the tetrahedral plan of the earth. Along fiord coasts typical fiords are found in the higher latitudes, and pass towards the equator into fiards, which in turn give place to rias. In the fiord regions themselves, in the higher latitudes, are wider rift-inlets and sounds associated with typical networks of true fissure fiords, and nearer the equator the wider rift channels disappear, and only the fiord reticula remain. This succession is wonderfully constant.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

CALCITE CRYSTALS FROM A WATER TANK.—In view of the frequent occurrence of crystals of carbonates, especially dolomite, in certain argillaceous sediments, the observations of the late R. F. Gwinnell on calcite crystals formed in a water-tank are of interest (*Mineralogical Magazine*, July, 1913). The crystals were deposited in sand-like heaps in a tank into which water was led, through an old leaden pipe, from a spring in the ferruginous beds at the base of the Marlstone (Middle Lias) to the north of Grantham, Lincolnshire. They were formed during the dry summer of 1911, when the flow of water, although not ceasing, was reduced to a mere trickle. Under microscopic examination the crystals were found to be colourless, of rhombohedral habit, and giving the usual tests for calcite. This determination was confirmed by chemical analysis, which showed that the deposit contained 95·65 per cent. of calcium carbonate, the rest being alumina, ferric oxide, and silica. The deposition of these crystals under artificial conditions of comparative aridity has a bearing on the formation of similar carbonate crystals in ancient sediments laid down under arid conditions, under which direct precipitation of carbonates from solution may well have taken place.

LAND CLASSIFICATION AND GEOLOGY.—Recently the people of the United States became aware that they had been too lavish with their lands, and that more than half the public domain had been alienated. Now, therefore, the examination and classification of the public lands has been made an essential preliminary to their disposition and development, and the Geological Survey was commissioned to carry out a scientific examination of the lands still remaining to the nation. Pending the accumulation of this quantitative knowledge the land is withdrawn from settlement and exploitation; but as soon as any area is accurately known, and its highest use ascertained, it is restored to entry, and is so disposed as to secure the maximum benefit to both settler and State. From the results of geological examination by its field officers the Land Classification Board of the United States Geological Survey is enabled to say whether the highest utilisation of certain areas may be attained by working metalliferous deposits, coal, oil, gas, phosphate, or salines, or by using it as a reservoir or water-power site, or merely as agricultural land. On the basis of information thus obtained the public-land administrative officers make the most useful allocation of the land that is possible. In the case of coal a most exact quantitative survey is made, and a valuation becomes possible. After classification and valuation the lands are restored to entry, and may be acquired under the coal-land laws at the valuation prices. Prior to land-classification many persons fraudulently obtained coal and other valuable mineral lands under the cheap and easy mode of entry relating to agricultural lands. The principles, purposes, and methods of land classification are explained in Bulletin 537 of the United States Geological Survey, which makes most interesting reading. It presents a clear formulation of a new method in which the science of geology is made of practical value to the public. Although it is rather late in the day to voice the sentiment it is perhaps a pity that all the public land of our own country is so hopelessly alienated.

ORIGIN OF TEKTITES.—Under the term "tektite," Professor Suess includes all the peculiar pebbles of obsidian-like glass which have been described under the names of moldavite, billitonite, and australite. These have frequently been assigned an extra-terrestrial origin; and Dunn regards australites as the blebs from the bases of glass-bubbles ejected from volcanoes and distributed by the wind over the Australian plains (see "KNOWLEDGE," August, 1913, page 308). G. P. Merrill has recently compared tektites with a series of undoubted obsidian pebbles from various localities in North and South America and Iceland, and finds that the latter have the same structures and peculiarities of surface-markings as the tektites. Moreover, he shows that the chemical composition of one of these obsidian pebbles does not sensibly differ from that of tektites (*Proceedings U. S. Nat. Mus.*, 1911, 481–6). Dr. Merrill concludes that while the theory of the meteoric origin of tektites is not controverted by these observations, it cannot be regarded as proved until these bodies have actually been seen to fall on to the earth's surface.

In connection with Dunn's theory of the origin of australites, the observation by Mr. F. W. Moon of volcanic ash in Mexico, consisting largely of perfect bubbles of volcanic glass, is of great interest and importance (see letter in "KNOWLEDGE," November, 1913, page 409). It proves what Dunn was unable to prove, that volcanic glass-bubbles are capable of being formed and of being distributed over the earth. More information concerning this occurrence is desirable.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

DURATION OF RAINFALL.—It is generally believed in this country that every other day is a wet one. This supposition is approximately correct, as the number of "rain days" in the year is about the same as the number of rainless days. A "rain day" is held by meteorologists to be a day on which an amount of 0·01 inch or more fell during the twenty-four hours ending 9 a.m. of the next day. This may be spread over the whole twenty-four hours, or it may only occupy a few minutes in falling, but it gives no information as to the actual duration of the rainfall. This can only be obtained from self-recording rain-gauges, and it is satisfactory to learn from *British Rainfall* that there is an increase in the number of these instruments in use.

At Camden Square, London, where a Casella self-recording rain-gauge has been in use since 1881, the following are the average values for the thirty-one years, 1881–1911:—

Rainfall.	Duration.	Intensity rate per hour.	Rain days.
24·13-in.	426·9 hours.	·057-in.	162

In 1912 the values were:—

Rainfall.	Duration.	Intensity rate per hour.	Rain days.
27·88-in.	516·2 hours.	·054-in.	180

The duration in 1912 exceeded the average by twenty-one per cent., and the number of rain days eleven per cent. in excess of the average for the same period; the year was thus one of very persistent rainfall, but with an intensity slightly below the normal.

The following values from the same class of instrument show the monthly duration of rainfall in hours at several stations in various parts of the country during 1912:—

Station	London.	Thrapston, Northants.	Cirencester, Glos.	Hodsock, Notts.	Southport, Lancs.	Cray Reservoir, Brecon.
Height above sea-level	111-ft.	262-ft.	366-ft.	56-ft.	39-ft.	1030-ft.
January...	88·8	89·8	110·8	108·7	105·0	236·0
February	44·7	39·5	58·5	29·9	53·8	179·3
March ...	59·8	51·9	106·7	60·2	115·7	220·2
April ...	1·6	1·8	4·8	2·0	6·6	40·8
May ...	25·8	24·2	33·7	49·8	62·4	88·5
June ...	54·2	56·1	68·3	60·3	71·8	132·2
July ...	22·2	60·1	46·5	48·5	49·6	104·8
August ...	66·2	100·3	106·3	72·5	96·0	189·5
September	25·7	24·5	19·3	24·5	30·4	33·7
October...	32·1	41·3	67·8	25·9	62·7	134·5
November	37·2	35·1	38·9	37·8	56·1	143·3
December	57·9	55·7	100·8	36·3	73·2	242·2
Year ...	516·2	580·3	762·4	556·4	783·3	1745·0
Rainfall...	27·88	31·36	42·01	33·45	37·13	82·83

April stands out prominently as a very dry month, the duration of rainfall in many districts being less than two hours. The months of greatest duration were January, March, and August. It is interesting to notice that in the mountainous districts, where there is a heavy rainfall, the duration is considerably greater than at stations at a much lower elevation.

TORNADO IN WALES.—We are accustomed to think that tornados only occur in the United States and that nothing of the kind is likely to be experienced in the British Isles. On Monday, October 27th, however, a little after 5 p.m., a most violent storm of the tornado type, accompanied by vivid lightning and heavy rain, occurred in South Wales and passed over the district in which Senghenydd is situated, where the recent appalling colliery disaster occurred. From the accounts in the local papers it appears that the storm started on the mountain west of Treforest and rushed up the eastern side of the Taff Valley to Cilfynydd, whence it roared up Cwm Eldeg, and then over the north-eastern flank of Llanfabon Mountain, and down into the Taff Valley. From here it rushed up the western side of the valley, and expended its fury upon the highest houses in Abercynon. It then seems to have turned off at a tangent to Quaker's Yard and Treharris, where its career apparently ended. The track of the tornado was only about two hundred yards in width, but within this area everything was devastated. Mr. Clement Edwards, M.P., in an appeal for monetary help for the sufferers, states that many hundreds of houses have been ruinously damaged, and that over two hundred families have lost beyond repair most of their furniture and all their bedding and bedclothes and wearing apparel. Among the more extraordinary effects of the storm it may be mentioned that half a corrugated iron roof was carried for several miles, through valleys, across villages, and over mountain tops, and the tins of the sheets detached and wound round posts as a doctor wraps a bandage round a broken wrist. A four-ton oak tree was carried away for nearly a quarter of a mile. Unfortunately two men lost their lives, one being caught by the fury of the storm and hurled a distance of one hundred and fifty yards into a field, and the other being struck on the head by a slate.

EFFECT OF ATMOSPHERIC CONDITIONS ON WIRELESS SIGNALS.—Dr. E. W. Marchant read a paper at the recent meeting of the British Association on the effect of atmospheric conditions on the strength of wireless signals sent out from the Eiffel Tower in Paris at 10.45 a.m. and 11.45 p.m., and received at Liverpool. The results obtained show that there is a maximum variation from 0·6 to 1·3 in the strength of the signals received on different days in the same month; the average strength of signal being assumed to be 1·1, and that the current received on a fine clear night is about 1·7 times as strong as that received in the daytime.

Although no certain relationship can yet be regarded as established between the strength of a signal and the weather conditions at the sending and receiving stations, so far observation has shown that rain in Paris always corresponds with diminution in strength of received signal. In one case, with a wind of six meters per second velocity, blowing in a north-west direction, the signal-strength fell to half its normal value. The most favourable condition for signalling appears to be a cloudy sky at both sending and receiving stations, the signals being weaker when the sky is clear or covered with light clouds. Rain at the receiving station appears to have a comparatively small influence on the strength of the received signals. The result of a set of special signals sent from the Eiffel Tower on the evening of Saturday, July 26th, 1913 (by the courteous arrangement of Comm. Ferrié), at intervals of thirty minutes, between 7 and 10 p.m. (which includes the time of sunset), shows that the increase in strength of night signals occurs just after sunset, there being an abrupt increase in strength of about 70 per cent. This change is quite sudden, there being comparatively little alteration in signal-strength until the sun has set, and no perceptible increase in strength afterwards. There appears to be some evidence that signals are slightly stronger just after sunset than during normal night conditions.

MICROSCOPY.

By F.R.M.S.

DENDROMONAS VIRGARIA WEISSE.—At one of the excursions of the Quekett Club during the autumn the above-named organism was obtained in some quantity; though probably not very rare, it is certainly not frequently recorded. Owing to its exceeding transparency and delicacy, and the small size of the composing units, it would be easily overlooked by anyone unacquainted with it. Saville Kent gives an excellent representation of it from which Figure 535 is taken.* As will be seen it is a tree-like form. The stem, called the "zoödendrium," is rigid, dichotomous, and copiously branched. At the end of each branch is attached a somewhat flattened pear-shaped animalcule, the forward end obliquely truncated. It has two flagella of unequal length, and is without a mouth, food being taken in at all parts of the body. It has a nucleus and one or two contractile vacuoles, and is practically a stalked monad. The whole is perfectly transparent, and while the individuals are extremely small—about 8μ in length—the entire organism is of considerable size, often consisting of more than one hundred zoöids, and being about 1–130″ in height. In consequence it is very difficult to observe satisfactorily. For finding it and for a general view a half-inch objective with good dark background illumination answers, but for anything like a complete examination the highest power that can be brought to bear on the object is necessary, with a careful adjustment of light; the use of a coloured screen is advantageous. In the present instance, specimens were fairly numerous on some fine grass stems which had evidently been submerged a long time, but it was not found possible to preserve them long under examination, as the zoöids soon became detached from the pedicle; the stem and branches, however, remained visible afterwards. In most of the specimens it was noticeable that the animalcules were arranged on a more regular level than the illustration indicates, the mass forming, when looked at from the side, a thin plate on the top of the beautifully hyaline regularly-branched stem. In a surface view, at least in the larger specimens, the pear-shaped bodies were seen considerably compressed towards the middle of the group owing to crowding, and were often angular in consequence. Kent says of it: "Among all of the numerous stock-building pedicellate varieties of the Flagellata, few, perhaps, excel the present one in the exuberance of growth and graceful symmetry of the erect branching zoödendrium. The associated colonial stocks have been observed in such abundance on the finely-divided leaves of Myriophyllum and other water plants as to present the aspect of a perfect forest growth of tiny crystal trees, each terminal leaflet replete with life, and quivering with the combined vibratory action of their flagella." Figure 535 represents an adult colony; at A is an isolated monad under high magnification; and at B a colony of two monads in process of longitudinal division, all from Saville Kent's "Manual of the Infusoria."

JAS. BURTON.

QUEKETT MICROSCOPICAL CLUB.—October 28th, S. C. Akehurst, "A changer for use with substage condensers." This was on the principle of the Zeiss sliding objective changers.

S. C. Akehurst, "A trap for free-swimming organisms." This was exhibited in two forms and took advantage of the phototropism exhibited by most pond animals.

James Murray, "The Gastrotricha": a valuable contribution dealing with this small group of minute animals, chiefly freshwater, and of doubtful affinity. The paper describes their form and structure, their haunts and habits, gives a historical sketch of the group with its classification, a key to the genera, and a list of the eighty-three species, including one new one, which have been described, and concludes with a lengthy annotated bibliography. The paper, with a plate of some forty figures, appears at length in the November issue of the Club's *Journal*.

E. M. Nelson on "An improved form of Cheshire's Apertometer" and M. A. Ainslie, "A variation of Cheshire's Apertometer"; two papers describing improvements designed to facilitate and render accurate determinations of the second decimal place of N.A. with this instrument.

F. J. Cheshire did not think the form of Apertometer he had introduced some ten years ago capable of greater accuracy than he had then given it. He described another method of estimating N.A. which he considered an improvement on the older one.

PHOTOGRAPHY.

By Edgar Senior.

TESTING FOR "HYPO" IN MOUNTS, PRINTS, AND WASHING WATER.—If silver prints are mounted upon card that contains traces of "hypo" owing to this body

* "Manual of the Infusoria." Plate XVII, Figure 1.

having been used as an "antichlor" in neutralising the bleaching agent used in the manufacture of the paper or the material from which it was made, its presence may bring about fading of the print. On this account mounts for silver prints should be selected with considerable care. There are, however, several delicate tests that may be applied which will detect "hypo," even when present in very small quantity, the following being one of them. Take about three or four square inches of the card to be tested and tear it up into small pieces and put these to soak in a glass beaker which is about half filled with distilled water, after which add about half a dram of pure strong sulphuric acid and a little pure zinc. The beaker is then to be covered with a piece of filter paper upon which a few drops of a solution of lead acetate have been allowed to fall. The presence of "hypo" will be indicated by the acetate of lead becoming brown from the formation of lead sulphide, and if after the expiration of about half an hour there is no appearance of stains, it may be assumed that "hypo" is absent. In any case the rapidity with which the stains are developed will depend upon the quantity of "hypo" present. The test depends upon the nascent hydrogen evolved by the action of the sulphuric acid upon the zinc, reducing the sodium thiosulphate ("hypo"), with the formation of sulphuretted hydrogen, which combines with the lead acetate to form lead sulphide, the reäctions being expressed by the equations

$$Na_2S_2O_3 + 4H_2 + H_2SO_4 = 2SH_2 + Na_2SO_4 + 3H_2O$$

$$Pb\ (CH_3COO)_2 + SH_2 = PbS + 2\ (CH_3COOH)$$

The presence of "hypo" in prints may readily be detected in a number of ways, the iodide of starch test being commonly employed for the purpose, the solution being made up in the following manner. A small piece of starch is taken and boiled in about three drams of distilled water until a clear solution is obtained, to which when cold about a dram of iodine dissolved in alcohol is added: this causes a dark-blue coloured solution to be produced due to the formation of iodide of starch. "The addition of iodine dissolved in water by the aid of potassium iodide will answer instead of iodine in alcohol." To apply this test to ascertain whether "hypo" is present in a print, small pieces of the latter are boiled in a test tube containing some distilled water; the solution is then allowed to get quite cold when one or two drops of the iodide of starch are added to it, and should the blue colour be discharged the presence of "hypo" is indicated, but should the blue colour remain it may be assumed that this salt is absent. The presence of "hypo" in the washing water of prints is readily shown by taking two test tubes and filling one with pure distilled water and the other with the water to be tested, and if a drop or two of the iodide of starch solution be added to each, sufficient to give a faint blue colour to one when viewed by looking through it at white paper, a total absence of any colour in the other will show that "hypo" is present in it. The presence of "hypo" is also easily shown by means of an alkaline solution of potassium permanganate, for which purpose the following formula by Professor Bottcher is to be recommended:—

Potassium permanganate (pure) ...	$1\frac{1}{2}$ grains
Caustic soda	$15\frac{1}{2}$,,
Water (distilled)	$18\frac{3}{4}$ ounces

When using this solution the presence of "hypo" is shown by the pink colour changing to a green, owing to the reduction of the manganese salts. The washing should therefore be continued until a small quantity of the water contained in a test tube will allow of some of the pink solution being added to it without its becoming green.

PHYSICS.

By ALFRED C. EGERTON, B.Sc.

SPARK PHOTOGRAPHS AT HIGH PRESSURES.—The curious phenomena which attend the passage of electricity through gases are manifold; the nature of the effect is chiefly dependent on the pressure. At ordinary pressures the usual spark discharge is obtained; as the pressure increases, so it becomes more and more difficult for the spark to pass: the length of the air gap must be decreased, and when the discharge passes a fatter spark is obtained and a larger current is carried across the gap. At low pressures, the discharge passes more readily until a certain lower limit of pressure is reached, when the discharge passes again with great difficulty. The discharge first appears as an elongated spark; then as a straight but rather fuzzy strip; then it fills the whole space between the two electrodes, and then appears the Faraday dark space near the negative electrode, which is surrounded by a luminous glow; then, again, behind this appears the Crookes dark space, where the negative electrons are ejected normally to the surface of the electrode. As this space begins to show, so the discharge usually breaks up into a series of light and dark bands. Finally the Crookes space fills the whole tube, and if exhaustion is carried very much further the space refuses to carry any discharge of electricity.

The study of these phenomena has led to the wonderful developments of physical science during the last twenty years. The positive, the negative or kathode, and the X-rays and the rays they in turn give rise to—secondary rays—were all discovered during investigations to explain these electric discharges; indeed, much light has been thrown on the nature of matter and its relation to electricity by such work done mainly by Sir J. J. Thomson and those who have been inspired by his genius. An atom of matter is built up of negative charges of electricity, some free to move as they will, others bound, some controlling the chemical properties of the atom, others resident within and taking no part in chemical actions. These negative charges are held together by the rest of the atom which is positively charged. Whether this charge is concentrated in a central nucleus or whether it is distributed throughout the mass of the atom is still an open question; the positive portion is associated with the chief portion of the mass of the atom. The effects obtained in the electric discharge in gases are mainly due to the action of charged particles (electrons) or positively charged atoms on the molecules of gas in their path. If the velocity of the charged particle is sufficient it will "ionise" the molecule on collision with it; that is to say, it will split it into oppositely charged parts. The current is carried at the lower pressures by these moving ions.

The explanation of the discharge through gases at high and ordinary pressures is dependent on similar considerations. A discharge will pass through some gases more readily than others; through neon the discharge passes most readily. In most cases of the conveyance of electricity through gases the ions have to be produced by some kind of rays, but in the spark discharge there are many more ions produced in a given time in the neighbourhood of the electrodes than recombine in the same time, and the discharge, as it were, "supports itself." The differences in the ease with which the discharge will pass through the gas depend on the amount of energy required to ionise the molecules of the gas. Investigations on these matters have been most ably carried out by Professor Townsend, of Oxford.

Amongst the mass of literature on these subjects we may note a paper read before the Röntgen Society in April, 1913, by Professor A. W. Porter. The terminals of an induction coil are connected to two electrodes, one on either side of a photographic plate. The photographic plate is situated in a dark chamber, in which the pressure may be raised up to ten atmospheres. When the negative electrode is against the sensitive side of the plate, at ordinary pressures, fanlike impressions of the discharge are obtained on developing the plate; but on raising the pressure the fanlike expansions separate into two filaments. The negative discharge gives figures with lines of discharge which are characteristic of the positive spark lines for the same gas; that is, a positive rebound must occur after the negative discharge has taken place.

The distinction between the negative and positive discharges is very marked, but they are somewhat more similar at higher pressures. The fanlike discharges are shown to be due to the presence of nitrogen. The spark in oxygen passes easily and the effects at higher pressures obtained with air are due to the presence of oxygen, the negative discharge in nitrogen being very difficult to obtain at high pressures. In hydrogen the discharge merely amounts to a glow round the terminal. The positive discharges, when the positive electrode is put against the sensitive side of the plate, are not so distinctly different in different gases, and they merely become finer at higher pressures. These experiments will help to define many curious effects obtained in the brush and spark discharge, but there is much which remains to be cleared up. The actual condition of affairs at the negative electrode is, perhaps, one of the most interesting points upon which the above researches may throw some light.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

COMMENSAL CRUSTACEANS IN CHAETOPTERUS TUBES.—Professor A. S. Pearse has studied three Crustaceans — *Polyonyx macrocheles*, *Pinnixa chaetopterana*, and *Pinnotheres maculatus*—which occur as commensals in the tubes of *Chaetopterus variopedatus* at Wood's Hole. The two first-named are not closely related, *Polyonyx* being a Galatheid and *Pinnixa* a true crab of the family of Pinnotherids, but they have many similarities. Like most Crustaceans, they are strongly thigmotropic, and creep into crevices or tubes, which would easily account for their taking up their abode with Chaetopterus. They are rarely found elsewhere. They become quiet when a shadow passes over them, which has probably protective value. They feed by "net casting," after the manner of barnacles, and this is admirably suited for the capture of food within the tubes. The "nets" in both are formed by the inner blades (or endopodites) of the third maxillipede, which are well supplied with plumose setae and are swept through the water. Both forms have the last leg shortened. Both have a long breeding season, producing one brood after another, and this is perhaps fostered by the sheltered life. They gain from their association with the worm, but the worm's view of the situation is unknown.

REMARKABLE BLIND CEPHALOPODS.—One of the most precious spoils of the Michael Sars North Atlantic Deep Sea Expedition of 1910 (carried out under the auspices of the Norwegian Government and the superintendence of Sir John Murray and Dr. Johan Hjort) was a blind cuttlefish, *Cirrothauma murrayi* n. g. et sp. apparently adapted for deep sea life. Three thousand metres of wire were out when it was captured. The specimen is perfectly gelatinous and semi-transparent. Its fragility recalls that of a Ctenophore. A delicate web unites the arms. The nerves can be seen shining through the whole length of the arms. The gelatinous body exhibits an exceedingly faint violet colour, and only the parts round the mouth, the proximal portions of the arms, and the web exhibit the purple chocolate colour peculiar to many deep-sea animals. Chromatophores are absent, except a rhombic one between the two fins. Very peculiar minute suckers (thirty-six in number) poised on long spindle-shaped and clumsy stalks of gelatinous substance occur on the inner side of the arms. They are evidently out of function, being flattened and without a sucking pit, and smaller than the normal proximal suckers. In each stalk there is a curious structure which may be a luminescent organ and reflector. The eye is minute, without a lens, with a very degenerate retina and optic nerve. There are deep-sea cuttlefishes with small eyes, but no case save this one is known where the structure of the eye is involved. Its degeneration has gone further than in many blind vertebrates.

PHOSPHORESCENCE OF PENNATULIDS.—Professor W. A. Herdman has recently described the "phosphorescence" of *Funiculina quadrangularis*, the largest British Pennatulid. The light on the bare part of the colony was more intense that that produced by the polyps. "The long bare lower part of the stem, nine inches to a foot in length, when gently stroked in the dark glows with a continuous sheet of light of (it seems to me) a pale green colour which flickers or pulsates like a lambent flame." In *Pennatula phosphorea* the luminosity seems to be confined to the polyps. It is more general and more lasting than the sparkles that the polyps give in *Funiculina*. In the report on the spoils of the Michael Sars Expedition, the artist has given a figure of the luminescence of *Umbellula güntheri* which was still brilliantly phosphorescent although drawn up from the immense depth of more than five thousand metres. Dr. Hjalmar Broch refers to Sir Wyville Thomson's note that the spectrum of Pennatulid phosphorescence is very restricted and sharply included between b and D. Niedermeyer found that the phosphorescence of *Pteroeides griseum* was restricted to the polyps and small zooids, and is temporarily lost after exposure to sunshine, which probably destroys, for the time being, the product of some intracellular secretion. Although its phosphorescence is only seen by us when we stimulate these Pennatulids, Broch suggests that deep-sea forms may show it without irritation.

NOTICES.

CHANGE OF ADDRESS.—We are asked to announce that Messrs. Haseltine, Lake & Company, Patent Agents, have removed from 7 and 8, to No. 28, Southampton Buildings, Chancery Lane, E.C.

OPTICAL LANTERNS.—Messrs. Newton & Company's new catalogue is noteworthy for the many types of science lanterns listed, and is particularly valuable on account of the variety of arc lamps and other projection illuminants therein described.

SCIENTIFIC BOOKS.—We have received from Mr. H. K. Lewis his quarterly list of new books added to the circulating library. It contains the books published from July to September. Under the heading, "Technology," we notice that the first volume of the new edition of Lewkowitsch's "Chemical Technology and Analysis of Oils, Fats, and Waxes" is included.

THE "WELLCOME" PHOTOGRAPHIC RECORD AND DIARY, 1914.—This useful little pocket guide to photography has been reissued by Messrs. Burroughs, Wellcome & Company. Particular attention is given in this edition to blue and green toning and the production of various colours by development. It should find a place in every photographer's library.

SCIENTIFIC, INDUSTRIAL AND TECHNICAL BOOKS.—Messrs. Crosby, Lockwood & Son have published a new illustrated catalogue of books coming under the above heading, and we are asked to announce that they will be willing to send a copy post free to all who may be in any way interested.

SECOND-HAND MICROSCOPES.—Messrs. H. F. Angus and Company have issued their fourth catalogue under this title. A good selection of instruments, objectives, and accessories, as well as general optical and physical apparatus, will be found therein.

NATURAL HISTORY BOOKS.—In Messrs. John Wheldon & Company's latest catalogue will be found, besides general literature, a list of important remainders of books on Natural History, and many sets of scientific journals, both English and foreign.

THE SCIENTIST'S REFERENCE BOOK AND DIARY, 1914.—Once again we have pleasure in noting the appearance of this handy pocket book. In addition to a diary and space for memoranda it contains tables useful for everyday reference and a short account of the progress of science in 1913. It is published by Messrs. James Woolley, Sons & Company, Limited, of Manchester.