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KNOWLEDGE

AN ILLUSTRATED MAGAZINE OF SCIENCE

SIMPLY WORDED - EXACTLY DESCRIBED

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Edited by A. COWPER RANYARD.

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INDEX.

INDEX OF THE PRINCIPAL ILLUSTRATIONS.

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CONTENTS.

A LAND OF SKELETONS.

By R. Lydekker, B.A.Cantab.

NEXT to Australia, which, as regards its fauna, stands quite apart from the whole of the rest of the world, South America possesses a greater number of peculiar types of animals than any other region at the present day. A traveller, for instance, starting from Europe may wander eastwards across the northern part of Asia, as far as Japan, without ceasing to meet with types of mammals and birds perfectly familiar to him; while the same is, to a great extent, the case if his footsteps are directed to India or Africa. It is true, indeed, that in both the latter countries he will come across creatures like elephants and rhinoceroses which are now unknown in Europe, while in Africa he will be confronted by hippopotami, giraffes, and ostriches. All these animals, however, once existed in Europe during the later portions of geological history, and may, accordingly, be counted as pertaining to the European fauna. Still more striking is this similarity of the fauna with that of Europe if the traveller's route happen to lie across the northern half of the New World, where he will meet with many mammals, such as the bison, grizzly bear, and wapiti, which are scarcely to be distinguished, even specifically, from their Old World allies; while others, like the reindeer, wolf, and fox, are absolutely identical. On the other hand, when South America is reached, it will be found that not only are all the mammals and birds specifically different from those of Europe, but likewise that many of them belong to genera or groups absolutely unknown beyond the confines of that country, while Old World types are relatively scarce. For instance, the whole of the typical representatives of that group of mammals technically known as edentates, such as the armadillos, ant-eaters, and sloths, are exclusively confined to South and Central America; while the monkeys of that continent are quite different from those of the Old World, and the pretty little marmosets are peculiar to it. The camel-like animals known as guanacos and vicunias, together with their domesticated representatives the llamas, are likewise at the present day exclusively characteristic of South America, although there is reason to believe that they were originally introduced from the north. Then, again, opossums (which, by the way, must not be confounded with the creatures commonly so called in Australia) are among the most characteristic of South American mammals, although some range as far north as the United States. The rodents, or gnawing mammals, are likewise remarkable, not only for their numerical abundance, but likewise for the large size of several of their members which belong to genera peculiar to the continent. Among these the capivara or carpincho (*Hydrochœrus*), commonly known as the river hog, is the largest living member of the order, its skull measuring about a foot in length. Another characteristic aquatic type is the coypu (*Myopotamus*), generally termed by Europeans nutria, which is properly the Spanish name for an otter, and easily recognized by its red incisor teeth. Of the terrestrial species the most familiar is the viscacha, which inhabits warrens, like the prairie marmot of North America, with which, however, it has no affinity. Not only is South America remarkable for the number of peculiar types of mammals it contains, but it is likewise noteworthy for the absence of a number of Old World and North American forms; especially notable is this paucity among the ungulates or hoofed mammals, which are represented solely by the aforesaid guanaco and its allies, by a group of deer differing considerably from all Old World species, although represented in North America, and by several species of tapirs—the latter animals being at the present day known elsewhere only by a solitary kind from the Malayan region, although they were formerly abundant over a large portion of the Old World. Consequently, such well-known and important groups of ungulates as the oxen, goats, sheep, antelopes, horses, rhinoceroses, hippopotami, and elephants are totally unknown in a wild state at the present day in South America, although two of them, viz., horses and elephants, formerly existed there. Equally characteristic are the birds of South America. Although it will only be possible here to make allusion to a few among these, we may especially mention the entire group of humming birds, together with a peculiar family of perching birds commonly known as wood-hewers, and technically as the *Dendrocolaptidæ*, of which the well-known oven bird (so-called on account of its dome-shaped mud nest) is a familiar example. The large gallinaceous birds termed curassows and guans are also very characteristic; while still more distinctive of the country are the tinamus, which, although structurally allied to the ostriches, are so like partridges in form and habits that by English residents in the country they are commonly so termed. Another characteristic South American bird which is commonly misnamed by Europeans is the rhea; this bird, which is almost universally designated an ostrich, differing from its African relative by having three toes instead of two. Yet another remarkable avian type is to be found in the large and somewhat goose-like chaja (pronounced chahá), or horned screamer, which

* See article on "Armadillos and Aard-Varks."

takes its English name from the spur on its wings and its loud cry—the latter being sometimes heard when the bird is so high in the air as to be almost or quite invisible. Among characteristic South American reptiles may be mentioned iguanas (a name often applied incorrectly to lizards from other parts of the world) and caimans; the latter being a group of alligators, distinguished by having an armour of bony plates on the under as well as on the upper surface of the body. The huge horned frogs (*Ceratophrys*) are likewise distinctive of the country among the batrachians.

Such are a few of the leading features of the existing fauna of South America, which are sufficient to show how totally different is the animal life of this country from that of all the rest of the world. If, however, we go back to the late geological periods of the earth's history, we shall find that this peculiarity and distinctness of the South American fauna was even more intensified than it is at the present day; this being largely due to the circumstance that at one time the Isthmus of Darien did not exist—so that the northern and southern portions of the New World were disconnected. Since the time when a connection was formed between the two continents, their faunas have, however, naturally tended to blend together, and hence at the present day, and during the Pleistocene period, the animals of South America are less sharply differentiated from those of the northern half of the continent than would have been the case had the Isthmus of Darien not been formed. It is further interesting to note that during the Tertiary period there appears to have been some kind of connection between the faunas of South America and Australia.

The country that has afforded us the most information with regard to the extinct fauna of South America is the Argentine Republic, which includes not only Buenos Ayres and the adjacent provinces forming Argentina proper, but likewise the whole of Patagonia. Confining our attention, in the first place, to the province of Buenos Ayres and some of the neighbouring districts, we may note that the greater part of this vast tract of country is one boundless level plain formed by an alluvial deposit of rich black mud brought down from the higher lands of the interior by the tributaries of the Rio de la Plata, and which constitutes the most extensive pasture-land in the world. Near Buenos Ayres and the valley of the Rio de la Plata this alluvial deposit, which in places alternates with sandy beds, is of immense thickness;* but further to the south it thins out rapidly. In some places in the neighbourhood of La Colina, about a hundred miles from Bahia Blanca, for instance, the black soil is not more than a couple of feet in thickness, and is underlain by a hard white calcareous deposit, locally known as "tosca," and much resembling some of the deposits formed by hot springs.† That the black alluvial deposit, which, from forming the whole of the pampas, or plain country, is known to geologists as the Pampean formation, is of fresh-water origin, is perfectly clear; and it is probable that it has been largely formed in marshes and swamps, one of its most striking features being the total absence of pebbles or stones. Indeed, throughout the country, except in the neighbourhood of the mountains, there is not a vestige of rock or stone to be seen, unless it be in the few places where the aforesaid "tosca" has been brought to the surface. In spite of its fresh-water origin, there is, however, evidence that portions of the Pampean formation have been submerged beneath the sea. For instance, in the neighbourhood of the city of La Plata there occurs a bed of marine shells overlying the alluvial mud; all the species of molluscs being now found living in the Bay of Monte Video. I have also observed a similar bed at Santa Lucia, in the Banda Oriental, at an elevation of about one hundred feet above the sea, which was overlain by a considerable thickness of sands, and the same deposit occurs far inland at the town of Parana. From these data it may be inferred that after the temporary subsidence of the pampas, during which the marine beds were deposited, there has been a considerable elevation (which is probably still going on) of the whole country; and that the whole of these movements have taken place at a very recent epoch indeed.

At the present day the Argentine pampas, with the exception of a few willows along the river courses, is practically destitute of trees (save where they have of late years been planted around the various settlements), and forms a boundless sea of grass, relieved here and there by tussocks of the tall pampas grass, or giant thistles, and adorned in spring with the scarlet verbena and other bright-hued flowers. Till the introduction of the countless herds of horses, cattle, and sheep, which now roam over its extent, this vast tract of country was tenanted by the guanaco, the pampas deer, the viscacha, and the rhea, which, with the exception of certain carnivores, were almost the only animals of any size to be found throughout its length and breadth.

The rich black alluvial mud of the pampas, which, as we have seen, is entirely of fresh-water origin is, however, the tomb of thousands, if not millions, of the skeletons and bones of a host of extinct animals, which tell us that the country was once inhabited by a fauna stranger than that found in any other part of the world at any epoch of its history. While many of these extinct creatures were allied to the existing South American mammals, although of vastly greater bodily size, others, of equally gigantic dimensions, were utterly unlike all known animals, either living or extinct. As we intend to describe some of these extinct mammals in succeeding articles, we shall make but brief mention of them here. We may observe, however, that while the gigantic glyptodons were the representatives of the diminutive armadillos of to-day (although some of the latter flourished side by side with their huge cousins), the megathere, which rivalled an elephant in bulk, together with its allies the mylodons, were akin both to the sloths and the anteaters of Brazil, and as they were evidently terrestrial in habits they may be conveniently spoken of as ground sloths. From the structure of these latter animals, which were pretty evidently adapted to sit up on their massive haunches and tear down the branches of trees with their powerful front claws, we may infer that the physical features of this part of Argentina must have been very different from what they are at present, and that in place of continuous tracts of unbroken grassy plain there must have been large areas of forest land, as in Brazil at the present day. In these forest tracts may have wandered the two species of mastodons which were the contemporaries of the ground sloths; but the existence at the same time of several species of horses (some closely akin to living species, while others were markedly distinct) seems to point to the presence of grassy plains alternating with the forest tracts. The same is probably indicated by the numerous species allied to the guanaco, which flourished at the same time, and some of which attained the dimensions of a camel; while the various kinds of deer may also have inhabited the same regions. The gigantic hoofed mammal, known as the *Toxodon*, which had ever-growing teeth like those of a rodent, was, however, prob-

* Near Buenos Ayres it has been bored into for depths of fifty and ninety feet.

† At Buenos Ayres the alluvial deposit itself is called "tosca."

ably an inhabitant of swamps and marshes; while the still more extraordinary *Macrauchenia*, with its slender, camel-like neck, and long three-toed limbs, probably stalked over the plains, cropping here and there the foliage from some tree or copse. Rodents, nearly related to existing South American types, were likewise common; and there were also certain large carnivores, such as a species of sabre-toothed tiger, and a huge bear-like creature. With the exception of these carnivores, together with the guanacos, horses, deer, and elephants which are unknown in the older formations, and are therefore probably late immigrants from the north, all the animals of the Pampean formation are peculiar to South America. A further distinctive feature of this fauna is the large bodily size attained by so many of its representatives, this being especially the case with the glyptodons, mylodons, megatheres, guanacos, mastodons, macrauchenia, and toxodon, all of which would come under the designation of giant animals. In this respect the Pampean fauna corresponds with that of the Pleistocene period of Europe, with which it also agrees approximately in age, seeing that there is evidence of the contemporaneous existence of man with several of the extinct mammals.

In certain parts of the Pampean formation the remains of these animals occur in extraordinary profusion, and generally in a most perfect state of preservation. At times they are found sticking out from the perpendicular cliffs or *barancas* bordering the river-valleys, while many are met with in sinking wells or making other excavations. In well-digging, of course, only a portion of a skeleton is obtained in the case of a large animal, which is the cause of the imperfect condition of the majority of specimens in European museums, and it is only when excavations, like those during the construction of the docks at La Plata or Buenos Ayres, are made that entire skeletons are obtained, unless, indeed, special works are undertaken for the purpose of obtaining fossils. It does not, however, appear that the remains are at all evenly distributed through the Pampean, some localities being much richer than others, and among these Lujan (pronounced Luhán), near Buenos Ayres, being especially notable. Although the museum of the Royal College of Surgeons contains an entire skeleton of a megathere, together with the shell of a glyptodon, while the British Museum is the fortunate possessor of a complete specimen of a mylodon, the museums of Europe give us but a very poor idea of the number and beautiful preservation of these marvellous fossils. To gain any idea of the true state of the case it is necessary to visit (as I have recently had the opportunity of doing) the museums of Buenos Ayres and La Plata, and more especially the latter. There the visitor will be absolutely lost in astonishment at the long array of perfectly mounted skeletons of numbers of these creatures, while the unmounted skeletons and isolated bones displayed in the wall-cases will convince him that I am not exaggerating when I speak of Argentina as a land of skeletons.

That the animals I have spoken of should have died off one after another through the long ages during which the Pampean mud was accumulating is in accordance with what we should expect to occur, while the perfection of their preservation is sufficiently accounted for by the nature of the deposit itself. The marvel, however, is in regard to the total disappearance of the whole of the larger forms and the reduction of the fauna of the pampas to its present condition, together with the concomitant loss of the forests. It is not that the country is unsuited at the present day to the existence of the larger types of animal life, as witness the countless herds of horses and cattle with which its plains are now covered, together with the luxuriance and rapidity with which many kinds of trees flourish when introduced. Neither, I think, can it be due to a glacial period (although there appears to be evidence of the prevalence of a cold period in Patagonia), since any glaciation of the pampas would have assuredly removed the greater part of the alluvial formation, besides having left indisputable evidence of its presence. Man, too, cannot be credited with the extinction of either the fauna or the flora. It has been suggested that the number of guanaco with which the country was overrun previous to European settlement may have caused the destruction of the forests; but we must remember that similar animals existed in greater variety during the Pampean period, while even if the disappearance of trees were due to their agency, this would have had no effect on plain-loving forms like horses. That the disappearance of the latter animals may have been due to the number of pumas is another suggestion; but it will be obvious that this could have had nothing to do with the destruction of gigantic creatures like the glyptodons and the megatheres. The problem is further complicated by the circumstance that the remains of many of these creatures occur in caverns in the interior of Brazil, where the climate is still, and probably always has been, tropical. It would seem, therefore, that we must be content to regard the depletion of the fauna and flora of Argentina as one of the unsolved problems of science.

So much space has been occupied by the foregoing survey of the Pampean fauna and the preliminary observations on the present condition of the country, that but little remains to devote to the older formations. At Parana, and also on the coast at Monte Hermosa, near Bahia Blanca, there occur, however, certain Tertiary deposits which are evidently somewhat older than the Pampean beds, although containing a closely allied fauna. The most interesting feature connected with this formation (which may probably be correlated with the upper Pliocene of Europe) is that the mammals are for the most part of smaller size than their relatives of the Pampean; this being especially shown by the glyptodons, and by those ground sloths known as scelidotheres, which are near allies of the mylodons. When we reach the still older beds of Santa Cruz, in Patagonia, which are probably of Miocene age (although they have been correlated with the lower Eocene, we find not only this diminution in the size of the mammals still more marked, but we likewise notice the disappearance of all the northern forms, such as deer, horses, guanaco, and elephants, thus showing that we have reached the period when South America was disconnected from the northern half of the continent, and possessed an absolutely peculiar fauna. Instead of glyptodons with a shell of eight or ten feet in length, we meet with species in which the carapace did not measure more than a yard; while in place of mylodons bigger than a rhinoceros, we are confronted with a species not so large as a Highland sheep. The camel-like *Macrauchenia* was likewise represented by several much smaller allies, while the various species of *Nesodon*, which represented the gigantic *Toxodon* of the Pampean, were either small or moderate-sized animals. Somewhat curiously, there were, however, several kinds of gigantic flightless birds which are quite unknown in the higher beds, and appear to have been allied to the flying birds of the present day, instead of, as might have been expected, to the ostriches and rheas.

In subsequent articles we propose to enter into the consideration of the leading structural peculiarities of some of the most remarkable of the extinct mammals from the "Land of Skeletons."

BARK-BORING BEETLES.

By E. A. Butler.

ABOUT two hundred years ago, an English knight, Sir Matthew Dudley by name, planted in his grounds in Northamptonshire a number of young elm trees which were destined to have a more than passing interest. The misfortunes that befell them caused their memory to be perpetuated in the annals of British science by becoming enshrined in the *Philosophical Transactions* of the then recently formed Royal Society. All went well with the saplings for a time, but one dry summer one of the trees began to show symptoms of ill-health; its leaves became yellow and began to drop prematurely. As this particular tree stood higher than the rest and in shallower soil, Sir Matthew attributed its ill-health in some measure to the drought, and therefore caused the earth about its roots to be loosened, and two hogsheads of water, together with a quantity of manure, to be supplied to it, by which means the tree was for a time restored to a fairly prosperous condition. But Sir Matthew, being a close observer of nature, had noticed at the same time that on its bark there were "numbers of little black flyes of the beetle kind," and the removal of portions of the bark showed that these beetles had perforated it, and had made tunnelled excavations in its inner layers. He rightly conjectured that the beetles had something to do with the bad condition of the tree, though he regarded the insufficiency of moisture as the primary cause of its unfortunate condition. In endeavouring to link together cause and effect, and so to trace the proper sequence of events, he hit upon the idea that the drought had caused the sap of the tree to become thick and syrupy, and that the sap in this condition had formed an attractive bait for the beetles, which had then still further weakened the tree by their burrows.

The remedial measures adopted seem to have checked the evil for the time; but on the advent of another dry summer a few years afterwards, several of the trees again looked sickly, and particularly the one previously attacked. Examination showed that in them all the bark at its attachment to the tree was dry, and that there were "vast numbers of these little flyes, who had pierced the bark in multitudes of places." Having adopted the same remedies as before, Sir Matthew visited the trees again the next morning, and found that in one case sap was oozing from the bark through the holes pierced by the beetles, and that numbers of flies and wasps were congregated on the trunk, busily engaged in sucking up the sweet liquid. The removal of a little bark revealed plenty of moisture beneath, and showed that all the burrowing beetles had either gone or been drowned in the flood of sap which had inundated their burrows. This tree was ultimately saved, but the bark of many of the others, which seem to have been more damaged and further advanced in ill-health, remained dry, and the beetles still had things all their own way with them. Being naturally anxious as to the fate of his trees, Sir Matthew, to whom the beetles were evidently something quite new, carefully examined the bark and found that each beetle had made a "strait perpendicular channel from the entrance upwards, about two inches long, very little if at all bigger than just to move themselves straitforwards in"; for, he adds, "I observed they all of them, if disturbed, came out backwards." Further observation showed that "all along on each side the channel, as close the one to the other as they well could so as yet to be distinct, there were small channels running horizontally from it, in every one of which, at the extremity thereof, was a maggot, in size just the bigness of the small channels, very lively, whitish, and almost transparent." He at once recognized that these transverse channels must have had a different origin from that of the central perpendicular one (Fig. 1). While that was the work of the parent beetle, it was evident that the side branches were excavated by the maggots which were found at their terminations; for they were too narrow to admit of the entrance of the perfect insect. The eggs were evidently laid at regular intervals along the sides of the central gallery, and then the grubs hatched from them began at once to burrow in directions parallel to one another and at right angles to the mother's gallery, increasing the diameter of their tunnels as they advanced, to accommodate their own enlarged dimensions, and leaving the burrow behind them more or less blocked up with "very small particles which when dry become fine dust," the remnants of food and excrement.

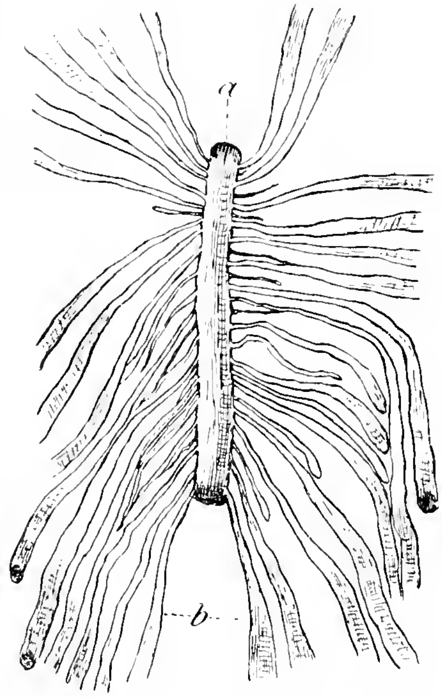


Fig. 1.—Bark burrowings, or "typograph" of *Scolytus destructor*. *a*, mother gallery; *b*, larval galleries.

But the whole life-history of the little pests was not yet fully disclosed, and time was necessary to permit of their proceeding with their metamorphoses. Accordingly we find further observations undertaken a few months later, both upon living trees and upon felled timber stored in the timber yard. The central channel was now found in all cases to contain the dead body of the mother beetle, while the side channels were empty, their occupants having escaped each through a neat circular hole in the bark at the end of its burrow. At the mouth of this hole, however, each had left, as evidence of its former presence, a "whitish, pretty tough skin, exactly the colour and size of the maggot." This, of course, was the chrysalis skin; so that it was evident that the larvæ had matured in their lateral burrows, had there become pupæ, and the perfect beetles produced from these had eaten their way into daylight, making a hole in the bark just large enough to admit of their crawling out. Such is the earliest English account of the life-history of that terribly destructive timber-pest, the little beetle now called *Scolytus destructor*, which was so ruinous in its effects on the above occasion that scarcely any of the trees were saved. In all essential details these observations have been repeatedly confirmed by subsequent entomologists, and few results of insect energy are now better known than these bark-sculptured family records, or "typographs," as they are called, each of which registers the total work of a mother and her entire youthful progeny till the latter have reached maturity, and have left the maternal home to push their own fortunes in the world.

The beetle which is responsible for this damage to elm trees is a stoutly and compactly-built shining insect, of somewhat cylindrical outline, averaging about one-fifth of an inch in length (Fig. 2). Its body is black, but the appendages thereto, such as legs, antennæ, and wing covers, have more or less of a reddish tinge. The head and thorax are very large and powerful, occupying between them half the length of the entire insect; and the biting jaws, upon the strength of which the success of the burrowing operations depends, are, of course, stout and very strongly made. The head is furnished above with a pretty clothing of yellowish hairs, which can easily be seen when the insect is viewed in profile, but are not very distinctly visible when it is looked at full-face. But the one feature by which especially it may be recognized and distinguished from all others of similar habits, except those few that belong to its own genus, is the curious shape of the abdomen. This looks as though a slice had been taken off it behind, since it slopes abruptly upwards from a short distance behind the last pair of legs to the ends of the wing covers (Fig. 3). Half a dozen species belonging to the genus *Scolytus* are known to inhabit Britain; they are all very much alike both in shape and coloration, but the fact that the various species attack different trees is a considerable aid towards their discrimination. The habits of all are similar, though not identical. The family to which *S. destructor* belongs contains about fifty British species, many of them minute, but all of strong build and cylindrical outline, as befits insects whose sole occupation consists of burrowing in bark. The economy of the group has been much studied by Dr. A. Chapman of Abergavenny, whose observations have been published in entomological periodicals, and from these some further particulars may now be given.

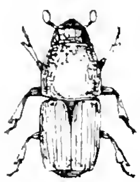


Fig. 2.—*Scolytus destructor*, or Elm-bark Beetle, magnified four diameters.

Fig. 3.—Side view of Elm-bark Beetle.

The female *S. destructor* makes preparations to lay her eggs early in June. She will attack preferably elm trees that have been felled during the previous winter, and Dr. Chapman avers that he has never met with traces of the insect in perfectly healthy growing trees, though, of course, it may be found commonly enough in those that are sickly. The female does not burrow straight inwards at the spot on which she alights; but, selecting one of the grooves in the bark, she gets to the bottom of this and often widens it for some distance, and then enters the bark itself. The real opening to the tunnel, therefore, lies at some distance from the commencement of the burrows, and hence these entrance orifices are not so easily seen as those by which the beetles make their exit, since these latter run straight outwards from the ends of the galleries and appear like holes carefully made with a bradawl. The female commences her labours by herself, before she has received the overtures of a partner, who, in fact, does not put in an appearance till she has already started her internal burrow. But when she has got her burrow well in hand, the expected suitor arrives, or, if he do not, the labour must be stopped to wait for him, as no further progress can be made till he has come. He appears rarely to enter the burrow, the toil of excavation being left entirely to his partner. Should the female be so unfortunate as not to be discovered by any member of the opposite sex, the burrow begun in trust will have to be left unfinished and its purpose will never be realized, as no progeny will ever occupy it. But if all goes well, the continuation of the burrow can proceed. It is made straight up the trunk for about three inches, and as it is pushed forward eggs are deposited at regular intervals on each side, each in a little depression close to the wood. About a hundred are thus fixed in double row along the tunnel; they are glutinous as laid, and become coated with a rather thick layer of "frass," as the powdery refuse in the burrows is termed.

Something like three weeks will have been consumed in the construction and peopling of the central channel, but before the end of that time the eggs first laid have hatched, and the little white footless maggots have begun to make their transverse burrows, side by side, though still not in actual communication, and yet so close as only to leave a very narrow wall between. These burrows are in the softest part of the bark, the cambium layer and adjacent soft tissues being devoured, though but very little impression is made on the wood beneath. When the tree is stripped, one can see that while the bark itself contains the greater part of each burrow, one side of each has slightly encroached on the wood, so that the bared trunk shows in feeble outline a pattern corresponding to the typograph which appears deeply cut in intaglio in the bark.

In about a month's time the larvæ will be full-fed; most of them will then burrow for about half an inch straight into the wood at the end of their burrows, and then excavate a little chamber, which is to be the winter quarters. Where this communicates with the larval burrow a plug of frass is placed to block up the entrance—a wise precaution, for otherwise, if the bark should fall off during the winter, as the damage it has received might well cause it to do, they would be exposed, not only to the severity of the weather, but also to the attacks of insectivorous birds; while if the bark remain on, they will then be doubly protected. Some of the more enterprising ones, however, do not behave thus, but hurry through their changes and come out as perfect beetles in August, piercing to the outside a straight circular burrow at the end of their gallery. What becomes of these individuals is not yet very clear. Of course, those that have burrowed into the wood escape next spring in the same way as their predecessors. We thus notice that there are two sets of cylindrical holes made in the bark of the tree—the entrance holes of the parent females, partially filled up and not very conspicuous; and the exit holes of both males and females of the young brood, which are open and easily seen. There are also two distinct classes of galleries—the vertical one made and occupied by the mother of the family only, and serving as her mortuary chamber when she expires at the close of her labours; and the lateral galleries made and occupied solely by the larvæ. Thus the whole typograph contains, as we said above, the family history of one complete generation, carved in wood, and left as a permanent memorial long after the generation whose adventures it chronicles has passed away.

The bark of ash trees is often found to be channelled in a somewhat similar way; but this is easily seen to be the work of a different insect, as there are some striking differences in the plan of the typograph. We still have the central channel and the host of side channels running at right angles to it, but the actual directions are exactly reversed; the central channel is now horizontal, and the side channels are perpendicular, running above and below the transverse main trunk. Moreover, the main trunk is composed of two arms which lie nearly in the same straight line, but diverge right and left from an exceedingly short perpendicular stem, the whole forming a figure something like a **T** of greatly exaggerated breadth and diminished height (Fig. 4). The beetle whose family record is preserved in this form is called *Hylesinus fraxini*. It is a smaller and much duller insect than the preceding, and more regularly cylindrical, without the curiously cut-off abdomen so characteristic of *Scolytus*. The economy of

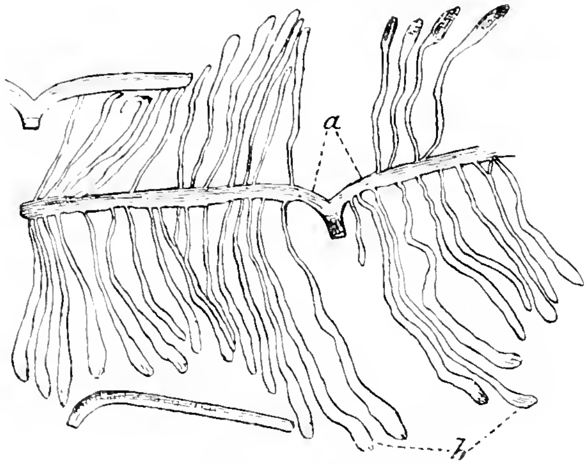


Fig. 4.—Bark burrowings, or "typograph" of *Hylesinus fraxina*, Ash-bark Beetle. *a*, mother gallery; *b*, larval galleries. (To avoid confusion, the larval galleries of one system only have been shown.)

this insect is very similar to that of *S. destructor*, but the male takes a somewhat more practical interest in the serious business of life. Both beetles may be found in the burrows during the course of construction, frequently one in each branch, and of course it is an obvious suggestion that one of these branches is made by the male, and the other by his partner; but it is difficult to say how much truth there is in such a suggestion, and it seems not unlikely that even in this case the female dees the greater part of the work, though apparently her mate does something to assist. Both beetles also usually die in the burrow, and their corpses may sometimes be found still lying there several years after death. Damp and mildew, however, in time do their work, and the corpses decay and disappear.

The other members of this group are more or less like those already described, and the cylindrical form, short legs, and large thorax will usually enable them to be recognized. They attack a variety of trees, some devoting their attention to the trunk, others to the branches and smaller twigs. Elm, ash, oak, beech, birch, hazel and hornbeam are all more or less liable to attack, and fruit trees, such as apple, pear, plum, cherry and apricot, are by no means exempt. A large proportion are devoted to the different species of firs and pines, and some attack shrubs, such as ivy, furze, and broom. But wherever they are found, they always leave their signature behind, in the typograph on the inner surface of the bark, and its fainter reproduction which is seen on the wood when the bark is removed. Until an affected tree is stripped, the evidences of their presence, apart from any sickly appearance the tree may present, are not striking, and the slight indications outside can give no notion of the vast extent of the damage which may lie concealed within. These little beetles must be carefully distinguished from another set of wood-borers, some of which are not unlike them in both shape and general appearance, but which do not leave a typograph behind them, since they burrow into the substance of the wood itself, instead of confining themselves to the bark. Belonging to this latter group is the troublesome household pest which makes furniture "worm-eaten" (*Anobium domesticum*). Wood-borers such as this are distinct from the bark-borers, not only in habits, but in structure too, and are therefore, for systematic purposes, placed in a different section of the beetle order.

There are two somewhat opposing aspects in which these bark-boring beetles may be regarded. In the first place, in so far as they attack living trees, they cannot be regarded as otherwise than terribly destructive. Though the solid timber, it is true, is scarcely injured at all, and the actual amount of material destroyed bears a ridiculously small proportion to the total bulk of the tree, yet the death of the tree is insured by the fact that it is just the most vital part that is attacked. The centre of the life and growth of the tree lies in the layers which intervene between the hard bark on the outside and the hard wood on the inside; it is here only that the cells of which the tree is composed still remain soft and retain their power of self-multiplication, and therefore, so long as this particular part of the tree is intact, its functions can go on more or less regularly, and its life can be maintained. But when once these layers are tampered with, the health of the tree suffers, and the gradual removal of the growing and multiplying tissue is necessarily followed by the death of the tree, though the solid timber is still available for use. In consequence of their enormous numbers, some of the smaller species are in this respect even more destructive than the larger ones.

There is, however, another light in which the ravages of these insects may be regarded. In many cases, no doubt, they merely accelerate the destruction of trees which from other causes are passing into decay, while some seem to prefer fallen timber to that which is growing; and it is in this latter respect that they may to some extent be regarded as useful agents in the economy of nature. In the interests of surrounding vegetation, it is important that fallen trunks should be removed as speedily as possible, and many are the natural agencies that combine to bring about such a result. Amongst these, damp is of course one of the most important, as it provides the conditions necessary for the growth of fungi, which, growing on the wood, derive their nourishment from it, and accelerate its dissolution. But much of the material of which the bark is composed is of the nature of cork, and is impervious to moisture, so that as long as the bark remains on the tree the fungi have not a fair chance. To meet this difficulty, there come in these bark-feeding beetles, which speedily loosen the bark and cause it to crack so that it soon falls off, and then the solid wood is exposed to all sorts of destructive agencies—whether physical such as damp, vegetable such as fungi, or animal such as wood-boring insects—and between them they make short work of the trunk. In virgin forests, no doubt, such insects as these are of material assistance in promoting the growth of new vegetation, by aiding in the removal of the old. In countries like our own, however, which are well under the control of man, such a function is, no doubt, scarcely needed, and to us these bark-boring beetles seldom appear in any other light than as a nuisance.

PERIODICAL COMETS DUE DURING THE REMAINDER OF THE PRESENT CENTURY.

By W. T. Lynn, B.A., F.R.A.S.

It can scarcely be said that any one of the known periodic comets is due during the present year. The late M. Tempel was the first discoverer of no fewer than three comets which were calculated to be moving in orbits of short period; but the periodicity of one of these, which was discovered in the month of November, 1869, was not recognized until after its rediscovery by Prof. Swift in 1880 (an unobserved return must have taken place in 1875), in consequence of which it is usual to call it Swift's comet. The body known as Tempel's first periodical comet was discovered by him at Marseilles on the 3rd of April, 1867: the period was found to be about six years, and it duly returned in 1873 and 1879, but has not since been seen. His second periodical comet, which was discovered at Milan on the 3rd of July, 1873, was calculated to have a period about five and a quarter years in duration. It was observed again in 1878, but not afterwards, so that it seems rash to speak of a return as due in the present year, though three times the length of a period will in the spring have elapsed since 1878, when the comet passed its perihelion on the 19th of July.

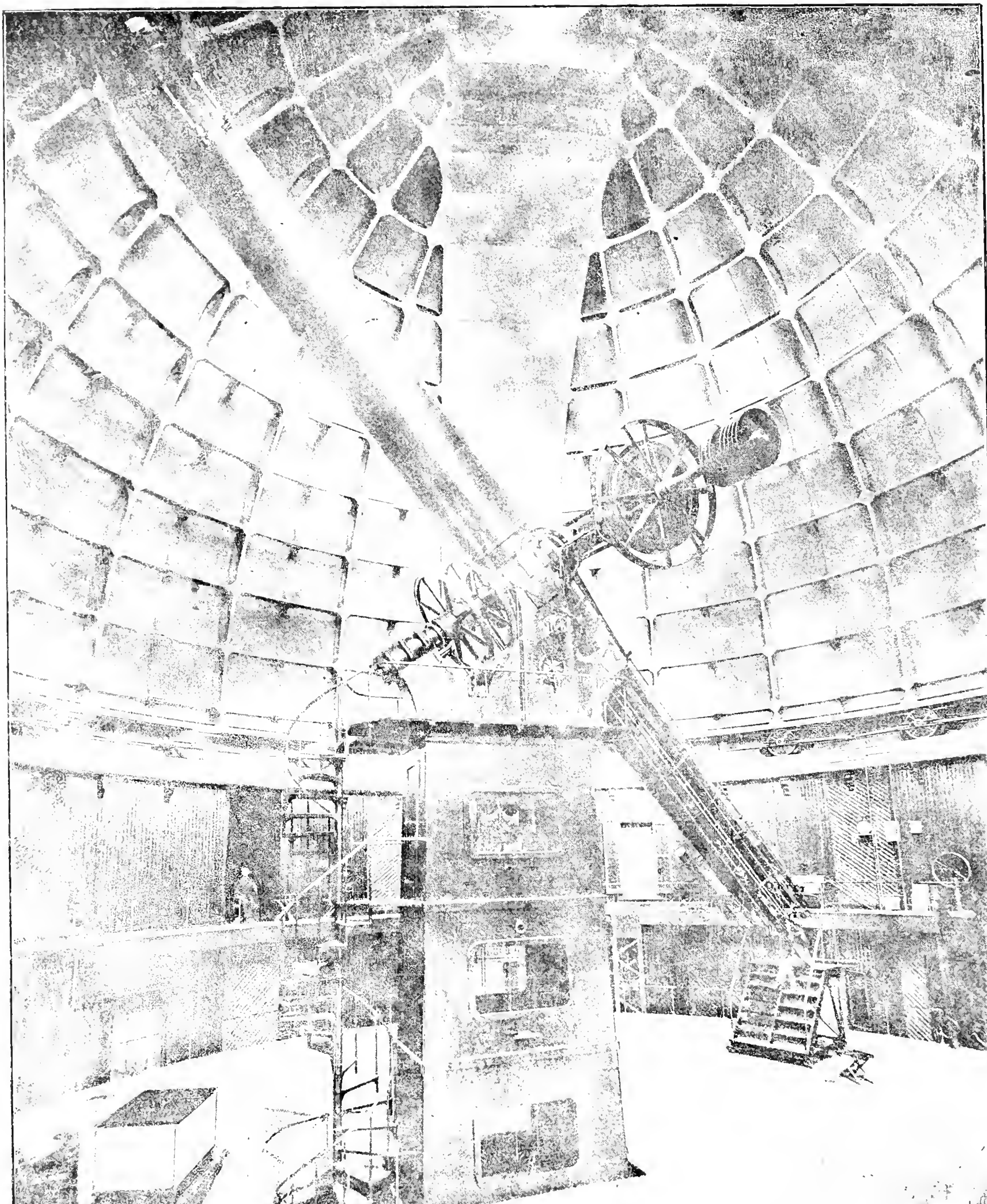
But we now have to refer to a comet which has returned so regularly during more than a century, that it has come to be looked upon as a friend whose periodical visits may be confidently expected. I now allude to Encke's comet, which, first discovered by Méchain in 1786, only acquired its name after the return in 1818, when its orbit was accurately determined by the illustrious Seeberg astronomer, who became director of the Berlin Observatory in 1825. He found that the period was much shorter than that of any other known comet, and that its duration amounted to only twelve hundred and twelve days, or about three and one-third years. Extending his investigations, he showed that this was slightly diminishing by a little more than a tenth of a day at each return, and suggested, as the probable cause of this, the action of a resisting medium in the inner portion of the comet's orbit (when in perihelion it passes within the orbit of Mercury) checking the tangential motion of the comet and causing it to be drawn somewhat nearer to the sun, so as to shorten its length of revolution, and therefore its period. The comet has been observed in some part of the world at every return since 1818; and whilst Encke lived he was able to show that the above effect continued to appear and with the same rate of progress, confirming the truth of his theory as to its cause. Nor was it easy to take any other view of the phenomenon, with such a *vera causa* apparently fully able to explain it. But after this had gone on for about fifty years from the time that Encke first called attention to it, Von Asten and Backlund, who had followed up his investigations, found that in 1868 the observed diminution of the length of period dwindled to one-half its original amount, and it has apparently continued to go on at this diminished rate ever since. It is to be hoped that more light will, before long, be thrown upon this remarkable circumstance, which imparts additional interest to further observations of Encke's comet. It was last in perihelion on the 18th of October, 1891, and the next return to that position will be due on the 10th of February, 1895.

A passing reference may here be made to Brorsen's comet, which was discovered at Kiel in 1846, found to have a period of about five and a half years, and was observed at several subsequent returns, but the last of these was in 1879. As we cannot venture to predict its return in 1895, we will pass on to 1896, in which year two periodical comets will be due. One of these is known as Faye's, having been discovered by that astronomer at Paris on the 22nd of November, 1843. Le Verrier calculated its orbit, and found that the length of its period was about seven and a half years: it was duly observed at every subsequent return, passing its perihelion on the last occasion on the 20th of August, 1888, so that another return may be expected in 1896. The other comet due in that year was discovered by Mr. Brooks, at the Smith Observatory, Geneva, N.Y., on the 6th of July, 1889: great interest was imparted to it by Mr. S. C. Chandler's investigations, which showed that its period when under observation was about seven years, but that the orbit had been much disturbed by a near approach to the planet Jupiter in 1886, and that the comet was very probably identical with Lexell's comet of 1770, which had not (in consequence also of Jovian attractions) been seen since the year of its discovery, though calculated to have a period of only about five and a half years. However plausible this view seemed, later investigations made by Dr. Lane Poor have (as was pointed out by the writer in an article contributed to the number of Knowledge for last November) thrown very considerable doubt upon it, which can only be cleared up by the results of the observations which it is to be hoped will be obtained in 1896.

In 1897 also two periodical comets will be due. The first of these was discovered by D'Arrest at Leipzig in 1851, found to have an elliptic orbit with a period of about six and a half years, observed in 1857 and at every subsequent return except that due in 1884 (when it was unfavourably placed), passing its perihelion on the last occasion on the 16th of September, 1890, so that another return will be due early in 1897. The other is Swift's comet, to which we have already alluded, and which since it acquired its name in 1880 has only been seen at the last return in 1891, having been unfavourably placed for observation in 1886. But, as already remarked, it was first discovered by Tempel in 1869, and another return may be expected early in 1897.

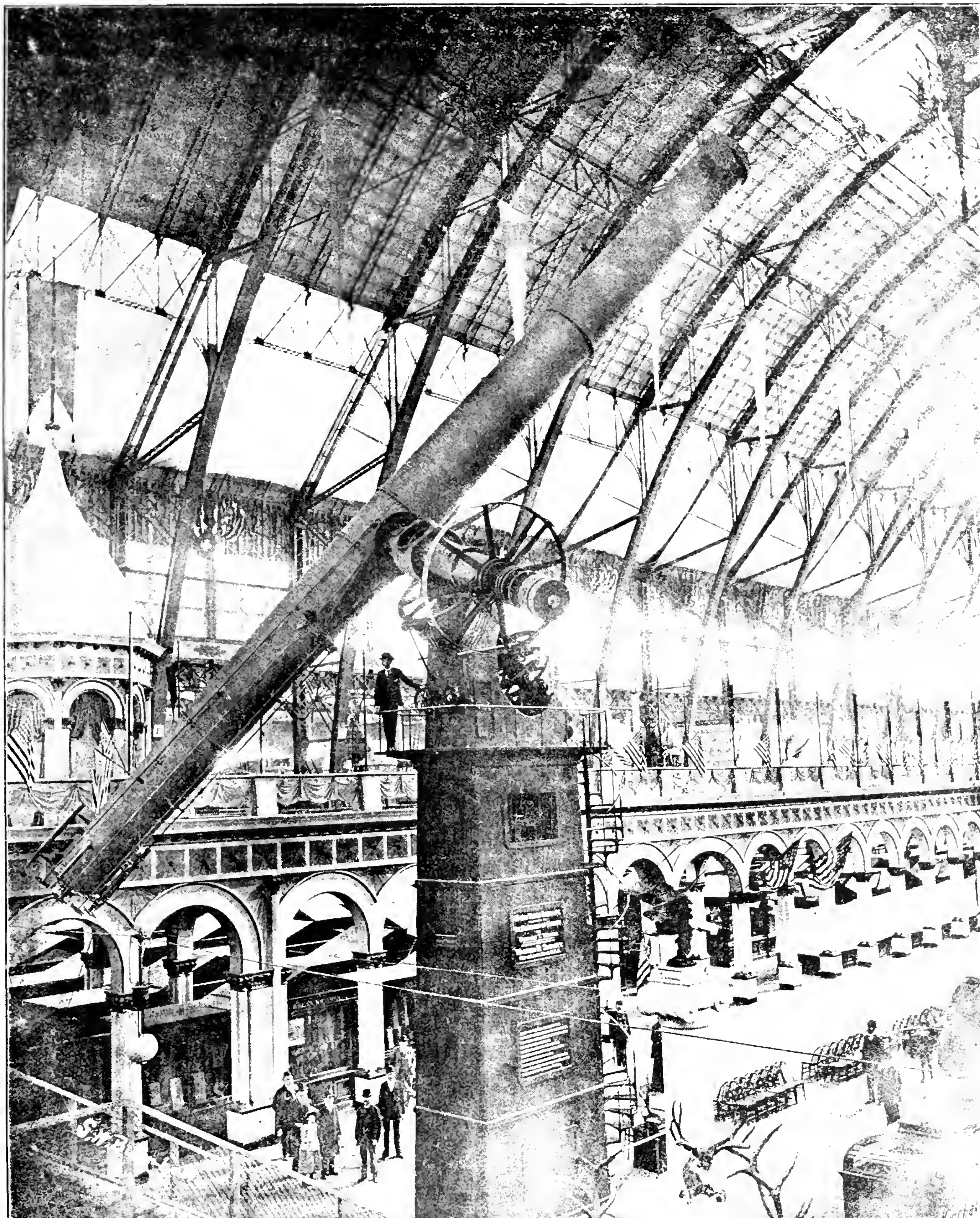
In the summer of 1898 a return will be due of the comet known as Winnecke's, since he detected it in 1858, and showed that it was identical with one discovered by Pons so far back as 1819, with a period of about five and a half years; it escaped observation in 1863 (as it afterwards did in 1880), but was observed near perihelion in 1869, 1875, 1886, and 1892, so that another return may be expected in 1898. About the same time a return of Encke's comet will again be due; and in the autumn of the same year a fine comet, which was discovered by Dr. Max Wolf of Heidelberg on the 17th of September, 1884, found to have a period of nearly seven years, and well observed at the last return in 1891.

In the last year of the present century a return of Tuttle's comet will be due. This body occupies a unique position in having a period of somewhat less than fourteen years. It acquired its name after Mr. Tuttle had detected it in 1858, but the calculations made of its orbit showed that it was identical with one discovered by Méchain (also the first discoverer, as we have seen, of Encke's comet four years before) in 1790, and it has since been observed at returns in 1871 and 1885, passing its perihelion on the 11th of September in the latter year. The interesting comet discovered by Mr. Holmes at Islington in November, 1892, will also be due in 1899, as its period is less than seven years. Later in the same year another return may be expected of Mr. Finlay's comet, which has a period of about six and a half years, and has, since its discovery by Mr. Finlay in 1886, been observed at the return which took place in the summer of last year (1893). But, in addition to all these, a very interesting cometary visitor will be eagerly looked for in 1899; we mean the one moving in the same orbit as the Leonids, or mid-November meteors. The comet has only hitherto been seen in the winter of 1865, when Tempel discovered it on the 19th of December, and it passed its perihelion on the 11th of January, 1866. Its period, like that of the meteoroids, is about thirty-three and a quarter years; and it is the comet of shortest period which moves in a retrograde direction, all those of shorter periods revolving round the sun in the same general direction as the planets.



The Lick Thirty-six-inch Refracting Telescope.

From a photograph taken by Mr. BURNHAM within the Dome of the Lick Observatory. Focus, 57 feet 10 inches.



The Mounting of the Forty-inch Refracting Telescope, presented by Mr Yerkes to the University of Chicago

From a photograph by Mr BURNHAM taken in the Chicago Exhibition. Focal length nearly 64 feet

THE GIANT REFRACTING TELESCOPES OF AMERICA.

By A. C. Ranyard.

We live in an age when "records" are almost daily being broken, but it is now almost half a century since the largest telescope yet turned to the heavens was completed by the father of the present Earl of Rosse. He cast his gigantic mirror, six feet in diameter, on the 13th April, 1842, and after nearly three years' labour it was mounted at Parsonstown in February, 1845. This great telescope, contained in a tube seven feet in diameter, with a focal length of fifty-four feet, still remains the greatest light-grasping instrument which has been turned to the stars; but its defining powers are very inferior to many smaller instruments which have since been made.

It was not till 1846, a year after the completion of the Rosse reflector, that refracting telescopes reached a diameter of fifteen inches. In that year, Merz and Mahler, of Munich, completed two fifteen-inch refractors, one for Harvard College Observatory, and the other for Pulkowa. These comparatively small telescopes quickly showed themselves to be superior in defining power to the great Rosse telescope. With the Harvard telescope Prof. W. C. Bond, in 1848, discovered Hyperion, the eighth satellite of Saturn, a discovery which was almost simultaneously made by Mr. Lassell in England, with a reflector of two feet aperture of excellent defining powers. In 1850 Bond also discovered with the Harvard fifteen-inch refractor the crape ring of Saturn, a discovery which was likewise very nearly simultaneously made in England by Dawes, with a refracting telescope of smaller aperture.

For about fifteen years the limit of aperture for refracting telescopes attained by Merz was not exceeded; then America took the lead, and in 1860 Alvan Clark, the father of the present instrument maker, made an eighteen and a half inch refractor, with which he discovered the companion to Sirius. For ten years this remained the largest refractor in existence; then England took the lead with a twenty-five inch object glass made by Cooke, of York, for Mr. R. S. Newhall, of Gateshead, in 1870. Three years later, Messrs. Alvan Clark and Son made the twenty-six-inch refractor for the Washington Observatory, with which the satellites of Mars were discovered. Then followed two thirty-inch refractors, one made by the Brothers Henry, of Paris, for the Nice Observatory, and the other by Messrs. Alvan Clark and Son for the Russian Imperial Observatory at Pulkowa; and, lastly, the thirty-six-inch refractor made by Alvan Clark and Son for the Lick Observatory. The optical excellence of the great Lick telescope is vouched for by the work done with it by Mr. Burnham on close double stars, and by the discovery made with it by Mr. Barnard of the fifth satellite of Jupiter.

American astronomers have always shown a preference for refracting telescopes; with the exception of the late Dr. Henry Draper, who figured and mounted for himself a twenty-eight-inch silver on glass reflector, no American has constructed a reflecting telescope of any considerable size. Their scientific enthusiasm has restrained them from merely endeavouring to outdo the Earl of Rosse in the construction of instruments of great light-grasping power, and has turned their inventive genius to the difficult problems involved in the evolution and growth of the achromatic telescope. The French still retain the lead as the makers of large discs of optical glass from which the large refractors are made. The disc of flint glass from which the flint lens of the object glass of the Lick telescope was made took three years to manufacture. It was repeatedly tested and the defective parts were cut out and replaced by fresh optical glass which was welded to the original mass by pressure at a white heat; the disc was then slowly allowed to cool, and again tested, and any new defects found were again operated upon.

The difficulty of manufacturing large homogeneous discs of optical glass is, at present, the chief obstacle in the way of increasing the size of achromatic telescopes. Such large masses of glass are very heavy, and when supported by their edges in a cell their weight causes the lenses to bend; but a small amount of flexure causes less disturbance in the image thrown by a lens than a similar amount of bending of a speculum would cause in the image thrown by a speculum.

For if a reflecting surface is shifted through a small angle the reflected ray is shifted through double the angle, while a similar change in the position of a refracting surface causes only a very slight shift in the direction of the refracted ray. Thus it happens that though lenses can only be supported by their edges, while specula can be supported at their backs as well as at their edges, the small distortions due to the weight of material cause a greater disturbance in the image thrown by a large reflector than in the image thrown by a large refractor; otherwise large reflectors would be vastly superior instruments to large refractors, for with reflectors light of all colours is brought to the same focus, while the difficulty of achromatizing a lens increases with its diameter, and the larger a refractor the greater must be the ratio of focal length to aperture in order to obtain the same degree of achromatism. Thus the focal length of the Lick telescope is fifty-seven feet ten inches, to an aperture of thirty-six inches, and the Yerkes telescope will have an aperture of forty inches, and a focal length of nearly sixty-four feet, or a ratio rather less than one to nineteen instead of one to twelve as with small achromatics.

With every increase in focal length all the mechanical difficulties connected with the mounting and the size of dome and shutter increase as the cube of the focal length, for the weight of all the parts increases as the cube of their lineal dimensions. Consequently every effort is made to keep down the focal length of such large telescopes, so far as it reasonably can be kept down consistently with a sufficient degree of achromatization for defining purposes. An observer who looks through one of these large refracting telescopes for the first time is greatly struck with the amount of outstanding colour around the stars. The violet end of the spectrum is generally left outstanding, and the star appears bathed in a field of violet light, which however, interferes very little with the sharpness of vision.

Our second plate shows the mounting of the great telescope which Mr. Charles T. Yerkes is presenting to the University of Chicago. It is dwarfed by the size of the Exhibition building, but if the size of the figures standing in the neighbourhood is compared with the telescope it will be seen that it is much larger than the Lick telescope, which at first sight looks larger.

The lenses for the Yerkes telescope are already roughly figured, but they are not finished. Mr. Alvan Clark was present at the last meeting of the Astronomical Society, and gave the Fellows an account of the way in which the work is proceeding. I have also received some additional information from Prof. Hale, who is at present in Berlin.

The flint lens is very white. It is a particularly fine piece of glass and weighs about three hundred pounds. Its thickness is about one and a half inches at the centre and two and three-quarter inches near the circumference.

The crown lens weighs about two hundred pounds. It is about three inches thick at the centre and seven-eighths of an inch at the circumference.

The flint lens corrects the crown so that the minimum focus will be at about wave-length 561.

For photographic work with the spectroscope in the blue, violet and ultra-violet, a small lens will be used near the focus for correcting the chromatic aberration at the centre of the field only. Dr. Huggins has used such a lens with his visual objective, and succeeds in bringing the spectrum from F to H satisfactorily to focus. The spectroscope thus remains in its ordinary position, while in the Lick telescope, when the photographic correcting lens is placed over the objective, the focus is changed from fifty-seven feet ten inches to forty-seven feet ten inches, and in practice the spectroscope is not used when the corrector is in place. The principal advantages of the small correcting lens are: (1) small loss of light from absorption; (2) no change in the principal focal plane; (3) convenience in handling: (4) its weight is so small that no change in the balancing of the telescope is necessary on adding the corrector. Its chief disadvantage is that a small lens so near the focus only gives a small field of view, but this is immaterial for stellar spectroscopy.

The telescope, dome and shutter will be moved by electric motors controlled by buttons on a key-board at the eye end, but the motions can also be directed from the balcony at the head of the telescope, and from a table in the observing room.

Hydraulic rams, which can also be controlled electrically in the same manner, will lift or lower the whole floor of the observatory, so that no observing ladders will be necessary.

The clamps of the telescope are operated by powerful electro-magnets, and it has been found that the instrument can be instantly clamped much more firmly than in a longer period by hand.

The driving clock, which weighs about one and a half tons, is never allowed to run down, but when the weight has descended to a certain point it automatically starts an electro-motor, which winds the clock up again.

All the motions, clamps, &c., can be operated in the ordinary way by hand.

The dome for the Yerkes telescope will be eighty feet in diameter, and the observing shutter will be fifteen feet wide.

The tube for the Yerkes telescope is forty-two inches in diameter at the objective end, fifty-two inches at the centre, and thirty-eight inches at the eye end. The sheet steel forming the tube varies from 7·32 inches in thickness at the centre to 1·8 inches at the ends. The total weight of the tube is six tons.

The declination axis carrying the tube is of forged steel, twelve inches in diameter and twelve feet long; its weight being one and a half tons. It runs in segmental bearings in the declination sleeve, which weighs four tons.

The polar axis carrying the whole system is of forged steel, fifteen inches in diameter at the upper bearing and twelve inches at the lower bearing, and weighs three and a half tons.

The great weight of the bearings on these axes is almost wholly relieved, and the resistance changed from sliding to rolling friction by means of three bracelets or live rings of steel rolls. One of these encircles the declination axis near the tube, and one is placed above each bearing on the polar axis. These anti-friction live rings are pressed against the axes by means of adjustable springs.

The pier or column is made in five sections. The base section weighs about eighteen tons, the other sections weigh about five and a half tons each. The height of the column from base to top is thirty-one feet four inches. Each section of the pier is above six and a half feet high. The head of the pier is of cast iron, in one piece, and weighs five and a half tons. The total weight of the pier and head is about forty-five tons. The height from the base of the pier to the centre of motion is forty-three feet six inches, and the total weight of the whole telescope and mounting will be about seventy-five tons.

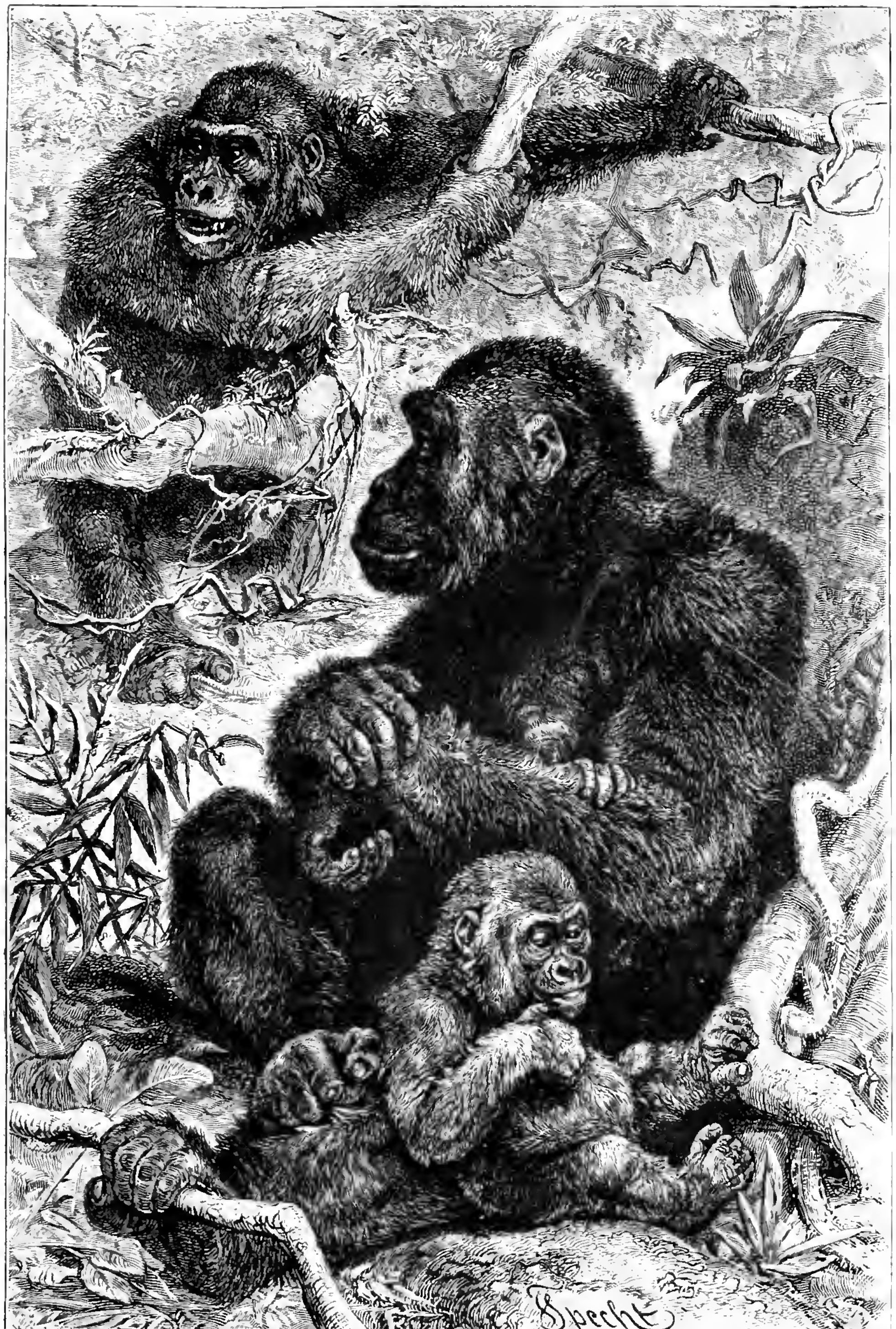
Mr. Yerkes has purchased about fifty acres of land on the borders of Lake Geneva, Wisconsin, as a site for the new Observatory. The plans for the building are now being prepared and its construction will be commenced in the spring. The Observatory will be about one hundred and fifty feet above the lake, and at a distance of about seventy-five miles from Chicago. Prof. Hale has been appointed Director of the Observatory, and Mr. Burnham has recently been appointed Professor of Practical Astronomy in the University of Chicago and Astronomer in the Yerkes Observatory. No other members of the staff have as yet been appointed. With two such exceptionally able astronomers, one may confidently look forward to many important discoveries being made on the borders of Lake Geneva.

The size of Knowledge will, from the commencement of this year, be increased by the addition of four pages.

Notation for the Lines of the Hydrogen Spectrum.—Prof. H. C. Vogel has recently suggested (*Astr. Nach.* 3198) a slight change in the notation for the lines of the hydrogen spectrum, which will do away with a present cause of confusion. The four lines in the visible portion of the spectrum, C, F, "near G," and h, have long been known as $H\alpha$, $H\beta$, $H\gamma$, and $H\delta$. When Dr. Huggins discovered the series of hydrogen lines in the ultra-violet region of the spectra of white stars, he distinguished these by the letters of the Greek alphabet, beginning with the line at λ 3889 as α. From the first it was extremely probable that these lines were due to hydrogen, but now that their origin is definitely established, the occurrence of a double α and β, &c., in the series is a decided inconvenience. Prof. Vogel therefore proposes, and Dr. Huggins supports his proposition, to call the fifth hydrogen line, formerly known as H or H_1, $H\epsilon$; and the first line of the Huggins series $H\zeta$. All the other lines of the Huggins series will thus be advanced five steps in the Greek alphabet, and the line λ 3704, formerly known as ι, will now be $H\xi$.

A restoration of *Coryphodon*, one of those large mammals that appear so suddenly in the lower Tertiary rocks, by Prof. Marsh, appeared in the *Geological Magazine* for November. He controverts entirely Osborn's opinion that this animal walked upon the tips of its toes with its fore limbs after the fashion of the elephant, while with its hind limbs it was plantigrade after the fashion of a bear. Perhaps the most striking characteristic of these early mammals is the minute brain, which is proportionately even less than that of many reptiles and amphibia. The cast of the brain case, both of this animal and its near relative the *Deinoceras*, show a ratio of brain to skull less even than that obtaining in the frog.

The *Lancet* bacteriologists could scarcely be expected to leave our ice alone during the terrible heat wave of last summer. In the laboratory cultures from 400 to 700 colonies of bacteria per cubic centimetre of melted Norwegian ice were obtained, and with this distressing fact they inoculated the press and produced a mild epidemic of paragraphs. The advice tendered the public was to use ice from distilled or sterilized water, but where is it to be obtained?



GORILLAS AT HOME.

Notices of Books.

The Royal Natural History. Edited by RICHARD LYDEKKER, B.A., F.G.S., &c. Parts I. and II. (London: F. Warne & Co.) If the two parts of this book which have been already published are fair samples of the thirty-six in which it is to be completed, the complete work will certainly be the handsomest and most readable book on general zoology which has as yet appeared. It does high credit to all who have had a hand in its production, being not only full of information conveyed in simple and more comprehensible language than zoologists ordinarily employ, but it is beautifully illustrated with wood-cuts and coloured pictures that exhibit a high degree of artistic merit controlled by scientific accuracy. In the two parts before us we have the first instalment of Mr. Lydekker's treatise on mammals, which is to extend over fifteen monthly issues, and is to be followed by an important section devoted to birds, to which Dr. Bowdler Sharpe, Mr. Ogilvie Grant and Mr. Macpherson are to contribute largely: the remaining twelve parts will continue the survey of the descending series of forms of life to the lowest of the invertebrates. Part I. has a capital introductory chapter on mammalian characteristics, and the attack on the constituent orders is opened with an exhaustive survey of the Primates, which are reviewed *seriatim* from the anthropoid apes to the colobine monkeys: the subsequent groups down to the marmosets occupying the second part. Every genus is described in full, over a hundred and thirty representative species coming under notice, most of them at considerable length, with much that is interesting as to their distribution, habits, and history; and this information is not of the obsolete, hearsay kind frequently thought good enough for repetition in popular works on zoology, which contain much that the student has subsequently to unlearn. The chief place amongst the many excellent features of this work must be given to the broad and powerful treatment of the palæontological side of the subject, which, as our readers already know, Mr. Lydekker is specially fitted to deal with. Every species is compared with its nearest allies or direct representatives as revealed in the record of the rocks. The illustrations are very numerous and cannot be too warmly praised. The first, which we are permitted to reproduce represents a gorilla family.

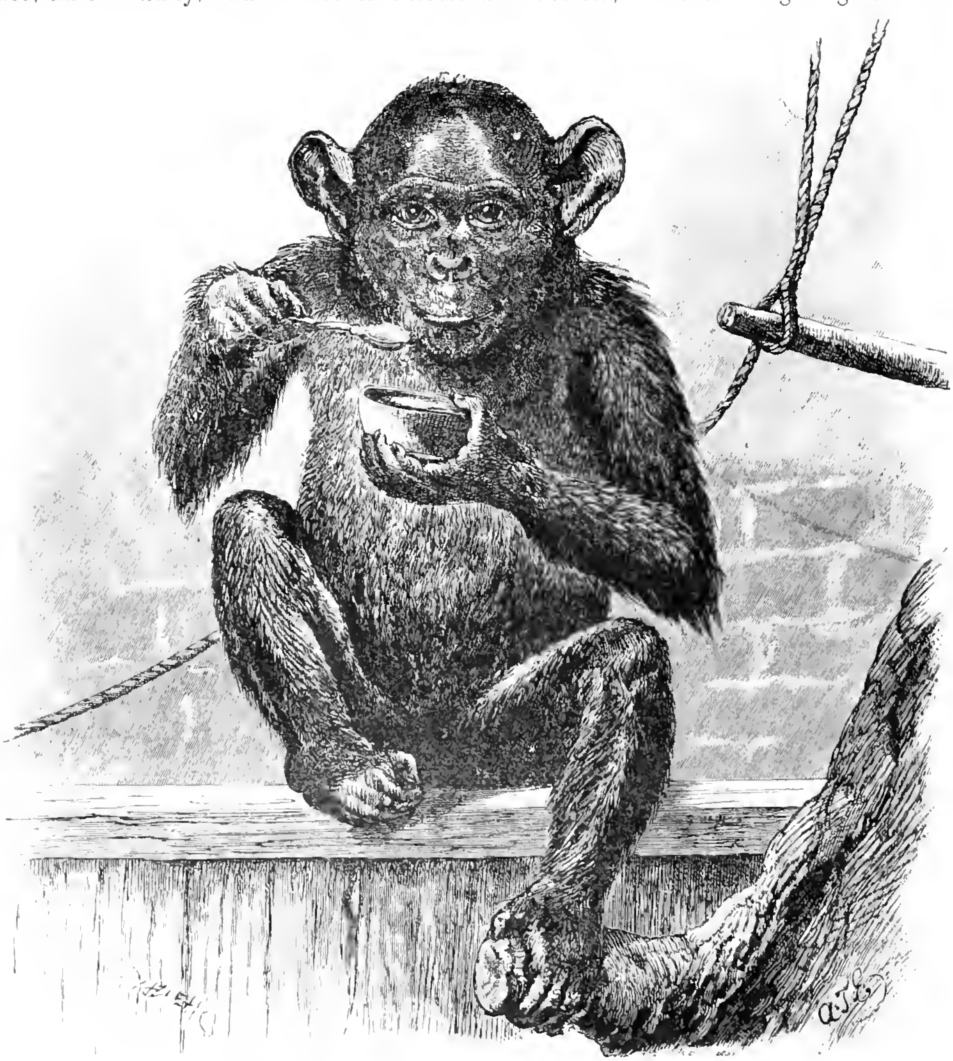
Mr. Lydekker's description of the larger anthropoid apes will be found extremely interesting. He reminds us that a full-grown male gorilla, if standing in a perfectly upright position, will generally measure rather more than six feet in height; and since his body is much more bulky, and his limbs are longer than those of man, he is considerably the largest representative of the Primates. Gorillas habitually live in small families, having young ones of various ages with them. They live a wandering life and do not frequent the same sleeping-place for more than three or four consecutive nights, travelling considerable distances through the dense forests in search of fresh supplies of suitable food.

Although in appearance male gorillas are somewhat unwieldy creatures, yet they are most active and indefatigable climbers, and are said to ascend to the very tops of the forest trees, where they pass from tree to tree almost as readily as the far lighter spider-monkeys of Brazil. They are also capable of taking leaps from great heights to the ground without damage to themselves. Herr von Koppenfels says that he saw an adult spring from a tree at a height of some thirty or forty feet, and on alighting disappear into the scrub.

Of all the large man-like apes, those which on the whole make the nearest approach in bodily structure to man are the chimpanzees of western and central equatorial Africa. In the autumn of 1883 a young chimpanzee, called "Sally," was purchased by the Zoological Society of London. Mr. Bartlett, the superintendent of the society's gardens, soon recognized that she was very different from the true or common chimpanzee, and he considered that the animal was probably one of the black-faced chimpanzees, termed by Du Chaillu "bald chimpanzees." The ordinary chimpanzee has a white or pale flesh-coloured face, hands, and feet, and is a vegetable feeder, but "Sally" showed a disposition to live upon animal food. Mr. Bartlett says that soon after her arrival he found that she would kill and eat small birds; seizing them by the neck, she would bite off the head and eat the bird—skin, feathers and all. For some months she killed and ate a small pigeon every night, but after a time her keepers supplied her with cooked mutton and beef tea, upon which she did very well. She was an expert rat-catcher, and caught and killed many rats that entered her cage during the night.

Mr. Bartlett soon recognized that her intelligence was far above that of the ordinary chimpanzee; she quickly recognized those who had once made her acquaintance, and paid marked attention to men of colour by uttering a loud cry—*bun, bun, bun*. Dr. J. G. Romanes made her acquaintance and endeavoured to test her mental powers. His account of her was written in 1889, after she had been nearly six years in the Zoological Gardens. He compared the intelligence of "Sally" to that of a child a few months before emerging from the period of infancy, and considered that it was far higher than that of any other mammal, with the exception of man.

In spite, however, of this relatively high degree of intelligence, the creature's power of making vocal replies to her keepers, or those with whom she was brought into contact, were of the most limited kind. Such replies were restricted to three peculiar grunting noises. One of these indicated assent or affirmation; another, of very similar intonation, denoted refusal or distrust; while the third, of totally different intonation, was used to express thanks or recognition of favours. In disposition, says Dr. Romanes, "Sally" was like many of her sex, apt to be capricious and uncertain, although on the whole she was good-humoured and fond of her keepers, with whom she was never tired of a kind of bantering play, which was kept up at intervals almost continually. By singing in a peculiar kind of monotone in imitation of her own utterances, her keepers were usually able to induce her to go through a series of remarkable actions, the meanings of which were not very apparent. First she would shoot out her lips into a tubular form, uttering at the same time a weird kind of howling note, interrupted at regular intervals. The pauses would, however, gradually become shorter and shorter, while the sing-song became



"Sally," the Black-Faced Chimpanzee.

louder and louder, until it finally culminated in a series of yells and screams, not unfrequently accompanied with a stamping of the feet and a violent shaking of the netting of her cage. After this climax the utterance of a few grunts terminated the performance.

It occurred to Dr. Romanes (from whose account Mr. Lydekker quotes) that "Sally" would be a good subject on which to test the powers of an ape's intelligence. He found, however, that his experiments were seriously hampered by the effects on the creature of the visits of the numbers of people who were constantly passing in and out of the room in which she was kept, and there is consequently little doubt that under more favourable circumstances the results obtained would have been more remarkable than they are. Having secured the assistance of the keepers, Dr. Romanes requested them to ask "Sally" repeatedly for one, two, or three straws, which she was to pick up and hold out from among the litter strewing her cage. The number of straws asked for was constantly varied and never followed any regular order, and when the correct number was presented the animal was rewarded by a piece of fruit, while if the number was incorrect her offer was refused. In this way the ape was easily taught to associate these three numbers with their names. Lastly, if two or three straws were demanded she was taught to hold one or two in her mouth until she had picked up the remaining straw, and then to hand the two or three straws together. This prevented any error arising from her interpretation of vocal tones. As soon as she understood what was required, and had learnt to associate these three numbers with their names, she never failed to give the number of straws asked for. Her education was then extended in a similar manner from three to four, and from four to five straws. Here Dr. Romanes allowed her education to terminate. But one of her keepers endeavoured to advance her instruction as far as ten. Although she very rarely made a mistake in handing out one, two, three, four or five straws, and was usually accurate in handing out as many as six or seven, when the numbers eight, nine or ten were named the result became more and more uncertain, so as to be suggestive of guess-work.

It was evident, however, that she understood the words seven, eight, nine and ten to betoken numbers higher than those below them; and if she was asked for any of these numbers, she gave some number that was above six and not more than ten. On the whole, therefore, while there was no doubt that "Sally" could accurately count up to five, beyond five her accuracy of computation became progressively diminished. Owing to the method of picking out the straws above described, the operation was a slow one, and imposed a considerable tax upon her patience; and as her movements were deliberate and her store of patience small, Dr. Romanes thought that the uncertainty which attended her dealing with the numbers six and seven was more frequently due to her losing patience than to her losing count, although after seven he believed that her computation of the numbers became vague.

We heartily concur with the popular Secretary of the Zoological Society in commending "The Royal Natural History," not only to every naturalist, but to every lover of nature.

Our Household Insects: an account of the Insect Pests found in Dwelling-Houses. By Edward A. Butler, B.A., B.Sc. (Lond.), Author of "Pond Life," "Silkworms," &c. (London: Longmans, Green & Co.)—Mr. Butler is already well-known to the readers of Knowledge, and they will welcome this collection of his papers, issued in book form, and provided with an index. We usually associate the pursuit of entomology with summer weather and the open air; but Mr. Butler's book will afford occupation for winter evenings, without imposing on readers the necessity of going very far from their own firesides; though it is to be hoped that they will not meet in their homes with specimens of every insect described by him. Thanks to the spread of education, and to the improved observance of the precept that "cleanliness is next to godliness," fleas, bugs and lice are now practically banished from most middle-class dwellings. On the other hand, there are no houses in which representatives of some of the insects whose history is related in this book cannot be found. The common cockroach (otherwise known as the black beetle) is, perhaps, the largest and best known of all household insects; and Mr. Butler wisely devotes some thirty pages to a sketch of its life-history and anatomy. As it is the largest of household insects, it is the best of them for dissecting purposes, and its internal organs can be studied without the use of a high power microscope; and with the advantages of Mr. Butler's guidance, any ordinary observer who has not first-class appliances can obtain some practical knowledge of the digestive, circulatory and nervous systems of the insect world. As Mr. Froude has attempted to whitewash Henry VIII., so does our author attempt to whitewash the wasp; but we fear that suspicion of wasps is so deeply rooted in the human breast that it will be long before men, and especially women, will learn to regard a wasp with equanimity, and to look upon him as a benefactor to mankind. Why do we always speak of the wasp as "he"? As a matter of fact, the male wasp is without a sting, and can be easily distinguished from the female and from workers by his antennæ, which are longer than theirs; but when a wasp is buzzing, who stops to consider the length of his antennæ? The ladies of the household will be interested in studying the various clothes moths, of which at least four species are known, though probably more species suffer from the mistaken zeal of the housewife when she is defending her beloved stores of linen and furs; and it should be remembered that when she discovers the moth issuing from the cupboards the mischief is already done, for the winged moth does not damage clothes, it merely lays the eggs from which come the caterpillars, who are the destructive agents. It is pleasant to find that some of the best known and most noxious household pests are importations to this country, and are not aborigines. The cockroach and the bed bug were unknown in England till the sixteenth century. By the way, these two insects are deadly enemies, and in the London slums the cockroach proves himself a friend of man by devouring numbers of bugs. Mr. Butler tells us of other insects that have not been acclimatized, but have been brought to this country in packages of foreign goods. He has discovered a fine large South American weevil in a gooseberry tart; and I remember sitting beside a friend when he found a Russian beetle in a cranberry pie. In England we think with disgust of savages who are in the habit of eating insects; but beetles and meal-worms are frequently ground up with corn into flour, and are not detected in bread and pastry, and it is not only corn which is liable to be thus adulterated. A recent writer says, "I have known bushels of cocoa nuts, which were every one worm-eaten and full of maggots, with their webs, cast-off skins, pupæ, and cocoons, all ground down to make chocolate—flavoured, I suppose, with vanilla."

Mr. Butler's method of writing will stimulate many to observe for themselves. We trust that he will not let the pen drop from his fingers, but will continue to instruct us in the habits of insects with the same charm of style and accuracy of observation which this book displays.

Oxford. A. Ballard.

Weather Lore: a Collection of Proverbs, Sayings, and Rules concerning the Weather. By Richard Inwards, F.R.A.S. (London: Elliott Stock, 1893). Mr. Inwards' handsome book, of nearly two hundred pages, contains an interesting mine of weather lore. Many of the proverbs afford evidence of keen observation, though most may be said to be only of interest as they point to ancient superstitions and the universal tendency of mankind to form general conclusions from a too limited observation of facts. Mr. Inwards notes that a great many proverbs about the weather come from Scotland, and but very few from Ireland. He has collected the "fossil wisdom" about the weather from Roman and Saxon times onward, and notes that proverbs concerning particular days must, on account of the reformation of the calendar, be held to refer to times a little later than the dates now affixed.

Science Notes.

Mr. Enock, in the *Entomologist*, seems to forebode a plentiful crop of Hessian fly this year. The farmers, he says, are actually "sowing Hessian fly," by spreading the screenings from the threshing machine with the rough manure. He suggests *free* distribution of illustrated sheets by the Board of Agriculture; but one is tempted to ask, What is the Royal Agricultural Society doing?

Every student of astronomy has read of the luminous outburst observed upon the sun by Messrs. Carrington and Hodgson in 1859, and the magnetic disturbances which were supposed to be caused by it or to be simultaneous with it. Two brilliant objects appeared upon the sun, near the edge of a sunspot, and, after travelling a distance of about thirty-six thousand miles across the surface in five minutes, disappeared. There can be little doubt as to the accuracy of the solar observation, but the statement that the phenomenon was immediately followed by a magnetic storm does not appear to be founded upon fact, though the majority of astronomical text-books lay great stress upon the connection between the two phenomena. An examination of the case has led Mr. W. Ellis, of Greenwich Observatory, to the following conclusions: (1) The solar outburst in 1859 was seen independently by two observers; the fact of its occurrence seems, therefore, undoubted. (2) The corresponding magnetic movement was small. (3) Many greater magnetic movements have since occurred. (4) No corresponding solar manifestation has been again seen, although the sun has since been very closely watched. The erroneous impression has been long-lived, but apparently it must now be abandoned.

The probable origin of cannibalism has recently been discussed by H. Henkenius. He considers that hunger was the original incentive, and that the vice was persisted in from choice. Many writers are of opinion, however, that religious motives are accountable for the origin of the custom, and in Polynesia and Central America it certainly occurs most frequently in connection with religious ceremonials. Peschel has pointed out that tribes distinguished by a certain social and intellectual advance are frequently, up to a certain point, more cannibalistic than their less civilized neighbours; and this would support the view that one chief motive for the practice may be the rather complex idea of acquiring the strength and virtues of the fallen. The proceeding would certainly seem to be antagonistic to the instincts of the greater number of mammalian species, and to require as a condition such a conflicting incentive to these as a strong mental persuasion would supply.

A curious statement is made in the report of the Royal Commission on the Water Supply of the Metropolis. It is stated that disease-generating bacteria flourish better in distilled water, or water previously sterilized, than in ordinary river water where other bacteria, as for instance those engaged in putrefaction, are present. There is a natural antagonism between pathogenic and non-pathogenic bacteria. Hence where we have very pure water, such as is obtained from the deep chalk, an accidental fouling by infective matter may be more disastrous than if the supply were ordinary river water. This would tend to revolutionize our conception of the necessary conditions of safety in the matter of drinking water.

Letters.

The Editor does not hold himself responsible for the opinions or statements of correspondents.

COMPARISON OF STAR-PHOTOGRAPHS.

To the Editor of KNOWLEDGE.

DEAR SIR,—In the October and November numbers of KNOWLEDGE are letters from Mr. Glew and Mr. Wilson on a method of comparing different photographs of the same region of the sky, for detecting changes, by superposing a positive (on glass) from one of the negatives over the other negative.

I originally proposed this method in the *Astronomische Nachrichten* (No. 3101) nearly two years ago, and have used it before and since that time.

I enclose a copy of the *Nachrichten* containing my note on the subject, which I would thank the Editor if he would kindly reproduce in KNOWLEDGE, as it seems not to have reached the eyes of some readers, though it was noticed by several astronomical journals when it was published in the *Nachrichten*.

Mount Hamilton, California, E. E. BARNARD.
November 20th, 1893.

A simple and rapid method of detecting changes on celestial photographs due to motion or variability of the celestial bodies. By E. E. Barnard.

"The general adoption of photography for the charting of the heavens suggests the desirability of some means of facilitating the comparison of photographs of any one region on different dates, for the detection of change or variability.

"The most careful inspection of such plates by the ordinary methods would be laborious, and would scarcely reveal changes unless they were very striking—repeated measurements of every object being out of the question.

"In thinking this matter over, it would seem that an admirable and almost instantaneous method is applicable where the photographs have been made with the same instrument—the scale remaining unaltered.

"Suppose two such photographs to have been made on different dates. From one of these negatives, say number one, make a glass contact positive. Superpose this upon negative number two—film to film. Since the scale in each case is the same, the superposed negative number two will completely blot out every image on the positive from number one, if in the meantime none of the objects has moved. If, however, any change has occurred, the images of the moving objects on the positive will not be obscured, and by holding the two plates, so superposed, to the light the eye will instantly detect the fact by the unobscured image of the object on the positive from plate number one. Now if the interval between the dates of the two photographs is not so great that the moving object has left the region photographed, it can be easily found on plate number two by making a positive of that plate and superposing it on negative number one; the position of the object again being made evident by the unobscured image.

"It would seem that this method would be about the only one at all applicable to a photographic search for any planet exterior to Neptune, as the slow motion of such an object would prevent its trailing on the plate, and it could not possibly be distinguished from the multitudes of small stars on the photographs by ordinary inspection.

"Photographs made with an interval of a few years, and thus compared, would at a glance reveal displacements due to proper motions of the stars—assuming that the scale suffered no change in the meantime.

"Comparisons thus made would also readily reveal the presence of variable stars.

"In superposing two negatives of the same region of the sky, correctly oriented to each other, very singular and interesting systems of circles, &c., are formed. These change their positions and extent with every slight shifting of one of the negatives from exact coincidence with the other."

PHOTOGRAPHIC NEBULOSITIES IN THE MILKY WAY.

To the Editor of Knowledge.

Dear Sir,—In the continuation of the photography of the Milky Way, one of the plates having shown near its edge a rather remarkable and large nebula where none had been previously recorded, I decided to give a specially long exposure on it, though the object fell in a blank region of the Milky Way, in one of the large dark areas. With the nebula in the middle of the plate, on October 13th, 1893, an exposure of seven hours was given, from 8h. 20m. to 15h. 20m. standard Pacific time. The instrument used was the Willard lens, with which all the Milky Way and comet photographs have been made. The aperture of this instrument is six inches and the focal length thirty-one inches.

The resulting picture shows a very singular and remarkable object—a straggling group of bright stars in the centre of a vast nebula over 2° in diameter. This nebula, which is roughly roundish, has numerous irregular vacancies and zigzag lanes in it, and seems to mingle indefinitely with masses of small stars and become part of them. As shown by the photograph it occupies a very singular region, distantly surrounded by vast multitudes of small stars.

The group of stars itself is visible to the naked eye as a hazy spot, about 3° north-west of the variable μ Cephei. The brightest star in the group is D.M. + 56° 2617, whose position for 1855·0 is α = 21h. 34m. 29·8s., δ = + 56° 49·7′, which may also be taken to represent the place of the nebula.

The bright star near the north-west corner of the unenlarged plate is α Cephei. Five degrees south, and a little west of α is shown the red star Σ 2729, which is a beautiful double. Preceding Σ 2729 is the 6·5 magnitude star D.M. + 57° 2309. This latter star the photograph shows to be surrounded by a rather unsymmetrical dense circular nebulosity. The nebulosity is a little denser following the star. The position of this object for 1855·0 is α = 21h. 13m. 21·1s., δ = + 57° 58·9′.

This was not previously known to be nebulous, though the nebulosity can be seen as a hazy glow about the star with the telescope. In the 36-inch the star itself is found to be a very unequal double. Two nights' measures give for it position angle 274·1°, distance 4·40″. The smaller star is about 13½ magnitude.

I also send an enlargement which I have made of the central part of this plate showing the large nebula to better advantage, the magnification being about 2⅓ times. This brings out very beautifully the singular structure of the sky in the region of the nebula. When viewed at a distance of a few feet the effect is enhanced; it is then seen that the sky (or Milky Way) is broken up into numerous black cracks or crevices. Looking at these peculiar features, I cannot well see how one can avoid the conclusion that they are necessarily real vacancies in the Milky Way, through which we look out into the blackness of space. I am aware that Mr. Ranyard is opposed to this view, and I would like to have his opinion of the real nature of these apparent crevices in the Milky Way, as shown on this particular plate.

Among the many curious things shown on this photograph, besides others which I have not the time to elaborate on, will be seen a curious arch of small stars close following the second brightest star in the nebula. About 3° following the nebula, and a little north, is a very singular elliptical dark opening surrounding an island of small stars.

In reference to nebulous stars, I would say that a photograph on September 17th, 1893, with three hours' exposure, shows ω Orionis to be nebulous; there is a curved spur of nebulosity running from the star north-westerly, and a larger mass some 20′ north of the star. λ Orionis is also nebulous, with the heaviest part of the nebulosity to the west. These are verified with the 12-inch.

Another picture, with a longer exposure, seems to show a large elliptical nebulosity attached to and extending southerly from α Orionis. This latter, however, must be verified by another and longer exposure, though the nebulosity, if real, is strong enough on the present plate.

Mount Hamilton, California, E. E. Barnard.
November 14th, 1893.

To the Editor of Knowledge.

Dear Sir,—The interesting article on the solar faculæ, in the December number of Knowledge, prompts me to send you some results of my own recent experience with regard particularly to the reversals of the H and K lines on the sun's disc and in the prominences, these being in some respects at variance with the conclusions of M. Deslandres.

A careful examination of all the spectrum photographs I have obtained appears to show that, whilst every true facula giving a continuous spectrum reverses the calcium lines, other bright reversals are sometimes present, having no corresponding faculæ. In certain spot spectra, for instance, the reversals are found to be continuous over the whole of the disturbed region, very intense but single over the spots, and wider with a central absorption line in the neighbouring faculæ. As a rule, however, the umbra of a spot appears to give no calcium light. Thus, I should be inclined to agree that the forms photographed with H or K light by Prof. Hale, and recently also by myself, would be more correctly described as "faculous gaseous protuberances" than faculæ, for they evidently do not correspond exactly with faculæ.

Where I differ from M. Deslandres, however, is in regarding both kinds of reversal as ordinary prominences seen in projection upon the disc, and I think I have obtained ample evidence showing that this may be true only with regard to what I may call the eruptive reversals having no corresponding faculæ. According to my experience, the ordinary faculæ do not reverse the hydrogen lines. If these objects were really prominences one would expect to find the hydrogen line ε, the companion to H, of the same relative intensity as it is in the prominences at the limb; but I have failed as yet to find any trace of this line. Furthermore, I have several times observed the faculæ reversal when at the limb without finding any prominence over it, and I think I may say that, as often as not, the calcium reversal ends abruptly in the chromosphere.

Again, the faculæ are concentrated in the zones of spot formation, and cover such vast areas as to present the appearance in Prof. Hale's beautiful photograph of two nearly continuous belts, one on each side of the equator, forcibly reminding one, as Prof. Hale has himself remarked, of the equatorial belts on Jupiter. The prominences, however, are by no means confined to this region; in recent years I have found them mostly developed in much higher latitudes, in zones which appear to drift from mid-latitudes towards the poles (see *Astronomy and Astro-Physics*, No. 105, p. 127). The prominences found in the faculous region, say ± 40°, are very sparsely distributed in longitude, and the area occupied by them is certainly much less than that covered by faculæ. Thus I do not think that there is any direct correspondence between these phenomena.

The comparatively rare metallic and eruptive prominences are, however, found almost exclusively in the spot regions, and I think it highly probable that these are developed from faculæ in disturbed regions, and it is to these that I should attribute such phenomena as the sudden veiling of a spot by calcium vapour, so well shown in the photographs taken by Prof. Hale on July 15th, 1892 (*Astronomy and Astro-Physics*, No. 110), and I will venture to predict that these eruptive reversals will show also the companion line to H reversed; thus distinguishing them from the true faculæ.

My conclusion, therefore, is that monochromatic photographs obtained by Prof. Hale's method in H or K light will show faithfully all the true faculæ, but that occasionally these forms will be masked by an overlying extension of calcium vapour or by a prominence of exceptional brilliancy. The ordinary prominences, I believe, cannot thus be photographed in projection upon the disc.

Yours truly,

J. EVERSHED.

To the Editor of KNOWLEDGE.

Gore Lodge, Glenageary, Co. Dublin,
5th December, 1893.

DEAR SIR,—Referring to your observations relative to my moonlight photograph, which you reproduced in your issue of this month, the camera used had no "cap" arrangement, and the shutter was closed by me before removing the camera from the position in which the exposure was made. I feel perfectly convinced that the plate received no such irregular exposure as you imagine; but it has been suggested to me that the lightning-like marks may be due to some phosphorescent insect having crawled over the lens or plate.

Yours truly,

ROBERT R. LEVINGSTON.

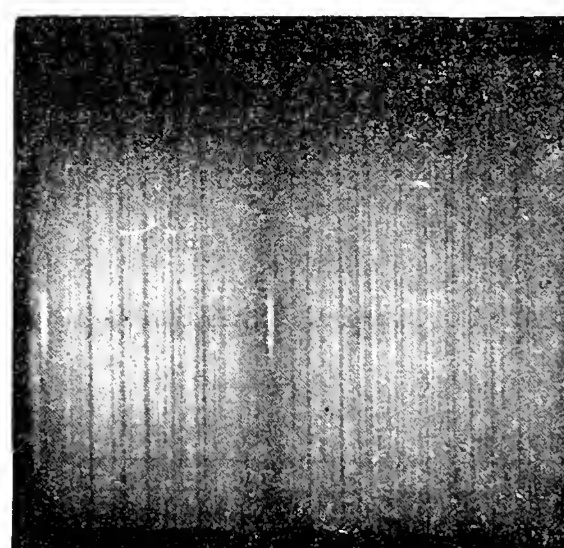
[If a phosphorescent insect had crawled over the lens during the exposure, its light might have thrown a faint general illumination on the whole plate; but no image of the insect would have been thrown on the plate. The fact that the lightning-like trace does not extend to the edge of the plate, but stops at the line which marks the edge of the dark side, seems to show that the line was traced while the plate was exposed in the dark slide. Supposing that the light from a luminous insect crawling over the plate was sufficient to leave a photographic trace, one would expect the photographic action to be brightest at the centre of the path and to decrease in brightness gradually towards its edges; but the band on Mr. Levingston's plate has sharp edges. On the other hand, if the light was derived from a firefly in front of the camera, it must have been at a considerable distance, or its image thrown on the plate would have been out of focus and soft at the edges, in a camera which gave sharp images of a distant mountain; but it is hardly conceivable that a distant firefly would have been sufficiently bright to give such a trace, and we know from the breadth of the trace that the luminous object which caused it must have subtended about half a degree in diameter as seen from the camera.—A. C. RANYARD.]

THE SOLAR FACULÆ.

By Prof. GEO. E. HALE.

THE almost simultaneous discovery of the doubly-reversed H and K lines in the spectrum of the faculæ, made by M. Deslandres and myself in 1891, was not altogether unexpected. Several years earlier, Prof. Young had seen this bright pair of lines in the spectrum of spots, but their position at the extreme limit of the visible spectrum made satisfactory observation impossible. Prof. Young found, however, that the bright lines were not confined to the spot itself, but extended on to the disc for a considerable distance.

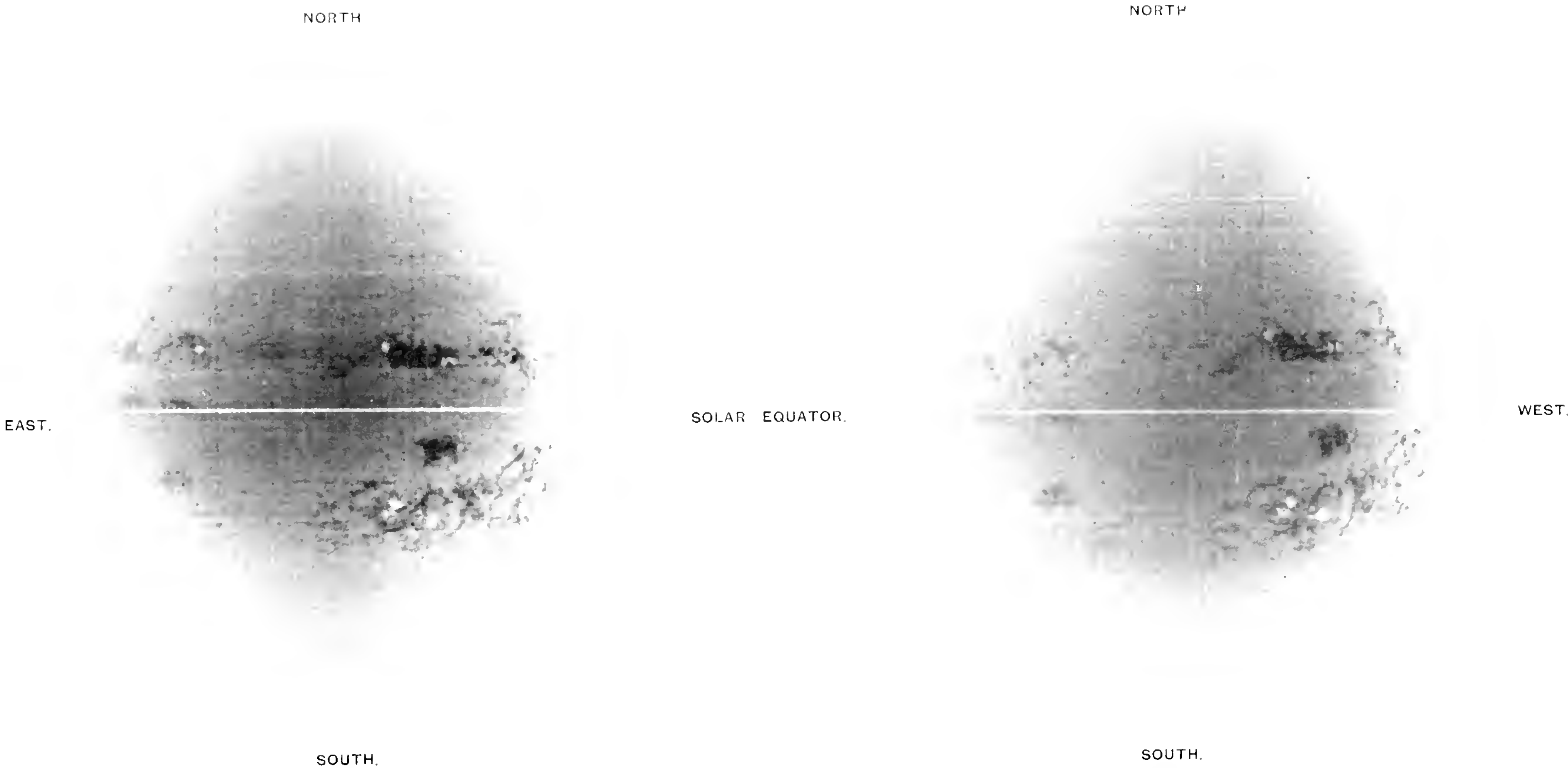
With the application of photography the difficulties of visual observation disappeared, and the bright lines were found, not only in the neighbourhood of spots, but also in extensive regions irregularly distributed over the solar disc. A dark central line of double reversal, which had escaped the eye of the observer, was also clearly registered upon the photographic plate. With a sufficient dispersion it is occasionally found that the doubly-reversed lines extend entirely across the sun. They are not uniformly bright, but have alternate maxima and minima of intensity. In the minima the lines sometimes seem to disappear completely, but it appears probable that with sufficient dispersion they could be photographed at any point on the disc. The accompanying cut, which is a direct reproduction of an enlarged photograph of the K



Sun's Limb.

H K

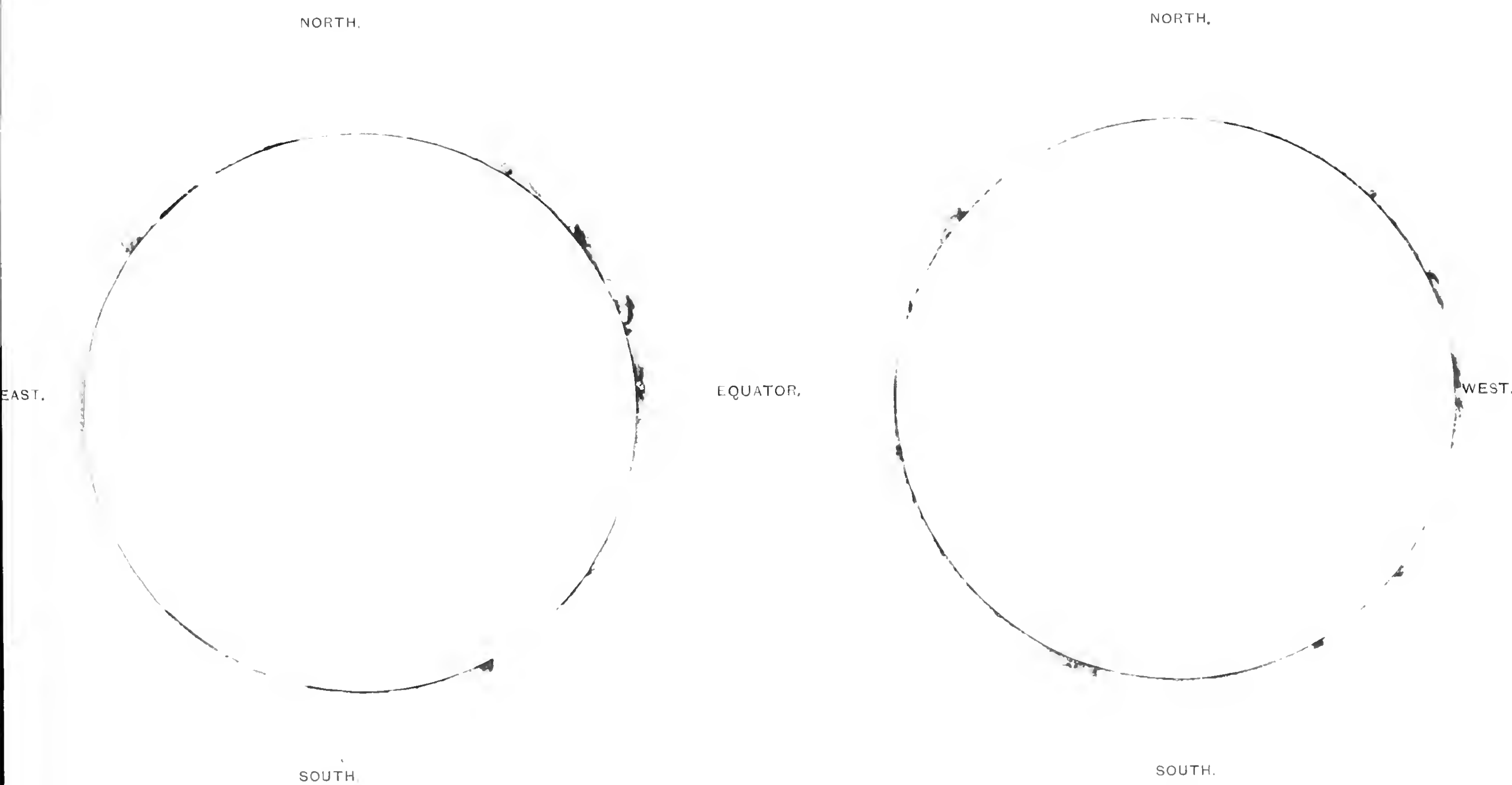
line (H is just on the edge of the field), will perhaps give an idea of the character of the double reversal. On the original photograph the lines are unbroken throughout their whole length, and of nearly uniform intensity on either side of a strongly-marked maximum. H and K are



MONOCHROMATIC IMAGES OF THE SUN, dark representing light, showing the regions in which the Calcium line K is bright.

Photographed with a moving slit by Prof. GEO. E. HALE, at the Kenwood Physical Observatory, Chicago, U.S.A.

Direct Photo-Engraving Company, 9, Barnsbury Park, N.



TWO SPECTROGRAPHS OF THE SOLAR CHROMOSPHERE AND PROMINENCES.

Photographed with a moving slit on the K line by Prof. GEO. E. HALE, at the Kenwood Physical Observatory, Chicago, U.S.A.

Direct Photo-Engraving Company, 9, Barnsbury Park, N.

almost identical in appearance, except that the latter is always the brighter of the two.

The question has been raised as to whether the bright lines with dark centres are true double reversals, or simply close double lines. A moment's consideration of the facts of the case ought to leave no room for doubt on this point. If a photograph of the spectrum is taken with the slit lying across the sun's limb, it is found that the two bright lines of the double reversal unite into a single bright line at the edge of the disc, and this single bright line exactly coincides in position with the central dark line of the double reversal. This is shown in the photograph from which the cut was made, but the reproduction fails to bring it out.

The investigations of Cornu and other physicists, on the reversal of the lines of metallic vapours in the electric arc, offer most striking analogies to the phenomena just described. Through the kindness of M. Cornu, I have recently had the pleasure of examining some of his photographs of reversed lines. The investigations were confined to the ultra-violet, and the calcium lines which correspond with H and K were not specially studied. The reversals of other lines are similar, however, and will serve our present purpose equally well. An ultra-violet line of aluminium on one of the photographs reproduces the solar H and K reversals so perfectly that it might readily be mistaken for one of them, were there any doubt as to its mode of production.

In M. Cornu's experiments an image of the arc was formed on the slit of the spectroscope. A portion of the metal, or one of its salts, was introduced into a cup-shaped cavity in the lower carbon, and vaporized by the passage of the current. Under these conditions the central portion of the arc, where the line of sight passed through the cool exterior vapour to the intensely heated vapour and the glowing carbon poles, showed the aluminium line reversed—two narrow bright lines enclosing a narrow dark line. At the edge of the arc, however, where the line of sight passed through only the cooler vapour of the exterior, the two bright lines united into a single bright line, corresponding in position with the dark line seen in the first case.

We thus arrive at a basis for the interpretation of the H and K reversals in the sun. In the arc we have a reversed line produced by the absorption of the cooler vapour of the exterior. The chromosphere would seem to play the part of the absorbing vapour in the sun. At the base of the chromosphere, or below it, is the hotter vapour corresponding with that at the centre of the arc. Here is the seat of the brilliant radiation of calcium, which produces the two bright components of the doubly-reversed H and K lines. The upper part of the chromosphere, on the other hand, acts as an absorbing screen, and produces the central dark line of the reversal. A photograph of the solar disc secured by means of the spectro-heliograph (using the K line) should therefore show, not the entire chromosphere, but only its lower and hotter parts.

The distinction is an important one when it is remembered that photographs taken with the spectro-heliograph show the entire surface of the sun to be mottled over with small, irregularly-shaped, bright regions, which seem to form a nearly unbroken reticulation (*Astronomy and Astro-Physics*, May, 1893, p. 450). This is not to be mistaken for the well-known "granulation," nor for the "réseau photosphérique" of M. Janssen. Neither does it seem at all probable that the brighter regions are merely elevations in the chromosphere, for if the upper part of the chromosphere acts as an absorbing medium, and produces the dark central line of the H and K reversals, an increase in the depth of the chromosphere would certainly not diminish the absorption. It seems likely that the reticulation represents a true facular network, for the small faculæ seen without the spectroscope near the sun's limb, and well described by Secchi (*Le Soleil*, German edition), are probably parts of the same reticulation. Probably no sharp distinction can be made between the base of the chromosphere and the upper surface of the underlying faculæ. The latter seem to be in intimate connection with the interior of the sun, and one might therefore expect to find the H and K lines very bright in them.

In this connection it should be remarked that the H and K lines over spots are frequently somewhat narrower and less brilliant than on the disc, and the central dark line is often absent. I have explained this as probably due to the fact that we are here dealing with the radiation of the chromosphere overlying the *cooler* region of the spot. (*Astronomy and Astro-Physics*, 1892, p. 815).

In a recent paper on the "Physical Constitution of the Sun" (*Astronomy and Astro-Physics*, 1893, p. 832), Father Sidgreaves has expressed his belief that faculæ are prominences seen in projection on the solar disc, and M. Deslandres has advocated a similar hypothesis in the December number of KNOWLEDGE (see also *Comptes rendus*, Nov. 27th, 1893). As my own position in regard to the subject is evidently not fully apprehended by M. Deslandres, I shall endeavour in what follows to state it as clearly as possible.

In a note dated January 18th, 1892 (*Astronomy and Astro-Physics*, February, 1892, p. 159), I wrote as follows in regard to the regions on the sun's surface in which I had found the H and K lines to be doubly reversed: "On January 12th, 1892, it was found possible to photograph the *forms* of some of these reversed regions, using a moving slit apparatus just completed for our large diffraction spectroscope by Brashear. The K line in the fourth order spectrum was employed, as is customary in the case of prominences. The reversed regions are of great extent, and in appearance closely resemble faculæ. Several explanations may be suggested to account for them. They may be :—

"1. Ordinary prominences projected on the disc.

"2. Prominences in which H and K are bright, while the hydrogen lines are absent.

"3. Faculæ.

"4. Phenomena of a new class, similar to faculæ, but showing only H and K bright, and not obtained in eye observations or ordinary photographs because of the brilliant background upon which they are projected."

Subsequently I found, by comparing photographs of faculæ near the sun's limb, made at the focus of a telescope in the ordinary manner, with photographs of the reversed regions made with the spectro-heliograph, that there was a very close agreement in form. For this reason I adopted the provisional name "faculæ" in subsequent references to the bright regions shown on spectro-heliograms, reserving an exhaustive discussion of the phenomena until sufficient material had been collected for that purpose. Part of this material, in the form of about three thousand spectro-heliograms and several hundred ordinary photographs of the sun, has already been collected and partially reduced. It is intended that one of the first volumes of publications to be issued by the Yerkes Observatory shall be devoted to a discussion of these results. At the present time, and at a distance from my photographic and other records, I can discuss the subject only in a provisional way.

No one can doubt that prominences, and particularly eruptive prominences, are closely related to faculæ. To this point I have already called attention in the following words: ". . . In a great many photographs taken with the spectro-heliograph, faculæ are shown projecting above the sun's limb. And the intimate relationship between faculæ and eruptive prominences is not less evident, especially in composite photographs showing faculæ and prominences on the same plate. When we consider that *eruptive* prominences probably rise from faculæ, it is not at all surprising that such prominences sometimes show a continuous spectrum in addition to their bright lines. For a violent eruption would naturally carry up with the prominence some "dust-like" matter from the facula, which would give a continuous spectrum." (*Astronomy and Astro-Physics*, November, 1892, p. 815.)

The projection of faculæ at the limb, while very frequently shown in short exposure photographs* of the sun's disc, is rarely much greater than the average depth of the chromosphere. If faculæ are prominences seen in projection, or if they are always covered by prominences, as Father Sidgreaves and M. Deslandres hold, these projections should be much higher—*i.e.*, we should always find a prominence above one of these projecting faculæ. As a matter of fact, the long exposure spectro-heliograms of the chromosphere rarely show prominences at such points: when prominences are present they are almost invariably eruptive, and of small extent at the base. But the projecting faculæ give the reversed H and K lines, even when no prominence is present. M. Deslandres states, however: "Les facules sont, par définition, les plages brillantes de la surface solaire, plages qui, à l'intensité générale près, donnent les mêmes raies noires que les parties voisines, et correspondent aux parties élevées, aux montagnes de la photosphère. Elles sont distinctes des flammes de calcium andessus d'elles." (Knowledge, December, 1893, p. 230.)

It is probably true that the faculæ are ordinarily quite different from the prominences which sometimes cover them, but I cannot see that any evidence, other than a "definition," is offered to prove the absence of the bright H and K lines from their spectrum. These lines may have their origin in hot calcium vapour distributed through the mass of the facula, or confined to its outer portion,† but I by no means consider it proved that the spectrum of faculæ does not contain the bright H and K lines.

Leaving for a moment the question of faculæ, let us next consider whether prominences projected on the solar disc should be rendered visible by the spectro-heliograph. The reasoning which has already led us to the conclusion that the nearly continuous reversals of the H and K lines on the disc originate at the base of the chromosphere would seem to apply with greater force to the base of prominences, for here the H and K lines are apparently brighter than in the surrounding chromosphere. And, in fact, I have previously shown that certain outbursts on the solar disc, which there is every reason to believe, are true eruptive prominences, have been photographed at the Kenwood Observatory with the spectro-heliograph (see *Astronomy and Astro-Physics*, 1892, p. 611; *ibid.* p. 920, Plate xlvi., photographs of the eruptive prominence of July 15, 1892; *ibid*, 1893, p. 454). Such brilliant outbursts are quite exceptional, only seven having been found in over two thousand spectro-heliograms.

While it is thus certain that some prominences can be detected on the sun's disc, it is equally certain that others cannot. Since January, 1892, bright regions in which the H and K lines are reversed have been found only in or near the sunspot zones. Not having access to our records, I cannot give the northern and southern boundaries of this facula zone with accuracy, but I do not think we have photographed a single bright calcium region more than 70° north or south of the equator. During the same period our photographs have shown great numbers of prominences of higher latitude than 70°, and prominences have not been uncommon in the near vicinity of the poles. Thus there are bright prominences which give no indication of their presence when projected on the disc, for by no flight of the imagination could the small and evenly-distributed meshes of the facular reticulation be supposed to represent the bases of such large and brilliant prominences. In the face of this difficulty I prefer to wait for further evidence before adopting the conclusion that quiescent prominences in the sunspot zones can be photographed when projected on the disc.

M. Deslandres has suggested that the reversals of calcium on the solar disc be called "*flammes faculaires*, nom qui est en accord avec les faits, et évite toute ambiguité" (Knowledge, December, 1893, p. 231; *Comptes rendus*, November 27th, 1893). I regret that, for the following reasons, I cannot consistently adopt this name:—

1. The use of the identical term "flame," commonly employed to describe one variety of chemical combination, is objectionable because we do not know that the solar and terrestrial phenomena referred to are in any way similar.

2. I have offered evidence to show that many faculæ are not covered by prominences, but themselves give the H and K lines.

3. Even if it could be shown that all faculæ are covered by prominences, it would seem unnecessary to replace the well-known term "prominence" by a less satisfactory synonym.

For the present, if one does not wish to commit himself by speaking of faculæ and prominences on the disc, the general term "calcium reversals" may perhaps be used, though it is not altogether free from objection.

As to the electric origin of the bright H and K lines in the sun (Deslandres *loc. cit.*), it seems to me that the merely negative evidence at our disposal is not a safe foundation on which to build an argument. It is true that the hydrogen spectrum has not hitherto been obtained in the laboratory by the simple effect of heat, but it does not follow that this gas would not give a spectrum of bright lines when subjected to solar conditions. The H and K lines of calcium had not been obtained artificially without electrical means until I succeeded in photographing their feeble radiations in certain flames (see *Astronomy and Astro-Physics*, 1893, p. 452). At solar temperatures these radiations may be greatly strengthened, and the gradual shift toward the violet of the maximum of intensity in the calcium spectrum noticed with increased temperatures renders such a strengthening probable.

While it seems quite possible, and even probable, that electricity plays some part in solar phenomena, the evidence upon which to base any very positive statements appears to be lacking.

Before passing on to the discussion of certain practical

* Obtained with the spectro-heliograph and also by direct exposure at the focus of a telescope.

† It may even be that the lines originate in the chromosphere overlying the faculæ. In this case the increased brightness of the lines, as compared with their brightness in other parts of the chromosphere, would have to be accounted for. Any such brightening, if due to the faculæ, would in all probability be confined to those parts of the chromosphere immediately overlying the faculæ, so that the form of the latter would still be obtained in spectro-heliograms.

questions, important in connection with future investigations of the sun, let us sum up some of the conclusions to which we have been led.

The faculæ are the elevated regions of the photosphere. They form an irregular reticulation over the entire surface of the sun,* and in the sunspot zones appear as irregular bright regions of varying extent. The spectrum of the faculæ is similar to the general spectrum of the sun, but is somewhat brighter, and contains the doubly-reversed calcium lines H and K.† The hot calcium vapour from which these lines emanate may be diffused throughout the mass of a facula, or confined to its upper surface. In the latter case, the base of the chromosphere and the upper surface of the facula would practically coincide. The white-hot particles giving a continuous spectrum would ordinarily be found only in the facula proper, and (more sparsely scattered) in the lower region of the chromosphere. *Eruptive* prominences are closely related to faculæ, and probably rise from them. It thus occasionally happens that a violent eruption carries some of the white-hot particles to a considerable distance above the photosphere. In such a case the prominence gives a continuous spectrum in addition to its bright lines. While some faculæ are covered by prominences, others do not appear to be so covered. Certain exceptionally bright eruptive prominences have been photographed in projection on the solar disc. Ordinary prominences in the region of the sun's poles are not shown in spectro-heliograms. Sunspots, even in their central parts, seem to be covered by the chromosphere (or by overhanging prominences). The chromosphere (or prominences) is frequently so bright as to completely hide small spots in spectro-heliograms.

As M. Deslandres has discussed the instruments and methods employed in my photographic investigations of the sun, I may perhaps be allowed to express an opinion as to the most advantageous manner of continuing these researches.

The spectro-heliograph used in the greater part of my photographic work has a pair of slits arranged to move in the focal planes of the collimator and observing telescope of a large diffraction spectroscope, attached to a 12-inch equatorial refractor.‡ It has proved itself a thoroughly practical instrument, and from two to twenty or more photographs of the forms of prominences and calcium reversals have been made with it on every clear day (with few exceptions) since January, 1892. The photogravure reproductions which accompany this article were made from negatives secured by the aid of this apparatus. Although they fail to bring out the more delicate details shown on the original plates, the illustrations surely demonstrate that the combination of a fixed spectroscope with two moving slits is not without certain merits. Neither my assistant, Mr. Ellerman, nor myself have experienced any difficulty in using a second slit 0·005 inch wide, and this width could be decreased were it considered desirable. By increasing the width of the second slit, and making a series of photographs of the K line at various points on the solar disc with the slit stationary, the character of the double reversals can be studied. This method of successive sections, which I first employed in 1891, seems to me quite as convenient as that used by M. Deslandres. As the slits always move together, there are no troublesome adjustments to be made by hand.

* At least during the maximum period of sunspots.

† The less refrangible hydrogen lines may also be present, but under ordinary conditions they are too faint to be recognized.

‡ This telescope will be removed to the Yerkes Observatory, where the spectro-heliograph will be employed, as at present, in securing a daily record of solar phenomena.

But after studying and experimenting with a great variety of instruments, I came to the conclusion early in the year 1893 that a spectroscope with collimator and observing telescope parallel (or nearly so) to each other, and slits fixed in the axis of each, the whole instrument being arranged to move on wheels at right angles to the axis of the large telescope, would possess important advantages over all other forms of spectro-heliograph. An instrument of this type, suitable for use with a heliostat for automatically photographing the sun, was described in my paper entitled "The Spectro-heliograph" (*Astronomy and Astro-Physics*, March, 1893, p. 256). I have since designed a spectro-heliograph on this principle for the 40-inch Yerkes telescope. A short description of this instrument will be found in the January (1894) number of *Astronomy and Astro-Physics*. The proposed "rotating spectroscope," for which M. Deslandres' various papers have claimed many advantages has, I believe, been recently abandoned for a spectro-heliograph of this class. A similar instrument is to be used at the Maharajah Takhtasingji Observatory at Poona, India.

The question raised by M. Deslandres, in regard to the best dispersion to employ, is a most interesting and important one. On the one hand, a feeble dispersion would seem to offer important advantages on account of the narrowness of the K line and the greater brightness of the image. On the other hand, it must not be forgotten that the fainter details of the reversals may be lost if the dispersion is insufficient. M. Deslandres recognizes this fact when he states that the exceedingly faint H and K reversals in the general spectrum of the sun are best obtained with a "spectroscope puissant" (Knowledge, December, 1893, p. 231); and again, when he remarks that for the study of the details of the reversals on the solar disc "une grande dispersion est nécessaire" (*ibid*, p. 232). This advantage of high dispersion is due to the fact that the width of the bright lines is not proportional to the dispersion, at least up to a certain limit. If by doubling the dispersion the lines were doubled in width, there would evidently be no change in their brightness as compared with the solar spectrum in which they lie. But, within certain limits, the brightness of the lines relatively to the solar spectrum increases with the dispersion. It is evident, therefore, that we must not employ too feeble a dispersion. I have found the fourth order spectrum of a Rowland grating (14,438 lines to the inch) very suitable, though I should have preferred prisms had circumstances permitted their use. The separation of the H and K lines at the focus of the observing telescope, where the photographic plate is placed, is nine millimètres. M. Deslandres uses a single prism, giving a separation of H and K of two millimètres, and magnifies the image of the second slit—and, consequently, the width of the K line—three diameters. The resulting separation of H and K on his photographic plate would thus be six millimètres, and the width of the K line two-thirds the width of the K line in my instrument, if the line were supposed to have a width proportional to the dispersion. As has already been pointed out, the width of a line is not proportional to the dispersion, and it is probable that there is no great difference in the effective width of the line in the two instruments. Thus, any question in regard to displacement due to motion in the line of sight, width of the second slit, &c., would apply almost equally in both cases; but the greater dispersion of the grating would increase the brightness of the K line as compared with the solar spectrum, and fainter and more delicate calcium reversals should be obtained by its means.

It would probably be advisable to have a set of three prisms for a spectro-heliograph, so that one, two, or three might be used as occasion required. The method of forming a magnified image of the second slit on the photographic plate, which we owe to Dr. C. Braun, formerly Director of the Haynald Observatory at Kalocsa, is in some respects a valuable one. Its principal defect—the widening of the K line and the second slit—can be avoided by enlarging the solar image before it enters the spectro-heliograph. In this case, however, it might not be possible to photograph the whole image on a single plate.

The larger solar spectroscope which is to be used with the Yerkes telescope will be specially arranged for the study of the H and K reversals on the solar disc. Among the attachments to be employed for this purpose will be a pair of long slits, arranged to move in the focal planes of the collimator and observing telescope. The method of photographing the K reversal in successive sections of the disc will thus be similar to that hitherto employed with the Kenwood Observatory spectro-heliograph, but the exposure will be made automatically by an electrical device controlled by an astronomical clock. As I have already remarked, the spectro-heliograph for the Yerkes telescope will be arranged on another plan.

Berlin, December 15th, 1893.

THE FACE OF THE SKY FOR JANUARY.

By Herbert Sadler, F.R.A.S.

Spots and faculæ continue to appear on the Sun's disc whenever he is visible. Conveniently observable minima of Algol occur at 10h. 40m. p.m. on the 10th; at 7h. 29m. p.m. on the 13th, and at 4h. 18m. p.m. on the 16th.

Mercury is a morning star for the first portion of the month, but owing to his proximity to the Sun and great southern declination he will be very difficult to observe. On the 1st he rises at 7h. 0m. a.m., or 1h. 8m. before the Sun, with a southern declination of 23° 35′, and an apparent diameter of 5″, $\frac{90}{100}$ths of the disc being illuminated. On the 7th he rises at 7h. 22m. a.m., or 45m. before the Sun, with a southern declination of 24° 11′, $\frac{93}{100}$ths of the disc being illuminated. After this he is too near the Sun to be observed, coming into superior conjunction on the 29th. While visible he passes from Ophiuchus into Sagittarius, without approaching any bright star.

Venus is an evening star, a most brilliant object during the first three weeks of January in the south-western sky. She sets on the 1st at 8h. 0m. p.m., 4h. after the Sun, with a southern declination of $13\frac{1}{4}$°, and an apparent diameter of $34\frac{1}{2}$″, $\frac{34}{100}$ths of the disc being illuminated. On the 11th she sets at 8h. 2m. p.m., 3h. 50m. after the Sun, with a southern declination of 9° 34′, and an apparent diameter of $40\frac{1}{4}$″, $\frac{26}{100}$ths of the disc being illuminated. She is now at her greatest brilliancy, that being precisely the same as on January 11th, 1886. On the 21st she sets at 7h. 51m. p.m., or 3h. 30m. after the Sun, with a southern declination of 6° 21′, and an apparent diameter of $47\frac{1}{4}$″, $\frac{17}{100}$ths of the disc being illuminated. On the 31st she sets at 7h. 19m. p.m., or 2h. 23m. after sunset, with a southern declination of 4° 12′, and an apparent diameter of $54\frac{1}{2}$″, $\frac{9}{100}$ths of the disc being illuminated. Her brightness is now only $\frac{6}{10}$ths of what it was on the 11th. She describes a looped path in Aquarius during the month, being stationary on the 24th.

Neither Mars nor Uranus rise till after midnight in January; and as Saturn only rises on the 31st at 11h. 26m. p.m., we defer an ephemeris of him till next month.

Jupiter is an evening star, and, with the exception of Venus, is the brightest object in the evening sky. He sets on the 1st at 4h. 13m. a.m., with a northern declination of 17° 17′, and an apparent equatorial diameter of 45·0″. On the 12th he sets at 3h. 28m. a.m., with a northern declination of 17° 15′, and an apparent equatorial diameter of $43\frac{1}{2}$″. On the 31st he sets at 2h. 16m. a.m., with a northern declination of 17° 27′, and an apparent equatorial diameter of 40·9″. He is almost stationary in a barren region between the confines of Aries and Taurus during the month. The following phenomena of the satellites occur while the planet is more than 8° above and the Sun 8° below the horizon:—On the 1st a transit ingress of the first satellite at 5h. 24m. p.m., and of its shadow at 6h. 24m. p.m.; a transit egress of the satellite at 7h. 36m. p.m., and of its shadow at 8h. 37m. p.m. On the 2nd an eclipse reappearance of the first satellite at 5h. 49m. 42s. p.m. On the 3rd a transit egress of the shadow of the third satellite at 5h. 12m. p.m. On the 7th an occultation disappearance of the second satellite at 0h. 38m. a.m.; a transit ingress of the first satellite at 0h. 45m. a.m.; an occultation disappearance of the third satellite at 0h. 48m. a.m.; a transit ingress of the shadow of the first satellite at 1h. 51m. a.m.; an occultation reappearance of the third satellite at 2h. 37m. p.m.; an occultation disappearance of the first satellite at 10h. 0m. p.m. On the 8th an eclipse reappearance of the first satellite at 1h. 16m. 31s. a.m.; a transit ingress of the first satellite at 7h. 13m. p.m.; a transit ingress of the second satellite at 7h. 21m. p.m.; a transit ingress of the shadow of the first satellite at 8h. 19m. p.m., and a transit egress of the satellite itself at 9h. 25m. p.m.; a transit ingress of the shadow of the second satellite at 9h. 33m p.m., and a transit egress of the satellite itself at 9h. 42m. p.m.; a transit egress of the shadow of the first satellite at 10h. 32m. p.m., and a transit egress of the shadow of the second satellite at 11h. 54m. p.m. On the 9th an eclipse reappearance of the first satellite at 7h. 45m. 31s. p.m. On the 10th an eclipse reappearance of the second satellite at 6h. 23m. 1s. p.m.; a transit ingress of the shadow of the third satellite at 7h. 21m. p.m., and its egress at 9h. 14m. p.m. On the 14th an occultation disappearance of the first satellite at 11h. 51m. p.m. On the 15th a transit ingress of the first satellite at 9h. 3m. p.m.; of the second satellite at 9h. 50m. p.m.; a transit ingress of the shadow of the first satellite at 10h. 15m. p.m.; a transit egress of the first satellite at 11h. 16m. p.m. On the 16th a transit egress of the second satellite at 0h. 11m. a.m.; a transit ingress of its shadow one minute later; a transit egress of the shadow of the first satellite at 0h. 27m. a.m.; an occultation disappearance of the first satellite at 6h. 19m. p.m., and its eclipse reappearance at 9h. 41m. 24s. p.m. On the 17th a transit egress of the first satellite at 5h. 43m. p.m.; a transit ingress of the third satellite at 6h. 27m. p.m.; an occultation reappearance of the second satellite at 6h. 38m. p.m.; an eclipse disappearance of the second satellite at 6h. 43m. 46s. p.m.; a transit egress of the shadow of the first satellite at 6h. 56m. p.m.; a transit egress of the third satellite at 8h. 21m. p.m.; an eclipse reappearance of the second satellite at 8h. 58m. 52s. p.m.; a transit ingress of the shadow of the third satellite at 11h. 22m. p.m. On the 18th a transit egress of the shadow of the third satellite at 1h. 16m. a.m. On the 22nd an occultation disappearance of the first satellite at 1h. 42m. a.m.; a transit ingress of the first satellite at 10h. 54m. p.m. On the 23rd a transit ingress of the shadow of the first satellite at 0h. 10m. a.m.; a transit ingress of the second satellite at 0h. 20m. a.m.; a transit egress of the first satellite at 1h. 7m. a.m.; an occultation disappearance of the first satellite at 8h. 11m. p.m., and its reappearance from eclipse at 11h. 37m. 17s. P.M. On the 24th a transit ingress of the shadow of the first satellite at 6h. 39m. P.M.; an occultation disappearance of the second satellite at 6h. 45m. P.M.: a transit egress of the first satellite at 7h. 35m. P.M.; of its shadow at 8h. 51m. P.M.; an occultation reappearance of the second satellite at 9h. 7m. P.M.; an eclipse disappearance of the second satellite at 9h. 19m. 31s. P.M.: a transit ingress of the third satellite at 10h. 13m. P.M.; an eclipse reappearance of the second satellite at 11h. 34m. 49s. P.M. On the 25th a transit egress of the third satellite at 0h. 10m. A.M.; an eclipse reappearance of the first satellite at 6h. 6m. 13s. P.M. On the 26th a transit egress of the shadow of the second satellite at 6h. 31m. P.M. On the 28th an eclipse reappearance of the third satellite at 7h. 3m. 36s. P.M. On the 30th an occultation disappearance of the first satellite at 10h. 4m. P.M. On the 31st a transit ingress of the first satellite at 7h. 15m. P.M., and of its shadow at 8h. 34m. P.M.; an occultation disappearance of the second satellite at 9h. 16m. P.M.; a transit egress of the first satellite at 9h. 28m. P.M., and of its shadow at 10h. 47m. P.M.; an occultation reappearance of the second satellite at 11h. 39m. P.M., and its eclipse disappearance at 11h. 55m. 21s. P.M.

Neptune is an evening star, and is well situated for observation. He rises on the 1st at 1h. 56m. P.M., with a northern declination of 20° 37′, and an apparent diameter of 2·7″. On the 31st he rises at 11h. 57m. A.M., with a northern declination of 20° 34′. During the month he pursues a short retrograde path in Taurus, through a region barren of stars to the naked eye.

January is a favourable month for shooting stars, the most noted shower being that of the *Quadrantids*, the radiant point being in R.A. 15h. 12m. and 53° north declination, the greatest display being visible during the morning hours of January 1st to 3rd.

The Moon is new at 3h. 7m. A.M. on the 7th; enters her first quarter at 0h. 9m. A.M. on the 15th; is full at 3h. 11m. P.M. on the 21st; and enters her last quarter at 4h. 51m. P.M. on the 28th.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of Problem No. 3.

Key-move—1. B to K8.

If 1. . . . R to KR5, etc., 2. Q to Kt6ch.
1. . . . K to K4, 2. Kt × Pch
1. . . . R to Q5, 2. B to Q7ch.
1. . . . R to Kt5ch, 2. Q × Rch.
1. . . . R to KB5, 2. Q × P, mate.

Dual after 1. . . . K to B5, by 2. Q to Kt3ch or 2. Kt × Pch.

Also after 1. . . . P to Q5, by 2. B to Q7ch or 2. Kt to Q5.

(There is also a dual mate in this variation.)

It is rather singular that no solver sent in *both* the above duals.

Solution of Problem No. 4.

Key-move—1. B to QKt6.

If 1. . . . K to Q4, 2. Q to KB2.
1. . . . K to Kt4, 2. Q to Q6.
1. . . . K to Kt5, 2. Q to K5.
1. . . . K to B6, 2. Q × P.

Solution of Problem No. 5.

Key-move—1. B to K3.

If 1. . . . B × P, 2. Q × BPch.
1. . . . K to K5, 2. Q to Kt5.
1. . . . K to K3, 2. Q to K7ch.
1. . . . P to B3, 2. Q to Kt5ch.
1. . . . Anything else, 2. B × Pch.

Some of our correspondents note the coincidence that these three problems, selected by ballot, are solved by moves of the Bishop. Still more singular is the fact that they were the first three problems sent in; and, what is more, sent in precisely in the order in which they were printed.

Correct Solutions received from the following:—

Ten Points.—Kt. J., F. R. Adcock, Semper, A. C. Challenger, H. Holmes, B. G. Laws, Chat, Guy.

Nine Points.—Birkenbaum, W. J. Jubb, Rascal, Buttercup, J. H. Christie, W. T. Hurley, A Norseman, E. W. Brooke, A. R.

Nos. 3 and 4 solved by Humilis (5); No. 3 by L. Bourne (4); No. 4 by H. S. Brandreth, Alpha, and W. A. Champion.

The leading scores will be published in tabulated form next month.

W. T. Hurley and *H. Holmes.*—The short mate takes precedence of others, which therefore do not count as duals.

Humilis.—Bird's *Chess History and Reminiscences* (Dean and Son) contains some curious information on the history of the game. There is no dual in No. 3 after 1. . . . R × Kt. If 2, QKt6ch, K to B5. 1. B to Q4 will not solve No. 4. Have you tried 1. . . K to K5?

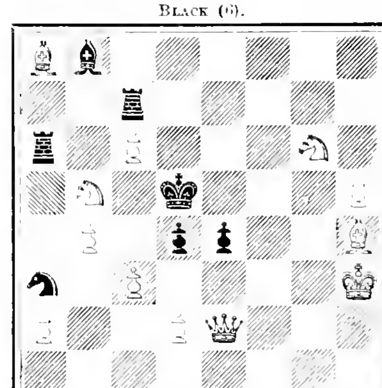
W. J. Jubb.—Third-move duals do not count in the score.

Rascal.—Is not your award of first prize rather premature?

L. Bourne.—No. 4. If 1. Q to QB2, P to Kt3 seems a good defence.
No. 5. If 1. Kt(B6) to K7ch, K to K3 (best).

A Norseman.—Solutions bearing post-mark of the 12th are just in time. It would be impossible to give any extension to suit particular cases.

Position No. 6.
"*La Retraite.*"
Black (6).



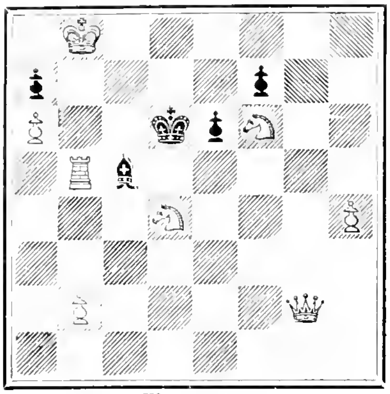
White (13).

White mates in three moves.

Position No. 7.

"*Cave Coquum.*"

Black (5).



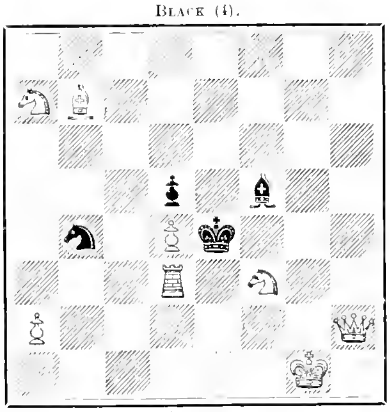
White (8).

White mates in three moves.

Position No. 8.

"*Morceau.*"

Black (4).



White (8).

White mates in three moves.

The following is the twenty-first game of the St. Petersburg match:—

Queen's Pawn Opening.

White (Dr. Tarrasch).	Black (M. Tschigorin).
1. P to Q4	1. P to Q4
2. P to K3	2. Kt to KB3
3. B to Q3	3. P to K3
4. Kt to KB3	4. P to B4
5. P to QKt3	5. Kt to B3
6. B to Kt2	6. P × P
7. P × P	7. B to Q3
8. Castles	8. Castles
9. QKt to Q2	9. B to Q2
10. P to B4	10. R to Bsq
11. R to Bsq	11. B to B5
12. R to Ksq	12. Kt to K2
13. P to Kt3	13. B to Ktsq
14. Kt to K5	14. B to B3
15. B to Ktsq	15. B × Kt
16. P × B	16. Kt to Q2
17. Q to R5	17. P to KR3
18. QR to Qsq	18. Q to Ksq
19. Q to K2	19. Kt to QB4
20. P × P	20. B × P
21. Kt to B4	21. Q to B3
22. Kt to Q6	22. QR to Qsq
23. R to Bsq	23. P to KKt3
24. P to QKt4	24. B to B6
25. Q to Q2	25. P to Kt3
26. P × Kt	26. P × P
27. Q × RP	27. R to Ktsq
28. B to K4	28. R × B
29. B × Q	29. Kt × B
30. Kt to K4	30. B × Kt
31. R × B	Resigns

A Note on Castling.

1. *Its advisability.*—Castling is usually to be recommended when the Queens and three or four other pieces are on the board; also where the opponent has two Rooks and minor pieces. If he has only one Rook and two or three minor pieces, it is generally better not to castle, but to come out with the King towards the centre of the board. Castling should often be delayed as long as possible. Nothing is so embarrassing to the adversary as uncertainty as to the future position of one's king. Of course, delay is useless when it is obvious on which side the castling must eventually take place.

2. *Its objects.*—The objects of castling are three: (*a*) To bring the Rooks into play, (*b*) to protect the King, (*c*) to protect the Pawns on one wing by means of the King. The third of these objects is often lost sight of.

3. *Which side to castle.*—This, of course, depends almost entirely on the position, but there are certain theoretical considerations which apply in all or most cases. Theoretically, for *end-game* purposes, it is better to castle on the Queen's side, for the King is then usually within two squares of both K3 and Q3; while a King castled on his own side is *three* squares away from Q3. The chief objections to castling on the Queen's side are—(*a*) the QRP is left unprotected; (*b*) Black often gains time by a check with Queen or Bishop at KKt4, etc.

Much depends on what files are cleared. If the King's file and KB file are open, it is naturally best to castle KR and bring the QR to K square. If, on the other hand, the two centre files are open, as in most variations of Philidor's defence and the Scotch and Centre Gambits, time is often gained by castling QR and bringing the KR to Ksq.

When two players castle on different sides, the result is usually an advance of Pawns on one side or the other against the castled King. This advance is a slow process and often leads to nothing, the Pawns becoming blocked. There is a sign by which it may often be predicted. When a strong player, his opponent having castled KR, plays P to KR3 before castling, it generally shows that he has in view (Castles [QR] perhaps and) P to KKt4.

Contents of No. 98.

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CONTENTS.

SEALING IN OPEN WATERS.

By Prof. John Milne, F.R.S., *of the Imperial University, Tokio, Japan.*

NEW laws and new mechanical devices have often much in common. Both may appeal to us on account of their apparent adaptability to the purpose for which they were designed, but before any definite conclusion as to their merits can be reached it is necessary to test them by the results of their operation.

During 1893 England took part in a conference, one object of which was to provide protection to the sealing industry in the North Pacific, and, judging from the comments of the press in England and America, the finding of the arbitrators gave general satisfaction. The award on the main point at issue, relating to the opening or closing of the Behring Sea, was sound, and to all fair-minded people the difficulties of previous years seemed at an end.

How far the regulations intended to protect the sealing industry, which were formulated at the conference, have been effective may be judged of by a consideration of what these regulations were, and of what has occurred since their promulgation.

First, we find that sealing is entirely prohibited within a radius of sixty miles of the Pribyloffs; secondly, that nets, fire-arms, or explosives are no longer to be used; and thirdly, that the Behring Sea is closed to hunters from May 1st to the end of July. Inasmuch as seals do not enter the Behring Sea before May, during August and September there are but few seals which venture far from the rookeries, and even of those that do so, in consequence of the fur being "stagey," from fighting and clambering over the rocks, the skins are no longer in good condition, and finally, as the only weapon left to the hunter appears to be a spear, we may conclude that the regulations have indirectly but practically closed one portion of the Behring Sea to a large fleet of English and American pelagic sealers. The protection of seals, therefore, rests with those who take them on the islands.

Further than this, the regulations state that the close season is to extend over an area north of 35° north latitude, and eastward of 180° meridian of longitude, or generally over the north-east portion of the Pacific Ocean. As to how these regulations will be regarded by nationalities other than those represented by the contracting parties we do not know, but the effect they have had upon those directly concerned has been to send to the Western Pacific a fleet of between sixty and seventy vessels, manned by at least fifteen hundred men.

Should the prohibited area be increased and the regulations become law, it does not seem unlikely that vessels may sail under flags other than those of America and England, while the difficulty of enforcing the new laws over an extensive area like the North Pacific will entail a considerable outlay. Already there are sealers flying German, Japanese and Hawaiian flags, an example of the latter being the steam barque "Alexander," which, with some six or eight other boats, is owned by a syndicate largely, if not wholly, composed of persons interested in the North American Commercial Company, to protect whose rights in the Pribyloffs the existing regulations have been so effective.

If the object of the regulations is to prevent the extermination of the fur seal the rules ought surely to be extended over the whole of the North Pacific, the Okotsk and Japan Seas, and a definite understanding should be arrived at as to the number which may be annually killed on the known breeding grounds. Such regulations would affect Americans, Russians, Japanese, pelagic hunters and all who feel that they have a right to capture whatever they find on open oceans and seas.

The American rookeries, as we have already shown, are now well protected, and all that is required is to definitely fix a limit to the number that may be slaughtered on shore. During the last three years it has been seven thousand, but in previous years it was one hundred thousand.

The Russian rookeries are guarded by an understanding that hunting shall not take place within thirty miles of any place where seals haul up, or within ten miles of any shore. How well this has been enforced may be judged of from the fact that during 1893 no less than five British vessels fell into Russian hands. The steam schooner "Warlock" had her papers, guns and ammunition seized in the port of Petropaulovsky, whither she had gone presumably for some legitimate purpose. The "Maud S.," the "Ainoko," the "Minnie," and the "Arctic" were arrested off the Commander Islands, according to their captors all within thirty miles of land. They were not found hunting, nor does there appear to have been any attempt at escape, believing themselves to be well outside the prescribed limits. Inasmuch as these islands and the neighbouring mainland—like very many other islands in the North Pacific—are represented on charts as being ten to fifteen miles out of their true position, and as foggy weather often makes it impossible to obtain the necessary observations for a true position, the investigation of questions of this description is surrounded with considerable difficulty. The cases in point, which are but repetitions of old events, however, suggest the necessity of providing against penalties for unintentional infringement, and the desirability of having more accurate surveys.

A circumstance deserving of note in connection with these islands is that the pelagic hunters, not finding enough to pay expenses, quickly deserted them, from which, however, it must not be inferred that there was any diminution in the number of seals hauled up upon the rookeries. One visitor to the islands stated that he had seen more seals in 1893 than he had ever seen previously, and, but for the arrangement with the English not to take more than thirty thousand, double that number might have been secured. It was, however, added that, in addition to the thirty thousand, there were thirty-two thousand more pelts of seals which had been killed the previous autumn.

Assuming the statement to be correct, this autumn killing is apparently a new departure sufficing to confirm the necessity of strictly limiting the number of animals that may be taken on the land.

The attitude of Japan towards pelagic hunting is difficult to understand. Europeans who left Japanese ports for the purpose of hunting sea otters, in 1881, discovered small rookeries of seals upon the Kurils. As these were left unguarded, they were regularly visited until the seals were exhausted. During this period the authorities in Japan not only prevented their own people from engaging in the newly-discovered industry, but so many obstacles were thrown in the way of Europeans that a fleet of about seventeen vessels, in 1893, had dwindled down to two or three. At this juncture the effects of the Behring Sea regulations drove the sixty or seventy vessels to which we have referred to the Western Pacific. Had their number been smaller, judging from the reception they received, they might have shared the fate of the pioneer fleet which had its birth in Yokohama.

Attempts were made to remove the Japanese who had shipped on board these vessels in America. A man-of-war was despatched to watch their movements, and newspapers had references to pirates and poachers who ought to be sunk or driven off the coast. Although a certain section of the Japanese showed displeasure at the advent of a foreign fleet, it may be inferred that when later in the season some forty vessels put into the harbour of Hakodate to ship their catches, to obtain provisions, and to spend their money, the storekeepers felt satisfied.

Up till recently the policy of Japan in these matters seems to have been detrimental to itself. By not having taken efficient means to protect its own rookeries, these have disappeared. The Japanese, either on their own account or in conjunction with Europeans, have been debarred from exploiting wealth near their own coasts, while sealers from other coasts have not been encouraged to winter and refit in Japanese waters, which, with sixty ships, means an expenditure of at least half a million dollars. So far as is publicly known, the only persons who can have benefited are the owners of the northern rookeries, the seals from which at the smallest computation annually consume six million tons of fish in the waters near Japan.

Although the pelagic sealer may feel that in waters where regulations have been applied his career is now ended, the fleet seems likely to be increased to one hundred or one hundred and fifty sail, and we may conclude that the result of the venture in 1893 off the coast of Japan proved satisfactory. The best catches were made in April and May, when one vessel, hunting with seven boats, on one day secured two hundred and sixty-eight seals. In June, although the seals (which are then moving northwards) are plentiful, foggy weather reduces the number of days when boats can venture far from the vessels. In July, excepting for those that choose to linger outside the thirty mile limit of the northern islands, hunting is over.

The total catch for 1893 was from sixty to seventy thousand. Forty thousand of these were shipped from Japan: the remainder were taken to the American coast.

The casualties have been numerous, arising from boats getting lost in the fogs, an unexpected breeze preventing them from regaining their ship, from which they may have ventured ten or fifteen miles, and from other causes. Some crews left their ships and have not since been seen; others, after a pull of one hundred or one hundred and fifty miles have reached Japan; others have been found in an exhausted condition on the northern islands.

The pelagic hunter, who risks both life and capital, cannot be said to make his money without enduring great hardships and facing many dangers. Whether he should be allowed to exist is a matter for discussion, but if the decision is in his favour—and he represents a large capital, a large force of men, and a considerable revenue—it is clear that regulations to guide his movements should be somewhat more lenient than those already promulgated in connection with the Behring Sea.

SOME EXTINCT ARGENTINE MAMMALS.

By R. Lydekker, B.A.Cantab.

In the article published in the last issue of Knowledge, under the title of "A Land of Skeletons," we brought under the notice of our readers some of the leading peculiarities of the living and extinct faunas of South America in general and of Argentina in particular, while something was said as to the geological features of the latter country. From the limits of our space we were, however, unable to make any mention of the structural peculiarities of the fossil mammals which are found so abundantly in the superficial formations of the Argentine, and since it is impossible to have an adequate idea of the interest attaching to this fauna without some acquaintance with the anatomy of a certain number of its representatives, we propose in the present communication to take into consideration the leading features of a few of the most remarkable types of one great group. As these animals are known solely by their bones, it is, of course, impossible to avoid the introduction of a certain amount of anatomical details, although we shall endeavour to put these in as popular and least repellant manner as possible.

As mentioned in the article referred to, among all the fossil mammals of Argentina some of the most remarkable are the extinct ungulates, or hoofed mammals, which, exclusive of the horses, deer, guanacos, and elephants, belong to groups almost unknown in any other part of the world. Before going further we must, however, remind our readers that the existing ungulates are divided into four groups or sub-orders, distinguished from one another by the structure of their feet. Of these the elephants, or proboscideans, as we have had occasion to mention in an article on that group, are specially characterized by having five toes to each foot, and by the two rows of bones in the wrist and ankle being arranged one above another in a linear manner: while the huckle-bone, or astragalus, of the ankle articulates with the leg-bone by a flat surface. On the other hand, in both the odd-toed or

* During the Pleistocene a few ground-sloths and glyptodonts entered North America.

perissodactyle ungulates, as represented by the rhinoceros and horse, and the even-toed or artiodactyle group of the order, of which we have familiar examples in the pig and the deer, the toes are never more than four in number, the bones of the wrist and ankle interlock or alternate, and the huckle-bone has a pulley-like surface for articulation with the large bone of the leg. Whereas, however, in the former of these two groups the middle toe is larger than either of the others and symmetrical in itself, in the second group it is the two toes corresponding to the second and third of the human limb which are larger than the others, while they are also symmetrical to a line drawn between them. There is likewise a well-marked difference between the huckle-bones of the two groups. The fourth group, represented only by the various species of hyrax—the coney of Scripture—need not detain us here.

Turning to the proper subject of our article, we commence our notice with one of the largest of the Argentine mammals, which derives its name of *Toxodon* from the peculiarly curved or bow-like form of its long molar teeth. As shown by the accompanying figure of a skeleton preserved in the La Plata Museum, this gigantic animal, which rivalled the large Indian rhinoceros in size, is remarkable for the peculiar lowness of the fore-quarters, in consequence of which the enormous head is carried much below the line of the back. Since the creature has much the general appearance of a rhinoceros, as shown by its relatively short and stout neck and limbs, while the number of toes to each limb is three, of which the middle one is symmetrical in itself, an observer might, at first sight, be disposed to place the toxodon among the odd-toed ungulates. A closer examination would, however, show that while the middle toe is not markedly larger than either of the others, the bones of the wrist are arranged on the linear plan, while in the ankle the upper surface of the huckle-bone is nearly flat, or intermediate between that of the elephants and the odd-toed ungulates. Omitting mention of certain other minor peculiarities in the structure of the limbs, if we now turn our attention to the teeth, we shall find that these also present features unknown in any living ungulates. We find, for instance, in the first place, that the upper jaw is furnished with two pairs of permanently-growing chisel-like teeth, comparable to the single pair of incisors in the rodents or gnawing mammals; these being opposed by three pairs of nearly similar, although horizontally placed, lower teeth. Such permanently growing incisor teeth are, however, paralleled among existing ungulates in the hyrax; but the toxodon stands alone in the order from the circumstance that the molar teeth likewise grow throughout life, instead of forming roots. Here, then, we have another point of resemblance in the toxodon to the rodent order. When we examine the form of the grinding surface of these molar teeth, there does not appear any marked resemblance to those of any existing ungulates. The link is, however, furnished by certain allied forms from the older Tertiary beds of Patagonia, known by the name of *Nesodon*, of which the first fragmentary remains were brought to Europe by Darwin, in the "Beagle"; the toxodon being confined to the Pampean deposits and the underlying beds

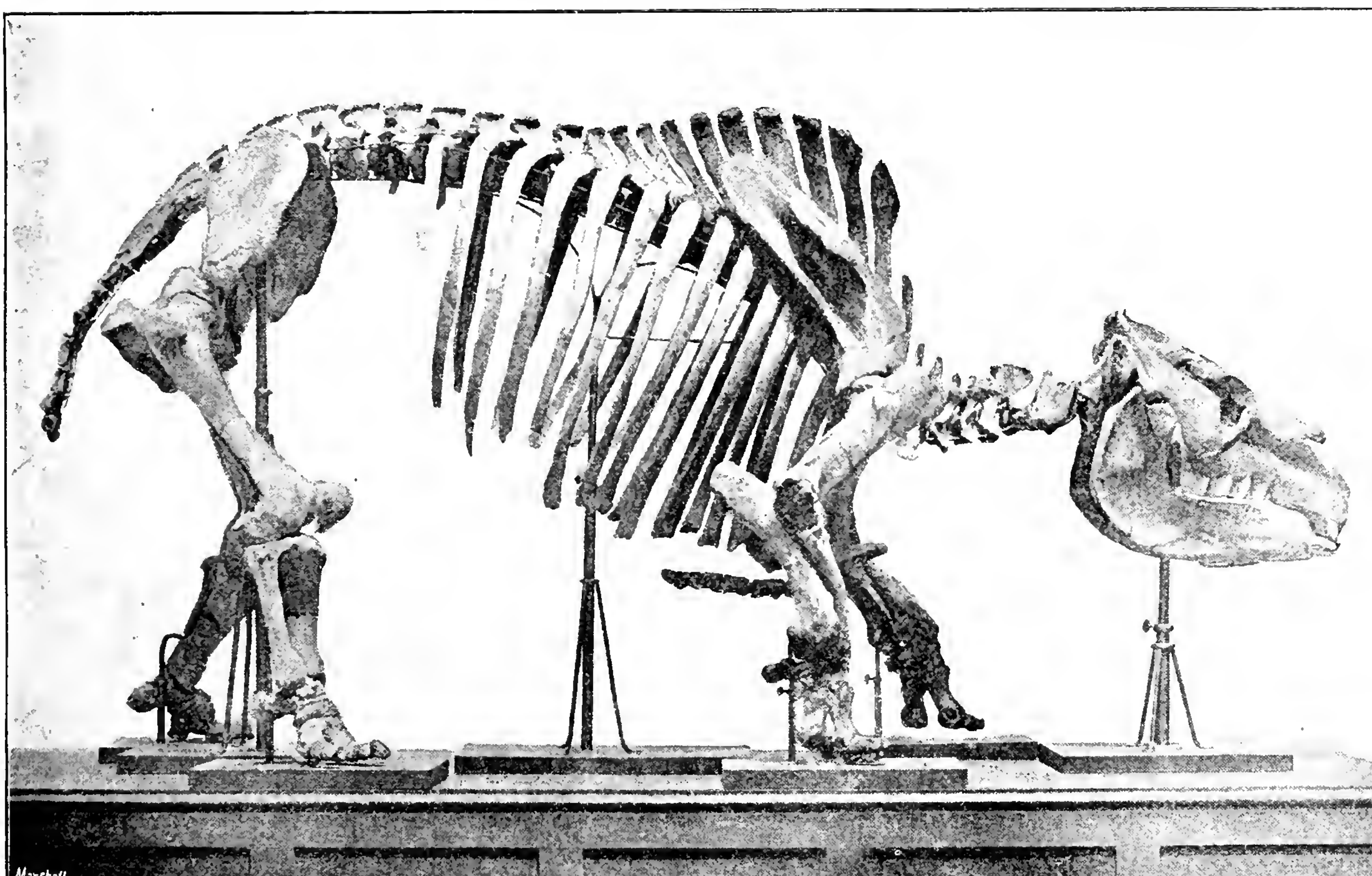


Fig. 1.—Skeleton of the Toxodon. About one-twelfth natural size.

* This feature is, perhaps, somewhat exaggerated in the restoration

of Monte Hermoso. Now, in the nesodons, the structure of the molar teeth clearly approximates to that characterizing the odd-toed ungulates, although belonging to what naturalists term a more specialized type. It is further noteworthy that in these nesodons, although the molar teeth grow for a considerable portion of life, yet they eventually form roots in the ordinary manner; the same being true of the incisors, with the exception of a single pair, which grow permanently. We see, therefore, that the permanently growing teeth of the toxodon are a specialized feature, which do not justify the reference of the creature to a separate subordinal group, while the older genus shows that these animals are clearly allied to the odd-toed ungulates, although sharply distinguished by the structure of their feet. Their feet being of a less specialized type than those of the latter (as is especially shown by the almost flat huckle-bone), while their teeth are more specialized, it is further evident that neither group can be ancestral to the other. Hence, the toxodon and its allies must be regarded as forming a separate subordinal group of equal value with the other sub-divisions of the great ungulate order. Where these remarkable creatures branched off from the primitive ancestral types of the latter, and how they first obtained an entrance into South America, where they gradually increased in size and specialization till the period of the Pampean, when they finally disappeared, is still an unsolved problem.

The interest of the toxodons does not, however, by any means end here. We have seen that the toxodon itself shows certain resemblances to rodents in the structure of its teeth; while it will be perfectly evident that such resemblances indicate no genetic affinity between the two groups, seeing it is certain that rodents are neither the ancestors nor the descendants of the toxodons. In a much smaller animal known as the typotherium, of which the skull is shown in the accompanying figure (2), these

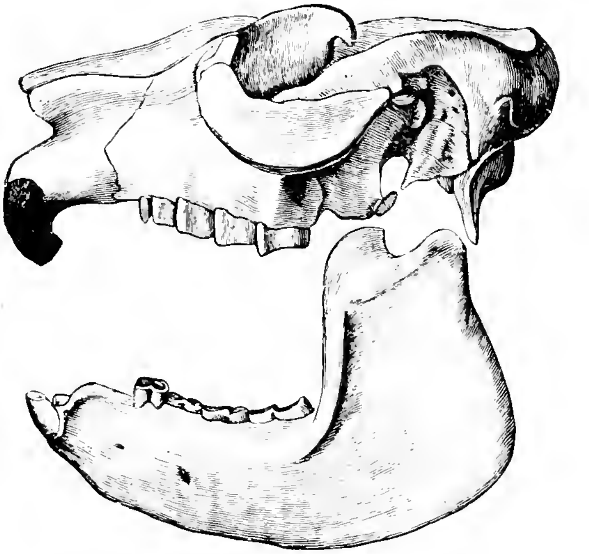


Fig. 2.—Skull of the Typothere. Half natural size.

rodent resemblances are, however, still more pronounced, as is especially shown by the incisor teeth, which are essentially those of a rodent. Moreover, in the hind feet the toes had lost the hoofs characterizing the more typical ungulates, and were probably protected by small nails. A still further step is exhibited by a much smaller Argentine mammal, of the approximate size of a hare, and rejoicing in the euphonious name of *Pachyrucus*. If it were not for the intermediate links, this creature would almost certainly be put down as a rodent, with which group it agrees in the structure of its teeth and toes, as well as in many other parts of the skeleton. Nevertheless, it is clearly a near ally of the typotherium, and therefore a member of the toxodon group. Here, then, we have one of the most remarkable known instances of the phenomenon of parallelism—a feature to which especial attention has been directed in previous articles. We have, in fact, displayed before us the origin of what we may call a rodent-ungulate; that is to say, an animal which, while certainly an ungulate by descent, has acquired such a marked resemblance to a rodent that, if we had not the intermediate links, it would certainly be regarded as a member of the same order. This wonderful instance gives us some insight into the intricacies of evolution, and serves to show the amount of value to be attached to the majority of phylogenies of the animal kingdom.

In addition to the slightly grooved huckle-bone, the toxodon group is characterized by at least one of the upper incisor teeth growing throughout life, and by the molar teeth being either rootless or not forming roots till a very late period. There is, however, a second group of allied extinct ungulates peculiar to the Argentine, in which all the molars are rooted at the usual period, while the huckle-bone is as flat as in the elephants, although of somewhat different form. This group is represented solely by two genera, both of which are confined to the Patagonian deposits, where they are represented by animals rivalling rhinoceroses in size, and furnished with molar teeth somewhat resembling those of the latter. One of these creatures, on which the somewhat cumbersome name of *Homalodontotherium* has been conferred, presents the rare peculiarity of having the teeth arranged in a regular even series without gap or interval, and with their crowns of equal height. Very different in dental characters were the members of the allied genius, *Astrapotherium*, in which each jaw was furnished with a huge pair of tusks, those of the lower jaw curving outwards and upwards after the manner of those of a wild boar, while both were kept sharp and keen by their points wearing against one another. In the presence of these enormous upper tusks, the astrapotheres resembled the extinct uintatheres of North America, alluded to in our article on "Tusks"; but they differed in the possession of tusks in the lower jaw, while it is probable that those of the upper jaw were incisors instead of canines. The most curious feature connected with these animals is, however, the close resemblance of their upper molar teeth to those of rhinoceroses; the similarity being so marked that if we were acquainted with the South American animal only by these teeth, it would probably be classed with the rhinoceroses. From the structure of the bones of the ankle it is, however, quite certain that these two groups of ungulates have no direct connection with one another, and that their common ancestor must have had molars of a much simpler type of structure. It follows, therefore, that the form of molar teeth characterizing both the astrapotheres and the rhinoceroses must have been evolved independently in the two groups; and that we have consequently here another very interesting case of parallelism. Although this type of tooth (which it must be remembered is one of considerable complexity) is admirably adapted for crushing vegetable substances, it is by no means the only one which could have been evolved from what we may probably regard as the primitive type; and it is, therefore, hard indeed to see how it can have been produced by evolution unaccompanied by design.

Strange and unique as are the foregoing creatures, they are exceeded in the former respect by the long-necked and long-limbed animal rejoicing in the name of *Macrauchenia*, so termed on account of the elongation of the vertebræ of the neck, which were first brought back by Darwin from the superficial deposits of Patagonia. In its general form the macrauchenia, of which a complete skeleton from the Pampean formation preserved in the museum at Buenos Ayres is represented in the accompanying figure (3), the nostrils is carried to a still greater degree. That a land mammal with its nostrils situated in this unusual position could not have managed to exist without a trunk is pretty evident, and we may therefore conclude that the macrauchenia was so furnished; while from its long slender neck and limbs we may further infer that it was

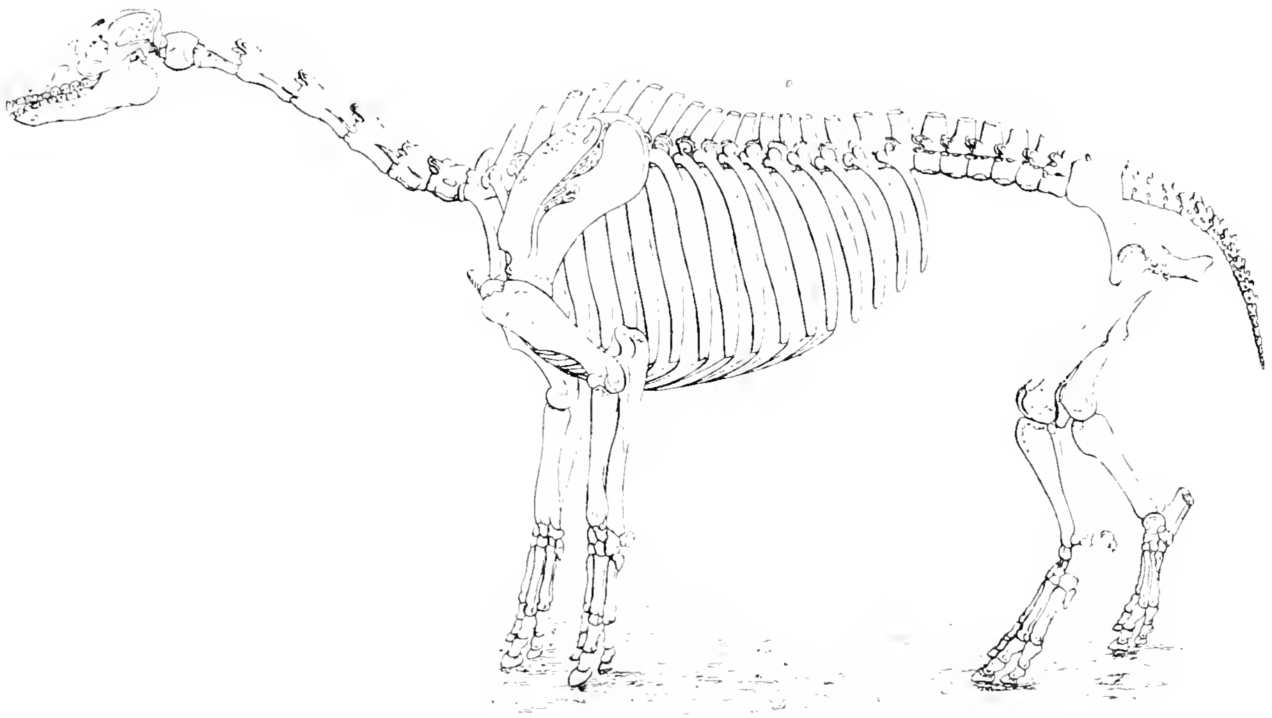


Fig. 3.—Skeleton of the Macrauchenia. About one-fifteenth natural size. (After Bravard.)

somewhat recalls a camel; and it is a curious circumstance that in common with that animal and its allies it differs from all other ungulates, with the exception of certain kindred Argentine forms, in that the vertebral artery of the neck pierces the sides of the vertebræ to take a course within the spinal canal, instead of passing merely through a loop of bone on the exterior. This remarkable resemblance is not, however, indicative of any affinity between the two animals, since if we look at the feet of the macrauchenia we shall find that they are of the odd-toed type, and are each furnished with three digits. Moreover, the huckle-bone has the pulley-like upper surface characterizing the odd-toed ungulates; while as the teeth approximate to those of the latter, we might be inclined to place the creature in that group. The wrist and ankle joints are, however, formed on the linear plan, and exhibit certain other departures from the odd-toed type, and it is therefore evident that the macrauchenia and its allies constitute a third subordinal group of extinct ungulates peculiar to South America. Although it is by its foot-structure that the macrauchenia is thus separated from all other members of the order, its most remarkable peculiarity is to be found in the structure of its skull. In an ordinary well-regulated mammal the aperture of the nose is situated quite at the anterior extremity of the skull. In the macrauchenia, however, the said aperture is an egg-shaped vacuity in the forehead, placed almost between the eyes. Some approximation to this remarkable arrangement is presented by the living tapirs, but it is more nearly paralleled by the elephants, and still more closely by the aquatic dugong, while among whales the backwardation (if we may coin a word) of

an inhabitant of open plains or thin forest, and was not a frequenter of marshes and swamps. It may be added that in its uninterrupted and even series of teeth the macrauchenia differs from all existing mammals save man, and agrees with its distant cousin the homalodontothere.

From its large size, the peculiar position of its nostrils, and the characters of its molar teeth, the zoologist is at once led to infer that the macrauchenia is a highly specialized creature: and it is of the greatest interest to find that this inference is converted into a certainty by the discovery of certain kindred forms in the older formations of the Parana and Patagonia, which are evidently the ancestral types from which the Pampean genus has originated. All these creatures were of relatively small size, with their molar teeth more closely resembling those of the odd-toed ungulates, and they show a gradual transition in regard to the position of the nostrils from the type of the macrauchenia to the ordinary form. The evolution of such an extraordinary creature as the one under consideration is, therefore, fully explained, although we have yet to learn the special reason for the peculiar position of its nostrils and the development of a trunk.

More or less intimately allied to the ancestors of the macrauchenia were certain contemporaneous ungulates from Patagonia, of which the largest did not exceed a tapir in size. With molar teeth so like those of the odd-toed ungulates from the Paris basin, described by Cuvier as *Palæotherium*, these Patagonian ungulates differed from the macrauchenia in having the dental series reduced in number and interrupted by gaps. Their most remarkable peculiarity is, however, to be found in the structure of their feet, which, in some forms at least, resembled those of the extinct three-toed horses known as the hipparions; the middle toe being very large, while the two lateral ones were small and functionless. There is, moreover, some reason to believe that in one genus the toes were reduced to a single large one on each foot, as in the modern horse. Be this as it may, the fact that there existed in South America a group of ungulates which exactly paralleled the horses in the evolution and structure of their feet is one of the most wonderful features in mammalian development that has ever come under our notice, and serves to render these prototheres (as the group is called) worthy of the best attention of the student of parallelism. It may be added that the high specialization of these animals is of itself sufficient to dispose of the idea that the strata in which their remains are entombed are equivalent in age to the lower Eocene of Europe.

This completes our survey of the groups of extinct ungulates peculiar to South America, which, brief as it is, serves to show how interesting they are alike to the pure anatomist and to the evolutionist, and also indicates their importance from a distributional point of view. With regard to the latter, it may be observed that since all these animals are clearly more or less intimately related to the ancestors of the odd-toed ungulates of the Old World and North America, while the edentates of South America have no near relatives elsewhere, and the extinct marsupials of the same area appear akin to those now living in Australia, it would seem that at some remote epoch there must have been a brief connection between North and South America, during which one or more primitive ungulates obtained entrance into the latter area, where they subsequently multiplied and developed into the numerous forms above noticed. If this be true, it will be evident that South American ungulates were originally immigrants from the north; those which are absolutely peculiar to the country having originated from an incursion which took place early in the Tertiary period, while the later types nearly akin to those of North America and the Old World did not arrive till the late Pliocene epoch, when a second connection must have been established between the two continents.

WEIGHING THE EARTH.

By J. J. Stewart, B.A., B.Sc.

Since Newton's splendid verification of the theory of universal gravitation, several attempts have been made to determine the mass of our planet, and hence the mean density of the materials composing it. Amongst the earliest of these which approached accuracy was the experiment by Henry Cavendish, the eminent philosopher, who anticipated last century some of Faraday's remarkable electrical discoveries. The method he employed was suggested by the Rev. John Michell, and is generally known as the Cavendish experiment. Michell constructed an apparatus suitable for the operation, but does not seem himself to have made any experiments: and alterations and improvements were made in the apparatus by Cavendish. The main principle of the method is that of comparing the attraction exerted by a leaden sphere on a small ball with the attraction exerted by the earth on the same ball—that is, with the weight of the latter. In the apparatus of Michell and Cavendish the attraction between two spheres of moderate size is balanced by the elasticity of a wire; the amount of torsion in the wire required to resist the attraction of the spheres being found, this gives the force of attraction which is equal to it. This force is then compared with the attraction of the earth on one of the spheres—that is, with the weight of the sphere; and hence, as the diameter and therefore the volume of the earth is known, its mass is deduced.

Michell's original apparatus consisted of a wooden arm six feet long, made so as to unite great strength with little weight. This arm being suspended in a horizontal position by a fine wire, from each end of it was hung a leaden ball about two inches in diameter, and the whole was enclosed in a wooden case to protect it from draughts of air. The force required to turn the arm is no more than that necessary to twist the suspending fibre, and as this was very slender, even a very small force, such as that produced by the attraction of a leaden weight a few inches in diameter, is sufficient to produce a sensible displacement of the arm. As the force with which the balls are attracted is excessively minute, not more than one fifty-millionth of their weight, a very small disturbing force is sufficient to destroy the success of the experiment. Cavendish found that the disturbing force most difficult to guard against was that arising from variations of temperature. Suppose that one side of the containing case is warmer than the other, this will cause the air next it to be rarefied, and it will consequently rise, while the air on the cooler side will descend, and thus currents will be produced which interfere with the deflections of the instrument to be observed.

In the apparatus as modified by Cavendish the balls were suspended by wires from a light arm made of deal and strengthened by a silver wire, so as to have the form of an open girder; thus lightness and strength were combined. The apparatus was placed in a room kept constantly closed, and the motion of the arm was observed from the outside by means of a telescope: thus errors, which might arise from the approach of the observer causing changes in the temperature, were avoided. The leaden weights, which were spheres a few inches in diameter, could be moved from the outside by means of a cord passing over a pulley. The weights were placed close to the balls, so that they tended to twist the suspending fibre round in the same direction and cause a movement of the arm. They were then turned round and placed on the opposite sides of the respective balls, so that they tended to move the arm round in the opposite direction. Between these observations of the deflections produced, the line joining the weights was set at right angles to the arm, so that they exerted no attraction on the balls, or rather, equal and opposite attractions which neutralized each other. The position of the arm could be read off on ivory scales graduated to one-twentieth of an inch, and read by a vernier to one-hundredth of an inch, and estimated to less. The scales were lit up by lamps placed outside the chamber, and their light was thrown by a lens on to the scales, the chamber being otherwise dark.

When the arm was drawn aside it vibrated backwards and forwards, the vibrations lasting a long time; thus the position that would be occupied by the arm if it were at rest had to be calculated. This was done by observing three consecutive extreme positions of the arm, the first and third being towards the same side and the second one in the opposite direction. The intermediate observation was compared with the mean of the first and third; this gave the position the deflected arm would have occupied if it had come to rest, damping of the vibrations being allowed for.

Next, the time of vibration was measured; from this could be deduced the force acting on the suspended balls. Possible error due to magnetic effects was looked for, but the observations were free from this. The effect of the leaden spheres on the arm was found to increase or diminish with standing, and this was found to be due to a difference of temperature between the weights and the case. In the first experiments made, the wire by which the arm was suspended was thirty-nine and a quarter inches long; its material was copper coated with silver. Its stiffness was such as to make the arm perform a vibration in about fifteen minutes. In the first observations the rods by which the leaden weights were suspended were of iron, but care was taken that there was nothing possessing magnetic properties in the arm. In later experiments the iron rods were replaced by copper, but no change in the observations was caused. Another series of observations was also made, using a stiffer wire. The force required to draw the arm aside, in opposition to the force of restitution in the twisted fibre, was found by observing the time of a vibration and calculating from this.

The following may serve as an example of the observations made :—

Motion of the arm on moving weights from positive position to middle position .. ... = 15·22
Motion of the arm on moving weights from middle position to positive position... ... = 14·5
Time of one vibration when in middle position... = 14m. 39s.
" " " " positive position... = 14m. 54s.

The positive and negative positions were those in which the leaden sphere tended to cause a twist in one direction and in the other respectively. The middle position was that in which the spheres were on the line bisecting the middle of the arm.

The density of the earth was deduced from the observations by comparing the force of attraction of the leaden weights on the balls suspended from the arm with the force of attraction of the earth on the same balls—that is, with their weight. The question is: What must the mass of the earth be when it attracts a ball on its surface—that is, four thousand miles from its centre—with a force greater in a known ratio than that with which the same ball is attracted by a sphere of lead of known mass, placed at a measured distance? Knowing the law of gravitation, that masses attract each other with a force varying as the product of their masses, and inversely as the square of the distance apart of their centres of gravity, we at once find what the mass of the earth must be, and this divided by the volume of the earth gives its mean density.

The corrections which Cavendish had to apply to his observations were:—

1. For the effect which the resistance of the arm to motion had on the time of vibration.
2. For attraction of the weights on the arm itself.
3. For their attraction on the farther ball.
4. For the attraction of the copper rods on the balls and arm.
5. For the attraction of the case on the balls and arm.
6. For the alteration of the attraction of the weights on the balls according to the position of the arm, and the effect which this had on the time of vibration.

The last correction was of the most importance; the others did not affect the result much.

Cavendish says:—"By a mean of the experiments made with the wire first used, the density of the earth comes out 5·48 times greater than that of water; by a mean of those made with the latter wire it comes out the same. The extreme results did not differ from the mean by more than one-fourteenth of the whole, and therefore the density should seem to be determined hereby to great exactness."

The value thus found differs but little from the latest determinations made by similar methods. Prof. Poynting's result (which I will refer to later) obtained quite recently, after great precautions were taken to secure accuracy, is 5·493. It is noteworthy that the guess made by Newton in the century preceding Cavendish's experiment, for the density of the earth, namely, five to six times the density of water, is remarkably near that which seems to be the value as determined by the best method.

The operation of weighing is so familiar to all that many are apt to forget what is actually done when anything is weighed. The method of weighing is adopted as a ready and easy means of finding the mass of a body—that is, the quantity of matter in it. This is done by comparing the attraction of the earth on the body in question with its attraction on another piece of matter whose mass is known. When the masses in the two scale pans of a balance are equal the mass of the earth attracts them equally, and the beam of the balance stands horizontally: the balance is in equilibrium, and the substances in the two pans are said to be of equal weight. But the attraction of the earth on a mass near its surface depends on the distance of that mass from the centre of the earth, so that a pound has less weight at the top of a mountain than in the valley below. The weights of bodies vary according to their position on the earth's surface, and the same mass has a greater weight at the poles than at the equator, because in the former place it is nearer to the centre of the earth, and the earth's attraction for bodies outside it is the same as if the whole mass of the earth were concentrated at its centre.

Again, at the equator the motion of the earth about its axis tends to cause a body to fly away from the axis and to decrease the weight of the body. Thus the weight of a body, far from being a constant quantity, varies as the body is moved from place to place. Nevertheless, the method of weighing is an accurate way of determining the amount of matter in a given body, because by this operation we simply compare two attractions, and the forces of attraction on the body and on the standard weights with which it is compared vary equally as the balance is moved from one position to another; thus, although a body is lighter at the equator, so also is the standard pound against which we compare it.

The comparison of weights is simple and familiar enough, but can we weigh the earth itself or find its mass? What can we compare it with? Here, again, what is to be done is to compare two attractions. If we can find the attraction of some mass—a part of the earth—on another mass, and then compare this attraction with that of the earth on the same mass—that is, with its weight—the problem is solved.

Several methods have been suggested for doing this. Perhaps the earliest attempt was that made by some French geographers, who observed by what amount the plumb line was deflected from the vertical owing to the attraction of a neighbouring mountain. This experiment was performed near Quito, in the Andes, but the observations were but rough and inaccurate; the deflection seemed to be quite noticeable, but the observations were taken in a tent, and it would be impossible under such conditions to guard properly against currents of air, which would disturb the instrument.

Later, the suggestion that this method of the plumb line should be used to find the earth's density, by taking observations near some suitably shaped mountain in the British Isles, was made to the Royal Society by Maskelyne, the Astronomer-Royal of that time. Schehallien, a mountain in the Scottish Highlands, was finally fixed upon, and the operation carried out there, the results being published in 1775. By trigonometrical measurements the distance between two points, one north and the other south of the mountain, was found, and from this the difference of their geographical latitudes was got. The true latitude of each point chosen was also determined by astronomical observations. The difference between the true and geographical latitude of the two stations depends on the amount by which the mountain deflects by its attraction the plumb line which was used to determine the vertical. This deflection was in an opposite direction at the two stations, in one case towards the north and in the other towards the south. The point south of the mountain had its latitude made less than the geographical latitude, because it was in the northern hemisphere; the point on the north side had its latitude made greater. Thus, if the mountain had been symmetrical in shape (and it was chosen because it approached to symmetry) the difference of the astronomically found latitudes would have been greater than the difference of their geographical latitudes by double the deviation produced on the plumb line by the mountain's attraction.

By laborious measurements the form of the mountain was next observed. As nearly as possible, its geological composition and the specific gravity of its material were determined, and then the attraction of this quantity of matter of approximately known distribution and density was compared with the attraction of the earth, which exceeds the former in a known ratio. Maskelyne's result for the density of the earth was 4·48—four and a half times denser than water; but it is pretty certain from later and better measurements that this value is considerably too low. The great defect of this method is the uncertainty which must occur as to the internal composition and structure of the mountain itself and the surrounding country. Cavities might be present in the hill, or places where the matter was much lighter or much heavier than the specimens taken from the surface; and all such unknown sources of error militate against an accurate determination. The same method has been employed by James, at the hill called Arthur's Seat, near Edinburgh.

Another and different method of finding the earth's mean density is that used by Airy. This consists in comparing the time of vibration of a pendulum at the top and at the bottom of a deep mine. The time of swing of a pendulum depends on the attraction of the earth upon it. At the bottom of a mine the outside layers of the earth consisting of the mass contained in the outer skin, whose thickness is the depth of the mine, cease to exert an attraction on masses within—the attractions of separate portions of this outer shell at opposite sides of the earth mutually destroy each other. The attraction, then, on a pendulum at a depth within the earth's surface consists of that produced by the inner core, and at the bottom of the mine we have come nearer to the core, but its volume and mass is decreased as the cube of the radius, so that its attraction is less than at the surface. On the other hand, the attraction above ground consists of that due to the core as well as that exerted by the shell. The observed times of vibration of the pendulums give a means of determining the amount of these two attractions—that of the core and shell respectively.

The volume of the outer shell is known, for it follows at once from the known depth of the pit, and it has to be assumed that the mass and density of the shell can be determined from observations on the geological strata passed through during the descent. Here comes in the weak point of this method; the true mass of the outer skin must remain uncertain.

Airy first attempted to apply this method at a mine in Cornwall, but met with various mishaps through accidents to his apparatus, and it was not till after more than twenty years from these first experiments that he, with the help of numerous assistants, carried to a successful conclusion his experiments, at the Harton coal pit, in the north of England. Pendulums were made to vibrate at the upper and lower stations. These were connected and compared electrically, and thus the intensity of gravity at the top and bottom of the mine was determined, and hence the earth's density.

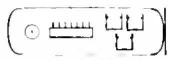
The result of this experiment comes out considerably higher than that by other methods, viz., 6·56 for the density of the globe, and we cannot have the same confidence in this determination as in that of the results of the Cavendish experiment, which do not differ much amongst themselves. All that Airy claimed for his method was that it was worthy of comparison with the previous observations, and deserved to stand on an equal footing with them.

(To be continued.)

THE COFFIN OF THE BUILDER OF THE THIRD PYRAMID.

By J. H. Mitchiner, F.R.A.S.

In the December number of Knowledge an interesting article appeared under the above title, in which Mr. Read calls the attention of English readers to an article written by Herr Kurt Sethe, published as far back as 1892 in the *Zeitschrift für Ägyptische Sprache* of Leipzig. Herr Sethe contends, on presumed philological grounds, that the coffin lid of Men-Kau-Rā, of the fourth dynasty, B.C. 3633, is not the original lid, but a later

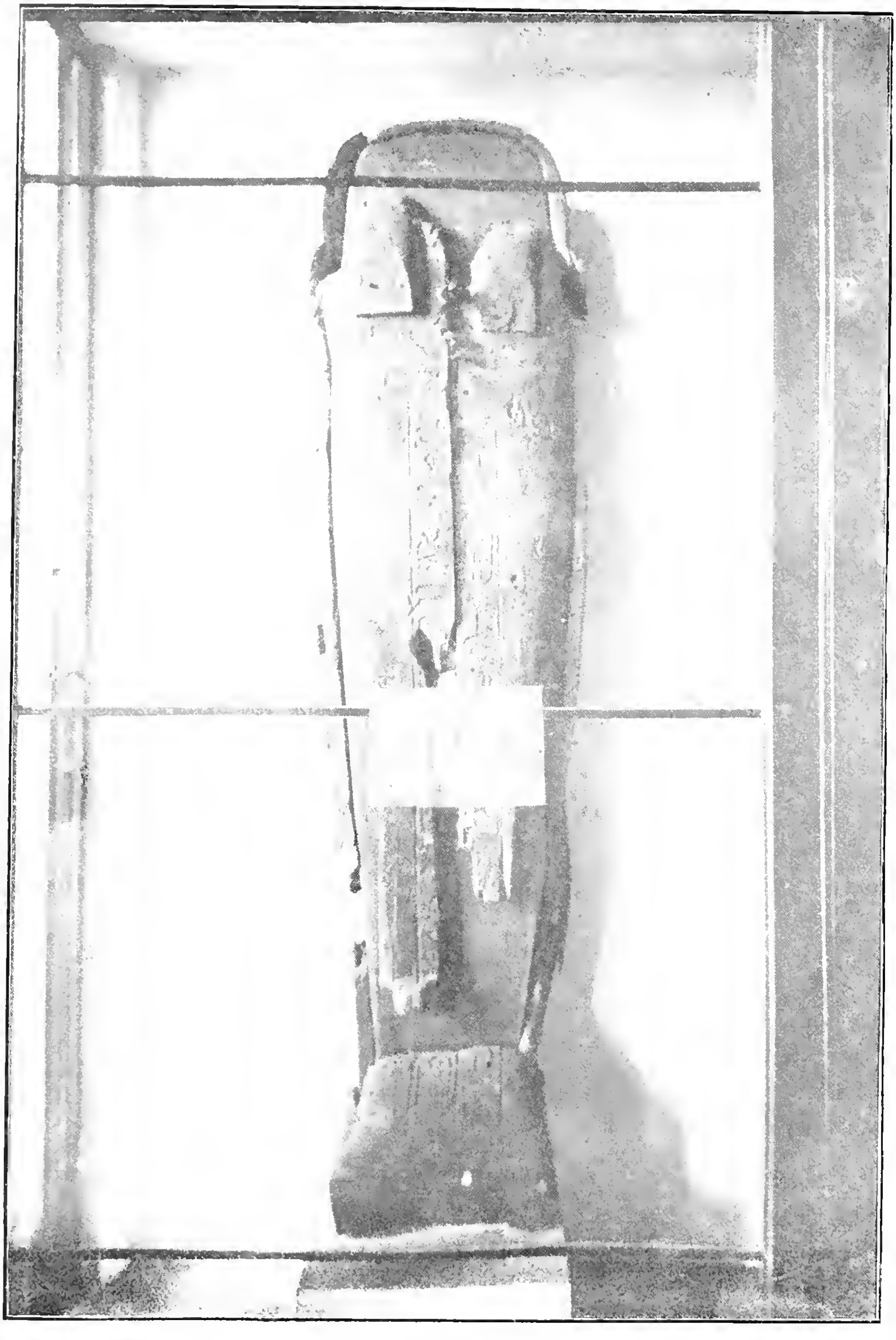


coffin lid substituted for the original, and that it probably dates from about the time of Tirhakah, B.C. 700. No arguments are offered in support of this extraordinary conclusion, beyond a general statement that the writing on the lid is ideographic in character. Moreover, it is asserted that the early texts are very deficient in these ideographic signs, and that the name of Osiris written with the ideographic prefix, as on the lid of this coffin, cannot be found so written till the middle of the fifth dynasty.

Philological study of all ancient languages reveals that among primitive peoples, however much divided by racial or climatic conditions, the representation of ideas invariably follows one common course of development. First, objects are depicted, then sounds are depicted, and ultimately an alphabetical system is evolved. Applying this law to the hieroglyphical writing of the Egyptians, in order to gauge the value of the argument of Herr Sethe, we are met by an initial difficulty. At what date in the distant past are we to ascribe to the Egyptians a system of pure picture-writing? of writing such as the primitive symbols of the Mexicans?

Our knowledge of Egyptian history commences with

Mena, B.C. 4400. Only very recently has it been discovered how it is that Egyptian tradition observes a complete silence as to history prior to this date. Mena was the Thinite Pharaoh who succeeded in restoring a native dynasty after the conquest of Egypt by the old Babylonian empire; and, it may be, the infinite pains taken by the Egyptians at a later date to destroy all evidence of the long and hated Hyksos interregnum was but a traditional repetition of similar efforts on the restoration under Mena, after the Babylonian conquest. We have no means of knowing the duration of that conquest, nor the names and number



THE COFFIN OF THE BUILDER OF THE THIRD PYRAMID,
now in the British Museum.

From a Photograph by Mr. A. Fisher, of Southsea.

of the native kings who reigned in Egypt anterior to it. We are compelled to commence with Mena. Yet at the period of this monarch, B.C. 4400 years, we find the Egyptians in possession of a perfectly developed system of writing, made up of alphabetical and phonetic characters, with a number of their ancient ideographs retained as determinatives. The Assyrian, Median, and Babylonian cuneiform writings also display slow development from old forms of picture-writing, obtained by very tardy degrees, extending over many centuries, and like the Egyptians, retaining as determinatives many of their ancient ideographs. China, after the lapse of three thousand years, has not yet emerged from its system of ideographs.

In the absence of records of Egyptian civilization pointing to a picture-writing age, we cannot find the base on which Herr Sethe erects his theory. Egyptian history, unlike the history of Greece, furnishes no archaic period of art and literature. Go back as far as we may, we fail to reach the cradle of its civilization. Its art supplies no *Branchidæ* statues, such as Greece furnishes, telling of the rude artistic efforts of the race prior to Myron and Phidias. A retrospect of five thousand years does not help us. The statues of Sepa and Nesa* betray an art with aims and instincts well developed; and they date from B.C. 3900! The close of the third dynasty produced the masterpieces of ancient art. Those two famous statues of Ra-hotep and his wife Nefert (the beauty), exhibited under glass in the museum at Boulak, are, with good reason, attributed by M. Marriette to the reign of (cartouche) Seneferu, B.C. 3766! The extreme beauty of the sculptures surpasses all subsequent work, and their interest is increased by the certainty of their great age. As in art, so is it in literature.

"We can hardly hesitate to assume," says Bunsen,† "whatever preconceived ideas it may disturb—that this genuine Egyptian writing, combining phonetic with figurative signs, is, in its essential elements, *at least* as old as the time of Menes."

Translation of the left hand column.

Nut
She grants
that thou
shalt be
a god;
never more
shalt
thou have
enemies,
King of the
North and South,
O Menkaura,
living for ever.

Translation of the right hand column.

Osiris,
King of the North and South,
Menkaura,
living for ever;
born of Heaven,
conceived by
Nut;
thou comest
of the race
of the
god
Seb.
Thy mother

Lid of Coffin of Menkaura, B.C. 3633.

We cannot reach, therefore, by history, tradition, or monumental remains, to the distant archaic age of Egyptian pure picture-writing. Of the four thousand years during which we are able to study the Egyptian records, we find that literature, like art, was constantly fluctuating; its eras of decadence being followed by intervals of revival. At some periods the scribes attempted to discard the use of ideographs, yet there appears to have been a constant, almost persistent, tendency to revert to the principles of the old system. We must remember, also, the latitude allowed the scribes, who followed no normal rule in writing, but often substituted one phonetic hieroglyph for another in cases where they had the same sound. Moreover, they omitted or inserted ideographs at times, in an apparently arbitrary manner, and for the sake of harmony of appearance substituted vertical for horizontal forms, as (hieroglyphs) s ñ "they," or (hieroglyphs), as it suited the stone to be inscribed.‡

Having regard to these facts, the attempt to erect an important hypothesis on the bare retention or omission of ideographs in a solitary inscription, or even from a host of inscriptions of any particular period of Egyptian history, seems to be rash to the last degree. There is abundant evidence to show that in the retention or omission of ideographs, throughout an extensive country and during a number of centuries, the writing constantly underwent changes and modifications. Whenever the object itself was the ideograph, they almost invariably at one period omitted the ideograph altogether, as in (hieroglyphs) *kaf*, over an ape, and in (hieroglyphs) *au*, over a cow. Moreover, hieroglyphical writing, especially in the case of temple inscriptions, unquestionably contained an *esoteric* as well as an exoteric meaning. By the use of ideographs the meaning packed as closely as the Latin. Hence it was retained for those inscriptions to a very late date. Plutarch mentions the inscription over the temple of Sais, comprising an old man, a youth, a hawk, a fish, and a hippopotamus, —(hieroglyphs), meaning "O all, whether

* "History of Art in Ancient Egypt." Perrot and Chipiez.

† "Egypt's Place in Universal History," vol. I., page 8.

‡ Wilkinson's "Egypt."

old or young, know that the gods hate impudence." This inscription is ideographic throughout.*

That the ideographic picture-writing method preceded the phonetic and alphabetical is abundantly clear, and, in the absence of all knowledge of the archaic period of Egyptian writing, any hypothesis built simply upon the presence or absence of an ideograph in a well-developed system of writing, and made the basis for fixing a definite date, and this without a shadow of other supporting evidence, is scarcely adapted to receive serious notice at the hands of our best Egyptologists.

It is doubtful if the entire number of inscriptions existing in the museums of the world, of periods anterior to the fourth dynasty, are sufficient to supply a satisfactory conclusion on the use or omission of determinatives in early writing. Bunsen writes†—"We may confidently state that the principle of determinatives was in full activity at the *commencement* of the chronological epoch." According to Herr Sethe, they do not occur in general use until the twenty-sixth dynasty, and, because the word "Osiris" on the coffin-lid of Menkaura is written with the determinative, he, on this ground, assumes the manufacture of another coffin two thousand years afterwards.

The hieroglyphic writing subsequent to the fourth dynasty, and dating from that period to the twenty-sixth dynasty, when submitted to a perfunctory examination, might lend an appearance of force to the contention. But the conclusion vanishes on attentive comparison. In the majority of pyramid texts, published by M. Maspero,‡ the peccant determinative in the name of Osiris is more frequently absent than otherwise, but closer study of other monumental inscriptions forbids any inference to be drawn, such as enunciated by Herr Sethe. In the long era extending from the fourth to the twenty-sixth dynasties, the word "Osiris" is found written both with and without the determinative. Appended are a few examples:—

Twelfth dynasty.—Liverpool Museum. Inscription on sepulchral monument. Osiris written *without* determinative.

Twelfth dynasty.—Inscription on tomb of the reign of Amenhat III. Osiris written *with* the determinative.

Thirteenth dynasty.—Inscription on leaf-shaped dish of green basalt. Osiris written *without* the determinative.

Thirteenth dynasty.—Fragment of dark wood, carved with the inscription "Royal oblation to Osiris, dwelling in Amenti." Osiris written *with* determinative.

Eighteenth dynasty.—Inscription on stela in museum of Marseilles. Osiris written *with* determinative.

Nineteenth dynasty.—Monumental inscription to Piaai. Osiris written *without* determinative.

Nineteenth dynasty.—Monumental inscription to Painchsi, scribe of the treasury under Rameses II. Osiris written *with* determinative.

Nineteenth dynasty.—Monumental inscription to Pamerau, a royal scribe. Osiris written *with* determinative.

Twentieth dynasty.—Inscription on stela in museum of Marseilles. Osiris written *with* determinative.

These examples should prove fatal to any theory of a definite law observed in writing by the scribes.

The Aztec picture-writers, who came down to the ships of Cortez, could depict all they *saw*, but could not represent the sounds which they *heard*. At the time of Mena, B.C. 4400, the Egyptians could do both, and their writing *then* marked a distant transition period, combining the systems alphabetical and phonetic, with ideographs as determinatives, and these latter, with variants, were retained ever after. We may, I think, relegate the hypothesis of Herr Sethe to the same category as the non-historical existence of Solomon, who, on philological grounds, received his *quietus* at the hands of some critics, because Sol-om-on is found to comprise the name of the sun in three languages, forgetting that any name associated with the great solar myth, so dear to many ancient peoples, would naturally be treasured and handed down to posterity centuries after its original meaning had been lost, and its application passed into other forms.

In conclusion, it should be shown that it was the practice of the Egyptians to substitute new coffins at periods as required. Moreover, should they in any solitary instance be proved to have done so, it is inconceivable, with their intense veneration for the past, that the slightest alteration, even in form, should have been permitted in the reproduction.

On a glass shelf, immediately over the coffin of Amamu, are the remains of the mummy found by Colonel Vyse in the third pyramid, lying by the coffin-lid of Menkaura. That the fragments are portions of the body of Menkaura there can be little doubt. The integrity of these remains is in no way called in question by the contention of Herr Sethe. The leg bone of the mummy reveals a badly anchylosed knee, and, as tradition asserts that Menkaura was a lame man, this, in itself, is indirect evidence in their favour, apart from the fact of their discovery in the heart of the pyramid erected by that Pharaoh.

* Wilkinson's "Egypt."

† "Egypt's Place in Universal History," vol. I.

‡ "Recueil de Travaux," par M. Maspero.

ON THE PROBABLE ENCOUNTER OF BROOKS' COMET WITH A DISTURBING MEDIUM ON OCTOBER 21, 1893.

By Prof. E. E. Barnard, *of the Lick Observatory.*

The photographs of Swift's comet made here in April, 1892 (see Knowledge for December, 1892), showed us what wonderful changes comets can pass through in a comparatively short time. Looking at these pictures, made on successive dates, it would be hard to convince anyone not familiar with the facts that they represent the same object at intervals of twenty-four hours. These enormous and remarkable changes, though they astonish us with their magnitude and rapidity, are nevertheless suggestive only of actual change in the comet itself, due to physical disturbances, the cause of which we do not yet know.

In examining these pictures, one looks to the comet alone for an explanation of the phenomena. There is no suggestion that any outside agency has had a hand in it, excepting, of course, the sun itself.

Another comet, however, has presented itself, of which an excellent series of pictures has been taken with the same lens used to take the photographs of Swift's comet over a year ago. This comet has passed through a series of changes that force one to adopt some other explanation to account for them than the physical peculiarity of the comet itself; and looking at the pictures of it, I cannot avoid the belief that the comet had nothing to do with the remarkable condition its tail got into, unless, indeed, it was to supply the tail to be interfered with by some outside and invisible influence.

The small comet discovered by Mr. Brooks, on October 16th of this year, was to all appearance, as examined with the telescope, a rather ordinary comet; a little below naked-eye visibility, and possessed of a tail that at best could only be traced for a couple of degrees with the aid of the telescope.

THE MUMMIFIED BODY OF KING MEN-KAU-RĀ, THE BUILDER OF THE THIRD PYRAMID, brought to England by Col. HOWARD VYSE, and now in the British Museum.

Reproduced from a Photograph taken by Mr. A. FISHER, of Southsea. The enlarged anchylosed knee of the shortened right leg is visible within the glass case on the shelf over the Coffin of Amamu.

THE LICK OBSERVATORY IN WINTER. From a Photograph by Prof. S. W. Burnham.

The comet was observed here with the twelve-inch refractor, on the morning following its announcement. Nothing seen during the measures of its position suggested that any phenomena of an extraordinary character would be recorded on the photographic plate; but the comet could only be examined for a few minutes before dawn would stop an exposure. It was, however, decided to try a plate the next morning, to see what might result from a short exposure. The time of dawn did not permit of more than half-an-hour, but the photograph was satisfactory and interesting, though it showed nothing of special interest about the comet, except that the tail was longer than had been expected from the eye view of it obtained with the twelve-inch refractor. The photographic plate also showed two small short "whisker" tails springing from the head of the comet, on each side the main tail (which itself was split along its axis into two strands). The morning of the 20th proved cloudy, but on the 21st another exposure was made to see if any change was taking place. No special change was noted, however, except that all the features were more strongly marked. The main tail, as before, was essentially straight.

The next morning the twelve-inch showed that some disturbance had taken place, for the tail near the head was distorted. An exposure was at once begun with the Willard lens. The resulting photograph was indeed remarkable (see the picture for October 21st). The tail now presented the aspect of a torch streaming in the wind. The appearance was precisely what we should expect had the comet's tail, in its flight through space, swept across or through some medium dense enough to break up the tail. I cannot see how anyone comparing this with the picture of the 20th, can escape the conclusion that the tail did actually enter a disturbing medium which shattered it. This theory is, I think, further upheld by the third of these pictures, taken the following morning (see October 22nd), where the tail hangs in cloudy masses like the broken smoke train from a locomotive. In this last picture a large fragment is actually torn off and completely separated from the end of the tail. In the second photograph (see the picture for October 21st) the entire comet was brighter, as if the disturbance had added to its light, as also seems to have been the case with the third photograph on October 22nd, for its exposure was much shorter, as flying clouds were obscuring the sky a considerable portion of the time.

Unfortunately, cloudy weather and moonlight did not permit another exposure until November 2nd, when the comet's tail seemed nearly to have recovered its normal condition, except at its end, where a fragment stuck out almost at right angles, and on November 3rd it was to all appearances again straight; and thenceforward, though considerable changes of a physical nature were taking place, the comet did not again repeat the phenomenon of October 21st and 22nd.

In all, up to November 19th, I have secured sixteen photographs of the comet on fifteen different dates. On November 15th two exposures were given of ninety minutes each, in hopes of showing some rapid changes, but the comet was then in a quiescent state, and the two pictures are very much alike. Some of the exposures in the middle of November have been upwards of three hours long.

Description of the Remainder of the Photographs.

I will give here a very brief survey of the different plates, following those already described, and which it is not possible to reproduce here.

On November 2nd the tail is about 4° long. It is irregular and somewhat curved. The end is abruptly turned through an angle of nearly 90°—a denser portion, about a degree long, projects abruptly from it towards the west.

On November 3rd the tail is almost straight and somewhat broader. The projecting mass is not shown—unless in an unrecognizably altered form.

On November 6th for 2° the tail is straight; for 2° more it is irregular and wavy; 6° from the head is a mass, one degree long, entirely independent of the tail.

On November 7th the tail is nearly straight, but somewhat irregular. It is 6° long. The detached mass is not certainly seen.

On November 10th the tail is 6° long. Very slender close to the head, then widens out in three distinct fans, the middle one being the main tail. A denser portion at the end almost detached.

On November 11th the tail is straight but irregular, and in several strands. A denser mass at the extremity. This plate shows a meteor trail parallel with the comet's tail and ·1° south of it.

On November 12th the tail is straight but slightly irregular. A detached mass $2\frac{1}{2}°$ from the end of the tail and south, and 8° from the head.

On November 13th the tail is short and brushy, with a faint straggling extension to Alpha Canes Venatici. This star is irregularly involved in a condensed mass of the cometary matter. A splendid meteor trail crosses this plate nearly parallel with the comet's tail, and 3° north. This trail is sharp and straight and very dense. It widens out as it left the plate, the meteor bursting in the sky a few degrees after leaving the plate.

On November 14th the tail is somewhat curved and irregular. There are two meteor trails on this plate—one a large one cut across near the edge of the plate; the other is near Alpha Canes Venatici.

On November 15th the tail can be traced 10°. It is straight. There is possibly a denser mass at the end of the tail. The two negatives made on this date are essentially duplicates.

On November 19th the tail is straight; a thin or weak place occurs in it, nearly isolating the end.

Cloudy weather since this last date.

In nearly every one of these photographs there are small "whiskers"—I cannot better describe them—slender thread-like tails—that spring out on each side of the head, and which extend generally from $\frac{1}{4}°$ to $\frac{1}{2}°$ from the head, and are inclined at a considerable angle to the tail.

November 27th, 1893.

IRREGULARITIES IN THE TAILS OF COMETS.

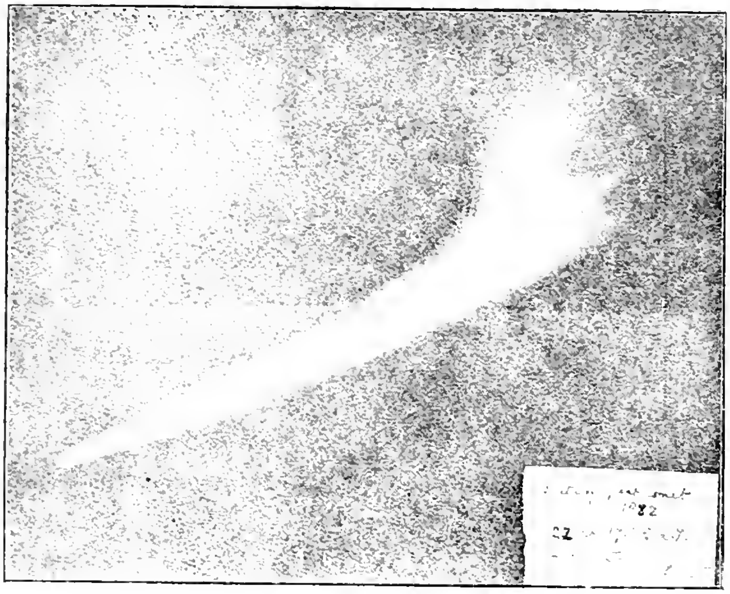
By A. C. Ranyard.

The beautiful photographs of Brooks' comet, of which Prof. Barnard has kindly sent enlarged copies for reproduction in Knowledge, exhibit most striking irregularities of structure, which are well worthy of close study, for the observation of deviations from assumed general laws has frequently led to fresh discoveries.

As a general rule, in large comets the tail streams from the nucleus in a direction away from the sun, as if the matter of the tail was repelled by the nucleus and was also repelled by the sun; and when the tail is curved it falls behind the *radius vector*, or line joining the sun and the cometary nucleus, so that the curvature of the tail is concave towards the part of space which has been traversed by the comet, as if the particles of the tail retained their original orbital motion, but being driven into a larger orbit fell behind the radius vector.

But in Prof. Barnard's photograph of Brooks' comet, taken on the 21st of October, the general curvature of the tail is for some distance from the nucleus concave towards the part of space to which the comet was moving, while the fainter and more distant parts of the tail exhibit a general curvature which is concave towards the region from which the comet was moving.

If the reader will carefully compare the stars shown upon the photographs taken upon the 21st and 22nd of October, he will see that in the twenty-four hours which elapsed between the exposure of the two photographs the nucleus of the comet had moved in a northerly or north by east direction through a distance which corresponds to about seven-eighths of an inch on the scale of our plate. The two small stars which are shown on the photograph of the 22nd of October (the one to the east and the other to the west, at a distance of about one-eighth of an inch from the centre of the nucleus) will be found on the photograph of the 21st of October at a distance of about seven-eighths of an inch from the nucleus in a direction nearly coinciding with the line joining the nucleus with the upper left-hand corner of the plate.



Sketch by Mr. John Brett of Comet (b) 1882, made 22nd October, 17h. Greenwich mean time.

If the matter of the comet's tail was deflected in its course from the nucleus by an encounter with a resisting medium which was stationary in space we should expect to find evidence of resistance in a direction contrary to the direction of the comet's apparent motion; but though the advancing side of the tail is notched and sharply defined in the lower half of the tail, the opposite or following side is most sharply defined in the upper and fainter parts of the tail, and the following side of the tail is more sharply defined than the preceding side in the photograph taken on the 22nd of October.

As in the photographs of Swift's comet, published in the December number of Knowledge for 1892, there is striking evidence in these photographs of Brooks' comet that the matter of the tail was not driven away in a uniform stream from the nucleus. Prof. Barnard has noticed the detached cloud completely separated from the end of the tail on the 22nd of October, and the rest of the tail in the photograph taken on the 22nd of October is broken into fragments, indicating short spasmodic outbursts, during which matter must have been driven away in considerable quantities from the nucleus, followed by quieter intervals. That these outbursts were of comparatively short duration is, I think, proved by the slight curvature of the tail, which indicates that the motion of the nucleus was not considerable during the time occupied by the passage of matter from the nucleus to the end of the tail. On the other hand, the velocity of the matter of the tail away from the nucleus does not seem to have been sufficiently great to disturb the definition of the notches on the edge of the tail in the thirty-five minutes during which the photograph was exposed, on the 21st of October.

Such rapid changes in the amount of matter driven away from the nucleus would seem to point to an irregular evolution of energy, such as might be caused by the passage of the nucleus through an irregularly distributed resisting medium, or through swarms of meteors, rather than to the evaporation of matter due to a steady increase of heat on approaching the sun.

The notches and irregularities in the edge of the tail, as well as the branching structures in the photograph of the 21st of October, seem to me to point to outrushes of matter from the nucleus through a resisting medium, in different directions, which outrushing matter has afterwards been driven away from the sun, rather than to a disturbance of the regular form of cometary tail due to an encounter of the matter in the tail with a resisting medium at a distance from the nucleus.

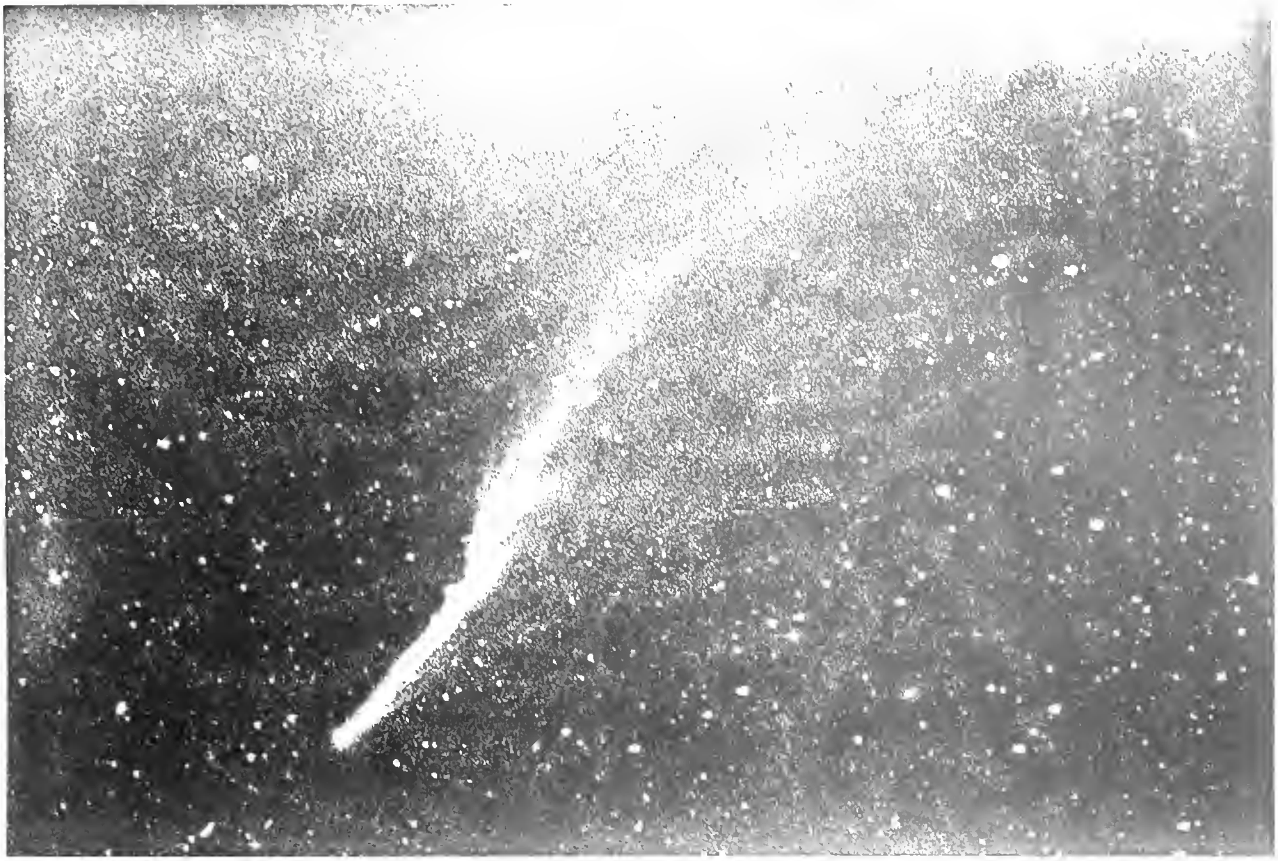
The general form of comets' tails, and the way in which they develop in size as comets approach the sun, and diminish again as they recede from their perihelion position, points to the conclusion that the development of cometary tails is chiefly due to the action of the sun's heat; but the irregularities of form we are discussing point to more sudden changes, causing an irregular development of heat in portions of the nucleus, which gives rise to radial outrushes of gaseous matter in various directions. Such irregularities in the evolution of gas from the nucleus might be caused by collisions or internal disturbances in a loosely-piled group of stones, or cluster of meteors, on approaching perihelion; or it might be due to the rapid passage of external groups of meteors, or clouds of meteoric dust, into a loosely-packed gaseous envelope surrounding the cometary nucleus.

Comet (b) 1882, from a photograph taken at the Cape of Good Hope Observatory. (Undated.)

Though the earth does not encounter groups of meteors sufficiently dense to materially raise the temperature of large regions of its upper atmosphere, it does not necessarily follow that denser groups of meteoric stones may not exist in other parts of the solar system, and it must be admitted

NORTH.

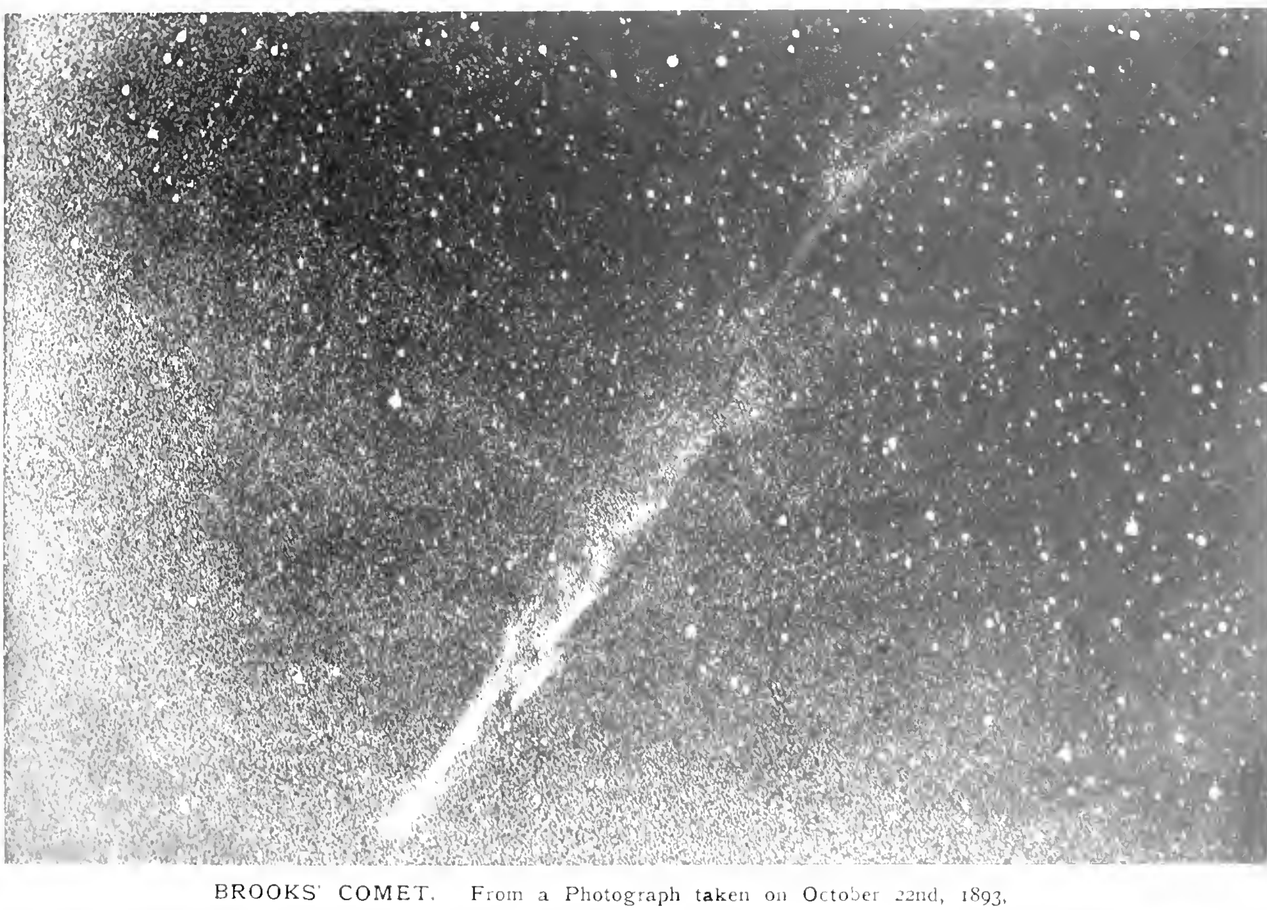
EAST



WEST

BROOKS' COMET, 1893, October 21st. Exposure, 16H. 37M. to 17H. 12M. Standard Pacific Time.

EAST.



WEST

BROOKS' COMET. From a Photograph taken on October 22nd, 1893,

By Prof. E. E. BARNARD, with the Willard Photographic Lens of the Lick Observatory. Exposure, 16H. 30M. to 17H. 15M. Standard Pacific Time. Both pictures are enlarged from the original negatives about $2\frac{1}{4}$ diameters. Scale, 1 inch = 0.87.

that the velocity of comets near to their perihelion distance is frequently large compared with the velocity of the earth in its orbit, and that the head or nucleus of comparatively small comets frequently greatly exceeds the earth in size, and would consequently sweep through a larger area.

But it seems more probable that the evolution of gas from a mass of stones, held together by the feeble action of their mutual gravity, may, as the mass is slowly heated, be sufficiently energetic to displace the stones, and thus bring fresh material to the surface to be acted on by the direct radiation of the sun.

If this is the case it would account for the irregularities in the structure of small comets being more marked than in large comets. For the larger the group of stones the greater would be the mutual attraction of its various parts, and the less would be the liability to its disturbance by the evolution of gas at a pressure corresponding to a given temperature; and the larger the group of stones the greater would be the density of the gaseous envelope surrounding it, and the greater would be the resistance to outrushes of gaseous matter from the nucleus.

We have at present diligently to collect facts. The branching structures shown in the photographs of Swift's comet, as well as the more striking branching structures shown in the photograph of Brooks' comet taken on the 21st of October, and the flattened heads of the small tree-like structures which project and form the notches at the eastern edge of the tail, present forms that remind one of the forms of solar prominences—that is, forms which are assumed by uprushing masses of gas passing through a resisting medium—and the conclusion pointed at, is that these similar forms have a similar origin, though spectroscopic and polariscopic observation of the light derived from comets' tails leads to the conclusion that the matter of which they are composed is not in the gaseous state.

The bright line spectrum seen in comets is generally only recognizable in the immediate neighbourhood of the nucleus, and the light from the tail is found to be polarized in a manner which indicates that its brightness is due to the light of the sun dispersed by a cloud of fine dust, the particles of which are on the average small compared with the wave-length of light. It would seem, therefore, that the gaseous matter evaporated from the nucleus is precipitated and then driven away from the sun in a cloud-like mass that retains the general outline or form which the gaseous matter had acquired during its outrush through the loosely-packed atmosphere surrounding the cometary nucleus.

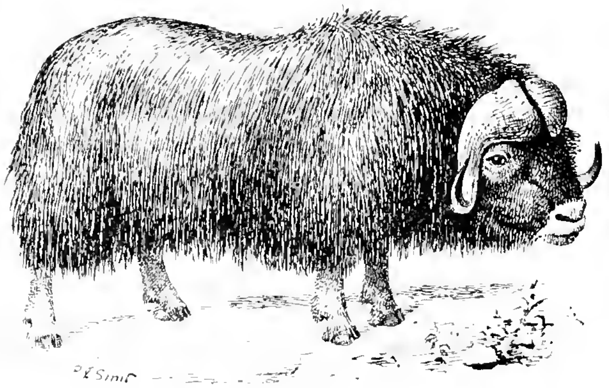
Even large comets have exhibited irregularities in their tails, notably the great comet of 1882 (*b*), in which the want of uniformity in the density of the cloudy matter of the tail was noted by several observers. I append a picture of this comet from a sketch by Mr. John Brett, which seems to be supported by the photographs obtained by Dr. Gill at the Cape of Good Hope with a portrait lens of two and a half inches aperture and eleven inches focal length. The mass projecting nearly at right angles from the end of the tail was noticed by several observers, while only a few noticed the faint veil of light shown in the photograph extending in a direction presumably towards the sun from the brighter parts of the comet near the nucleus.

Notice of Book.

Horns and Hoofs; or Chapters on Hoofed Animals. By R. Lydekker. London: 1893; 8vo, pp. 411. Illustrated, Horace Cox.—Mr. Lydekker's articles on big game, which have appeared during the last few years in the columns of the *Field* and *Land and Water*, have been very generally appreciated and we are glad to welcome their re-issue in volume form. In an ever-advancing science like zoology, progress is continually being made in our knowledge of animals, and we are glad to see that Mr. Lydekker has done his best to bring his chapters well abreast of the present time in regard to the numbers and characters of the species in the various groups treated of, though there are many groups left unnoticed. Thus the wapiti, and other horned animals of North America, are left without notice, and we look in vain for any description of such well-known animals as the European chamois, the American prong-horned antelope, the Rocky Mountain white "goat," and the extinct Irish elk.

It is obviously unreasonable to expect to find a complete treatise on horned and hoofed animals published in a series of articles intended for popular reading, but one may safely assert that no book which has hitherto appeared has contained such a complete list of horned and hoofed animals in the groups and regions treated of. The value of the work to naturalists would have been still further increased if Mr. Lydekker had given the various names or synonyms used by different authors in describing the same species. In a second edition he might, without detracting from the popular character of the book, give such synonyms in the index, with the authors who have used them, in chronological order, after the plan adopted by Sir Victor Brooke in his various papers on gazelles, sheep, and deer in the *Proceedings of the Zoological Society*.

In their original form, some of the chapters were not illustrated, but this deficiency has now been amended; while some of the figures which appeared in the columns



The Musk Ox (*Ovibos moschatus*).

of the *Field* and *Land and Water* have been replaced by new ones, in every way worthy of Mr. Lydekker and of the artists by whom they are executed. We notice, however, that there are still some outline figures which compare but poorly with the finished wood engravings; and if, as we hope it may, the book soon reaches a second edition, we would recommend the publisher to supply fresh ones.

Treating of the musk ox, which, as Mr. Lydekker points out, cannot be rightly classed as an ox, though its horns are at first sight so buffalo-like that the animal is almost always popularly regarded as a member of the bovine group, Mr. Lydekker remarks that, though in size and general appearance the musk ox recalls our smaller Highland cattle, its short tail, which is completely concealed among the long hair, and hairy muzzle, as well as the structure of its grinding teeth (which in the upper jaw are narrow, and have no additional column on the inner side), prove it to be essentially a sheep.

One would have liked to hear Mr. Lydekker's speculations as to why animals having such different pedigrees as the musk ox and the buffalo should have developed horns of such similar character. Unlike the horns of other oxen and sheep, they cannot be detached from the skull. They spring from rugged flattened bosses which form a horny mass protecting the forehead, and then curve downwards, and afterwards upwards, becoming thin and cylindrical before they terminate in the sharp points which are used for offensive warfare. Two other animals of very dissimilar character, the takin of Assam and the white-tailed gnu of Southern Africa, both of which are antelopes, have horns of very similar form protecting their foreheads, though their habits, surroundings, and relationships are entirely different from those of the musk ox and buffalo. Only the male of the white-tailed gnu, the buffalo, and the musk ox, have these forehead protecting horns, so that probably they are of some service for fighting purposes.

The musk ox is an essentially Arctic animal, well adapted by its massive feet (of which the sole is in part hairy) for getting over the roughest ground with facility. They associate in small herds, which Mr. Lydekker states do not usually comprise more than thirty individuals. At the present day it is confined to North America, to the north of latitude 60°. Its range seems to be steadily becoming more restricted. Thus it was formerly common in Alaska, skulls having been obtained by Captain Beechey, during the voyage of H.M.S. "Blossom" in 1825 to 1828,

The Head of a Cape Buffalo (*Bos caffer*)

from the frozen deposits of Kotzebue Sound, in Behring Strait, and they have also been found on the upper part of the Porcupine River in Canada. Its bones have been found, together with human remains, as well as those of the bison and reindeer, in the Dordogne, and at a still earlier period, when mammoths existed in England, it was a resident here, indicating probably Arctic conditions at the time. While the musk ox only inhabits regions which are covered with snow during a great part of the year, the Cape buffalo is usually found in reedy swamps from the Cape as far north as the equator, but some individuals are found inhabiting heavy timber jungles. These, according to Mr. Drummond, have more widely spreading horns. Nearly all books of African sportsmen teem with anecdotes of hair-breadth escapes from the charges of buffaloes. The massive horny shield on the forehead of the old bulls renders their heads practically safe from a shot, though it is just possible to kill them by a well-planted bullet in the line of junction of the two horns. In the Pleistocene times the buffalo, known as *Bos antiquus* of the Cape, had horns with a stretch from tip to tip of at least fourteen feet.

In speaking of rhinoceros horns, Mr. Lydekker describes one in my collection as measuring forty and a quarter inches long and twenty-two inches in basal circumference, weighing thirteen pounds. I have since obtained one measuring forty and a half inches in length with twenty-nine and a half inches basal circumference, and weighing twenty-four and three-quarter pounds.

Treating of wild oxen, wild sheep, wild goats, the antelopes of Asia and of Africa, the deer of Asia and of South America, wild pigs, and rhinoceroses, the book covers a wide area of ground. It is written in a thoroughly popular style, combined with Mr. Lydekker's usual care and accuracy, and will be invaluable, not only to travellers and sportsmen, but likewise to the stay-at-home lovers of natural history who are interested in the study of the larger horned and hoofed animals which the sportsmen speaks of as big game. Now that so many young Englishmen are making their home, either permanently or temporarily, in South and East Africa, the amount of information contained in the chapter on African antelopes, which cannot be obtained elsewhere in a collected form, ought alone to be sufficient to ensure the book a wide circulation. Both author and publisher are to be congratulated on the result of their efforts.

EDMUND LODER.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

RETURNS OF PERIODICAL COMETS, AND OF 1881 V. (DENNING).

To the Editor of KNOWLEDGE.

SIR,—Mr. Lynn, in speaking of the "periodical comets due during the remainder of the present century" (see his work on "Remarkable Comets," p. 39, and article in KNOWLEDGE, vol. xvii., p. 7), appears to ignore the periodical comet which I had the honour of discovering on the early morning of October 4th, 1881. Mr. Lynn, however, refers to this object on page 27 of his book, saying, "the period was determined to be about nine years, but the comet has not been seen since, probably owing to perturbations as it approaches the paths of several planets." I would point out to Mr. Lynn that the comet returned *unobserved* to perihelion in 1890 in consequence of its singularly unfavourable position near the sun, and that we are by no means driven to the alternative of planetary perturbations to explain its non-visibility on that occasion. Presumably no one looked for the comet at its return in 1890 because no one expected to find it, as the ephemeris computed and published by Dr. Matthiessen showed that it must escape observation, being more or less in the glare of the sun during the few months when it was tolerably near the earth. The comet is, however, likely to reappear at the close of 1898 or beginning of 1899, when its more favourable position encourages the hope that it may be redetected.

Dr. Matthiessen predicted the time of perihelion passage in 1890 to be May 9th, and gave the probable error of his determination as less than four days. From this it would appear that the orbit of the comet has been computed with considerable precision, though the available observations of it in 1881 only extended over the fifty days from October 5th to November 24th. The exact periodic time was given by Hartwig as 8·8335 years, by Plummer as 8·8578 years, and by Matthiessen as 8·6874 years. Chandler made it less, while Block at Odessa made it more. Of the several values, Matthiessen's is probably the most accurate, as he utilized an observation at Strasburg, on November 24th, not known to the other computers. If we adopt his period of 8·6874 years (=8 years and 251 days), as correctly representing the mean period of the comet, then returns may be expected in January, 1899, September, 1907, June, 1916, February, 1925, October, 1933, &c.

Including a few comets omitted by Mr. Lynn as too uncertain, and adopting the periodic times given in *Astronomy and Astro-Physics* for November, 1893, I have compiled the following table of probable cometary returns up to the end of 1900 :—

1894, April,	Tempel (1873 II.)	1898, June,	Swift (1889 VI.)
1895, Febry.,	Encke.	June,	Wolf.
June,	Barnard (1884 II.)	Septr.,	Tempel (1867 II.)
July,	Brorsen.	1899, January,	Denning (1881 V.)
1896, March,	Faye.	March,	Tempel (1866 I.)
October,	Brooks (1889 V.)	April,	Barnard (1892 V.)
1897, March,	Spitaler (1890 II.)	May,	Tuttle (1858 I.)
May,	D'Arrest.	May,	Holmes (1892 III.)
May,	Tempel-Swift.	July,	Tempel (1873 II.)
August,	Brooks (1886 IV.)	1900, Febry.,	Finlay.
1898, April,	Pons-Winnecke.	October,	Barnard (1884 II.)
May,	Encke.		

I have given the months of perihelion passage, but of course they are very doubtful in many cases. Their retention, however, serves to indicate the season. Wherever it seemed necessary to distinguish the comet by adding the year and number to the name, I have done so. The list shows that returns of periodical comets will be remarkably frequent in the last three years of the present century. For Tempel's comet (1866 I.) I have adopted Dr. Oppolzer's period of 33·176 years, but the mean period is probably a little longer than that, and corresponds with the $33\frac{1}{4}$ years of the Leonid meteors. Yours faithfully,

Bristol, January 8th, 1894. W. F. Denning.

Re LARGE TELESCOPES.

To the Editor of Knowledge.

Dear Sir,—In your interesting paper upon telescopes, in this month's Knowledge, you state that Lord Rosse's 6ft. mirror remains "the greatest light-grasping instrument which has been turned to the stars."

Surely you forgot Dr. Common's 5ft. silver on glass reflector. There can be no doubt of its superiority as a light-collector over a 6ft. metal reflector. The highest estimate I have found for Lord Rosse's metal is that it returns 67 per cent. of the incident light. The second reflection at the flat will be ·67 × ·67, or ·45 about.

A silver on glass in good condition reflects 91 per cent., and its effective return after second reflection will be ·91 × ·91 = ·83 nearly. We compare the light-gathering power of the two instruments by multiplying the square of the diameters of ·45 and ·83 respectively then, which comes out as 161·6 for Lord Rosse's, and 207 for Dr. Common's, or the latter collects more than one-fourth more light.

It appears to me that neither large refractors nor large reflectors are quite satisfactory, but there is no doubt the American refractors have much better atmospheric conditions than our English reflectors.

January 5th, 1894. Edwin Holmes.

[Mr. Holmes is, no doubt, correct when he takes into account the loss of light on a second reflection at the surface of a flat. But the instruments may be used with a totally reflecting prism in place of a flat, or a photographic plate may be exposed in the principal focus.

When only the one reflection at the speculum is taken into account, Lord Rosse's instrument has the greater light-grasping power. Adopting Mr. Holmes' estimates for the percentage of light lost by reflection at perpendicular incidence from speculum metal and from silver, the ratio of light-grasping power would be as 36 × ·67 to 25 × ·91, or as 24·12 to 22·75.

In comparing the loss of light when a flat is used, it should be remembered that less light will be lost when the angle of reflection is 45° than when the light is reflected at nearly perpendicular incidence, as from a speculum, and that a silver on glass mirror tarnishes much more rapidly than a speculum metal reflector; so that in ordinary use a silver on glass reflector stands at a greater disadvantage, as compared with a newly-polished instrument, than a speculum metal reflector.—A. C. Ranyard.]

To the Editor of Knowledge.

Dear Sir,—I beg to draw attention to a curious optical phenomenon, which seems to me worthy of more attention than it appears to have received.

When the eyes are fixed on a light at some distance, and partly closed, three pencils of rays, in the form of the letter Y, are usually seen apparently proceeding from it. One of the upper pencils disappears when the corresponding eye is closed, together with half of the lower pencil. Each pencil is seen to be made up of a varying number of separate rays.

I have found by experiment that the apparent arrangement of these rays varies remarkably, according to the structure of the eye of the observer. When the eye is normal the rays proceed directly from the luminous point of the flame; when myopic the rays cross each other and separate a short distance from the luminous point; when presbyopic the rays meet (or would if produced) beyond the luminous point. A concave or convex lens will enable anyone with normal eyes to see the appearances peculiar to presbyopic or myopic eyes respectively.

It is a curious fact that the arrangement of these rays in a particular eye is in fact a visible representation of the manner in which the actual rays reflected from outer objects traverse that eye, if we suppose the retina to occupy the place of the luminous point.

I suggest the following as a possible explanation :—The rays emitted from a luminous body, besides throwing an image of the body on the retina, have also the power of giving the sensation of an addition image, which takes the form of two pencils of rays proceeding from the luminous point. In a myopic eye the actual image as seen is badly defined, owing to well-known causes, and instead of a single image, a number of partly superimposed similar images are seen, each with its complemental pencils of rays. These rays cross each other and give the observed appearance. If a concave lens is now interposed between such an eye and the luminous body, and moved towards the eye so as to gradually correct its refraction, the images will approach, and form at length a definite image, giving two pencils of rays arranged exactly as in the normal eye. If the lens is brought still closer the rays will now, of course, converge behind the retina, and, as before, a number of ill-defined similar images will be seen, each with its complement of rays. Bearing in mind the direction in which the rays now fall on the retina, it will be seen that the various pencils will combine to form two large pencils with foci lying beyond the images, as in the presbyopic eye.

An explanation of the cause of these rays would be interesting. J. WALTER BROWN.

Belfast, January 16th, 1894.

[The rays referred to by Mr. Walter Brown are well known. They are produced by the reflection of light from the wet surface of the edge of the eyelid when it partly overlaps the pupil of the eye; and thus they are only seen, as Mr. Brown remarks, when the eyes are partly closed. He may satisfy himself that the rays are produced by reflection from the edge of the lid by a few simple experiments.

If he entirely closes one eye and partly closes the other when looking at a distant candle, so as to see one upward and one downward ray, he will find that the lower ray is eclipsed if the edge of a visiting card is brought slowly downwards between the eye and the candle, and that the upper ray is eclipsed if the edge of the card be brought between the candle and the eye from below upwards.

If he obtains the assistance of a friend to watch the operation, he will find that he begins to lose sight of the end of the lower ray at the moment that the shadow of the card reaches the edge of his upper eyelid, and similarly with the upper ray when the shadow of the card reaches the edge of his lower eyelid. On inclining his head to one side, he will find that the rays revolve in proportion as the head is turned round; and by carefully laying hold of his eyelashes, and stretching or twitching the lid, he may alter the position and form of the rays.

These pencils of rays are, no doubt, the rays which artists intend to represent by the diverging lines they draw from the picture of a candle, but they do not correspond to the very numerous and fine bright rays which we see diverging from the images of brilliant points of light such as electric arc lights, or the reflection of the sun from the bulb of a thermometer. These finer rays are seen when the eyes are wide open, and they are produced by radial inequalities in the structure of the crystalline lens of the eye—a curious structure grouped into six bundles or sectors, which is well shown in a picture in Helmholtz's "Physiological Optics" (see the French translation, p. 34).

The eyelids, when closing over the pupil, do not form a slit with parallel edges; and the two arms of the Y seen by Mr. Brown seem to indicate that while the edges of his upper eyelids are parallel, the edges of his lower eyelids are inclined to one another.—A. C. RANYARD.]

ENCKE AND SEEBERG

To the Editor of KNOWLEDGE.

SIR,—We have all heard of the complaint of Socrates that Crito confounded him with his corpse by asking him how he wished to be buried. By a stranger, or at any rate more unusual mistake, your readers this month must have thought that I had confounded Encke with his dwelling-place during the early part of his astronomical career. But what I wrote (p. 7, col. 1, line 20) was not "the illustrious Seeberg, an astronomer," but "the illustrious Seeberg astronomer," Encke having been at that place when he determined the orbit of the comet with which his name is indissolubly connected.

The Seeberg Observatory, founded by Duke Ernest II. in 1791, was situated a few miles from Gotha. Zach and Lindenau were successively directors of this establishment, where Encke laboured from 1815 until he was appointed director of the Berlin Observatory in 1825. The building at Seeberg had fallen into decay, and the instruments were transferred to a new observatory, erected at Gotha, in 1857, where Hansen, Encke's successor, remained until his death in 1874.

Yours faithfully,

Blackheath, Jan. 1st, 1894. W. T. LYNN.

THE ASTRONOMICAL SOCIETY'S MEDAL.

The Council of the Royal Astronomical Society have this year awarded their gold medal to Mr. S. W. Burnham, who has long been acknowledged as *facile princeps* of double star observers. He is not only a very keen-eyed observer, who has detected nearly all the very close and most difficult double stars that are known, but he has discovered more double stars than Sir William and Sir John Herschel, Wilhelm and Otto Struve, and Dembowski put together, and has made a most exhaustive study of the history of double star observation, which has enabled him, by a comparison of the observations of all the well-known double star observers with his own observations, to determine with far greater accuracy than was previously possible the forms of the apparent orbits of all the principal binary systems. Sherburne Wesley Burnham was born about 1840 at Thetford, Vermont, U.S.A. His first discoveries were made with an excellent six-inch refractor, made by Alvan Clark. Subsequently he worked with the eighteen and a half inch refractor of the Dearborn Observatory, Chicago, and then with the thirty-six inch refractor on Mount Hamilton. He retired from the Lick Observatory some two years ago, but he has now been appointed to the Yerkes Observatory, where he will have ample opportunities of using the forty-inch refractor.

STINGING INSECTS.—I.

By E. A. BUTLER.

AMONGST the varied powers possessed by insects, there are, perhaps, none that have made so forcible an impression upon the human mind as that of stinging. The intensity of the pain that follows a sting, contrasted with the insignificance of the being that causes it, and the quietness, suddenness, and unexpectedness of the operation, whereby there is no time left for the person attacked to put himself on his guard, or to prepare for defence, are circumstances well qualified to inspire caution. To facts like these may, no doubt, be attributed the very prevalent feeling of suspicion with which unknown insects are regarded, especially if they have a formidable appearance. In consequence of this widely-diffused distrust, many insects that are perfectly harmless are popularly credited with venomous powers, especially if their shape or general aspect suggests such a property. The prejudice thus created is most difficult to eradicate. It begins in the nursery. Children when quite young are cautioned against creatures that could in no way harm them, and this influence descends from one to the other as part of the inheritance of nursery traditions; the error is thus perpetuated, and shows at times such extraordinary vitality that the strongest assurances of experts are insufficient to dispel the illusion. And yet a very little general knowledge of insect structure is enough, without any close acquaintance with particular species, to enable an ordinary person to judge for himself whether any given insect is a stinger or not. We propose in this paper to endeavour to make clear what insects really are venomous, and what is the true nature of the stinging operation, as well as to say a word on behalf of some that are commonly, but calumniously, regarded as dangerous.

Confining our attention to the fauna of our own islands, we may state, in the first place, that the number of species possessed of this power of annoyance bears an extremely small proportion to the total insect population. The power is not indiscriminately distributed, but is confined to certain special groups; so that if one can only acquire a general knowledge of insect types and a readiness in the art of classification, or recognizing at a glance the order or sub-order to which an insect belongs, it becomes a very easy matter to estimate on *à priori* grounds the chances of its being a stinger. Whole orders, containing thousands of species in our own country alone, may be dismissed at once as including no members that indulge in the objectionable practice. But before indicating which they are, it will be necessary to define somewhat carefully what is to be understood by the word "sting." It is popularly used for at least four operations, which differ more or less widely from one another. The truest sense is doubtless that which implies (1) the making of a puncture, for offensive or defensive purposes, by means of a sharp-pointed and complex organ which is the equivalent of what in other insects becomes an egg-laying instrument, and is therefore placed at the *hinder* end of the body, and (2) the injecting into the wound thus made of some poisonous liquid secreted by the insect itself. The injection of an irritant poison easily explains the intense pain and other discomforts that follow such punctures. But in some cases a puncture is made defensively by a sharp-pointed instrument in the same position as above, but no poison is injected, since the gland necessary for its secretion is absent. Here no swelling or discomfort follows, and the only pain that is felt is the sharp prick at the moment when the puncture is made. By those who are unfamiliar with the insects, this would be at first regarded as a sting, for pain and inflammation are naturally expected to follow a sharp puncture, and it is only when the effect is found to be transient that the difference between this and the true sting can be discerned.

The third kind is that in which a puncture is made by a combination of fine perforating instruments which constitute the mouth organs, and are therefore situated at the head end of the body. In this case, as we have pointed out on previous occasions, it is a moot point whether any poison is instilled or not, no special poison glands being discoverable, unless the saliva itself possesses an irritating property; but however that may be, the operation is obviously one of a totally different character from those before mentioned, and its purpose is not essentially offensive or defensive, but consists merely of an endeavour to obtain food, though on occasion, possibly, use may be made of it for protective purposes as well. The two first mentioned, as being purely strategic actions, so to speak, are accomplished quickly by a sudden rapid plunge with a hard and stiff weapon; but the third is a slower process, and usually consists in forcing a collection of exceedingly thin and flexible hair-like organs gradually through the skin. This also is often followed by painful swellings and inflammation. All the actions already enumerated are more or less under the control of the insects themselves. But to these must be added those cases in which painful swellings are caused by the mere handling of the insect, through accidental contact with its glandular hairs, a species of injury unintentional and entirely beyond the control of its inflictor.

Under one or other of the above four heads may be arranged all the instances that may reasonably be described as stinging, by whatever insect the injury may be inflicted. Under the first head come the true vengeful stings, such as those of bees, wasps, and ants; under the third, the punctures made by bugs, gnats, and other flies, in their efforts to obtain the liquid food on which they subsist; flea-bites also may be ranked here, although there is some modification in the shape of the organs concerned. Thus, when we speak of the "sting" of a wasp, and the "sting" of a mosquito, we are referring to two totally different operations carried out by instruments placed at opposite ends of the body, and for totally different purposes—the one a fighting, and the other a feeding action; the one for forcing down poison into a wound, the other for sucking up blood out of a wound. Aristotle, and after him Pliny, long ago pointed out this distinction, showing also that the tail-stingers, such as bees and wasps, were *four*-winged, but the *mouth*-stingers, such as gnats and flies, *two*-winged.

FIG. 1.—Antennæ of Hornet: A, male; B, female. Magnified two diameters.

Under the second head will be included any punctures that may be made by ichneumon flies, which are the most insignificant of all in their effects; and under the fourth, those painful swellings that are caused by the hairs of the caterpillars of certain moths, such as the gold-tail and brown-tail described in a recent paper, and the processionary moths of the Continent. This fourth group, again, differs from all the rest, in that the power of stinging is possessed by the insect in its larval condition, whereas in all the other cases it pertains only to the adult.

We are now in a position to consider, from the systematic point of view, what insects those are that possess the stinging power in either of the senses described above. All insects that can voluntarily inflict punctures, whether distinctly poisonous or otherwise, with mouth or with ovipositor, are included in three only out of the eight or nine orders into which almost all insects are grouped, viz., the Hymenoptera, to which bees, wasps, and ichneumon flies belong; the Diptera, containing gnats and other two-winged flies; and the Hemiptera, or bugs. Thus we may dismiss from our thoughts altogether the following groups, as having no share in the opprobrium that rests upon the orders just mentioned: the order Coleoptera, containing over three thousand British species, which consist of beetles of all sorts, including many that have other popular names, and are not usually called beetles, such as ladybirds, glow-worms, weevils, cockchafers, and the like; the Lepidoptera, or butterflies and moths, with over two thousand British species, if we except the two or three whose caterpillars have irritating hairs; the Neuroptera and Trichoptera, or dragon flies, lacewing flies, and caddis flies, a total of between three and four hundred; the Homoptera, or frog-hoppers and plant lice, containing some hundreds of species; and the Orthoptera, or earwigs, cockroaches, crickets, and grasshoppers, a group feebly represented in this country, and including only between forty and fifty species. Here, then, we have a total of some six thousand British insects, to none of which does the charge of stinging apply. But this is by no means all, for of those three orders mentioned above, which contain the stingers, the Hemiptera (excluding the lice) yield only some half dozen, out of their total of nearly four hundred and fifty British species, against which the charge can in any way be substantiated; the flies only a small proportion of their total of over three thousand; and even the Hymenoptera, which contain most of all, probably not much more than an eighth of their four thousand or upwards. Hence it appears that, were it not for the fact that some of the stinging insects are amongst the commonest of the common, and that enormous numbers of specimens of them are to be found, we might, in consideration of the small proportion of the total number of kinds that are thus harmful, expect not very frequently to meet with any that would on this score justify distrust.

In the above list of non-stingers, the only ones that call for additional remark are the dragon flies. These large, rapacious, and usually powerful insects have, unfortunately, acquired a very bad name, and have a widely extended reputation for stinging, which is, however, nothing more than mere tradition, and has no foundation in fact. The popular prejudice against them is crystallized in the common names of some species, such as horse-stingers and devil's darning needles. The long, thin body, which is often twisted about as if in search for an object to attack, is, no doubt, partly responsible for the origination of the idea of their venomousness. Nevertheless, the idea is absolutely incorrect; as one writer has said: "In both its states of water and air, it can do everything wicked except the one thing it is popularly supposed to do best, namely, *sting*." No stinging organs are possessed by any species, and no power of doing direct injury to human kind exists amongst them, so that no one need fear handling any kind of dragon fly. The only possible suggestion of harm is in the jaws of the larger kinds, these being powerful (relatively), so that they can inflict a sharp pinch, but still not enough to pierce the skin.

Turning now to the Hymenoptera, as containing those insects that most truly merit the epithet "stinging," we find a special section of the order, to which the name of Aculeata, or sting-bearers, has been given just because they differ from the rest of their kindred by the possession of a poisonous sting. This section contains several sub-divisions, such as the ants, the fossores or digging wasps, the true wasps, both social and solitary, and the bees—these, too, including both social and solitary species. As the sting is a modification of the ovipositor, or instrument for depositing the eggs, it is of course found only in the females; hence, none of the males of the above insects are able to defend themselves by stinging, but may all be handled with impunity. Their longer, thinner body, and longer antennæ (Fig. 1) will often distinguish them; but sometimes they are totally unlike their partners, and therefore it is hardly possible to lay down general directions for recognizing them. In those species that are social the sting is carried not only by the true females, who are often few in number, but also by that curious and very numerous intermediate or third form which is characteristic of social insects, viz., the workers, who are a sort of abortive females. When, then, we speak of being stung by wasps or by the hive bee, it is almost invariably the workers who are the guilty parties. The only female in a bee-hive is the queen, and she is not met with in the open except at the time of swarming. Amongst the wasps, the females, or queens, are more likely to be met with, but they are far outnumbered by the workers. Amongst the ants, a certain family, the *Formicidæ*, are not provided with a usable sting, but merely with a rudimentary representative of that organ, though the poison gland is well developed and contains poison in abundance; this they eject at their foes with considerable force and to great distances, and as it is of a strongly acid character, it causes a smarting sensation on a sensitive skin, especially if injected, as often happens, into wounds already made by their jaws.

To illustrate the structure of the sting, we may take the instrument as found in the largest species, as, for example, a hive bee a humble bee (Fig. 2), or a wasp (Fig. 3). The plan is the same in all, with differences of detail only. When not in use, the whole of the sting apparatus is withdrawn between the pair of terminal plates of the body, which open like a mouth to allow of its extrusion. These must be removed before it can be seen: they can easily be torn off with a fine pair of forceps. The sting now stands revealed, and its most prominent part, which will be at once detected, is a strong dart, straight or curved according to the species; it is grooved on its under surface, and tapers to a not very sharp point. At its upper end it is expanded into a broad, pouch-like body, and both this and the greater part of its narrower continuation are double-walled.

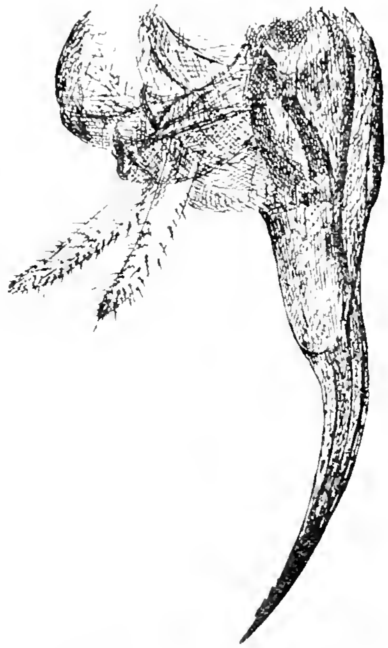


Fig. 2.—Sting of Humble Bee. Magnified fourteen diameters.

Within the groove lie two long, narrow lancets, which can be moved up and down in the dart, by running along two projecting lines like rails, which extend from top to bottom of the groove; they are worked by levers and muscles attached to their upper ends. The lancets are notched at the free end with teeth that point backwards, like the end of a savage's spear; throughout their length they are hollow, but their cavity communicates with the exterior by a little channel amongst the barbs. In communication with the pouch at the top of the dart is a membranous tube, which is connected with a thin-walled bag, the poison receptacle. From the upper end of this bag there passes a long, white, thread-like, coiled tube, which soon divides into two branches, each of about the same diameter as the undivided tube, and these ultimately end blindly in little knob-like swellings. The poison, which consists largely of formic acid, is secreted within these tubes, and is poured from them into the bag at the base of the sting, where it is stored till required. Close by the base of the sting there is a pair of hair-beset feelers, called collectively the sting-sheath, and intended to assist in guiding the dart to a suitable spot for attack.

In the act of stinging, the dart and its feelers are first thrust out between the terminal plates of the body, and the dart is pressed against the object attacked, so as to enter the skin; the lancets are then slid along their rails and pass out beyond the tip of the dart, thus making the wound deeper; at the same time poison passes from the bag in which it is stored, down the groove in the dart, and out at its extremity into the wounds; but some also finds its way into the interior of the lancets themselves, and so out through the channel near their tip, and thus into the wound at a deeper point. The recurved barbs on the lancets and dart of course operate as a drag in any attempt to withdraw the sting, and it is entirely a question of the relative strength of resistance whether the sting can be withdrawn or has to be left in the wound. Thus when the insect is alarmed and tries to pull out its sting suddenly, as is of course usually the case when, for example, a bee stings a human being, it often happens that the sting cannot be extricated quickly enough, but the bee in its struggles tears itself away, leaving the sting and all its appendages still sticking in the wound. According to Mr. J. D. Hyatt, if a bee be allowed to sting a soft piece of leather, it will be unable to withdraw the sting, and will tear itself away, leaving the whole apparatus beautifully dissected out, while the insect itself will fly away, apparently not seriously incommoded by the loss. It is stated that the queen bee is not very ready to use her sting against human kind, reserving it for despatching her rivals; and that when she does sting a human being, she is able to withdraw her sting more easily than a worker, by turning round on it as an axis, and so giving the instrument a corkscrew motion. Much of the muscular movement connected with the act of stinging seems to be of a reflex nature, so that it may take place some little time after the death of the insect, and it is the painful experience of most persons who incautiously handle dead wasps to find that death has not robbed them of the power of stinging.

With bees, whether solitary or social, the use of the sting is evidently, since the insects are entirely vegetarian in diet, merely a means of defence against enemies: but with the rest of the aculeate Hymenoptera the case is somewhat different. Wasps are hunters, and expert ones too; their young are reared on animal food, and the workers therefore hunt for prey to satisfy these claims. The sting here comes in very usefully as giving them an easier victory over the quarry, and as rendering it, when caught, powerless to interfere with its transportation to the nest. The same remark applies to ants. The fossorial Hymenoptera are somewhat differently circumstanced. Though a numerous group, they are not generally well known, and therefore have no popular names other than that of sand-wasps, which they share (wrongfully) with the solitary wasps. As their technical name implies, they are diggers, burrowing into the earth, or into wood, and they have a preference for sandy places, where the soil is easier to excavate. Each burrow is formed by one insect, and tenanted by one brood only, for they are solitary in habits, *i.e.*, the species consist only of males and females, and each female makes a home for her own brood alone; the young, therefore, do not depend upon the care of nurses, but are left entirely to themselves, and have to feed themselves from the moment of their liberation from the egg till they become pupæ. Nevertheless, they do not collect their own food, but a supply is provided by the mother before they are hatched. Thus, as they never need to leave their birth-cell, they can afford to do without legs, which would, in fact, only be in the way within the narrow confines of the cell; consequently, these larvæ always take the form of footless maggots. When the mother has made the cell, her next business is to begin to provision it. The larvæ are carnivorous, feeding upon caterpillars, flies, gnats, spiders, aphides, beetles, &c., the particular creature selected depending upon the species of fossor. Each species usually confines itself to one sort of prey; the mothers are, in fact, very good entomologists, able to distinguish the right kind of creature amongst the multitude of species of all kinds that they meet with in their explorations, and often far more keen in knowing how and where to get hold of a particular sort of insect than most human collectors. In proceeding to provision the cell, then, the mother hunts up a specimen of the proper sort of prey, deposits it in the cell, and then lays an egg upon it. A store of provisions of the same sort must now be got together in sufficient quantity to last the larva its whole lifetime, and there is also the further requirement that it must be in such a condition as to remain fresh, and neither dry up nor become putrid so long as the grub has any need of it. The sting enables the mother to make the necessary arrangements without difficulty. The prey, if thin-skinned, such as caterpillars, is often stung slightly when caught, enough to prevent it from struggling, but not so much as to quite kill it. In this condition it is stored up, too helpless to escape, but at the same time with as much vitality left as will serve to keep it soft and fresh, and prevent it from shrivelling up or becoming mouldy. Hard-skinned insects, such as beetles, are stung to death before being put beneath the ground; then the dampness of the soil softens their joints, so that by the time the grubs are ready to proceed to the feast, the feast has been reduced to a proper consistency for their jaws. The number of corpses, or semi-animate bodies, with which the larder is stocked of course depends upon the size of the insect to be reared as well as upon that of the prey itself. For a certain large species, which is shaped a good deal like an ichneumon fly, a single large caterpillar suffices; in other cases, a dozen or so of small spiders, or some fifty or sixty aphides, may be found piled up in a cell. Most of these fossorial Hymenoptera are smaller than the generality of bees and wasps, and hence their sting, though fatal to their legitimate prey, has generally but a trifling effect upon ourselves; in fact, several species are extremely reluctant to use their sting at all when handled.

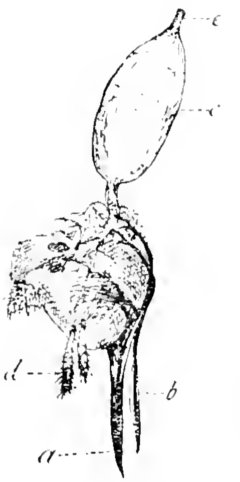


Fig. 3.—Sting of Wasp. *a*, dart; *b*, lancet, escaped from groove; *c*, poison bag; *d*, feelers; *e*, base of poison gland, the rest having been removed. Magnified ten diameters.

(*To be continued.*)

FOSSIL WOOD.

By the Rev. A. S. Wilson, M.A., B.Sc.

A DELIGHTFUL experience awaits the botanist on turning his attention to fossil plants. Entering the realm to which palæontology introduces us, forms of singular elegance and beauty greet the eye; others are seen, strange and grotesque, which bid defiance to all our previous conceptions. No one who is not altogether destitute of imagination can contemplate the exquisitely graceful outline of Sphenopteris, or the ornately sculptured stem of Ulodendron, in fairly preserved specimens, without catching a glimpse of this fairyland of palæontology.

We gain but an imperfect conception of any plant, however, from its external appearance alone; for its proper comprehension we must also know something of its life-history and internal anatomy. This presents little difficulty in the case of the leaves, buds and flowers enclosed in the amber obtained from the Eocene strata of Germany. Models of flowers belonging to the chocolate order, with all their parts perfect, have been obtained by forcing melted wax into certain cavities in the Tertiary tuffs near Sezanne, in France. But without recourse to any expedient of this kind Renault procured from the Carboniferous strata of

Grand Croix silicified flowers, in which the pollen grains contained in the anthers, as well as the details of the structure of the seed, could be readily discerned. Such materials enable us to trace the entire life-history of a number of fossil species. Rarely, indeed, are all the characters of the original plant retained by the fossil; a very vivid idea of extinct vegetable life can, fortunately, be obtained from the microscopic examination of specimens in which the minute structure of the tissues has been preserved. As a rule, it is only in true petrifactions that this occurs. From casts, moulds or impressions which constitute the great bulk of fossils the original substance has, for the most part, been removed; what remains is generally the merest film of carbonaceous matter in which no structure can be detected.

In coal, again, the mineralizing process has usually gone so far that the structure of the plants out of which it was formed is almost entirely obliterated. By subjecting exceedingly thin slices of coal to the microscope, Reinsh, however, detected even in anthracite evident traces of the tissues of the higher plants. From most kinds of coal, Schulze also, by maceration in petroleum, soda and other reagents, was able to separate organic fragments showing all the structural elements of wood. Wigan cannel coal and many other gas coals and lignites plainly reveal their vegetable origin, and from Bradford and Fordel collieries samples have been described consisting entirely of the spores and spore-cases of ferns. But our knowledge of the internal structure of extinct plants is mainly derived from fossils, which have resulted from the petrifying action of carbonate of lime or silica held in solution in water.

At the present day, springs and other natural waters possessing this petrifying power are of frequent occurrence, especially in limestone and volcanic districts. In the vicinity of some of the geysers of the Yellowstone Park of North America, for example, trees, still erect, in all stages of petrifaction may be seen; grasses, reeds and ferns are converted into stone round the hot springs in the island of St. Michael, and similar phenomena occur in many other localities. Subjected to the action of a petrifying spring, the substance of a plant is gradually removed, and as each particle dissolves it is replaced by a particle of carbonate of lime or flint, as the case may be. Now this transformation, which we can observe in operation, has occurred very largely in past geological time. The astonishing thing about this process is, that under favourable circumstances the exchange of material is effected without appreciably altering the structure. Polished sections of completely silicified palm stems from Antigua may be seen in many museums, in which, with the unaided eye, all the details of the endogenous structure can be easily recognized. Specimens of exogenous stems similarly preserved are also met with, exhibiting the pith, annual rings, and bark, almost as perfectly as a newly-felled tree. From the lower Eocene of Herne Bay, Carruthers obtained a silicified fern allied to Osmunda, in the cells of which, not only were the starch grains still visible, but traversing the petrified tissues could be clearly traced the mycelium of a parasitic fungus. More remarkable still, when thin sections of petrified wood are examined with the microscope, we find in many cases that its constituent cells not only retain their distinctive shapes, but the markings on the cell-walls are faithfully reproduced. Annular, spiral, reticulated, scalariform, pitted, and border-pitted markings, even the excessively fine cross striæ, may be seen as distinctly in the fossil as in sections of fresh plants. Nor is it only thick-walled, lignified cells that are petrified; even the delicate, thin-walled, transparent cells of the cambium layer are often as plain as in a section of living wood. This is the less surprising in view of what happens in the Equisetaceæ and other plants containing much silica. The horsetails are practically silicified while still living. The Charas and Corallines might also be described as living fossils, since they petrify as they grow.

The oldest plants of which the structure is known are Algæ from the Silurian strata of Wales. Silicified woods found by Dawson in the lower Devonian of Canada are by him referred to Coniferæ, but by Carruthers to the Algæ. Hugh Miller discovered wood resembling that of Coniferæ in the lower Old Red Sandstone of Cromarty. Wood of similar character occurs in the middle and upper Devonian, but is much more abundant in the coal measures. Oldham and Halifax are among the more noted English localities. Specimens have also been obtained from Granton and Craigleith quarries, from Coldstream, and Laggan Bay in the island of Arran, where some years ago Wünch discovered a number of stems with well-preserved structure. The volcanic deposits at Burntisland have also yielded considerable quantities. The Fife and Arran plants are referred to the genus Lepidophloios; they have excited considerable interest among British and foreign geologists. St. Etienne and Autun in France, Chemnitz and Dresden in Germany, are among the most noted localities on the Continent. Of the secondary or Mesozoic formations the oolite is richest in plant remains. Pinites occurs in this formation in the island of Eigg, and Hugh Miller states that cartloads of oolitic wood have been removed from the shore at Helmsdale and burnt for lime.

The Portland dirt-bed with its remarkable assemblage of fossil cycads, also belongs to the oolitic series. Cretaceous rocks in Greenland contain abundant remains of vegetation; woody tissue even occurs occasionally in the flint nodules of the chalk, and the Tertiary strata are particularly rich in fossil plants. Even forests of petrified trees are met with in some parts of the world, such as the eastern coast of Australia, Tasmania, near Cairo, and in several other places. In some of these the structure of the wood has been preserved; in others, as in the fossil grove at Whiteinch, it has disappeared.

Fossil wood thus occurs more or less plentifully in all formations except the earliest. The chief interest attaches to examples obtained from the older or palæozoic rocks. Most of these show a remarkable uniformity of structure and greatly resemble the wood of the araucaria or Chili pine. Wood of this type is known as araucaroxylon. From its coniferous character and abundance in Carboniferous strata the older geologists were led to infer that cone-bearing trees had been very plentiful during the coal period. This is now known to be an error, for although true conifers existed in palæozic times, their remains only occur sparingly in Carboniferous and Permian rocks. Wood of the araucarian type is now known to have been produced very largely by the Cordaitæ, an extinct family of plants at one time thought to be monocotyledons on account of their grass-like leaves, but since proved to have the closest affinity with the Cycadaceæ.

As we should naturally expect, it is the harder and tougher portions of vegetable tissue that most frequently appear in petrifactions. The internal substance of a fungus, seaweed or other thallogen, is entirely cellular. If we slice the stalk of the common tangle it is found to present a uniform appearance, and to admit of being cut with equal ease in all directions. On cutting across the root-stock of a fern, on the other hand, the knife encounters a circle of thick fibres embedded in the softer substance. These are the fibro-vascular bundles; they run in a vertical direction through the stem, uniting laterally at intervals, and forming a kind of internal framework. By scraping away the softer substance, a beautiful hollow cylinder of network, the fibro-vascular system of the fern, is exposed. This system, present in all the higher plants, assumes characteristic forms in the leading divisions of the vegetable kingdom. In the stem of a palm or other monocotyledon the fibres are irregularly scattered through the cellular substance; the softer part being in the centre, this arrangement is termed endogenous. The stems of dicotyledons and conifers, on the other hand, are exogenous and show a central pith surrounded by rings of wood and layers of bark. The young exogen has a ring of five bundles or so, reminding us of the adult condition of the fern stem, but every succeeding year a fresh ring of secondary bundles is formed towards the outside: the primary bundles at the same time greatly increase in diameter, so that very soon the vascular system in the exogen assumes much greater importance than it has in the fern, and ultimately constitutes the great bulk of the stem. Cellular ground tissue occupies all the space enclosed by the epidermis which is not taken up by the vascular framework. The ground tissue includes the pith, most of the bark, and the medullary rays. The last mentioned are vertical plates of tissue which pass from the pith to the bark, separating the bundles, and penetrating the meshes of the vascular system; to them is due the appearance known as the silver grain of wood, easily recognized even in fossil specimens. The primary vascular bundles formed during the first season are the only ones ever developed in ferns. Dicotyledons and Gymnosperms are the only living plants in which secondary thickening occurs. By this is meant the increase of thickness that occurs after the part has ceased to grow in length. A certain length of stem is produced during a season of growth. In ferns and palms this portion never becomes any thicker; the trunk of an exogen like the oak, on the other hand, increases in girth as long as it lives. With the single exception of Isoëtes, in no existing fern, club-moss, horsetail, or other Cryptogam does secondary thickening take place. The extinct Lepidodendron and Calamite differed in this respect very widely from their modern representatives. Williamson has shown that they possessed the power of forming secondary wood by exogenous growth. The loss of this power may perhaps account for the diminutive proportions of existing Lycopods and Equisetaceæ, to which the arborescent Lepidodendron and Calamite of palæozoic times were closely allied.

The separation of the secondary wood of exogens into rings is due to a difference between that formed in autumn and the portion added in spring; the autumnal wood is dense, the vernal is of looser texture and consists of larger and more delicate cells. This is, however, only the case in temperate climates where the seasons are marked. In tropical woody plants annual rings are not, as a rule, distinguishable. As indicating the former extension over the globe of a more uniform and tropical climate, it is interesting to note the entire absence of yearly rings in the fossil woods of the palæozoic strata.

The stem of Lepidodendron, though agreeing with that of an ordinary exogenous tree as regards the formation of secondary wood, was in other respects very dissimilar. In succulent and herbaceous plants the ground tissue preponderates over the vascular system, and Lepidodendron partook somewhat of the herbaceous character. There was a central axis or cylinder of small diameter relatively to the stem, consisting of a ring of wood which varied in thickness with age. Inside, the woody ring enclosed an enormous pith; outside, it was surrounded by a bark or cortex of great thickness. The bark of most trees is thin compared to the woody part, but the rind of Lepidodendron occupied in many cases quite four-fifths of the diameter of the stem. It consisted of three layers; the innermost had a delicate spongy character, and is rarely preserved. Of this tendency of the inner cortex to degenerate we have an extreme example in the modern Selaginella, in which the central axis is separated from the cortex by a vacant space traversed here and there by delicate horizontal cells or trabeculæ. In various members of the Lycopod family, Prof. Bower has recently found this inner layer of the rind to exhibit transition stages intermediate between the conditions in Lepidodendron and Selaginella. To compensate for the weakness of the vascular system, the outer cortex in many extinct Cryptogams was strengthened by strands of schlerenchyma, consisting of thick-walled cells forming the dictyoxylon-rind of Brongnart. A fossil stem in the writer's possession shows, in addition to the woody cylinder, scattered vascular bundles running up through the thick pith. Under the name Heterangium, Williamson has described a fossil plant with a similar arrangement. This condition, which combines the characters of endogen and exogen, is very exceptional among existing plants; species of Aralia and Phytolacca are among the few examples known. Williamson is also of opinion that in some lepidodendroid plants secondary thickening occurred within the pith, a peculiarity unknown in living plants.

A longitudinal section of a stem under the microscope in all cases shows the woody bundles to be made up of elongated tubes and cells, the walls of which exhibit dots, rings, spirals, and various other marks. In ferns and Lycopods the cell-walls are crossed by horizontal bars giving the ladder-like or scalariform character. Wood vessels are formed by the fusion of vertical rows of cells. Some of the larger of these, from the resemblance which their ring-like marking gives them to the windpipe of an animal, are named tracheæ. Strings of cells in which the partitions still remain also occur; such cells are the tracheides, so-called because of their likeness to the true vessels or tracheæ. Vessels proper are most abundant in the primary bundles forming the oldest wood next the pith; the bulk of the secondary wood, in conifers almost the whole of it, consists of tracheïdes. These are elongated tubular or prismatic cells, with oblique or tapering ends which dovetail with those of the cells above and below, and are distinguished as pitted, scalariform or spiral, according to their markings. Tracheides are not uncommonly six-sided, giving to the wood a columnar structure resembling on a small scale the basaltic pillars of Fingal's Cave or the Giant's Causeway. The arrangement of the tracheides often reminds one of a collection of organ pipes. The wood of the common arbor vitæ has an exceedingly beautiful structure; the tubular tracheides resemble so many glass flutes with the row of pits corresponding to the stops of the instrument. Crossing the transparent flutes, as if to bind them together, at intervals are seen the rows of brick-like cells so characteristic of medullary rays. Tracheïdes and medullary rays cross each other very much as warp and woof do in cloth, to which the texture of wood has some analogy.

Coniferous wood is easily recognized; its constituent tracheides exhibit the characteristic markings known as bordered pits. Each pit presents the appearance of a small circle surrounded by a larger one; the shape and arrangement of the pits vary, however, in different groups of Coniferæ. Göppert recognized four, but Krauss distinguishes six distinct types of fossil wood. Taxites, represented by the modern yew, has only been obtained from Tertiary rocks: the cypress type is found in the chalk, and the pine and cedar type from the Trias onwards; but all the wood of the older formations exhibits the araucarian structure. In palæozoic wood of the araucaroxylon type each tracheide commonly exhibits several rows of pits crowded together and mutually compressed, so that the outer circle or border of each pit presents a hexagonal rather than circular outline, giving a tesselated appearance to the markings as though the cell-wall were overlaid with minute mosaic. Coniferous wood is much simpler than that of dicotyledons: the latter includes, beside tracheïdes, cells and fibres of various kinds. Palæozoic is therefore distinguished from modern wood by the greater uniformity and simplicity of its structure.

The various elements entering into the composition of vegetable tissues and their symmetrical arrangements often give to microscopic sections, both of living and fossil plants, a remarkably beautiful appearance. The transverse section of the stalk of the common bracken, for example, is a lovely object presenting an elegant lace-like pattern. This feature is retained even in the fossil; silicified fern stems from Saxony have long been cut and polished wholesale on account of the graceful designs which the sections present. The starling's-breast mineral, or staarstein of the Germans, is also a fossilized fern, being formed from the stalks of species of Parsonieæ, and in the wood opals petrified vegetable tissues even attain the dignity of precious stones. We have only touched the fringe of a large and interesting subject but if we have succeeded in conveying the impression intended, the reader will have been able to form some slight conception of the singularly charming field of investigation opened up by fossil botany.

THE FACE OF THE SKY FOR FEBRUARY.

By Herbert Sadler, F.R.A.S.

Whenever the Sun is visible, its disc should be watched for spots and faculæ. On moonless nights the zodiacal light should be looked for in the south-west shortly after sunset. Conveniently observable minima of Algol occur at 9h. 10m. p.m. on the 2nd; 6h. 0m. p.m. on the 5th; 10h. 53m. p.m. on the 22nd; and 7h. 42m. p.m. on the 25th.

Mercury is an evening star, and is well situated for observation during the last two thirds of the month—in fact, this will be the most favourable evening apparition in the whole year. On the 11th he sets at 5h. 58m. p.m., or 54m. after sunset, with a southern declination of 11° 43′, and an apparent diameter of $5\frac{1}{4}''$, $\frac{93}{100}$ths of the disc being illuminated. On the 16th he sets at 6h. 32m. p.m., or 1h. 18m. after the Sun, with a southern declination of 7° 42′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{84}{100}$ths of the disc being illuminated. On the 20th he sets at 6h. 58m. p.m., or 1h. 34m. after the Sun, with a southern declination of 4° 25′, and an apparent diameter of $6\frac{1}{4}''$, $\frac{71}{100}$ths of the disc being illuminated. About this time he is at his greatest brilliancy. On the 26th he sets at 7h. 20m. p.m., or 1h. 48m. after the Sun, with a southern declination of 0° 6′, and an apparent diameter of $7\frac{1}{4}''$, rather less than $\frac{5}{10}$ths of the disc being illuminated. He is now at his greatest eastern elongation (18° 5′). While visible, Mercury passes through part of Aquarius into Pisces. On the evening of the 15th he will be closely *s. f.* λ Aquarii, 4th magnitude, planet and star being visible in the same field of view with a low power eye-piece; and on the 18th he will be near the 4th magnitude star φ Aquarii.

Venus is not very well situated for observation during February. On the 1st she sets at 7h. 13m. p.m., or 2h. 23m. after the Sun, with a southern declination of 4° 4′, and an apparent diameter of 55″, $\frac{8}{100}$ths of the disc being illuminated, her brightness being little more than half what it was on January 11th. On the 10th she sets at 6h. 24m. p.m., with a southern declination of 3° 43′, and an apparent diameter of 60″, $\frac{2}{100}$ths of the disc being illuminated, and her brightness being only about one-fifth of what it was on January 11th. After this she comes too near the Sun to be visible. She is in inferior conjunction with the Sun on the 16th, and after this becomes a morning star, but still too near the Sun to be conveniently observed. During the first ten days of February Venus describes a short retrograde path in Aquarius, without approaching any very bright star.

Mars and Uranus are both, for the purposes of the amateur, invisible.

The minor planet Pallas comes into opposition with the Sun on the 15th, her distance from the earth being about 115 million miles. On the 1st her R.A. is 9h. $28\frac{3}{4}$m., southern declination 20° 20′. On the 15th her R.A. is 9h. $18\frac{1}{2}$m., southern declination 15° 39′. On the 28th her R.A. is 9h. 11m., southern declination 10° 11′. She will appear as a $6\frac{1}{2}$ magnitude star during February, and may thus be possibly visible to the naked eye in the absence of moonlight. During the month she describes a retrograde path in Hydra, without approaching any naked eye star.

Jupiter is the brightest object in the evening sky, but his diameter is perceptibly decreasing. He sets on the 1st at 2h. 12m. a.m., with a northern declination of 17° 28′, and an apparent equatorial diameter of 40·8″. He sets on the 11th at 1h. 36m. a.m., with a northern declination of 17° 42′, and an apparent equatorial diameter of 39·4″. On the 28th he sets at 8h. 40m. a.m., with a northern declination of 18° 14′, and an apparent equatorial diameter of 37·4″. He pursues a short direct path in Taurus during the month, but does not approach any naked eye star. The following phenomena of the satellites occur while the planet is more than 8° above and the Sun 8° below the horizon:—On the 1st an eclipse reappearance of the first satellite at 8h. 2m. 8s. p.m. On the 2nd a transit egress of the second satellite at 6h. 34m. p.m.; a transit ingress of its shadow at 6h. 48m. p.m., and a transit egress of the shadow at 9h. 10m. p.m. On the 4th an occultation reappearance of the third satellite at 5h. 53m. p.m.; its eclipse disappearance at 9h. 23m. 9s. p.m., and its eclipse reappearance at 11h. 6m. p.m. On the 6th an occultation disappearance of the first satellite at 11h. 59m. p.m. On the 7th a transit ingress of the first satellite at 9h. 9m. p.m.; of its shadow at 10h. 29m. p.m.; a transit egress of the first satellite at 11h. 22m. p.m.; an occultation disappearance of the second satellite at 11h. 49m. p.m. On the 8th a transit egress of the shadow of the first satellite at 0h. 42m. a.m.; its occultation disappearance at 6h. 27m. p.m., and its eclipse reappearance at 9h. 58m. 2s. p.m. On the 9th a transit ingress of the second satellite at 6h. 47m. p.m.; a transit egress of the shadow of the first satellite at 7h. 11m. p.m.; a transit egress of the second satellite at 7h. 11m. p.m.; a transit ingress of its shadow at 9h. 26m. p.m., and its transit egress at 11h. 48m. p.m. On the 11th an eclipse reappearance of the second satellite at 6h. 5m. 9s. p.m.; an occultation disappearance of the third satellite at 7h. 51m. p.m., and its occultation reappearance at 9h. 54m. p.m. On the 14th a transit ingress of the first satellite at 11h. 4m. p.m. On the 15th an occultation disappearance of the first satellite at 8h. 23m. p.m., and its eclipse reappearance at 11h. 53m. 55s. p.m. On the 16th a transit ingress of the shadow of the first satellite at 6h. 53m. p.m.; a transit egress of the satellite at 7h. 47m. p.m.; a transit egress of its shadow at 9h. 6m. p.m.; a transit egress of the second satellite at 11h. 50m. p.m., and a transit ingress of its shadow five minutes after midnight. On the 17th an eclipse reappearance of the first satellite at 6h. 22m. 57s. p.m. On the 18th an occultation reappearance of the second satellite at 6h. 8m. p.m.; its eclipse disappearance at 6h. 25m. 19s. p.m.; its eclipse reappearance at 8h. 41m. 27s. p.m.; an occultation disappearance of the third satellite at 11h. 54m. p.m. On the 22nd a transit ingress of the shadow of the third satellite at 7h. 27m. p.m.; its transit egress at 9h. 25m. p.m.; an occultation disappearance of the first satellite at 10h. 20m. p.m. On the 23rd a transit ingress of the first satellite at 7h. 30m. p.m.; a transit ingress of its shadow at 8h. 49m. p.m.; a transit egress of the satellite at 9h. 43m. p.m., and a transit egress of its shadow at 11h. 2m. p.m. On the 24th an eclipse reappearance of the first satellite at 8h. 18m. 47s. p.m. On the 25th an occultation disappearance of the second satellite at 6h. 22m. p.m.; its occultation reappearance at 8h. 17m. p.m.; its eclipse disappearance at 9h. 1m. 28s. p.m. and its eclipse reappearance at 11h. 17m. 52s. p.m. On the 27th a transit egress of the shadow of the second satellite at 6h. 25m. p.m.

Saturn is an evening star, rising on the 1st at 11h. 22m. p.m., with a southern declination of 7° 21′, and an apparent equatorial diameter of 17¼″ (the major axis of the ring system being 40·7″ in diameter, and the minor 10·0″). On the 28th he rises at 9h. 31m. p.m., with a southern declination of 7° 1′, and an apparent equatorial diameter of 18¼″ (the major axis of the ring system being 42·5″ in diameter, and the minor 10·1″). He is almost stationary in a barren region of Virgo during February.

Neptune is an evening star, setting on the 1st at 3h. 51m. a.m., with a northern declination of 20° 34′, and an apparent diameter of 2·6″. On the 28th he sets at 1h. 57m. a.m., with a northern declination of 20° 35′. He is almost stationary in Taurus during the month. A map of the small stars near his path will be found in the *English Mechanic* for November 29th, 1893.

There are no very well-marked showers of shooting stars in February.

The Moon is new at 9h. 45m. p.m. on the 5th; enters her first quarter at 10h. 43m. a.m. on the 13th; is full at 2h. 16m. a.m. on the 20th; and enters her last quarter at 0h. 28m. p.m. on the 27th. She is in apogee at 10h. p.m. on the 1st (distance from the earth 252,320 miles); and in perigee at 9h. p.m. on the 17th (distance from the earth 225,610 miles).

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solutions of Problem No. 6.

Author's Key-move—1. Q to Bsq.
Solved also by 1. Kt to B4ch.

Solutions of Problem No. 7.

Author's Key-move—1. Q to Kt8.
Solved also by 1. Q to B6ch, and 1. K to B8.

Here the "*Coquus*," sportively alluded to by the composer, is present with his attendant handmaid.

According to the published rules, duals do not score in either of the above problems.

Solution of Problem No. 8.

Key-move.—1. Q to R6.

If 1. . . . K × R,	2. Q to Q2ch.
1. . . . B moves,	2. R to K3ch.
1. . . . Kt × R or KtB7,	2. B × Pch.
1. . . . Kt elsewhere,	2. Q or R mates.

In this problem there is a dual short mate after three of Black's possible moves. If this dual had scored at all it would have scored as one dual and not as three. But it does not score for the following reasons. The published rule reads—"Marks will be awarded as follows: For each dual continuation (on the second move), one point." Now a "continuation" is something *between* the key and the mate; a move made after the key, with a view to a mate. A mate is the *end*, and cannot therefore be a "continuation." If it is urged that the rule quoted contains the words "dual continuation (on the second move)," the reply is that the words "on the second move," being in parentheses, are merely explanatory of the word "continuation," which, in a three-move problem, invariably occurs on the second move. The reason why dual short mates, and dual third-move mates, do not score is that every solver is presumed to be capable of seeing every possible mate in one move.

We may mention that a well-known expert, to whom we submitted the case in point, entirely concurs in our view of the matter.

Correct Solutions received from the following:—

Eighteen Points.—Semper, B. G. Laws, Guy.

Fifteen Points.—Kt. J., F. R. Adcock, W. T. Hurley, A. C. Challenger.

Twelve Points.—W. J. Jubb, Rascal, Buttercup, A. R., Chat.

Nine Points.—Alpha, Birkenbaum, H. Holmes, J. H. Christie, E. W. Brook.

Nos 6 and 7 correctly solved by L. Bourne and A Norseman.

T. E. Ewing.—The Knight must be lost. If for instance 23. . . . P to QR4, 24. Q to QB2, threatening mate. Or if 23. . . . B to R8, 24. P to B3, threatening the same continuation if Black defends the Bishop.

G. D. Crowther.—If 1. Kt to K7ch, K moves; 2. Q to B2, R × Kt, and there is no mate.

H. S. Brandreth.—In No. 7, 1. Kt to B6 is nullified by 1. . . . B to Q5.

L. Bourne.—In No. 8, 1. B × Pch comes very near. But have you looked at the reply 1. . . . Kt × B?

W. T. Hurley.—White must not postpone the mate even to obtain variety.

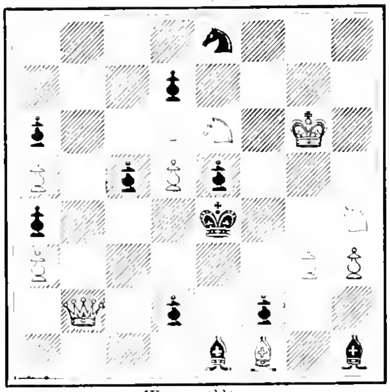
Leading Solvers' Scores.

Semper ...	36	Chat	29
B. G. Laws ...	36	Rascal	29
Guy	36	Buttercup ...	29
Kt. J. ...	33	W. J. Jubb	27
F. R. Adcock ..	33	Birkenbaum	25
A. C. Challenger ...	33	H. Holmes ...	25
W. T. Hurley ...	32	J. H. Christie ...	24
A. R. ..	29	A Norseman ...	22

Position No. 9.

"*Lieblich sind überstandene Mühen.*"

Black (11).



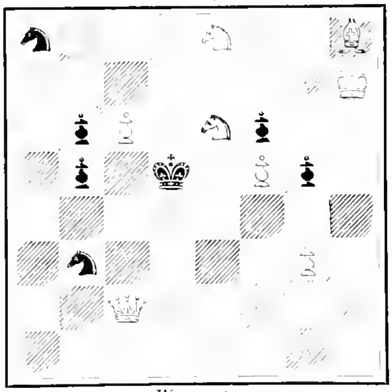
White (11).

White mates in three moves.

Position No. 10.

"*Nulli Secundus.*"

Black (7).



White (8).

White mates in three moves.

CHESS INTELLIGENCE.

A second tournament, closely following on that which resulted in Mr. Lasker's bloodless victory, was recently held at the Manhattan Club, New York. The players this time were all Americans with the exception of Herr Albin, who came out fourth. Mr. H. N. Pillsbury, of Boston, whose creditable performance in the previous tournament was anticipated in this column, took the first prize, Mr. A. B. Hodges being second, and Mr. J. W. Showalter third. Mr. E. Dalmar occupied an unaccustomed position at the bottom of the list of ten competitors.

The contests among the southern counties are exciting unusual interest this year. Sussex have defeated a weak Hampshire team, but lost to Surrey, who have also gained a decisive victory over Kent. The use of clocks is now enforced.

A very successful three days' "Chess Festival" was recently held at Hastings. Messrs. Bird, Blackburne, and Gunsberg all gave simultaneous performances, Mr. Bird coming out with slightly the best score. Three consultation games were also played, each of the three masters mentioned being partnered by members of the Hastings club. In these games Mr. Gunsberg had, perhaps, the best score, Mr. Bird being hardly in his best form.

Examples of Chess Master-play (Second Series), by C. T. Blanshard, M.A., is a well-arranged collection of seventy-six annotated games played by the masters and leading amateurs of all countries. English amateurs are well represented. Each game has a diagram, while the notes are taken from various sources. Short biographical notices of the players are appended, ranging in length from two or three words to eight lines in the case of a certain "eminent English theorist." The book is published at 2s. by Messrs. Simpkin, Marshall & Co.

Principles of Chess, by James Mason (Horace Cox, *Field* Office). Mr. Mason rivals Mr. Blackburne as a scientific exponent of the game of chess; as a scientific expounder of the game he has probably no equal in this country. The present handsomely bound volume of nearly 300 pages is published at the extremely low price of 2s. 6d. It is intended mainly for the learner, but there are few who cannot learn much from it.

Beginning with a description of the powers of the various pieces and the principles of playing them, the author proceeds to give numerous diagrams illustrating the way to take advantage of early mistakes. This is followed by a chapter on mates, and a comprehensive survey of the leading end-game positions. After a preliminary discussion on "attack" and "defence," fifty diagrammed middle-game combinations are shown; and here the author must be thanked for his thoughtfulness in placing the winning side, whether White or Black, next the reader. These combinations are all from modern match-play, and, though the names of the players are purposely withheld, many will recognize some of the positions. The openings, according to Mr. Mason's logical method, come last in order and perhaps least in importance. His plan is to illustrate the principal openings by means of annotated games, whole openings being sometimes most clearly and concisely explained in the notes to these games. We are glad to see that the author has included his own immortal Giuoco Piano with Winawer (1882).

The whole work is most original and suggestive, and if Mr. Mason may be considered by some to err in the direction of too much science, readers of Knowledge should be the last to find fault with him for this. Problems are the only department of the game (to beg the question) not represented in the book. But Mr. Mason does not consider that problems are Chess. We almost omitted to mention the excellent portrait of the author which adorns the volume.

Contents of No. 99.

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CONTENTS.

THE TENUITY OF THE SUN'S SURROUNDINGS.

By E. WALTER MAUNDER, *Sec. R.A.S., Superintendent of the Physical Department, Royal Observatory, Greenwich.*

IN trying to frame a satisfactory theory as to the condition of the sun, we meet a two-fold difficulty; we have so few facts to go upon, and yet, few as they are, it is difficult so to keep them before us as to give them their proper weight.

No fact is better known than that of the great distance of the sun from us, but how easy it is to forget the necessary consequence, viz., that the smallest portion of the sun's surface visible by us as a separate entity, even as a mathematical point, is yet really a widely extended area. We habitually use somewhat small apertures to observe the sun, or we cut down our object glasses by diaphragms in order to diminish the heat and glare. We therefore lessen the resolving power of the telescope, and as we are usually forced to content ourselves with low powers on account of the unsteadiness of the air during the daytime, the practical separating power of the telescope when used on the sun is of a lower order than it is under the best conditions upon stars. Bearing in mind, then, that a second of arc on the sun represents four hundred and fifty-five miles, it follows that an object one hundred and fifty miles in diameter is about the *minimum visibile* even as a mere mathematical point, and that anything that is sufficiently large to give the slightest impression of shape and extension of surface must have an area of at least a quarter of a million square miles; ordinarily speaking, we shall not gather much information about any object that covers less than a million.

Now this fact has an important bearing on some of our theories. We easily fall into the mistake of supposing that the most delicate details which we can see really form the ultimate structure of the solar surface; but it is not possible that they can do so. The finest granule, the smallest pore, as we see it, is only the integration of a vast aggregation of details far too delicate for us to detect; and the minute speck of brighter or duller material may, and probably does, contain within itself a wide range of brilliancy, not to speak of varieties of temperature, of pressure, of motion, and of chemical constitution.

This is the case when we are concerned with areas upon the solar disc; it is much more serious when we are dealing with sections of the sun's atmosphere—if the term "atmosphere" may be allowed—at and beyond the limb. The chromosphere, some eight seconds in depth, looks a narrow enough tire to the solar wheel, but its vertical depth is three thousand six hundred miles. We think of it as a homogeneous whole; but if the chromosphere be actually—as it appears to be, and as it has generally been regarded as being—a true solar statical atmosphere, an atmosphere of heated hydrogen, just as our own atmosphere is one of cool nitrogen and oxygen, how vast the range of varying conditions which are summed up to us in the smallest point that we can perceive of it. We know how in the case of our own atmosphere the pressure is reduced to one-half at a height of three and a half miles, to one-fourth at seven miles, to one-eighth at ten and a half miles, and so on. But the force of gravity at the surface of the sun is so much greater than at the surface of the earth, that, other things being equal, the density would double by a descent of a single furlong, and five miles would take us from a level where the density was only one hundred millionth of an atmosphere to where it exceeded that of solid platinum. And from the outside of the chromosphere to the level of the photosphere would involve a range, not seven hundred times as great as this, that is to say, in the proportion of the range from unity to seven hundred times a million million, but a range from unity to a million million to the seven hundredth power!

Of course it is clear that this is not a conceivable state of things, and the most natural course is to suppose that the heat of the sun is so great as to counteract the effect of the pressure of the upper layers of the atmosphere, and to render the unit of height something very different to that given above. Thus a temperature of 35,000° C. would suffice to bring us from a density of one hundred millionth of an atmosphere at the upper level of the chromosphere to a density no greater than that of mercury (at 0° C.) at its base.

This difference is, however, far too great a one to be accepted; but adopting it for the moment, what I wish to point out is the circumstance that the thin red circle of the chromosphere, which appears to us to be so truly homogeneous except at its upper surface, which seems to be a mere narrow line, scarcely to be called a band, would embrace atmospheric densities ranging over the whole of these tremendous differences. On the outside a density of only the one hundred millionth of an atmosphere; close to the sun a density equal to that of mercury. Yet we look at it and think about it as if it were substantially the same in character throughout.

Further, close to the apparent limb of the sun we get all these varying densities superimposed. We see the centre of the solar disc through a depth of three thousand six hundred miles of chromosphere; we see the limb through a depth of sixty thousand miles. When we pass beyond the limb we look through one hundred and twenty thousand miles of chromosphere, and every minutest point of light from the chromospheric region just outside the limb is the summation of every variety of density, from the rarest upper layers to the densest which rest on the photosphere itself. Indeed, since the chromospheric light which comes to us from close to the limb comes not only from the lowest but also from the highest strata, we might even assume that only the highest stratum had any real existence. A thin hollow shell, everywhere removed three thousand six hundred miles from the photosphere, would still *appear* to spring from the limb.

This fact, that it is the sum of a great number of superposed strata which are represented by a single point at the sun's limb, has a yet wider application. At the lowest stratum of the chromosphere we get the region of metallic vapours, which by their absorption give rise to the Fraunhofer lines of the solar spectrum, "the reversing layer," as it is commonly called. Above the chromosphere we get a region yielding faint lines of hydrogen, seen only during total eclipses. Above this we get the corona, properly so called, and above the corona we get those vast filmy extensions which Newcomb was able to trace to twelve solar diameters from the limb. We look through all of these whenever we scrutinize the sun's surface, and we see, not only that surface itself, but the integration of everything between us and it—reversing layer, chromosphere, prominences, cool hydrogen, corona, and streamers, and if there be anything beyond them, it too adds its quota to the general total. Yet, so little do these appear to be present, so little do they affect the distinctness of our view, that it requires a very distinct mental effort to realize, as we look at the chromosphere beyond the limb, that precisely the same layer lies over every point of the general disc. We have only to bear in mind the dimming and distorting effect of our own atmosphere, which, after all, in its total depth is only equal to five miles of air at the standard sea-level pressure, to be quite sure that all these various appendages have very little substance in them after all, or it would be far more difficult to photograph the solar spots and mottling than it is to map out the seas and continents of Venus.

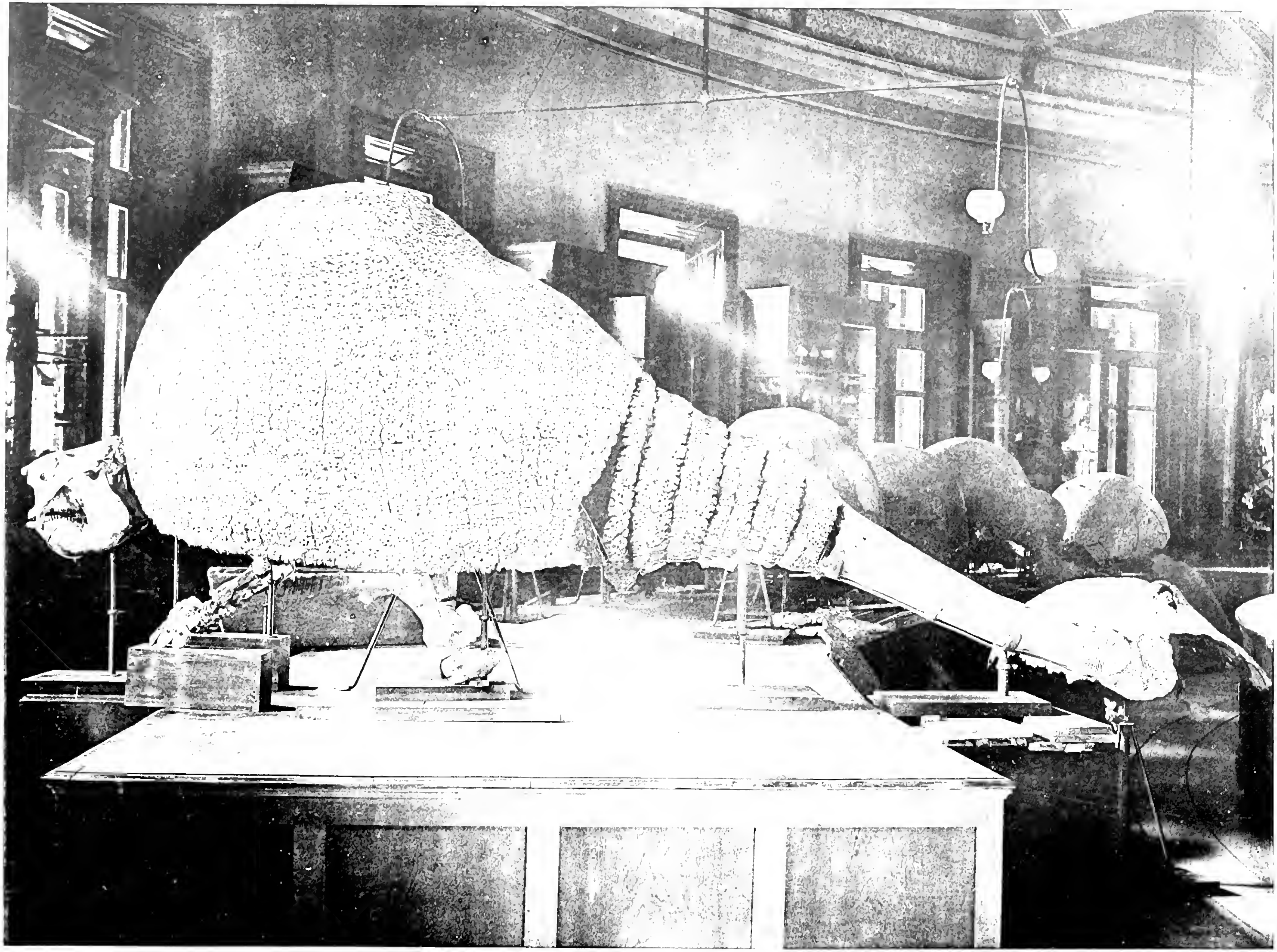
Indeed, it is not impossible that the amount of atmosphere above every square foot of surface of that planet may be actually greater than over a similar area of the sun. Glancing down the solar spectrum, we have no difficulty at all in picking out which are the densest and blackest groups of lines. Except for the two giants H and K—which stand, like Jachin and Boaz, at the gate from the visible to the invisible spectrum—and the probably fortuitous crowding of lines at G, the most prominent groups are those of oxygen, A, B, and α, or, in wet weather, the aqueous bands. In other words, the bands due to the influence of our own atmosphere rival or exceed those proper to the sun.

Just above I suggested, by way of illustration, a density for the chromosphere at its base equal to that of mercury, and at its summit of one hundred millionth of an atmosphere. Both these are inadmissible. The Fraunhofer lines of hydrogen are so narrow and sharp—F showing only a slight fringe—that we are certain they can only be produced at low pressure. One hundredth of an atmosphere would probably not be far from the mark, that is to say, about one millionth the density of mercury. But, on the other hand, the upper surface of the chromosphere is far too distinct, definite, and brilliant for so great a rarity as the hundred millionth of an atmosphere to represent its condition there. There are, then, only two alternatives; the one to assume a far higher temperature for the chromosphere than 35,000° C.—an assumption quite inadmissible on our present knowledge, for as we regard the photosphere as a condensation surface we are unable to adopt a temperature for it that would render carbon and silicon permanent gases—the other to adopt Mr. Ranyard's contention that we have not to do with a statical atmosphere in the chromosphere, but with molecules of hydrogen moving in free paths. We should probably require a temperature of fully 140,000° C. to give us a statical atmosphere, the base and surface densities of which would, in the least, fit in with the observed facts of the case. And the total amount of gas above every square foot of the solar surface would only be about five and a half times that above the same unit on the earth.

Outside the chromosphere we meet with a region of less brilliant hydrogen some seven minutes in depth. If the idea of a chromospheric atmosphere must be rejected, much more must we reject that of a coronal atmosphere. In any case even two hundred thousand miles depth of hydrogen fails to produce absorption lines in the solar atmosphere to surpass those which our own shallow envelope can produce. We may accept it as certain that the extensions which lie above this inner corona are much more attenuated, and that to find an adequate comparison for them we must not refer to mists or fogs, but to the unsubstantial phenomena of cometary tails and streamers. To speak, as some have done, of the corona as if it were an important part of the sun, and therefore to regard the solar diameter as amounting in reality to so many millions of miles, is about as absurd as it would be to regard the edge of a Channel fog as the veritable coast-line of England.

Apart from the failure of the corona to give any substantial evidence of its existence by selective absorption, or by any markings which we can distinctly recognize as coronal when seen projected on the disc of the sun, the fact of the low density of the sun as a whole is a strong argument against ascribing any appreciable density to its surroundings. Its mean density is but one quarter of that of the earth, even if we suppose that it is entirely comprised within the photosphere; or to put it another and better way, only about one thousand one hundred times that of air. If, then, we imagine the corona and chromosphere to contain any great amount of matter—above all, if we imagine a real solar atmosphere extending some considerable distance above the photosphere—we lower the mean density of the part of the sun below that level, and at the same time, by thus setting up an appreciable surface pressure, we render it more difficult to understand how it is that, with the enormous solar gravity and a radius of four hundred and thirty thousand miles, the mean density does not exceed what we are able very easily to produce in our terrestrial laboratories.

If the amount of matter above every square foot of the solar photosphere were equal to that above the same unit of the earth's surface, then the total mass of the sun's surroundings would bear one twenty-seventh of the ratio to the mass of the sun that our atmosphere does to the earth. Probably this is under the mark, but on the other hand, we can scarcely suppose there is twenty-seven times the amount of matter to the unit of surface, as this would render the reversing layer and the chromosphere far denser than we can imagine. On the whole, then, the entire system of the sun's appendages, chromosphere, prominences, corona, and streamers, probably do not form so important a part of the sun, so far as their total mass is concerned, as our atmosphere does of our own world; whilst they are, relatively, distributed over a much greater extent of space.



THE SKULL, LIMB-BONES, AND EXTERNAL ARMOUR OF THE CLUB-TAILED GLYPTODONT. About one-fifteenth the size of nature.

From a photograph taken in the Museum of La Plata. During life the animal was covered with a sparse coating of bristles, which came through the holes in the plates of the carapace, and seem to have been as thick as a porcupine's quill, while they were probably several inches in length. The oval, depressed, rough discs at the end of the tail carried during the existence of this Glyptodont, huge horns, probably very like those of an African Rhinoceros. Just behind the extremity of the tail is seen the carapace of another Glyptodont with a crater-like aperture [illegible] long row of carapaces belonging to other genera of the [illegible]

THE MAILED MONSTERS OF ARGENTINA.

By R. Lydekker, B.A.Cantab.

AMONG all the extinct mammals of the Argentine, none strike the beholder with more astonishment than those gigantic cousins of the modern armadillos of South America, collectively known as glyptodonts; their name being derived from the peculiar sculpture with which the grinding surfaces of their molar teeth are ornamented. In a previous article, entitled "Armadillos and Aard-Varks," we have already considered the leading characters of the great order of edentate mammals, of which the whole of the typical representatives are characteristic of South America, although a few of the extinct species wandered into North America during the Pleistocene period. We have likewise pointed out how the armadillos and their allies differ from the other members of the order, and have likewise made some mention of the glyptodonts themselves. There are, however, such great differences between the various kinds of glyptodonts, which are subdivided into several genera, that the group will well repay special investigation; and, indeed, no adequate conception of the extinct fauna of the "Land of Skeletons" could be given without devoting a separate article to these most curious animals.

As we have already pointed out elsewhere, both armadillos and glyptodonts differ from the other members of the order to which they belong in having their bodies protected by a bony shell or carapace, covering all but the under parts; the top of the head being covered by a similar bony shield, while the tail is encased in a series of bony rings, or in rings at the base and a long tube at the tip. Whereas, however, the armadillos (exclusive of the aberrant pichiciago, described in the article referred to) have a larger or smaller portion of the middle region of the carapace formed of movable transverse bands of plates, in the glyptodonts the whole structure is welded into a single piece. It must not, however, be supposed that this carapace consists of a single solid dome of bone, as, if it did, there would, of course, be no possibility of growth. On the contrary, the carapace, as shown in the beautiful figure taken from a photograph of the external skeleton of the largest member of the group preserved in the museum at La Plata, is composed of a number of polygonal or rhomboidal plates articulating together at their edges, and thus allowing of free growth. In very old individuals a considerable number of these plates may, however, become completely fused together. During life these bony plates were covered with small horny shields, as in the living armadillos; and they frequently show incised lines formed by the lines of union between such shields. For instance, in the members of the typical genus of the group, or ring-tailed glyptodonts, each bony plate was smooth and polygonal in shape, while the lines indicating the borders of the horny shields take the form of a rosette. Another important point of difference from the armadillos is to be found in the contour of the skull, which is short, deep, and rounded, instead of being long, flattened, and pointed at the muzzle. Then again, whereas the armadillos have small cylindrical teeth, those of the glyptodonts are large, and fluted at the sides, with their grinding surfaces marked by the aforesaid sculpture; while the whole series is in close contact, and forms one of the most efficient grinding machines imaginable. To support the enormous weight of the carapace, which in some of the larger kinds is considerably more than an inch in thickness, special

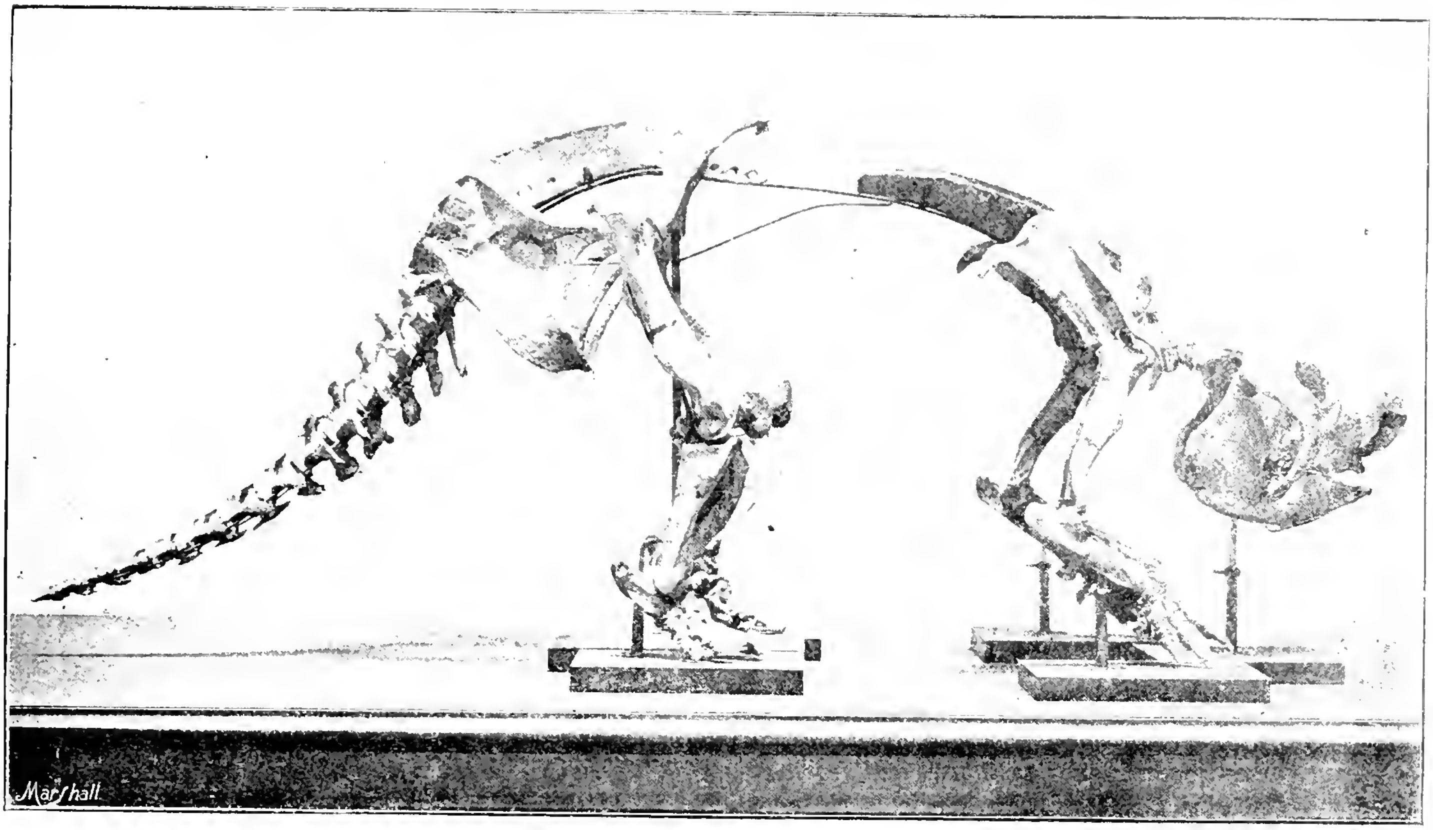


Fig. 1.—Internal Skeleton of the Smooth-tailed Glyptodont.

modifications are needed in the internal skeleton. Here we find, for instance, as shown in the foregoing figure, that nearly the whole of the vertebræ are welded together, so that a large portion of the back-bone forms a continuous solid tube. The vertebræ of the neck are also very short, and may be partially united, so that the movements of the head must have been somewhat limited. The reader will not fail to notice also the great strength and upright position of the haunch-bones, and the powerful build of the legs and feet; the latter terminating in five toes, armed with broad flattened nails. As an illustration of the various modifications of the same general plan of structure in use in the animal kingdom, it may be well to point out how essentially the arrangement of the armour of a glyptodont differs from that of an ordinary tortoise or turtle. In the latter the carapace is completely welded to the ribs, which are situated externally to the haunch and shoulder bones; whereas in a glyptodont there is no sort of connection between the carapace and the ribs, while the latter are internal to the haunch and shoulder bones. In these respects the leathery turtle holds a somewhat intermediate position between ordinary turtles and the glyptodonts, the carapace being composed of polygonal plates totally unconnected with the ribs, while the latter are situated externally to the bones of the shoulder and haunch.

Not less remarkable are the modifications of the vertebræ of the tail for the support of the rings or tube with which the latter is encased. In the first place, most of the vertebræ of this region are welded together so as to form a hollow tapering rod; while from each segment are given off radiating processes upon which the bony plates are borne, and as the whole of the latter are firmly welded together, the entire structure is of great strength.

When standing with the edges of its impenetrable carapace resting on the ground, its mail-crowned head partially withdrawn within the front aperture of its shell, and only the lower portions of the limbs exposed, a glyptodont must have been safe from all foes save savage man, and even he must have had a tough job to slaughter the monster, if indeed he ever succeeded in doing so. That man did exist with the later glyptodonts, or those which flourished during the deposition of the Pampean mud, is, however, proved by more than one kind of evidence. For instance, crude drawings of these animals have been found incised on some of the rock-surfaces of Patagonia, while in other cases human implements have been disinterred side by side with the bones and shells. Probably the empty carapaces of the larger members of the group were employed by the primitive inhabitants of Argentina as huts, and it is said that they are sometimes even so used at the present day by the Indians. That these animals were not killed off by any living foe—either human or otherwise—may be taken for granted; and we must therefore conclude that this result was probably due to the unknown causes alluded to in the first of this series of articles as having brought about the extermination of the larger Argentine mammals. It may be well to mention that although some of the living armadillos are carnivorous, it is perfectly evident from the structure of their teeth that all the glyptodonts subsisted exclusively on a vegetable diet.

The earliest known representatives of the group occur in the older Tertiary beds of Patagonia, and may be designated pigmy glyptodonts, although they have received the uncouth name of *Propalæhoplophorus*. These creatures, which lived side by side with armadillos nearly akin to existing forms, were the dwarfs of their race, the carapace not being more than a couple of feet in length. The plates of the carapace were smooth and ornamented with a rosette-like sculpture, of which the central ring in the fore part of the shell was raised into a prominent boss. In the form of these plates, as well as in the circumstance that the tail was surrounded from base to tip with a series of knobbed rings, these pigmy glyptodonts resembled the ring-tailed glyptodonts of the pampas, of which they may accordingly be regarded as the ancestral type. In the intermediate deposits of Monte Hermoso we meet with other glyptodonts which, while much larger than those of the Patagonian beds, were generally inferior in this respect to the giants of the Pampean; some of the species being nearly allied to the small Patagonian representatives of the group, while others belong to the same genera as those found in the pampas.

Passing on to a survey of the leading types of these creatures found in the alluvial mud of the pampas, where they occur in great numbers, we may first notice the one to which the name of glyptodont was originally applied. The carapace in this form is characterized by the polygonal plates being nearly smooth and marked by a rosette of incised lines, while those along the margin are raised into a series of bold knobs. In general contour the whole carapace forms a nearly regular oval dome, while the plates on the back of the head were knobbed and ridged. Although in the specimen first sent to England the tail of another species was unfortunately affixed to the carapace, it is now known that the armour of the tail took the form of a number of rings, gradually diminishing in diameter from the root to the tip, and severally ornamented with a series of conical knobs, thus forming a protective case against which little short of a steam hammer would have been of any avail.

Although one might have thought that these ring-tailed glyptodonts, as they may be conveniently termed, were sufficiently large and *bizarre* to have stood alone in the world, they were exceeded both in size and strangeness of form by the extraordinary creature of which the external skeleton is represented in the accompanying plate. In this stupendous monster, which measured upwards of eleven feet eight inches in a straight line, the carapace is characterized by its peculiar hump-backed form, while its margins lack the prominent knobs characterizing those of the preceding group. On closer examination it will be found that each of the component plates of the carapace, instead of being polygonal and marked by a rosette of lines, is rhomboidal and pierced by from two to five large circular holes. From the analogy of the living hairy armadillo—known in Argentina by the name of peludo, or hairy animal—it is quite evident that during life the holes in the plates of the carapace of the extinct monster, which, by the way, may be known as the "club-tailed glyptodont," or technically as *Dœdicurus*, must have formed the exits of large bristles, which were equal in diameter to a cock's quill, and were doubtless many inches in length. The whole body of the animal must, therefore, have resembled a gigantic porcupine. Still more extraordinary is the conformation of the huge tail, which had a length of about five feet. At its base this appendage was encircled by about half a dozen double bony rings, nearly as large at the base as the iron hoops in the middle of an ordinary beer-barrel; their component plates being pierced by the aforesaid holes for bristles. The whole of the terminal half of the tail is formed by one continuous piece of hollow bone, which, if we exclude whales, is one of the most massive bony structures in the animal kingdom, and is almost as much as a man can lift. Starting at its base in the form of a nearly cylindrical tube, this sheath rapidly expands at the sides and becomes flattened on the upper and lower surfaces, until at the tip it finally assumes the form of a depressed flattened club, which would have formed a most efficient weapon for a giant. Along the sides of its extremity this club is marked by a number of oval depressed discs, showing a sculptured pattern of ridges and grooves radiating from the centre, and some of them attaining a length of six or seven inches. From the structure of their sculpture it is quite evident that during life these discs must have formed the bases of huge horns projecting at right angles to the tail, which must thus have formed a veritable *chevaux-de-frise*. If, as is quite probable, these horns were as long as those of the common African rhinoceros, the tail of the dædicurus must have presented a most extraordinary appearance as it dragged on the ground behind its owner (for it is impossible to believe that any muscles could have raised such a stupendous structure). The use of these horny appendages is, however, hard indeed to divine, since the creature was amply protected by the underlying bone; and it is therefore probable that they must come under the category of ornamental appendages. Be this as it may, with its bristle-clad body and horned tail, the club-tailed glyptodont may well lay claim to the right of being the most extraordinary-looking creature that ever walked this earth during the whole duration of the Tertiary period. Another species belonging to the same genus, of which the remains are found in the Tertiary beds of Monte Hermoso, is remarkable for possessing a cone-shaped aperture in the middle of the hinder part of the carapace, of which the only conceivable use is that it acted as the point of discharge of a gland.

Nearly equal in size to the Pampean representative of the preceding genus, but distinguished markedly by the characters of the skull and the more regularly dome-like form of the carapace, is another monster from the pampas which has been described under the name of *Panochthus*. Although the plates of the carapace have the same oblong form as in the club-tailed glyptodont, they lack any perforations for bristles, and are marked by a number of patches of minute tubercles, so that this species may be spoken of as the tuberculated glyptodont. Doubtless the carapace was covered during life by thin horny shields, although the marks of these are not generally shown on the bone; and from the absence of bristles the creature must have been as smooth as the small existing mulita, or three-banded armadillo. The tail was much smaller than that of the club-tailed species, consisting at the base of a number of relatively small rings, and terminating in a tube of about a yard in length. This tube lacks, however, the terminal expansion and flattening of that of the preceding form, while the large discs with which it is

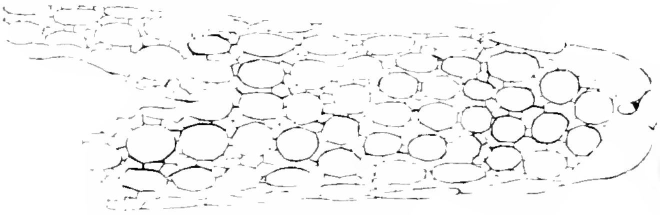


Fig. 3.—Terminal tube of the tail of the Smooth-tailed Glyptodont.

ornamented take the form of prominent rough bosses, which probably carried flattened horny knobs, instead of spines, during life.

The last representatives of the group to which we shall allude are much smaller species from the deposits of Monte Hermoso and the pampas, which may be known as the smooth-tailed glyptodonts, or technically, *Hoplophorus*. In these creatures the carapace was much more elongated and depressed than in the other kinds, while it projected forward on the sides of the shoulders in a manner somewhat like that of the armadillos. The plates of the carapace show a rosette pattern, not unlike that of the ring-tailed glyptodonts, but they are still smoother, and of an irregular oblong shape. As regards the tail, this consisted at the base of a number of smooth rings, fitting into one another at their junctions like the joints of a telescope; while at the end it terminated in a slightly flattened tube ornamented with a number of small, smooth, oval discs of about an inch in diameter, interspersed with which were arranged a few much larger but equally smooth and prominent discs along the sides. These discs of all dimensions were evidently coated with smooth scales of horn during life; and from the absence of apertures for bristles, the same smoothness doubtless characterized the carapace. The head was protected by a smooth shield of small tesselated plates; and the skull, as shown in our figure of the skeleton (Fig. 1), is characterized by the peculiar twisting and curvature of the bones of the nose.

Such are the chief characteristics of the better known representatives of the mailed monsters of Argentina—a group which was continued in a straight line from the pigmy glyptodont of Patagonia to the ring-tailed species of the pampas, while all the other giant forms of the latter must be regarded as lateral offshoots from the original stock, which continued, as is so often the case, to develop more and more *bizarre* characters until the date of their final disappearance. In conclusion, we must not omit to mention that a strange gigantic armoured creature, found commonly in the cavern deposits of Brazil, and also rarely met with in Argentina, seems to have been a kind of connecting link between the glyptodonts and the armadillos, having the carapace formed of a number of movable plates, arranged in a series of overlapping bands as in the latter, but with teeth of the type of the former. Unfortunately, however, this interesting creature, which must have been as big as a large rhinoceros, is known by such fragmentary remains that its full affinities cannot yet be determined, as we are still ignorant whether its skull approximated to the glyptodont or the armadillo type.

STINGING INSECTS.—II.

By E. A. Butler.

(*Continued from page 43.*)

At the close of our last paper we dealt briefly with the aculeate Hymenoptera, the sole representatives of the first of the four groups into which we divided "stinging" insects, for no others possess the true vengeful sting; we may now further consider the same group. In connection with what was said of the inability of bees to withdraw their stings when they have pierced such a yielding substance as soft leather or india-rubber, a correspondent has pointed out that the same disability rests upon wasps, but that these differ from bees, so far as his experience goes, in lacking the power to tear themselves away as a bee would do, leaving the sting behind. In fact, the wasp that has ventured to employ its sting in this way is completely trapped, and the writer states that he found the only way to liberate a prisoner so detained was to cut off its sting.

The accompanying plates, which represent the stings of the hornet and honey bee, are from photographs taken by Mr. T. E. Freshwater, and lent by Messrs. Newton and Co., of Fleet Street. The original photographs were obtained from microscopic slides, and therefore represent the objects crushed flat so as to secure suitable transparency for microscopic examination. In consequence of this crushing, the lancets in the hornet's sting have escaped from the grooved dart within which they are ordinarily concealed. But there is an advantage in this, for the backward-bent barbs at their tips have thus become very distinctly visible, and make it easy to understand the difficulty of withdrawing the sting from the wound. The two hair-beset feelers would, under natural circumstances, lie by the sides of the dart, where they serve the purpose of investigators of the surface on which the puncture is to be made. In this figure only the external part of the sting is shown, and this can be plunged into the wound as far as the point where the diameter of the dart suddenly increases. In the bee's sting, which may be compared with the figure of a wasp's sting in our last number, the lancets have retained their natural position, but their outline can be traced within the hollow dart: their long, slender ends can then be followed through the pouch-like thickening at the base of the dart until they curve round at the top and communicate with the levers, which appear as dark bars to the right of the pouch. The muscles by which this complicated mechanism is worked have been dissolved away so as to render the framework more distinct. From the head of the pouch-like enlargement, the delicate membranous tube which conveys the poison to the sting can be traced between the lancets and the levers. It leads into the poison bag, the whole of which is present and appears as a rounded body at the upper part on the right. The secreting tubes, which elaborate the poison and supply it to this receptacle, have been removed, as have also the feelers. When not in use, the whole of the apparatus shown in both these figures is withdrawn into a cavity between the terminal plates of the body, and nothing of it can be seen from the outside.

There is no doubt that a good deal of difference exists as to the readiness with which the different kinds of bees and wasps will resort to the use of the sting. Amongst the humble bees it has been noticed that the subterranean builders are far more irascible than those that construct nests above ground, and the most fiery-tempered of them all is the great red-tailed species (*Bombus lapidarius*), the big females of which will inflict a severe sting upon anyone who incautiously interferes with their quarters. Even amongst the same species, the readiness to bring the weapon into requisition varies with the temperature and other climatic circumstances, as well as with the nervous condition of the insect. That the creatures have "moods," and that these affect their pugnacity, is well shown in the record Sir John Lubbock has given of the adventures of a tame wasp he kept for nine months. It was not a true *Vespa*, nor indeed an English species at all, but a kind called *Polistes gallica*, which Sir John had obtained in the Pyrenees. He says: "I had no difficulty in inducing her to feed on my hand, but at first she was shy and nervous. She kept her sting in constant readiness; and once or twice in the train, when the railway officials came for tickets, and I was compelled to hurry her back into her bottle, she stung me slightly—I think, however, entirely from fright. Gradually she became quite used to me, and when I took her on my hand apparently expected to be fed. She even allowed me to stroke her without any appearance of fear, and for some months I never saw her sting." It is pathetic that the good mutual understanding thus established could not be prolonged into another season; but notwithstanding the greatest care taken on the human side, the rigours of the English winter proved too much for the constitution of the creature that had been born under sunnier skies. Paralysis set in, and soon the last record had to be penned, that "she could but move her tail, a last token, as I could almost fancy, of gratitude and affection."

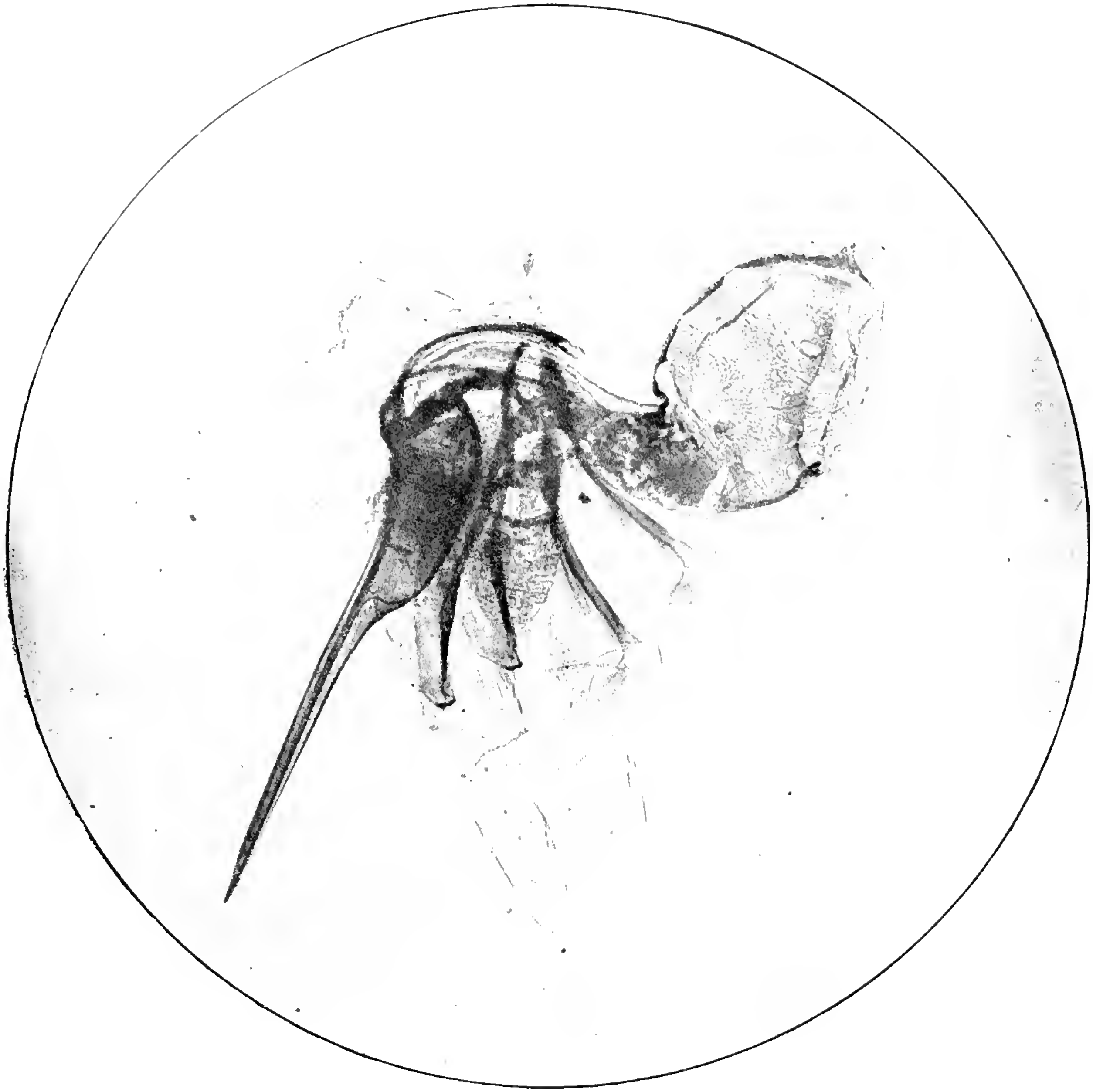
The aculeate Hymenoptera might be roughly divided into three sections, according to the nature of the food; first, those that are purely vegetarian in diet, viz., the bees; second, those that are omnivorous, viz., the ants and social wasps; and third, those that are distinctly carnivorous, viz., the solitary wasps and fossores. It has already been pointed out that this last group are excellent hunters, whose armoury consists of jaws and sting. Some of them manifest remarkable patience and skill in the search for provisions wherewith to anticipate the wants of their expected brood; in fact, it has been suggested that there may be distinguished amongst them species that, by long use, have brought their predatory practices to such a pitch of perfection that the pursuit and conquest of their prey has almost assumed the characteristics of a fine art, while others are still comparative bunglers at the work. A numerous section of this group consists of very active insects with an abdomen which is usually red, while the rest of the body is black; they hunt down spiders, which in some cases are considerably larger and heavier than their captors. M. Ferton has recorded in the *Transactions of the Linnæan Society of Bordeaux* a number of observations which he has made upon the habits of these insects, the *Pompilidæ*, and we give below some of the most interesting cases. It should be remembered that spiders also have a supply of poison, which is poured out through their jaws, so that in all contests between them and the *Pompilidæ* the advantage is not all on one side, but there are risks to be encountered by both parties. Nevertheless, the fly, although often the smaller of the two, is usually the braver.

Some of these *Pompilidæ* go boldly into the lairs of those spiders that construct such abodes, instead of waiting for a chance passer by, or hunting in the open. In such cases the spider seems usually to recognize that it has met with its match, and endeavours to escape as quickly as possible. M. Ferton relates of one species, which hunts a kind of spider that lives in a burrow closed by a stone, that the fly removes the stone, boldly enters the burrow, and slays the spider, afterwards dragging out its carcase and conveying it to its own nest. In another instance a Pompilid was seen digging vigorously at an isolated tuft of grass; suddenly it ceased its exertions and a spider was seen crawling cautiously up one of the grass stalks, and trying to escape by jumping from one to the other. Immediately the wasp was after it, prudently keeping, however, at arm's length, till at last the spider, having reached the edge of the grass-tuft, and apparently recognizing that it would stand no chance on the open ground with its pursuer close behind it, gave itself up for lost, threw itself to the ground, packed its legs up close to the body, shamming death, and awaited its fate. The wasp darted down upon it and gave it a couple of stings in the most vulnerable part, and all was over. Sometimes the sting was not sufficient to kill the prey, and then the legs of the spider were often bitten off by the wasp, lest there should be undesirable struggles on the way home. M. Ferton sometimes rescued the spider after it had been stung, and endeavoured, in some cases successfully, to resuscitate it. In one instance the spider was at first quite motionless, but after two hours it began to show signs of life, and, gradually regaining its powers, was by the next day fully recovered. It was noticed that an endeavour was always made to inflict the sting in the

STING OF HORNET, showing Dart, Lancets with Barbed Tips, and Feelers.

Enlarged from a Photograph by Mr. T. E. Freshwater. The scale of amplification is the same as that employed for the Bee's Sting on the opposite page.

Direct Photo Co., 9, Barnsbury Park, N.



STING OF WORKER BEE, showing Dart containing Lancets, Levers, and Poison Bag.

Enlarged from a Photograph by Mr. T. E. Freshwater.

Direct Photo Co., 9, Barnsbury Park, N.

centre of the under side of the prey. There is a good anatomical reason for this; in this position is placed the central mass of the nervous system, and a sting so directed as to pierce that important apparatus would no doubt at once produce paralysis, while similar wounds inflicted elsewhere would be followed by less serious results.

These are certainly marvellous facts, and indicate an amazing degree of sagacity on the part of the insect. But this is just the characteristic for which the aculeate Hymenoptera, as a body, are, above all insects, celebrated; indeed, it is in this group that insect intelligence reaches its highest grade of development. Numerous instances of similar skill and perseverance have been recorded by English observers, and especially by Mr. F. Smith, one of our earlier historians of these insects. Amongst other records may be noted some curious facts which he gives about one of our commonest fossores, *Mellinus arvensis*, a shining black-bodied insect with yellow bands (Fig. 4), which provisions its nest with various kinds of Diptera. He says: "It is amusing to see four or five females lie in wait upon a patch of cow-dung, until some luckless fly settles on it; when this happens, a cunning and gradual approach is made. A sudden attempt would not succeed, the fly is the insect of quicker flight; therefore, a degree of artifice is necessary. This is managed by running past the victim slowly, and apparently in an unconcerned manner, until the poor fly is caught unawares and carried off by the *Mellinus* to its burrow." A similar device is adopted by prettily variegated, but small, species belonging to the genus *Oxybelus*. When the first fly has been deposited, an egg is laid; the necessary number of victims are then soon secured, and the mother's task is complete. But the matter is not always so simple; there is the instability of the English climate to be reckoned with, and this may upset the calculations and multiply the anxieties of even these lowly creatures; for, as Mr. Smith adds, "sometimes she is interrupted by rainy weather, and it is some days ere she can store up the quantity required." A larva which was found feeding became full-fed in ten days; in that time it devoured the softer parts of six flies—the heads, the harder parts of the bodies, and the legs being the parts left untouched.

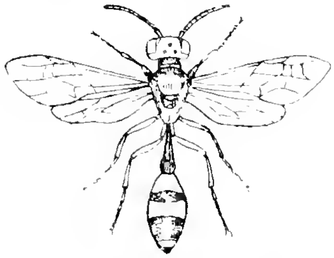


Fig. 4.—*Mellinus arvensis*. Magnified three diameters.

The same indefatigable observer, who spent many years of his life in gaining a knowledge of the habits of the aculeate Hymenoptera, records of a certain colony of a jet black fossor (*Trypoxylon figulus*) which preys upon spiders, that they had very sensibly constructed their burrows in a bank of light earth just under a hawthorn hedge which was tenanted by large numbers of small spiders; the hunters had therefore only to rush out of doors and flit up into the hedge in order to accomplish the task of provisioning with the least possible expenditure of time and energy. When the prey is small and gregarious, it will be captured in a wholesale manner; thus Mr. Smith states of another black species (*Pemphredon lugubris*), that he has seen the female "settle on a rose-tree, and scraping a number of aphides into a ball, fly off with it, carrying it in front of its anterior legs and under its head." One of our largest and most local species (*Philanthus triangulum*), a black and yellow insect, actually preys upon bees, using whatever kinds happen to be most abundant in the neighbourhood of its nest, but showing a preference for the hive bee. It is a bold-looking creature, but very slow to use its sting upon human kind, although it has no difficulty in overpowering the bees that constitute its prey. These it catches by lying in wait amongst the flowers they frequent, and pouncing on them as they are intent on gathering honey. Seizing the bee with its jaws between head and thorax, it at once inflicts a sting in the abdomen and thus renders its victim powerless; then grasping it tight with jaws and legs, it flies off with its burden to its nest.

One of the most curious of the solitary wasps is that called *Eumenes coarctata*. Like the rest of its tribe, it is black, with yellow bands, but it may be at once distinguished by the long, thin stalk that attaches the strongly pear-shaped abdomen to the thorax. This curious insect constructs little globular cells of mud on the stalks of heath plants. Each cell is the residence of one larva only, and is provisioned with small caterpillars. Others of the solitary wasps, belonging to the genus *Odynerus*, burrow into banks, and arrange at the entrance of the burrow a sort of cylindrical vestibule, made of fragments of the surrounding soil; it thus appears as a tube projecting from the mouth of the burrow, and curving downwards (Fig. 5). If the burrow be traced to its end, cells will be reached, which, when opened, display piles of half-dead caterpillars stored up for the young. Mr. T. R. Billups once found a colony of one of these insects at Chertsey, the entrance tubes of which were about an inch and a half long. On opening one of the cells he found a truly bountiful provision, testifying to great industry on the part of the collector; as many as thirty-three small caterpillars of moths, and four of saw-flies, all reduced to a semi-animate condition by the stings they had received, composed the lavish stock of this little larder.

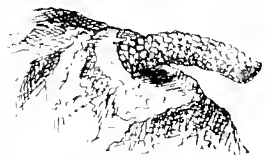


Fig. 5.—Tubular entrance to nest of *Odynerus*.

Notwithstanding their stings, the fossorial Hymenoptera and solitary wasps have to suffer much at the hands of parasites; ichneumon flies, golden wasps, and a set of dipterous flies (*Tachinidæ*), shaped rather like blue-bottles, make more or less havoc amongst their larvæ. Mr. J. E. Fletcher records having found in a damaged willow tree a pile of small cocoons crowded together in a small space. From a portion of this pile which he took home he bred twenty-seven examples of a black fossor (*Crabro leucostoma*), together with an ichneumon fly and a dipterous fly belonging to the above family. As the cells of the *Crabro* had been provisioned with small and delicate long-legged flies, of a family quite distinct from that of the parasites, the relics of four different kinds of insects had thus become associated in one spot, thereby affording to anyone who might find the collection after the insects had deserted it, an interesting zoological puzzle to determine the mutual relations of the different members of the company. Such associations of heterogeneous remains are sometimes brought about by the practice that some of these insects adopt of taking possession of the abandoned burrows of other insects, instead of putting themselves to the trouble of excavating their own. Thus Mr. Douglas records having found examples of the above-named *Trypoxylon* in the burrows of one of the bark-boring beetles we recently described. Spiders had been stored in the burrows as food, and one of the golden wasps was also present as a parasite upon the *Trypoxylon*. But in addition to these, another species of *Trypoxylon* had also made its home there, as well as a little solitary bee: so that in this one spot there were evidences, in one way or other, of the presence of no less than half a dozen different sorts of creatures, an association in large degree accidental, but still full of perplexing complications to anyone who was not familiar with the habits of the different members.

It is not always abandoned burrows that are thus appropriated by indolent excavators; sometimes burrows that have just been made by one species will be captured by another, though it usually requires some diligence and perseverance, as well as courage, to retain possession of a site thus surreptitiously gained. For example, a *Trypoxylon* was found frequenting the holes in a post which had been pre-occupied by one of the solitary wasps of the genus *Odynerus*. The little black invader had begun to lay in a stock of provisions in the shape of a small round ball containing about fifty aphides. The legitimate proprietor of the burrow, on her return, seized the pellet, and, flying out with it held between her legs, dropped it about a foot away from the entrance. The *Trypoxylon* again picked up her luggage and replaced it, but on the return of the wasp it was again turned out, and this continued several times, till, the wasp being absent longer than usual, the *Trypoxylon* had time not only to replace the obnoxious parcel, but also to cement up the entrance of the burrow. The *Odynerus* was thus checkmated, for though she repeatedly returned to the spot, she made no attempt to force an entrance through the barricade, but finally departed in search of more peaceful quarters.

We must now pass to the second of our groups of stingers, which comprises such other hymenopterous insects as are able to prick the skin, but not to make a painful wound, since no poison accompanies the puncture, and the effects are of the most transient description. Under this head come only certain members of the great group of ichneumon flies, and we may therefore dismiss them with but a brief notice. As before, it is only the females that possess the boring implement. Its structure is, in general plan, similar to that of the sting of bees and wasps, but there is no poison gland. There are two side pieces which act as a sheath, and a central barbed borer. The purpose of the instrument is, in general, to pierce the bodies of insects so that eggs may be inserted beneath the skin, for the ichneumon flies are, in their early stages, internal parasites, and their larvæ, which are fat maggots, devour the contents of the bodies of their hosts, in such a way, however, that no vital parts are touched till there ceases to be any necessity to prolong the life of the doomed victim.

The boring weapon is usually more or less visible outside the body, and is sometimes extremely long. A very long ovipositor usually implies that the host lives in rather inaccessible places, which the ichneumon itself cannot reach, as is the case, for example, with those insects that inhabit tunnels which they have excavated in the trunks of trees. In such cases the ovipositor can be passed in at openings which are too small to admit the body of the ichneumon itself, or it may even make an entrance for itself by being worked through the wood. The prey can thus be reached, and the eggs deposited in the proper situation. Even in English species this boring and egg-laying machine may be much longer than the body: one is now before me in which the body is half an inch long, while the ovipositor extends for nearly an inch beyond this. But from Japan comes the record of a species of Braconidæ which has the body three-quarters of an inch long, while the boring weapon attains the extraordinary length of six and three-quarter inches! The ichneumons with long ovipositors are not the ones to use them on human kind; the instrument is too flexible and too blunt to be used with any effect on the human skin. But some of the larger kinds that have very short ovipositors can give a sharp prick, which causes one to drop them immediately under the impression that a real sting has been received. However, the sensation is only momentary, and no lasting effect is produced.

(To be continued.)

THE SACRED WATER OF MECCA.

By C. A. Mitchell, B.A.Oxon.

Through the kindness of Lady Burton, I have been enabled to make an analysis of some of the water which the late Sir Richard Burton, disguised as a pilgrim dervish, brought back from Mecca in 1853.

The Zem-Zem Well, according to tradition, is the Well of Hagar, and is used for no other purpose than drinking and religious ablution. Each pilgrim to Mecca is anxious to drink and bathe in the water, but as there is not sufficient for all, the following device is adopted:—One Arab, standing on the wall of the well, draws the water up and pours it over the pilgrims as, stripped to the waist, they advance in turn. As it pours over him each drinks what he can, and the remainder runs down, soaking through the loin-cloth, back into the well, to be used again on succeeding pilgrims. If this practice has been continued day after day and year after year, it is not surprising to find that the water is very rich in chlorides, and that it contains a large quantity of solid matter in solution.

Sir Richard Burton described the water as extremely nauseous in its taste, and resembling a strong dose of Epsom salts. This observation is borne out by the analysis, which shows that magnesium sulphate (Epsom salts) is an important constituent. Its use is said to produce boils and other unpleasant results, and should the well happen to become infected with cholera germs, a far-reaching epidemic is the probable result. Large quantities of the water are exported from Mecca to other Mahommedan countries, and those who drink it are believed to acquire the facility of speedily learning Arabic.

The sample analyzed was contained in two small tin bottles which were hermetically sealed, and which had remained untouched since they were brought from Mecca. Together they contained about half a pint of the water. On opening them there was a slight evolution of gas, and the water within was found to contain a quantity of beautiful silky crystals in suspension, and a few earthy particles settled at the bottom. On examination these minute crystals proved to be a compound of tin, which had been formed by the long-continued action of the water on the interior of the tin bottles. These foreign matters being filtered off, there was left a clear colourless liquid with a slight smell, which was more perceptible on warming. No trace of tin could be found dissolved in the water.

In judging as to the fitness of a water for ordinary use, the chief points to be determined are the amount of solid matter left on evaporating a certain definite quantity, the amount of chlorine present in solution, the hardness, and the amount of free ammonia and ammonia in combination with animal or vegetable matter (*i.e.*, albuminoid ammonia).

As a general rule, waters which contain less than forty grains per gallon of solid matter in solution are not condemned if the other points are satisfactory. The method of determining this solid residue is to evaporate a definite quantity of the water in a platinum dish, and to weigh the residue, from which result the amount per gallon is calculated. The amount of solid residue left on thus evaporating some of the Zem-Zem water corresponded to two hundred and nineteen grains per gallon—a quantity characteristic of a strongly saline water.

Since chlorine (in combination with sodium as common salt) is one of the substances given off from the skin, its presence in water in any large quantity is an indication of probable sewage contamination. Should a water be found to contain as much as nine grains of chlorine per gallon, it would be looked upon with strong suspicion, although, if the well or spring from which it was taken should happen to be situated near a salt bed, the chlorine might be derived from that source. The amount found in the Zem-Zem water, viz., sixty-nine grains per gallon, whether derived from the soil or, as is highly probable, from the skins of the Arab pilgrims, condemned it absolutely.

The hardness was determined by a method devised by the late Dr. Clarke, and known as "Clarke's soap test." It consists in adding a solution of pure soap, of which the strength is known, to the water, until a permanent lather is produced. Each successive portion of soap solution added corresponds to a definite quantity of carbonate of lime, or its equivalent of other salts, dissolved in the water. As no lather can be produced until the soap has neutralized the whole of the lime or magnesia in the water, we can estimate very rapidly the hardness in this way. This is usually expressed in degrees, each of which corresponds to one grain of carbonate of lime per gallon. Thus, to say a water has fifteen degrees of hardness means that it contains constituents which produce the same degree of hardness that fifteen grains of carbonate of lime per gallon would do. The Zem-Zem water had forty-three degrees of hardness—about three times that of an average water.

The quantity of albuminoid ammonia is one of the most important data in estimating a water. A good water should not contain as much as ·1 part of ammonia in a million of water. The quantity of albuminoid ammonia in the Zem-Zem water, viz., 2·2 parts in a million, was characteristic of sewage effluent, and confirmed the conclusion already arrived at from the estimation of the chlorine.

Prof. Crookshank was kind enough to make an exhaustive bacteriological examination of some of the water, but was unable to find any trace of living organisms. The water was sterile, as might well be expected after its having been hermetically sealed and in total darkness during forty years.

The following were the quantities of some of the principal constituents of the water :—

	Grains per gallon.		Grains per gallon.
Silica	3·0	Potassium ...	24·3
Aluminium ...	·8	Ammonium ...	5·3
Calcium	·5	Chlorides ...	69·3
Magnesium ...	6·6	Sulphates ...	30·7
Sodium	38·3	Nitrates ...	19·9

SEWER GAS AND ZYMOTIC DISEASE.

By A. C. Ranyard.

THE fear, amounting to terror, lest we should breathe a whiff of sewer gas, has had potent and far-reaching influences on modern life. What is known as Sanitation has increased by leaps and bounds during the last quarter of a century, until the dread of sewer air has become a factor in legislation sufficiently powerful to procure the passing of Acts of Parliament that materially modify the rights of Englishmen; and yet most of the theories of the so-called Sanitary Science have been arrived at by the deductive method, which seriously led astray the pioneers of thought when groping after the first discovered laws of the physical sciences.

Perhaps the theory which has been most fruitful in causing a lavish expenditure on sanitary appliances (the fashions of which change almost as rapidly as the fashions in feminine head-gear) is the theory that sewer gas is heavily charged with the germs of disease. It is founded on two assumptions, both of which have been received as self-evident. The first assumption is that sewage matter swarms with the germs of disease; and the second is that the micro-organisms living in sewage matter can rise into the air with the effluvia or smell from sewage, and are carried wherever the sewage smell can be detected. To the more thoughtful there seemed to be a difficulty in supposing that micro-organisms could be carried into the air by evaporation. But the difficulty was quickly met by the theorists, who suggested that bubbles of gas *must* rise from the sewage sludge, and that such bubbles on bursting would project minute globules of liquid into the air, and the minute globules might carry the dangerous micro-organisms. The theory was ingenious, it was easily understood and was widely adopted, and the logical and natural consequences of panic and legislation followed. The public is not so deficient in the power of making logical deductions as it is deficient in the critical faculty which should lead us to test by experiment the axioms we too readily accept as self-evident.

It was not till 1883 that experiments were made by M. Miguel in the Paris sewers to determine the number of micro-organisms per litre of sewer air as compared with the number of similar organisms in the air above ground. He found an average of from 0·8 to 0·9 per litre in the air of the sewer under the Rue de Rivoli, in the neighbourhood of the point where the sewer joins the large collector of the Boulevard Sébastopol; and he states that the organisms in the air of the Rue de Rivoli may in summer exceed in number the organisms in the sewer air by five or six times, whereas in winter the ratio may be reversed.

Then followed a series of investigations on the subject, undertaken by Drs. Carnelly and Haldane, who made observations in the main sewer of Westminster Palace and in various sewers in Dundee. The general results they arrived at were that—

1. The carbonic acid gas in sewer air is about twice as much, and the organic matter about three times as much, as in the outside air at the same time.

2. The number of micro-organisms is less in sewer air than in the outside air at the same time.

3. The quantity of carbonic acid, organic matter, and micro-organisms in sewer air is less than in the air of naturally ventilated schools, and, with the exception of organic matter, it is less than in the air of mechanically ventilated schools.

4. Sewer air contained a much smaller number of micro-organisms than the air in any class of house they had investigated.

During the last year and a half, Mr. J. Parry Laws has been occupied on a series of experiments made on behalf of the London County Council in the sewers of the Metropolis. The first sewer experimented upon was that known as the King's Scholars Pond sewer, which runs in a straight line under the Green Park from Piccadilly on the north to the Buckingham Palace Road on the south. It was constructed some one hundred and twenty years ago, and has therefore been in use long enough, as

Mr. Laws remarks, to become contaminated in every possible way. One important peculiarity of this sewer is that no lateral sewers or house drains enter it from one end to the other, and that it is freely ventilated to the air of the park. In length it is about three hundred yards; it is barrel-shaped, about eleven feet high and nine feet wide, and is ventilated by open gratings in the crown of the sewer. These open gratings could be closed for the purposes of experiment, and sewage matter could be poured through them at various distances from the experimenter, so as to imitate as nearly as possible the splashing and disturbing effect of matter entering a sewer from a house at a known distance. A wooden staging was erected across the sewer, near to one of the entrances, from which the experiments were made.

Mr. Laws adopted the following process for determining the number of micro-organisms in the air. A known quantity of air was aspirated through a sterile tube, containing two sterile plugs composed of powdered sugar and glass wool. These plugs, which filter the air, were, after the completion of the experiment, transferred to two circular cultivating plates covered with nutrient gelatine in a liquid state; after careful mixing with a sterilized platinum needle, the gelatine was allowed to solidify by cooling. Each organism, therefore, becomes fixed, and if capable of growing in the medium it forms a colony, which, after the lapse of four to six days, is evident to the naked eye. In almost every case the colony consists of a pure growth of one species only. These colonies were examined microscopically, and re-sown in sterile cultivating tubes, containing nutrient gelatine or agar-agar, for further study.

In a report to the London County Council, recently issued, Mr. Laws gives a list of the micro-organisms detected by him in the air of the sewer above-mentioned as well as in the air of other sewers. All the micro-organisms tabulated by him belong to the class known as non-pathogenic—that is, they are harmless bacteria—and, with one exception, they are species commonly found in air and water.

He says: "There are two points with reference to the organisms in sewer air to which I wish to call special attention—firstly, the absence of bacillus *coli communis* and *micrococcus ureæ*, two organisms which must be present in sewage in immense numbers; secondly, the almost entire absence of any organisms capable of very rapidly liquefying gelatine, the only exceptions being the common hay bacillus (*bacillus subtilis*) and a micrococcus mentioned in my first report. In sewage, on the other hand, a large number of organisms, for the most part bacilli, possess this property of very rapidly liquefying gelatine."

In the splashing experiments conducted in the King's Scholars Pond sewer, Mr. Laws found that when the splashing was sufficiently violent to produce a very fine state of division of the sewage, organisms from the sewage were occasionally carried to a distance of from fifty to sixty yards; but, as a general rule, there is comparatively little draught in the sewers, and the particles are carried no great distance, and quickly subside again into the sewage at the bottom, or are caught on the wet walls of the sewers, and Mr. Laws found that, as a general rule, a decrease in the number of organisms in the fresh air above ground was followed by a decrease in the number of micro-organisms in the sewer air.

These experiments entirely sweep away the theory that zymotic diseases are spread by micro-organisms carried by sewer air. It may be regarded as demonstrated beyond dispute, that certain kinds of micro-organisms invariably accompany certain diseases, and reproduce similar diseases when introduced by inoculation into the bodies of men or animals, even after one or more generations of such organisms have been grown in sterilized media. So that such diseases must be produced by the micro-organism, and not by any organic matter or product of putrefactive decomposition allied to the dangerous class of poisons known as ptomaines.

But as far as infection by micro-organisms is concerned, it seems that the sewer rats have more reason to complain of our ventilating their homes with the bacteria-laden upper air than we have to complain of infection by micro-organisms carried by sewer air into our streets and houses. In a matter of such great importance, involving risks of life, and—what is even of more importance—involving the healthy condition, happiness, and working power of millions, we must proceed with all scientific caution, and must not conclude without prolonged further investigation that sewer air is not injurious. It may have an indirect effect in lowering our vital power and rendering us more liable to the attacks of micro-organisms derived from other sources.

We have at present very few accurate statistics to go upon, but general observations seem to show that the men who work in sewers are not more subject to zymotic diseases than other classes of the community—in fact, they seem to be rather less subject to them—and the children of the sewer-men, who live at the outfall works and who spend a great deal of their playtime upon the ventilating grids of the sewers, seem to be very healthy little creatures. As far as I can learn, there has been no recent outbreak of zymotic disease amongst them, while the rest of London has been passing through a long period of feverish anxiety, and the permanent hospitals and temporary fever hospitals have been crowded to overflowing with infectious patients.

I have made what inquiries I can from Mr. Laws, and others who have come into contact with workers in sewers, to find what precautions the sewer-men take before they eat their dinners. I am informed that much of their work involves the plunging of their hands into offensive-looking sludge, but it is only the more fastidious of them who carry a rag or a handful of cotton waste in their pockets, with which they give their hands a rub before they sit down to eat. The rest, perhaps, give their hands a rub on their trousers or coat, and set to work at their food at once, without carefully cleaning their nails, or washing their hands with disinfectants, as a doctor would think necessary under similar circumstances, and yet these men are comparatively healthy, and, if anything, are less subject to zymotic diseases than their neighbours. Such facts would almost lead one to doubt whether our theories as to infection by sewage, and our dread of a whiff of sewage air, may not be as mistaken as the superstitious belief of the savage in the protecting power of his amulet, or as unfounded as his terror of the evil eye.

But we must proceed cautiously if we wish to follow the scientific method, and must remember (as Mr. Charles Booth, the present President of the Statistical Society, forcibly pointed out in a very interesting address, delivered in November last, on the results of the census of 1891 with regard to the statistics of life and labour in London), that the results which the statician offers us need to be very carefully analyzed before we dare to found extensive theories upon them. To form a sure foundation for reasoning by the inductive method, we need a series of

* "Report to the Main Drainage Committee of the London County Council on Sewer Air Investigations, by J. Parry Laws, F.I.C. Steel and Jones, 4, Spring Gardens, S.W. Price 6d.

simple experiments which can only be interpreted in one way; but the results which the statician offers us are frequently the outcome of many causes acting concurrently. It may be that sewage poison has but little effect on those who live an active and out-of-door life, while on the town-liver and the sedentary worker it produces a depressing effect, which predisposes him to the attacks of zymotic disease. It is certain that the small amount of organic matter in sewage air is easily detected by the nose, and with some a strong smell of decomposing animal matter will even leave a taste in the mouth, which may be detected for hours or even days; this is especially the case with those who are not accustomed to such effluvia.

Mr. Laws found that the amount of carbonic acid gas in sewage air is, on the average, a little more than double that which is generally to be found in the upper air. What may be called the normal quantity of carbonic acid gas in the upper air is ·04 per cent. Mr. Laws found that in the King's Scholars Pond sewer the amount of carbonic acid gas varied from ·044 as a minimum to ·1604 as a maximum, and that the average quantity was ·0918 per cent. But this quantity of carbonic acid gas is not sufficient of itself to produce unpleasant effects when breathed. Dr. Angus Smith states that he found ·1 per cent. in the air of a well-ventilated soda-water factory in Manchester, and it was believed to produce no bad effects on the workers. But, as Messrs. Harold Wager and Auberon Herbert show in a little book recently published by Messrs. Williams and Norgate, entitled "Bad Air and Bad Health," when in a crowded room the amount of carbonic acid gas arising from respiration reaches ·08 per cent. the air becomes disagreeably close, and an unpleasant odour is experienced which gives rise to headaches. They believe and endeavour to show that this is caused by the organic impurities expired from the lungs; but the residual differences which give rise to the remarkably different physiological effects of the bracing air of mountains and the seaside, as compared with the close air of cities, remains almost as much a mystery as it was to the early chemists, who could detect no sensible difference on analysis.

M. Ch. Féré, who has written a remarkable work on the "Pathology of the Emotions," has brought together many facts tending to prove that the emotions have an intimate connection with liability to infectious diseases. He quotes some curious statistics with respect to the facility with which weak-minded persons succumb to acute diseases, and endeavours to prove that depressing emotions have an action on the development of tuberculosis, phthisis, and especially on puerperal infection—his theory being that the depressing emotions have an action on the development and healthy activity of the leucocytes or white globules, whose chief mission is to protect the organism against the invasion of microbes.

The following is the sort of evidence referred to: M. Hervieux, resident medical officer of a lying-in hospital, made notes as to the effect of the moral emotions on puerperal infection, and found a large number of cases in which young women, in a fair way towards recovery, had taken a chill and become mortally ill after a visit or untimely reproaches from their mother or relatives, or after the agitation or perplexity occasioned by their resolving to abandon their child—unfortunate girls, till then doing well, falling ill on carrying out the resolution and succumbing in a short time.

If fear plays a part in the spread of zymotic disease, it is evidently important to sweep away any superstitious dread of conditions which may not really be dangerous. With the spread of sanitary appliances there has been a wide spread of sanitary theories, some of which are evidently no better than depressing superstitions. The improved sanitary conditions have generally brought with them an increase of light, cleanliness, and ventilation, but they have been working concurrently with the depressing influence of the fear of an unseen enemy—sewer air—which was believed to bear with it deadly microbes.

The following figures, taken from the fifty-fourth annual report of the Registrar-General, published in 1892, show how little the effect of these sanitary improvements, working concurrently with such depressing superstitions, and the increasing strain of modern life with its trains and telephones and social discontent, has been upon the number of deaths from zymotic disease, though the number of deaths from all causes, per million of the population per annum, has steadily decreased from 1858 to 1890.

Annual Death Rates from Various Causes to a Million Persons living in Groups of Years from 1858—1890.

Cause of Death.	3 Yrs 1858-60	5 Yrs 1861-65	5 Yrs. 1866-70	5 Yrs. 1871-75	5 Yrs. 1876-80	5 Yrs 1881-85	5 Yrs 1886-90
From all Causes	22221·3	22582·0	22424·6	21932·4	20790·0	19103·4	18905·4
Small Pox	219·3	218·6	104·8	470·8	78·4	79·4	13·2
Measles ...	480·0	456·6	428·4	373·2	384·8	413·0	468·4
Scarlet Fever ..	891·0	982·4	959·8	758·6	679·6	435·8	240·6
Typhus				81·4	34·2	22·8	6·6
Enteric Fever	792·9	921·8	849·8	375·8	277·2	216·0	179·2
Simple and Ill-defined Fever				140·2	69·2	34·2	16·6
Whooping Cough	494·3	515·8	545·0	498·6	527·0	458·6	443·6
Diphtheria	372·3	247·6	126·8	120·8	121·8	156·2	169·6
Other Miasmatic Diseases	75·7	46·0	59·6	25·4	18·2	17·0	45·6

Science Notes.

There appears to be some probability of the ultimate extinction of india-rubber-producing trees. It is proposed to preserve existing forest and thickets, and to require that collectors working a grove should plant, at the same time, a certain number of trees. It is also stated, in a paper by Dr. Ernst on this subject, that the primitive and wasteful method of evaporating the juice over a wood fire is still extensively practised, instead of the improved processes now known. It would not only be a public inconvenience, but possibly even a severe hindrance to certain branches of scientific work, if an india-rubber famine were to occur.

The discovery of a fault in south-west Cornwall has been prophesied by Mr. Charles Davison on the strength of the phenomena of the Cornwall earthquakes of May, 1892. He would infer that the fault will run east and west, and slope to the south. Such a fault is not shown on the geological survey map of the district. Mr. Davison is of opinion that these shocks are the last dying movements of the series of changes in relative level which have resulted in the formation of the English Channel. A cursory glance at the survey map of the region, however, will incline the reader to the view that the general direction of the faults in Cornwall is north-west and south-east rather than parallel with the Channel axis, as this view would seem to require.

THE STOCK DOVE.

By Harry F. Witherby.

The Stock Dove (*Columba œnas*) is so called on account of its habit of building in the stocks of trees. Once, it was erroneously supposed that our domestic pigeons sprung from this bird, and hence some thought it had thus acquired the name of Stock Dove. It frequents woods and coppices, and does not seem to mind what sort of trees they are composed of. The Stock Dove is often confused with the Rock Dove (*C. livia*), a bird very much like it in colour and general appearance, but widely differing from it in its habits.

The Rock Dove is probably the species from which all our domestic pigeons are derived. It is an inhabitant of rocky places on the sea coast, and frequently builds in companies in caves; it is especially common in Scotland, where the Stock Dove is rarely seen. Unless in very exceptional circumstances, the Rock Dove and the domestic pigeon do not roost or even settle in trees, and in this both differ from all other members of the pigeon tribe.

Stock Doves. Male on the left. Female entering nest.

Again, the Rock Dove may always be distinguished from the Stock Dove and other wild pigeons by a patch of white feathers on the back, just above the tail: a distinguishing mark which is apparent in most varieties of the domestic pigeon.

The Stock Dove is very local in its habits, being plentiful in some districts and scarce in others. In England it is not found far north, but is common in certain localities of Norfolk; and the same may be said of its occurrence in most of the midland counties. It is also common in some places in Hampshire and other southern counties. In certain parts of the country it remains all the year round, while in others it is migratory, leaving its breeding haunts about the end of October.

The nest, if a collection of sticks may be so termed, is usually placed in a hole of an old or pollard tree. The height of the hole from the ground varies considerably, a hole not more than five or six feet up being sometimes chosen, whilst at others it is often as many as sixty feet from the ground. The same place is very often resorted to year after year, and the nest is thus gradually increased in size.

I have seen one in a hollow tree, which consisted of a mass of sticks some three feet deep; and on the top of this a Stock Dove was sitting on two eggs, going in and out through a hole on the east side of the tree. On the south side of the tree, and about a foot below the Stock Dove, was another hole in the tree. Here, in a cavity formed by some of the sticks having fallen away, a Tawny Owl (*Strix aluco*) was sitting on her eggs. Taking a stand below where the Owl was sitting, and looking up through a crevice, the Stock Dove could be seen on her nest above. This strange partnership was the more remarkable as the Stock Doves feed their young in the day, while the Owls are abroad at night. Both pairs went about their duties peaceably, and did not seem inclined to molest each other.

In the open country of Norfolk the Stock Dove lays its eggs in deserted rabbit burrows, about a yard from the entrance, often not making any nest, but laying on the bare ground. It also occasionally builds under very thick furze bushes.

It rears two broods in the year, the first eggs being laid at the end of March or beginning of April. The eggs are usually two in number, but occasionally three are found. They are pure white, very much like those of the Wood-pigeon, but somewhat shorter. The birds sit very closely during incubation, both taking their turn on the nest; the young are hatched in about seventeen days. When about four or five weeks old, they are considered a great delicacy. If reared from the nest they become very tame in captivity.

The food of the Stock Dove consists of buds, young green leaves, seeds of plants and trees such as acorns and beech-mast, and grains of various sorts. They may often be seen feeding with Wood pigeons, and in the autumn and winter many join the flocks of these birds and cause great devastation in the cornfields.

The flight of the Stock Dove is exceedingly rapid, and when driven from its nest it comes out of the hole with a rush, and beating its wings together once or twice with a loud noise, it dashes swiftly away.

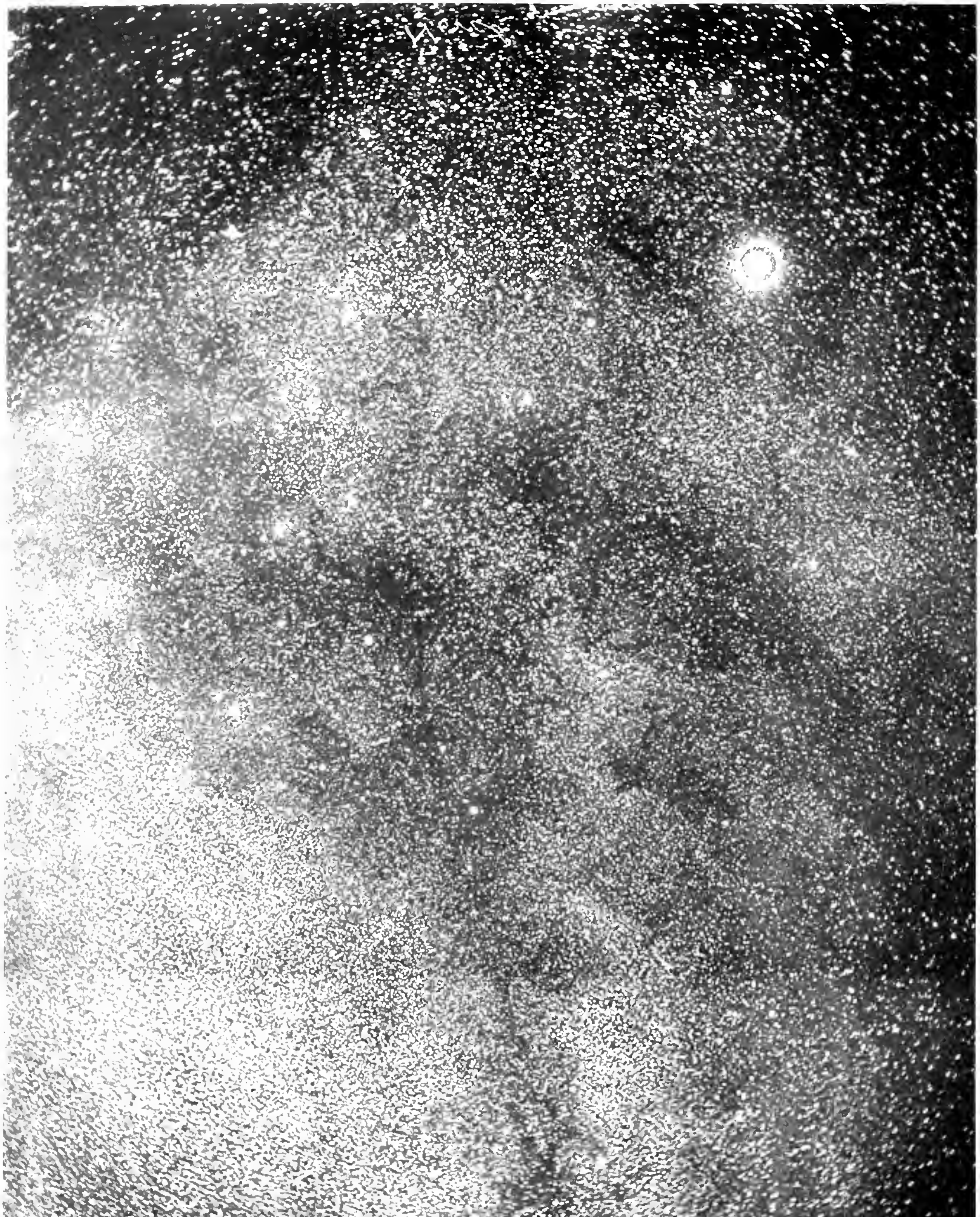
The note of the Stock Dove is a simple "coo-oo-oo," the last syllables being more prolonged than the first.

The length of fully-grown male birds is about one foot two inches, and their stretch of wing is about two feet two inches.

The head and crown are bluish-grey, the back of the neck being of the same colour, whilst the sides of the neck are of glossy iridescent green and claret colour. From this claret colour on the neck it derives its Latin name *œnas*, from οἶνος—wine. The breast is a purple-red, shading off downwards to bluish-grey. The back is bluish-brown above

NORTH.

EAST.



WEST.

THE MILKY WAY IN THE CONSTELLATION CEPHEUS.

From [illegible] at the Lick Observatory by Mr. E. E. Barnard with a camera of 6 inches aperture and 31 inches focus. Exposed [illegible] hours on October 13th 1893 from 8h. 20m. to 15h. 20m., Standard Pacific Time. Scale of this plate — 1 inch equal to about 1°.5[illegible]. The large star in the upper right hand corner is α Cepheus.

EAST. SOUTH. WEST.

THE MILKY WAY IN THE CONSTELLATION CEPHEUS, showing the nebulous region and dark structures which are traceable on a smaller scale on the opposite page.

This plate corresponds with the central region of the opposite plate, but the photograph has been enlarged about $2\frac{1}{3}$ diameters, and has been printed so as to show fainter nebulosity.

and bluish-grey between the wings, while the tail coverts are grey. The tail and wings are bluish-grey, shading off to a leaden-grey.

The female, as is the case with most of the pigeon family, is smaller and less brilliant in colouring than the male; but otherwise she resembles her mate. Young birds, before their first moult, have not the beautiful metallic tints spoken of above on their necks.

THE STRUCTURE OF THE MILKY WAY.

By A. C. Ranyard.

The beautiful photograph of the Milky Way in Cepheus, reproduced in our plates, will well repay very careful study. The plate on the left hand will bear examination with a magnifying lens, and if there still remain any readers of Knowledge who are sceptical as to the actual existence of dark structures in the Milky Way, they will find ample evidence in this plate to convince them of the existence of narrow streams and branching tree-like structures of semi-opaque material, which evidently acts like a fog in space, cutting out the light of the bright nebulous matter on which the dark structures are seen superposed—evidence which, if thoughtfully studied, must completely satisfy the objectors who have rather hastily advocated the theory that the dark channels and tree-like structures may be explained as accidental interspaces between bright nebulous clouds.

The plate on the right hand has been made on an enlarged scale (about two and one-eighth diameters) from the central region of the photograph represented in the opposite plate. It has also been treated so as to bring out with greater contrast the gradation of faint tints, so that some of the long lines of stars and associated dark channels are more strikingly exhibited in the enlarged picture than in the smaller but sharper reproduction of Mr. Barnard's original photograph.

I will ask the reader to devote a little time to the careful examination of both of the large plates of the region reproduced in Fig. 1. Close to the bottom edge of Fig. 1, over the words "a little," is a narrow dark channel which leads into a large dark area, within which a few isolated stars are sprinkled. From this dark area spring several branching dark structures. The most notable of them is one which reaches nearly to the top of the block in Fig. 1. From it there spring several small dark branches or expansions of the main stream on either hand. There are at least three such expanding heads, or opposite pairs of branches, one above the above. I would ask the reader to compare it with the great branching structure in the Orion nebula, referred to later on. This is not by any means the only dark branching structure which springs from the large dark area shown in Fig. 1. Another series of dark branching channels may be traced springing from the upper part of the dark area on the left hand. They branch in a complicated manner, and mostly end in expanded heads. There are also some narrow, dark, branching channels which run into the nebulosity on the left-hand side of the dark area.

Fig. 1.—Region a little to the right of the centre on the enlarged plate, and a little below the line joining the words "East" and "West" on the opposite plate.

It will be seen that all the linear dark channels and dark structures branch or fork in a direction away from the dark area, and it seems difficult to resist the conclusion that we have evidence here of streams of dark nebulous or semi-opaque matter, which have been projected from the dark region into a surrounding resisting medium. I would ask the reader to compare this region with the region of the Milky Way in Sagittarius, shown in the photographs reproduced in the January number of Knowledge for 1893. In each case we seem to have a black area, from which dark structures radiate into surrounding bright nebulosity, and it will be remembered that we found a similar radiation of dark structures from the larger dark region in Sagittarius shown in Knowledge for December, 1891, and discussed on page 232.

In the enlarged plate, several narrow dark channels, associated with lines of stars, will be recognized running in undulating lines nearly horizontally across the plate. One of the most striking of these runs through a small dark area to the south of the dark area shown in Fig. 1. This dark channel, like most of the others, is very narrow and intensely black, and runs in a wavy line nearly from one side of the page to the other. It cannot be reasonably suggested that such a dark channel is merely the interspace between two bright nebulous areas, for such a theory would involve the assumption that both of the bright nebulous areas have irregularly curving edges which accurately fit into each other, leaving everywhere the same breadth of narrow interspace between them. The chains of stars running parallel with the dark channels also bear witness to their having a physical existence, and not being due to a mere effect of perspective.

Several such dark channels are to be found in this region of the Milky Way. One runs horizontally from *a* to *b* across the middle of the region comprised in Fig. 2, but it is best shown on the larger plates and on the glass transparencies sent by Mr. Barnard. In this region there are several minute dark channels alineated with stars, which branch away from the annular dark channel. Many of them can be recognized in Fig. 2.

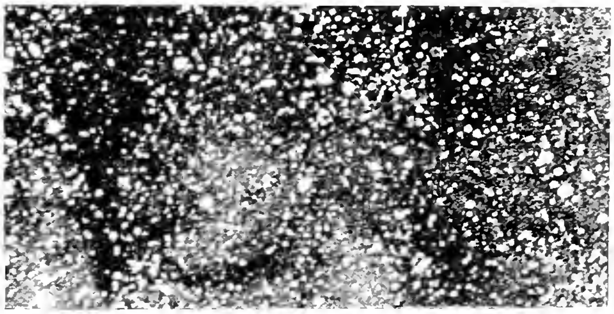


Fig. 2.—Region to the north of that shown in Fig. 1, showing bright nebulosity surrounded by a dark channel.

In trying to interpret the vast phenomena presented to us by the Milky Way, we must in the first instance note facts, and where we can recognize them we must carefully note analogies; and though the structures which have been photographed in comets, in the corona, and in the Orion nebula are probably on a diminutive scale compared with those presented to us in the Milky Way, it is interesting and may be very useful to note analogies between them.

In Swift's comet (see photographs in Knowledge for December, 1892) and in Brooks' comet (see the plate in the last number of Knowledge) we seem to have evidence of a series of tree-like and branching structures rising one above the other. In this region of the Milky Way (see Fig. 1) we have a somewhat similar series of tree-like structures one above the other, apparently arising from the same trunk or stream of outflow. Fig. 3 is a key diagram to the plate showing the structures on the eastern side of the Orion nebula. In the great branching structure which seems to spring from the eastern side of the dense quadrilateral mass of nebulosity surrounding the Trapezium, one tree-like form seems to rise above another, as if they belonged to successive outbursts that were being carried along in a stream flowing outward from the Trapezium region. If this is not the case, and there is any analogy between the prominence-like forms *b*, *c* and *d* (see index diagram, Fig. 3) and solar prominences, we must suppose that *b*, *c* and *d* have all been projected from different centres of explosion. But the cometary branching structures, which we naturally assume all come from the nucleus or head of the comet, seem to afford an explanation, or at least to throw some light upon the process by which such structures could take their form while passing through a resisting medium near or around the seat of explosion, and might afterwards be carried away in a stream as the matter of a comet's tail is carried away.

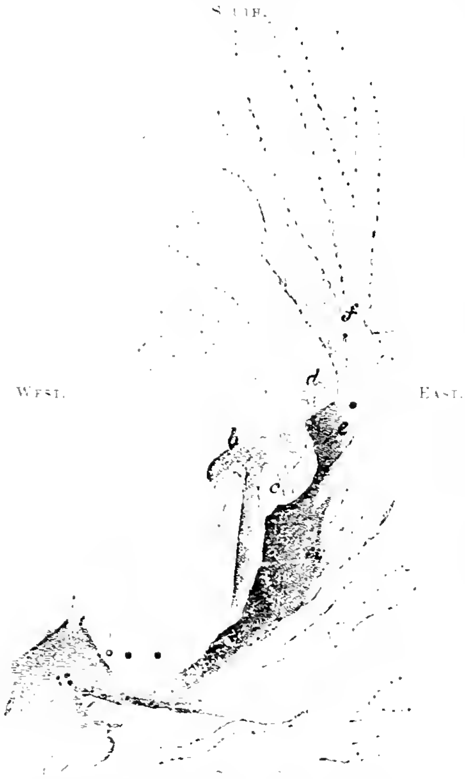


Fig. 3.—Diagram showing great curving structure on the eastern side of the Orion Nebula.

But there is a still more striking analogy between the strange form presented by Brooks' comet on the 21st October and this great structure in the Orion nebula. One edge of the structure is much sharper than the other, and it is curiously notched with sharply-defined bays or indentations on the side which is most sharply defined, as is the case with the tail of the comet. In the Orion nebula structure there are small as well as large notches. Two of these small notches are very sharply defined in the under-exposed picture (reproduced in Fig. 2 of the plate). They lie to the east of the lower part of the stem of the structure marked *b* in diagram, Fig. 3.

It is worthy of notice that the notched structure of the Orion nebula is surmounted by a branching structure very similar to the branching structure which surmounted the notched region of Brooks' comet on October 21st, and that there are other structures in the Milky Way and in nebulæ with one edge sharper than the other, and in which the sharply-defined edge exhibits notches or indentations. I would invite the reader to compare the plate of the region of the Milky Way about ξ Cygni, published in Knowledge for December, 1891, and any photograph he may possess of the nebula near ξ Orionis.

In *The American Naturalist* for January, Mr. S. W. Williston reports the discovery in the Niobrara Chalk, in Kansas, of a Plesiosaurus skeleton, with which were associated more than a hundred hard flinty pebbles, varying in weight from 1 to 170 grams, and of conspicuous colour. These he concludes had been swallowed by the Plesiosaur to aid in digestion, a habit still in vogue among crocodiles.

Dr. Hickson, in his new book, *The Fauna of the Deep Sea*, points out in a very vivid manner an extraordinary danger to which the deep-sea fish are liable. At the great depths at which they live the pressure is enormous—about two and a half tons on the square inch at a depth of two thousand five hundred fathoms. It sometimes happens that in the excitement of chasing a prospective meal the unwary fish rises too high above his usual sphere of life, when the gases in the swimming bladder expand, and he is driven by his increasing buoyancy rapidly to the surface. If he has not gone too far when consciousness of his danger grows greater than his eagerness for prey, the muscles of the body may be able to counteract this, but above this limit he will continue to float upward, the swimming bladder getting more and more inflated as the unfortunate creature rises. Death by internal rupture results during this upward fall, and thus it happens that deep-sea fish are at times found dead and floating on the surface of the ocean, having *tumbled up* from the abyss.

Notice of Book.

The Dawn of Astronomy: a Study of the Temple-Worship and Mythology of the Ancient Egyptians. By J. Norman Lockyer. London, 1894.

The idea upon which this work is based occurred to Mr. Lockyer while inspecting the ruins at Eleusis, and the remains of the Parthenon, in the spring of 1890. The directions given to the foundation-lines of these buildings struck him as peculiar, and implied, he rightly conceived, an underlying motive. Old Christian churches, he remembered to have heard, were often built so that, on their respective feast-days, the rising sun should shine directly through their eastern windows. Could it be that this arrangement was merely a survival of an antique practice? He turned to Egypt for a reply. There, numerous temples, dating from a grey fore-time, had been measured by the French in 1798, and by the Prussians in 1844. There, too, astronomical considerations were known to have been, in some cases at any rate, influential upon architecture. The Great Pyramid is a standing example. If our readers desire to satisfy themselves upon the point, they need only refer to Mr. Proctor's demonstration in "The Old and New Astronomy," that the tomb of Cheops was used, some five thousand years ago, as a meridian observatory.

To Egypt, accordingly, our present author went both in person and by manifold inquiries; with results of most curious interest. To some among them exception may be

STRUCTURES ON THE EASTERN SIDE OF THE ORION NEBULA.

Both pictures have been made from negatives kindly lent by Dr. Isaac Roberts.

1.—Made from a long-exposed photograph of the Orion Nebula, showing notches on the eastern edge of great branching structure.

2.—Made from a photograph taken with a shorter exposure, showing the well-defined eastern edge of the same structure, with small and large notches.

taken; but he claims for none more than a provisional character. There can, however, be little doubt that all the sacred edifices in the Nile valley were built with some reference to the heavenly bodies. This is suggested by their very structure. From the inner sanctuary of each, the line of view was invariably kept clear to the horizon, whither the eye was often guided through rows of massive pylons, or along far-stretching avenues lined with obelisks, columns, or statues. The purpose of this open light-route was evidently that the rays of a rising or setting luminary might, at certain annually recurring moments, flash transitorily upon the image of the enthroned divinity. "Manifestations" of this kind are indeed positively stated in some of the mural inscriptions to have given the signal for the commencement of solemn celebrations; hence the temples were expressly planned to secure their unfailing display. For the most part, it was sun-illumination which was thus led captive to the shrine of the god or goddess; but a considerable number of temples face too far south or north of the equator to have ever been available for solar observations. These, we are now informed, were oriented, each to a particular star. Thus, there can be no question but that the goddess Isis was represented in the heavens by the blazing Sirius; and it may also be admitted that the temple of Isis at Dendera was erected as a kind of spy-tube upon the yearly reappearances at dawn of her stellar *alter ego*. This took place on the 20th of June, the Egyptian New Year's Day, and was hailed with clamorous exultation. From a comparison of the actual aspect of the temple with the lie it should now take in order to comply with the ancient conditions of its existence, Mr. Lockyer places its foundation at about 700 B.C. The localization of a star naturally implies a date, since precessional movements occasion a continual shifting of rising-points, as viewed from any determinate spot on the earth's surface. A temple, of which the axis was designed to be threaded by the emerging beams of a certain star, must then have been built at a strictly calculable epoch. In two, or at the utmost three hundred years, it would become superannuated. The star of its cult would no longer shine into it. Originally aligned with a moving object, it now remains as a perennial record of the interval which has elapsed since that primary, though comparatively transient, agreement was complete. Hence the chronological value of this method, provided only that satisfactory assurance can be obtained as to the individual stars to which the temples were oriented. Mr. Lockyer's identifications are not meant to be final. The admission of Canopus, it may be remarked, as an object of worship in Upper Egypt, would carry the time back to 6100 B.C. A great deal of research, however, including surveying operations and the labours of decipherers, is requisite before the brilliant suggestions contained in the volume before us can be either received or rejected without hesitation.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

IRREGULARITIES IN THE TAILS OF COMETS.

To the Editor of KNOWLEDGE.

DEAR SIR,—I have been very much interested by the articles on Brooks' Comet in the last number. On the one hand, it seems to me that Prof. Barnard does not prove the assumption which gives the title to his article—"On the Probable Encounter of Brooks' Comet with a Disturbing Medium"; and, on the other hand, I do not understand how the explosions you speak of, or the great and sudden changes in brightness, could be caused without some encounter or external influence more irregular in its action than the slow increase or decrease of the sun's heat, due to the comet's changing position. Prof. Barnard seems to assume that the whole comet was stirred up by the collision of its tail with a resisting medium. He says:—"In the second photograph (see the picture for October 21st) the entire comet was brighter, *as if the disturbance had added to its light*" [the italics are my own]; and he goes on to say, "as also seems to have been the case with the third photograph on October 22nd, for its exposure was much shorter, as flying clouds were obscuring the sky a considerable portion of the time." No doubt the rapidly-varying brightness is proved beyond dispute by the photographs, but I do not see how a blow upon a comet's tail could affect the brightness of its head or nucleus. If the matter of the tail is, as we have hitherto supposed, always streaming away from the nucleus, such a theory, at all events, needs further proof than Prof. Barnard gives.

It seems to me more probable that the irregularities in the tail are as you, Mr. Editor, suggest, due to irregularities in the quantity of matter streaming away from the nucleus, as well as due to changes in the direction in which the streams of matter are driven forth from the head of the comet. But I cannot conceive how the sun's slowly increasing heat acting upon the nucleus could cause such sudden outbursts in different directions.

The phenomena presented are intensely interesting because they are so mysterious. My father felt great difficulty in accepting the ordinarily received theory that comets have been captured from outer space and deflected into closed orbits by the larger planets, because, with bodies of sensible diameter like comets, the nearer and further parts would be differently acted upon by the planets they approached, and the various parts of a large group of stones would consequently be deflected into very different orbits.

The elongated nuclei of some comets, and the small attendant comets which have been seen alongside some large comets, seem to show that the material of the nucleus has been torn into pieces by perturbations, and has in some instances been stretched out into a stream of nuclei or isolated clusters of stones arranged in a line. It seems to me to be worth considering whether the notches in the tail of Brooks' comet may not have been due to some repelling action around an invisible attendant comet, such as was observed, or, at all events, was photographed by Prof. Barnard, in the midst of the tail of Swift's comet.

It will also be seen that the ejected matter from the nucleus was pretty evenly distributed on either side, as it streamed away from the head of the comet, while if something had run against the tail of the comet, its fragments would have been drifted to one side of the general axis of the tail. In the second photograph, taken on October 22nd, the even distribution of matter driven back from the nucleus is even more noticeable.

Yours faithfully,

Brighton, 7th February, 1894. HARRY PROCTOR.

Many of the older readers of KNOWLEDGE will, I feel sure, join with me in welcoming Mr. Harry Proctor as a contributor to our pages. His theory, as to the possible action of attendant comets, seems to me to be well worthy of consideration. We know that some three or four comets, whose paths approach the earth's orbit, are accompanied by widely distributed flights of meteors distributed along and around their orbits. If the matter driven from the main nucleus of a comet varies in quantity from day to day and hour to hour, it is easy to conceive that smaller swarms, which accompany the main cluster, may from similar causes vary in brightness, sometimes becoming bright enough to be recognizable, and then rapidly dying down in brightness so as to be lost to sight again.—A. C. Ranyard.]

To the Editor of Knowledge.

Leigh Sinton, Malvern,
February 9th.

Dear Sir,—I was greatly pleased with the photo-reproduction of the summit of Mount Hamilton and the Lick Observatory in this month's Knowledge; but I looked in vain for any letterpress description. I have never seen anything beyond the usual type of newspaper paragraphs about it, and I am sure that other readers besides myself would be interested in some reliable statements. *E.g.*, Is the full aperture of the giant lens normally used on fine nights? What power can be used on double stars and on planets respectively? Does Jupiter appear as clear and free from halo and colour as in a 6-inch instrument? Also, are photographs of the planets successfully made? You have familiarized your readers with exquisite photos of the moon and of star-groups, but I have never seen any attempt at a photographic view of, say, Jupiter or Saturn.

Yours truly,
C. Robinson, B.A.

[Photographs of Jupiter and Saturn will be found in Knowledge for November, 1890. The photographs there reproduced are from negatives taken by Prof. W. H. Pickering. Good photographs of the planets have been obtained at the Lick Observatory, and also by the Brothers Henry and M. Loewy at the Paris Observatory; but comparatively little progress has been made in this direction since 1890. Both Jupiter and Saturn show a great deal of colour in the most perfect achromatic telescopes, as well as in reflecting telescopes. The globe of Saturn exhibits delicate tints of blue and brown, and Jupiter is exquisitely coloured with deep tints of red, yellow, blue, and rich chocolate brown.

As far as I am aware the full aperture of the 36-inch refractor is always used, but none of these great telescopes bear a power of 100 per inch of diameter, which is spoken of by the Rev. T. W. Webb in his "Celestial Objects" as the power which the best telescopes of either kind (*i.e.*, reflecting and refracting) should bear under favourable circumstances on stars. It seems to me, though I feel great diffidence in differing on such a subject from Mr. Webb, that he would have been nearer the mark if he had spoken of a power of 40 or 50 per inch as the limiting power which can be advantageously used on large telescopes under favourable circumstances. I should like to hear what Mr. Burnham and Mr. Barnard have to say on this subject.—A. C. Ranyard.]

PERIODICAL COMETS.

To the Editor of Knowledge.

Sir,—Let me remind Mr. Denning that in Dr. Matthiesen's paper, to which he refers, it is expressly stated that if the comet, as seemed probable and we now know was the case, escaped observation in 1890, it would be very difficult to predict the approximate time of its appearance at the next following return. It underwent some rather strong perturbations by Jupiter in 1887; and though Dr. Matthiesen did take account of these so far as was practicable, it must be remembered that the whole time of the comet's visibility in 1881 was considerably less than three months, so that the knowledge of its motion in its present orbit could not be very precise, nor the means of calculating the perturbations very accurate.

In my list of expected returns of comets, both in my article in Knowledge and in my little *brochure* on "Remarkable Comets," to which Mr. Denning does me the honour to refer, I limited my notices to those of which the return might be expected with some confidence during the years assigned. For this reason I omitted both Denning's comet of 1881 and the comet which was known as Tempel's second periodical comet. The latter was seen at two returns only, and escaped observation during those due late in 1883 and early in 1889. It is true that the positions were unfavourable on both these occasions, but comets seldom escape observation now entirely from that cause, being so diligently looked for in both hemispheres with much more powerful telescopes than formerly. Another return will be due shortly, but under the above circumstances can hardly be looked forward to with much confidence.

In my article I inadvertently spoke of 1899 as the last year of the present century, which, of course, should be 1900. Mr. Denning apparently follows suit, and means 1897, 1898, and 1899 by "the last three years of the present century." Let us hope that his comet will return some time in the last of these, after which its period will be better known. Yours faithfully,

Blackheath, February 9th, 1894. W. T. Lynn.

LUNAR CRATER PLAINS.

To the Editor of Knowledge.

Sir,—I have been away on a five months' cruise around the colonies of Australia, and have only just seen your interesting article—beautifully illustrated—on "The Great Lunar Crater Tycho," in Knowledge for August.

Some of the references therein to the "Theory of Lunar Surfacing by Glaciation" (published by Messrs. Thacker and Co., 87, Newgate Street) have taken me rather aback, and, as I am sure you would desire to see any serious misinterpretations rectified, I beg to send a few explanations.

The view of the subject which I take is so revolutionary, and it is naturally so speculative and many-sided, that I must at first expect a large amount of misapprehension, and trust to time, and opportunities such as this, to remove them as they arise.

In the first place I see you say I assume "that the lunar surface consists entirely of ice." This is hardly correct. I assume that in the main the surface, whether hill or plain, is composed of *snow*; occasionally and rarely of ice, as in the three dark spots on "Alphonsus," which, even then, would be so covered with floe *débris* and meteoric dust stain, that specular reflection would be impossible.

Beneath this snowed surface—especially on the maria and sunk plains—the ice, I take it, lies hidden, more or less roughened by *débris*, yet often level in the main over large areas. Hence I do not look on the "lunar plains as surfaces of virgin ice," as many suppose, capable of specular reflection.

At page 11 of the "Theory" above referred to I say "the outer surface is a snow surface stained by an accumulation of meteoric dust."

Again, you say that I think "the craters and pit-like depressions are due to the action of hot springs, which have not flowed continuously, but that water has from time to time issued from vents in the soil, and has melted the ice above the vent; the water is then supposed to have flowed back to the warm interior of the moon, taking with it a part of the surface ice that has been melted, and by a series of such ebbs and flows Mr. Peal conceives the terraced walls of the lunar craters to have been built up."

I do not recollect ever having referred to springs of hot water or ebbing and flowing. The "vents" and "heat orifice" I take to be similar to those seen in terrestrial volcanoes, where, as Prof. Judd points out, some ninety per cent. of the total output is steam, or heated aqueous vapour.

On page 22 of the "Theory" I call them "cold volcanoes."

On our earth we have numerous cases of submarine vents, which at times raise the temperature of the water, and even at last rise to the surface and form the "oceanic islands." All I assume is that these existed on the moon, and during its long era of refrigeration they retarded, for very long periods, the glaciation of the sea on large and small sub-circular areas, a cluster of small heat orifices or vents, as in Plato, at times producing a lagoon in the ice sheet, as effectually as one large one.

But in all cases a time must necessarily come when, through the persistent fall in secular temperature, these lagoons, in various stages of formation, solidified, and any aqueous vapour subsequently given off at the old or any new orifice, would be piled as snow over and around the vent, and would form the well-known "cone," simulating our volcanic cones, in all but their universal whiteness.

In the deeply terraced craters—which, as a class, are not overlapped by other rings—the material of the successive terraces I assume to be taken from the lagoon surface by evaporation, and deposited at once around the margin as snow, thus at one operation forming the new terrace, and still further lowering the level of the enclosed floor.

Ice cliffs of seventeen thousand and twenty thousand feet high are no part of my "theory." On page 8 of it I say, "again it has been objected that snow mountains of twenty thousand feet elevation are quite inconceivable, but we may recollect that the gravitation on the moon would be but one-sixth of ours, and that thus the lunar snow in packing down, or piling up, would probably not have one-fourth the same mass in an equal volume as ours. Terrestrial ice on the moon would weigh lighter than cork to us, and lunar snow peaks and ridges would rise as an almost inconceivably light material, into an intensely cold airless void. Though of such a light and flocculent nature, they would appear to us, and practically be, as permanent as solid rock masses. With us the lower layers of deeply piled snow become pressed to ice, and there seems to be no reason why the bases of lunar ranges should not be of similar nature."

I may add that it is now found that at low temperatures ice becomes a non-viscous solid, like glass; and that as temperature falls, both snow and ice become more and more diathermanous.

The occurrence of small craterlets on the rims and slopes of large craters and sides of mountains I, of course, do not attribute to an output of "warm water," but to the exhalation of *steam* through orifices due to faulting—similar to the formation of the crater chains over faults or clefts.

The extraordinary outcrop of minute crater cones *all over* the lunar surface, which is probably still going on, when taken in conjunction with the slow subsidence of the lunar maria, as evidenced by the clefts, seems to me a beautiful demonstration that there is still a large store of internal heat in our satellite, beneath the now glaciated crust.

I "account for the fact that the lunar plains and floors of the deeper lunar craters are generally of a much darker tint than the higher ground upon the moon," not by assuming that the former are virgin ice, and the latter snow, but solely as the effect of gravitation, which occasionally removes from cliffs, rugged and elevated regions, the meteoric dust stain, which needs must lie (and accumulate) for ages on levels and gentle slopes, like the outer incline of the rings—see Aristarchus, &c.—at sunrise.

Sibsagar, Assam. S. E. Peal.

[If the lunar plains had acquired their dark tints by the fall of meteoric matter which was originally deposited on high ground, we should expect to find the darker colouring near the base of the lunar mountain ranges, and that all high ground would be fringed by an edging of darker shade. But the dark tints are nearly uniformly distributed over the lunar plains, and we seem to have evidence in lunar photographs that matter of various degrees of darkness, as well as white material, has flowed in streams from some of the lunar craters.—A. C. Ranyard.]

ANIMAL HEAT.

By Vaughan Cornish, M.Sc., F.C.S.

In a former article it was shown how plants and animals assimilate food from their environment, seizing upon the same elements and building up compound substances, which, though not identical, are of the same general character and class in both the vegetable and the animal world.

In our last two articles we described the changes of composition which take place in the life of plants and animals as essentially chemical changes, following the same laws and brought about by similar causes as the reactions studied by a chemist in his laboratory. In the growth of the animal or plant many causes co-operate besides chemical causes. For example, the form and structure of its parts are determined by laws which are outside the ken of the chemist. But chemical forces, besides building up the substances of which animal and vegetable bodies are made, maintain the bodily heat which is inseparable from animal life, and which, along with the power of locomotion, forms to the ordinary observer perhaps the most obvious and essential distinction between animals and plants. Lavoisier first proved to the world the nature of the chemical changes which occur in burning, and showed that in respiration the same chemical process (oxidation) is going on. Every chemical change is accompanied by a heat change. Lavoisier not only recognized this fact, but he appreciated its importance more than most of his immediate successors. Accordingly he set himself to investigate *quantitatively* the heat changes which occur in the phenomena of burning and of respiration, both being from his point of view phenomena of oxidation.

How well Lavoisier understood that without measurement there is no science is shown by the fact that he used the *calorimeter*, or instrument for measuring quantities of heat, with the same diligence as he showed in the use of the balance. Calorimetry, that branch of science which deals with the measurement of quantities of heat, owes its origin to the joint work of Lavoisier and Laplace, who were the inventors of the ice-calorimeter. The principle of their method was to measure the quantity of heat by the weight of ice melted. Thus, in order to determine the quantity of heat given out by one pound weight of iron in cooling from the temperature of boiling water to that of melting ice, the iron was placed in the central chamber of a box furnished with a lid and having two annular chambers outside the central chamber. The outer annular chamber or compartment was filled with ice to protect the next compartment, also filled with ice, from the warming effects of the external air. All the heat received by the inner ice compartment comes, therefore, from the body placed in the central chamber. The weight of ice melted measures the quantity of heat received, the water formed by the melting of the ice being run off from the bottom of the apparatus, which is funnel-shaped and provided with a stop-cock for the purpose. The above arrangements served for the comparison of the specific capacities for heat of different materials, as shown by the heat given out by them in cooling through a certain range of temperature.

In the experiments on the heat given out in burning and in respiration, the arrangements were slightly different. We give Lavoisier's description, retaining the old term *caloric*, which may be taken to mean "heat considered as a measurable quantity." Lavoisier writes: "To determine the quantity of caloric disengaged during combustion and during animal respiration, the combustible bodies are burnt, or the animals are made to breathe, in the interior cavity, and the water produced is carefully collected. Guinea-pigs, which resist the effects of cold extremely well, are well adapted for this experiment. As the continual renewal of air is absolutely necessary in such experiments, we blow fresh air into the interior cavity of the calorimeter by means of a pipe destined for that purpose, and allow it to escape through another pipe of the same kind; and that the heat of the air may not produce errors in the result of the experiments, the tube which conveys it into the machine is made to pass through pounded ice, that it may be reduced to 32° before it arrives at the calorimeter. The air which escapes must likewise be made to pass through a tube surrounded by ice included in the interior cavity of the machine, and the water which is there produced must make a part of what is collected, because the caloric disengaged from the air is part of the product of the experiment."

By means of this apparatus, or "machine" as he calls it, Lavoisier compared the quantities of heat evolved during the burning of a given weight of carbon and of hydrogen, and of a given weight of animal and vegetable substances formed of carbon and hydrogen, such as wax in a wax taper, and olive oil burnt in a little lamp. He also, as we have seen, determined "the quantity of caloric disengaged during respiration," a research connected with that on the loss of weight during respiration, in which his colleague Seguin was the *corpus vile* in place of the guinea-pig, which was found so "well adapted" for calorimetry. Seguin used to be sewn up in a varnished air-tight silk bag, the edges of which were accurately cemented round his mouth, leaving only a slit for breathing. He was weighed in a delicate balance from time to time.

Since the days of Lavoisier thermo-chemistry, or the study of the heat-changes which accompany changes of chemical composition, has made considerable progress in spite of the many practical difficulties which surround the subject. One of the most important of the laws which have been experimentally established is that "the initial and final stages of a chemical reaction alone determine the amount of the heat change."

For instance, the conversion of a given weight of carbon to carbonic acid is accompanied by the evolution of a quantity of heat which is the same whether the carbon be burnt rapidly in oxygen, or whether in a slow and roundabout series of chemical changes the carbon is successively a constituent of a number of vegetable and animal substances before finally attaining the form of carbonic acid in the expired breath of animals. This law, which has been experimentally proved to hold in a variety of cases, enables us to calculate the heat-giving power of foods without having to ascertain the various changes and modifications which the food undergoes in the animal body. We know the final products, and that is sufficient. Thus, sugar taken into the body is sooner or later completely converted into carbonic acid and water; in other words, it is completely burnt. The heat given to the body by one ounce of sugar is therefore, by the second law of thermo-chemistry as it is called, the same as the heat evolved by burning an ounce of sugar. This quantity can be experimentally determined by the use of Lavoisier's calorimeter, or one of the modern improvements upon his original apparatus. We are thus enabled readily to compare the heat-giving power of different foods and food stuffs, and it is by the use of such thermo-chemical methods that the figures quoted in previous articles have been ascertained. For instance, the starch equivalent of fats, two-and-one-third, is the proportion which the heat-giving power of fats bears to that of an equal weight of starch.

Every chemical change is accompanied by a heat change, but it must not therefore be supposed that every chemical reaction is accompanied by an evolution of heat. There may equally well be a disappearance of heat. It is the former class of reaction, those in which heat is evolved, which are often accompanied by striking phenomena such as evolution of light, &c. Hence the popular idea that a chemical change is necessarily accompanied by an evolution of light and heat. By the second law of thermo-chemistry the initial and final stages only determine the heat reaction. Take the case of the carbonic acid of the atmosphere, and the various changes the carbon undergoes after its assimilation by the green portion of a plant and during its subsequent changes in the body of some animal which has fed upon the plant. The final stage is that the carbon is restored to the air as carbonic acid. The initial and final stages are identical and the total heat reaction is *nil*. While the carbon has been in the animal body it has been gradually oxidized up to carbonic acid, and during the whole of this time heat is being evolved; hence the warmth of the animal. The heat thus given out by the carbon taken into the body as vegetable food is (by the second law of thermo-chemistry) exactly equal to the heat *absorbed* during the process of converting the carbon of carbonic acid into the state of chemical combination in which it is found in the plant. How is it, then, that the frigorific effects of plant growth are so much less patent and obvious than the heating effects of animal life? It is mainly due to the circumstance that, in order to bring about chemical changes in which there is an absorption of heat, some external agent must act, and must keep on acting, in order that the chemical reaction may proceed, and in the case of the decomposition of carbonic acid in the presence of the green colouring matter of plants this external agent is the sun's rays. Hence, the cooling effect which results from the feeding of plants upon their atmospheric food is to a great extent masked by the fact that the cooling action only takes place in presence of a potent heating agent—the sun's rays. Still, let anyone compare the climate of a forest and of a sandy desert in the same latitude, and reflect that the difference is partly due to the fact that in the one case all the heat rays are reflected back, but in the other case a part of these rays are employed, without apparent heating effect, in splitting up carbonic acid. This gives some idea of the cooling action of plant life, which contrasts so sharply with the warmth of living animals.

Let us consider for a moment what chemical changes, and heat changes, take place after the death of a plant. Decay and decomposition, which are mostly processes of oxidation, are accompanied by heating effects. Many such cases can be called to mind, such as the heating of hay in the stack. On the other hand, the surest evidence of death in animals is the loss of bodily warmth. Thus, the opposite functions of plants and animals, with regard to heat, are more sharply contrasted in the phenomena of death than of life. The contrast must not be pushed too far, since when decay sets in there is a heating effect with animals also, though not perhaps so marked as in the case of plants.

Warmth and power of locomotion we have chosen as two marked and obvious characteristics of living animals distinguishing them from plants. The power of locomotion which animals possess depends upon their warmth. The ordinary movements of an animal are made against some kind of resistance, and when motion is so accomplished physical work is performed. Physical work is measured numerically by multiplying the amount of the force by the distance moved against its resistance. All bodily work may be expressed in this way. The systematic and continuous use of the rational and thinking faculties is often called work, but for present purposes we exclude brain labour from the scope of the term "work," which we shall employ in the physical sense only. Plants cannot do work, animals can do work. Combinations of mechanism (pulley, screw, lever, &c.) cannot do work, they only vary the proportion of the two factors of work, distance and force; but engines, like animals, actually do work, for an engine is provided with a source of energy as well as with a train of mechanism. A steam engine, as far as chemical science and heat science are concerned, is closely analogous to an animal. From this point of view, it is an animal very much simplified. Energy is obtained in the steam engine and in animals by burning carbonaceous material. Both the engine and the animal can do work as long as the same chemical action furnishes them with the same kind of energy. Without fuel or food both grow cold, and no work can be done.

By the study of the steam engine, Hirn proved that every foot-pound of work done entails the disappearance of a definite quantity of heat between the boiler and the condenser of the engine. The relation is about one thousand three hundred and seventy foot-pounds of work for each unit of heat, as that quantity which will raise one pound of water one degree in temperature. Roughly, Hirn's method was as follows:—He determined the total amount of heat put into the boiler from the amount of the water supplied per diem and from the temperature of the steam. The amount of heat returned to the condenser was calculated from similar data. The amount of mechanical work done was measured by a Watt's *indicator*. In this instrument the amount of work done is indicated by the movement of a pencil point upon a sheet of paper. The position of the pencil point, which indicates the work done, is determined jointly by the pressure or *force* of the steam, and the *distance* through which the working piston has moved. The work registered by the indicator is partly the work done in overcoming the resistance of the parts of the engine, which we will call internal work, and partly external work, such as raising a weight or driving a shaft. Hirn found that, if he increased the external work of his engine, there was a greater loss of heat between the boiler and condenser of the engine, one unit quantity of heat disappearing for each one thousand three hundred and seventy foot-pounds of additional external work. A great variety of methods has given practically the same value for the mechanical equivalent of heat, and we may confidently apply the value obtained to the solution of problems upon the relation of food and work in animals. In the animal body there is "internal work" to be done, just as there is in the steam engine. In neither case can the whole of the heat furnished by the fuel or food be converted into external mechanical effect. This would require, in the case of the steam engine, that no heat at all should reach the condenser, and that the condenser should be at the absolute zero of temperature, a condition which it is impossible practically to attain. In the case of an animal, if all the heating power of its food were used for external work the temperature of the animal's body would sink to that of its inanimate surroundings, a condition obviously incompatible with life. As a matter of fact, about one-fifth of the energy which the food develops can be obtained in the form of external mechanical effect. The rest is required for the internal work of the body. This is a much larger proportion of external effect than in the case of a steam engine, or other heat engine, where the *efficiency*, or proportion of the mechanical equivalent of the heat supplied to the external work done, is more like one-twentieth per cent.

The heat developed in the body by one pound of the carbo-hydrates (starch, &c.) has a mechanical equivalent of about two thousand eight hundred and sixty foot-tons. *One* pound of oil or fat is in the same sense equivalent to six thousand four hundred and fifty foot-tons. About twenty per cent. of this is available for external work, so that we may say that if a man is to do three hundred and twelve foot tons of work he may supply himself with the requisite store of energy by taking four ounces of fatty food in addition to the *maintenance* diet necessary to meet the daily waste of the body. Three hundred and twelve foot-tons is about the average amount of work done in a day by an English labourer, whose diet would probably comprise about four and a half ounces of fat. People often puzzle themselves why it is that working makes a man hot rather than cold, seeing that heat is used up to produce mechanical effect. The analogy of the steam engine will enable us more readily to explain this apparent anomaly. When a locomotive is going sixty miles an hour, more work is being done than when it is going thirty miles an hour. More heat is converted into work when the engine is going fast than when it goes comparatively slowly; but no one would expect the heat in the engine as a whole to be less when the pace is great. The draught will be greater and the consumption of coal greater, and so much greater that, although there will be more heat converted into mechanical effect by the working of the piston, yet the engine as a whole will be hotter. It is so also in the case of the animal body. When bodily work is being done, the contracted (*i.e.*, the working) muscle seizes upon a greater quantity of the oxygen of the arterial blood than in the case of the uncontracted muscle in its state of rest. The blood of the veins may contain as much as seven and a half per cent. of oxygen when the muscles are at rest, but a working muscle may leave as little as one and a half per cent. of oxygen in the venous blood. This means that there must be a corresponding increase in the amount of carbonic acid given off by the lungs, which in fact may be as much as five times greater during work than during repose. Respiration is deeper and more rapid, more oxygen is inhaled, the combustion of the food goes on more quickly, and an increased supply of carbonaceous food is required to supply the fuel for combustion. Thus it is that the temperature of the body is maintained during work, although the work is done at the expense of food which otherwise would produce animal heat.

THE ROOT-TUBERCLES OF PEAS, BEANS, AND VETCHES.—I.

By J. PENTLAND SMITH, M.A., B.Sc.

A GREAT amount of interest has been excited of late by the discovery of the function and use of the nodules which are found on the roots of plants belonging to the natural order *Leguminosæ*—plants whose fruit is a pod or legume.

The subject is interesting alike to the botanist, chemist, and agriculturist; to the botanist because of the biological problems connected with it, to the chemist because of the light it sheds on the complex chemical processes occurring in the soil, and to the agriculturist from the practical conclusions to be drawn from the data afforded by purely scientific investigators. It is a fascinating subject from whatever standpoint we choose to regard it.

Agriculturists have noticed that the cultivation of one species of plant on the same soil, year after year, is detrimental to the well-being of plants; and they have found that if crops are grown in certain successions good yields are the result.

De Candolle explained this by saying that the roots of plants excrete into the soil a specific substance, injurious to crops of the same kind. It became evident, however, that by a system of rotation, not only were better crops obtained, but a smaller quantity of manure was required for their production. Liebig's explanation of the benefits accruing from a rotation of crops seems more acceptable than that of De Candolle—in fact it is now known, as the result of numerous analyses, to be the correct explanation: one species of plant abstracts from the soil larger amounts of certain salts than another.

A short *résumé* of the manner in which a plant furnished with green leaves obtains its supply of food will form a fitting introduction to this subject. The essential materials of plant food are carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, sodium, &c. This has been determined by an analysis of plant tissues and of the *living* part of the plant, the protoplasm. They must either be obtained by means of the roots from the soil in which the plant is growing, or taken from the air by the leaves. Experiments have shown that both sources are drawn on. The greater part of the carbon and oxygen are obtained from the air by the leaves, and the soil is the storehouse from which other elements are drawn. This is rather startling when we recall the fact that, estimated roughly, about four-fifths by volume of the atmosphere is composed of nitrogen, about one-fifth of oxygen, and the rest chiefly of carbon dioxide (commonly called carbonic acid gas). It has long been known that the green colouring matter, chlorophyll, in the presence of bright sunlight, possesses the power of breaking up carbon dioxide into its constituent elements, carbon and oxygen; the carbon and part of the oxygen being retained by the plant, while the remainder of the oxygen is given off into the atmosphere. In performing this function of carbon assimilation the plant is purifying the air. Though the counter process of respiration which is going on continuously day and night has the opposite effect, the oxygen evolved during the day is in excess of the carbon dioxide produced during that time by the respiratory process.

An interesting experiment, devised by Engelmann, illustrates very forcibly the part played by chlorophyll-bearing plants in the economy of the world. He projected a fine spectrum of the sun's rays on a slide containing a filamentous alga (that is, a thread-like sea-weed), and a quantity of the bacterium, *Bacterium photometricum*, which has such a passion for oxygen that it collects in its hosts at the edge of the cover glass, where there is a greater supply of that element. The result was the assemblage of masses of the bacterium in the red-yellow and blue-violet parts of the spectrum, showing that carbon assimilation was proceeding most actively at these points. Green plants are thus, by virtue of their possession of chlorophyll, the converters of the unorganized carbon dioxide of the atmosphere into a form available for plant

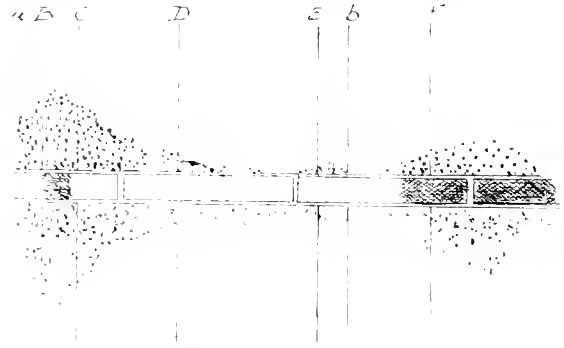


FIG. 1.—A filamentous Alga, on which the solar spectrum has been projected. (After Engelmann and Vines.) In the water are quantities of the bacterium, *Bacterium photometricum*, which have aggregated themselves in the red-yellow and blue-violet parts of the spectrum. This bacterium is an oxygen lover, and its accumulation at these parts of the spectrum shows that carbon assimilation is proceeding most actively in the regions where chlorophyll exhibits the most marked absorption bands.

food. And in the performance of this function they convert the kinetic energy of the sun's rays into a potential form, as Engelmann's experiment clearly shows. This afterwards, in becoming kinetic, supplies the motive power whereby the chlorophyllous plant is enabled to carry on its life processes, just as the potential energy of a wound-up watch spring, in changing into moving energy, carries the works of the watch; or the water, which dammed up on the hillside is endowed with potential energy in virtue of its position, assumes the kinetic form when the sluice is withdrawn, and drives the mill-wheel. This point is an extremely important one and must not be lost sight of in the discussion which follows, for according to this view of the case all non-chlorophyllous vegetable organisms and all animals must directly or indirectly prey upon chlorophyll-bearing plants, as they alone can assimilate the carbon which enters so largely into the composition of all living bodies. Hence all fungi and other plants characterized by the non-possession of chlorophyll must either be saprophytic (*i.e.*, live on dead organic matter) or parasitic (*i.e.*, prey upon the living bodies of other plants or animals). It is for this reason the suggestion has been made that green-coloured plants were the living forms first evolved from non-living matter, although this view is negatived by Ray Lankester in his article on "Protoplasm" in the *Encyclopædia Britannica*.

The water absorbed by the roots from the soil contains small quantities of salts of potassium, calcium, &c., in solution, and this is the source, as previously mentioned, of the other constituents of protoplasm. These unite with the assimilated carbon, and the resultant protoplasm is the last link in the chain of complex organic compounds formed by their union. The energy of the solar rays is consumed in the production of plant protoplasm, and the decomposition of this substance supplies the kinetic energy that is the motive power of the life processes of all other plants and of animals.

During the last fifty years Sir John Lawes and

Dr. (now Sir) J. Gilbert have carried on an elaborate series of investigations in scientific agriculture at Rothampstead, which has made that little place famous and has earned for the authors a world-wide renown. In the course of their numerous experiments they found that in the case of leguminous crops, such as peas, beans, and vetches, it was impossible to account in the usual way for the whole of the nitrogen contained in them. It was in excess of what could have been derived from the rain or the combined nitrogen of the soil supplied in the manure. An examination of the roots of these plants, moreover, invariably disclosed the presence of nodules of various sizes and in varying quantities, and a chemical analysis of these tubercles showed them to be rich in nitrogen, and at certain periods teeming with minute organisms, whose life-history we shall presently discuss. Fig. 2 is a reproduction of an actual photograph of the roots of some pea-plants on which, unfortunately, the nodules are very small. The nitrogen of the air can be the only source of this extra supply of nitrogen, yet for years past it had been strenuously denied that green plants have the power of making use of this vast inexhaustible reservoir. These results, however, of two of the experimenters, startling in the extreme, again brought up the question of nitrogen fixation, and it was attacked by such men as Berthelot, Hellriegel, Wilfarth and Warrington. A paper from the pen of Lawes and Gilbert appears in the *Transactions of the Royal Society* for 1890. It commences with a summary of the results obtained up to that time. "In previous papers, of all the various results discussed, those of Hellriegel and Wilfarth were considered to be by far the most definite and significant; pointing to the conclusion that, although the higher chlorophyllous plants may not directly use the free nitrogen of the air, some of them, at any rate, may acquire nitrogen brought into combination under the influence of lower organisms, the development of which is, apparently, in some cases always coincident with the growth of the higher plant whose nutrition they are to serve." The authors then instituted experiments with a view to confirm these conclusions. They state that these have amply confirmed the results of Hellriegel, and that the fixation of free nitrogen by the growth of the Leguminosæ under the influence of microbe seeding of the soil, and the resulting nodule formation on the roots, may be considered as fully established.

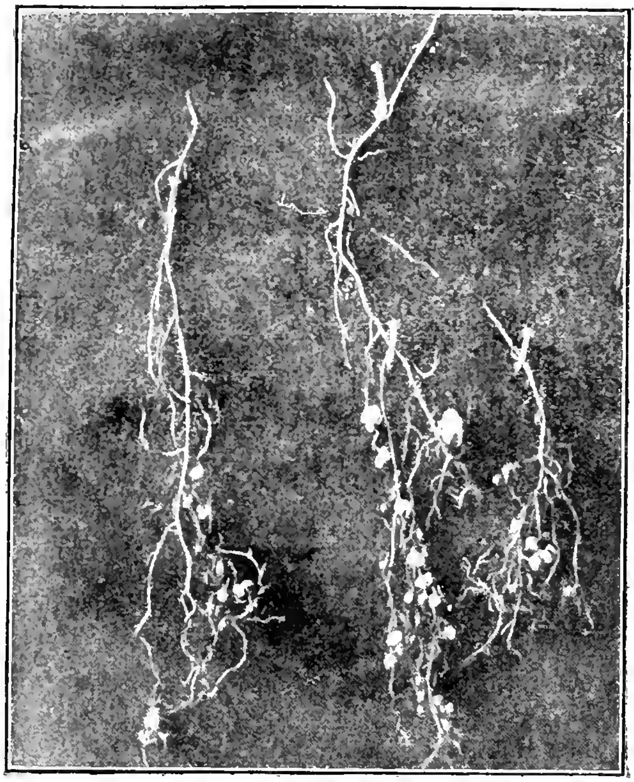


Fig. 2.—Block made from a photograph of Roots of poorly grown Pea-plants, with badly-developed nodules.

It is thus seen that the excess of nitrogen cannot be explained by any of the commonly received theories of vegetable physiology we have in outline explained, and also that the importance of this source of nitrogen cannot be over-estimated from an economical point of view. It would take us beyond the limits of our space to give in anything like an intelligible manner the life-history of the organism to whose growth the formation of these nodules is due. Next month we shall give in detail the facts so far as known, and illustrate these with reproductions from the original drawings of Prof. Marshall Ward, who has fully worked out the subject.

In the meantime we would briefly call attention to the important practical bearing of the facts known in connection with the formation of these tubercles. Two or three years ago, Prof. Vines, in a paper in the *Annals of Botany*, gave some statistics embodying the results of experiments undertaken to show the influence of the chemical character of the surroundings on tubercle formation. From these it appears that if there is a copious supply of nitrogen in the form of soluble salts, no tubercles, or at least only a few, are formed. And Lawes and Gilbert state, in the paper already referred to, that the evidence of experiments seems to indicate that there is a less development of nodules when the soil is rich in combined nitrogen; while Hellriegel, who agrees that leguminous plants do make use of soil nitrogen, considers that by the aid of the tubercle-forming organisms they draw upon the free nitrogen supplied by the air, and that the formation of the tubercles is, within certain limits, inversely proportional to the supply of combined nitrogen in the soil. It appears that something like this at least is the case, and we can at once see how important is a knowledge of the process going on from an agricultural point of view. At present agriculture in England is in a precarious condition, in which any knowledge which may lead to an economy in the supply of manure will be welcomed. The most expensive manures are generally those containing nitrogen, manures such as nitrate of soda and farmyard manure. The latter, however, contains only a small percentage of nitrogen in a readily available form. Heavy clay soils and very porous soils would not be much benefited by the application of artificial nitrogenous manures, as they require that added, which will make the one less and the other more tenacious in character. But although farmyard manure is cheap in itself, yet the cost of putting it on the soil is considerable, especially if a large area has to be treated; but in such cases the growth of leguminous crops may be resorted to. To quote from the *Gardeners' Chronicle* of 7th May, 1892:—

"In our own country Mr. Mason, of Eynsham Hall, Oxfordshire . . . has devoted about two hundred acres to the practical application of the recently-acquired knowledge in regard to nitrogen fixation. Stated in a few words, this idea is to reduce the area under roots and to grow instead mixed crops of Leguminosæ—beans, various clovers, &c.—liberally manured with basic slag and kainit (manures which contain phosphorus and potassium especially) and to convert the produce in the first year into silage, and in the second into hay. The land is thus occupied for two years, and the assumption is that in this way highly nitrogenous crops will be obtained with mineral, but without the highly-expensive nitrogenous manures, and that the land will be left in high condition for the growth of saleable crops, such as potatoes or grain, which require nitrogenous manuring. In other words, the plan is to grow nitrogen-accumulating crops for home consumption, and afterwards nitrogen-consuming crops for sale."

THE FACE OF THE SKY FOR MARCH.

By Herbert Sadler, F.R.A.S.

Sunspots show but little, if any, diminution in number. The zodiacal light should be looked for after sunset in the west, during the absence of the Moon. A conveniently observable minimum of Algol occurs at 9h. 24m. p.m. on the 17th.

Mercury may be observed as an evening star during the first week of the month. On the 1st he sets at 7h. 21m. p.m., or 1h. 44m. after the Sun, with a northern declination of 1° 26′, and an apparent diameter of 8″, about $\frac{3}{10}$ths of the disc being illuminated. On the 8th he sets at 7h. 0m. p.m., or 1h. 10m. after the Sun, with a northern declination of 2° 32′, and an apparent diameter of $9\frac{3}{4}$″, rather less than $\frac{1}{10}$th of the disc being illuminated, and his brightness being about one quarter of what it was on February 18th. After this he approaches the Sun too closely to be visible, coming into inferior conjunction on the 14th. While visible he describes a looped path in Pisces, a little to the east of the 6th magnitude star 22 Piscium.

Venus is a morning star, and is fairly well placed for observation. She rises on the 1st at 5h. 18m. a.m., with a southern declination of 6° 59′, and an apparent diameter of $54\frac{1}{2}$″, $\frac{7}{100}$ths of the disc being illuminated, and the apparent brightness of the planet being about equal to what it was on February 2nd. On the 12th she rises at 4h. 43m. a.m., with a southern declination of 8° 46′, and an apparent diameter of $46\frac{1}{4}$″, $\frac{17}{100}$ths of the disc being illuminated, and the apparent brightness of the planet being about equal to what it was on January 23rd. On the 22nd she rises at 4h. 20m. a.m., with a southern declination of 9° 23′, and an apparent diameter of $40\frac{1}{4}$″, $\frac{3}{4}$ths of the disc being illuminated, and the apparent brightness of the planet (she being now about her greatest brilliancy) being slightly less (in the proportion of 204 to 218) to what it was on January 11th. On the 31st she rises at 4h. 5m. a.m., with a southern declination of 9° 3′, and an apparent diameter of 34″, $\frac{32}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was on January 22nd. During the month she describes a direct path in Aquarius, being about 3° south of the $2\frac{1}{2}$ magnitude star β Aquarii on the morning of the 15th, and about 1° south of the 5th magnitude star ξ Aquarii on the morning of the 19th. She does not approach any other naked-eye stars very closely.

Mars is invisible for the observer's purposes.

Pallas (*cf.* "Face of the Sky for February"), is still visible, though she decreases in brightness to the 7th magnitude by the end of the month. On the 1st her R.A. is 9h. $10\frac{1}{2}$m., southern declination 9° 44′. On the 15th her R.A. is 9h. 7m., southern declination 3° 32′. On the 31st her R.A. is 9h. 10m., northern declination 2° 46′. She thus pursues an almost perpendicular path through Hydra, starting from the S.W. of Alphard, and crossing to θ Hydræ. On the last day of the month at transit she will be in the same field of view with the last-named star, 19′ of arc following it on almost exactly the same parallel of declination. As the Moon will be absent, this will be a capital opportunity, if the night proves fine, for picking up Pallas, as she transits about 8h. 30m. p.m. A notice of the various measures which have been made of the diameter of this minor planet will be found in "Face of the Sky for April," 1890.

The minor planet Ceres comes into opposition with the Sun on the 7th, at a distance from the earth of about 159 million miles, the planet appearing as a star of the 7th magnitude. On the 1st her R.A. is 11h. $45\frac{1}{2}$ m., northern declination 20° 14′. On the 15th her R.A. is 11h. $33\frac{1}{2}$m., northern declination 21° 32′. On the 31st her R.A. is 11h. 21m., northern declination 22° 7′. At transit on the 5th she will be only about 12′ of arc *s p* the $4\frac{1}{2}$ magnitude star 93 Leonis. During the month she describes a slightly curved retrograde path from a little to the west of this star in the direction of δ Leonis. An account of the various estimations of the dimensions of this minor planet will be found in "Face of the Sky for May," 1890.

The minor planet Vesta, the largest of all the asteroids, comes into opposition with the Sun on the 6th, at a distance from the earth of about 125 millions of miles. She then appears as a $6\frac{1}{2}$ magnitude star, falling to the 7th magnitude by the end of the month. On the 1st her R.A. is 11h. $31\frac{1}{2}$m., northern declination 14° 55′. On the 15th her R.A. is 11h. $18\frac{1}{2}$m., northern declination 16° 41′. On the 31st her R.A. is 11h. $5\frac{1}{2}$m., northern declination 17° 55′. She thus describes a retrograde path in Leo from a point just three degrees almost due west from β, towards θ, being at transit on the 9th just 15′ of arc due north of the $5\frac{1}{2}$ magnitude star 85 Leonis. For measures of the diameter of Vesta, *cf.* "Face of the Sky for January," 1890.

Jupiter, though still the most brilliant object in the evening sky, should be looked for as soon after sunset as possible. He sets on the 1st at 0h. 37m. a.m., with a northern declination of 18° 16′, and an apparent equatorial diameter of 37·2″. On the 15th he sets at 11h. 53m. p.m., with a northern declination of 18° 48′, and an apparent equatorial diameter of $35\frac{3}{4}$″. On the 31st he sets at 11h. 4m. p.m., with a northern declination of 19° 29′, and an apparent equatorial diameter of $34\frac{1}{2}$″. During the month Jupiter pursues a direct path in Taurus, through a region barren of naked-eye stars. At about a quarter past nine p.m. on the 25th a $10\frac{1}{2}$ magnitude star will be about 70″ north of Jupiter; on the evening of the 26th an $8\frac{1}{2}$ magnitude star will be situated about 1′ *n p* the planet, and at about 10h. p.m. on the 30th a $10\frac{1}{2}$ magnitude star will be about $\frac{1}{2}$′ of arc north of Jupiter. The following phenomena of the satellites occur while the planet is more than 8° above and the Sun 8° below the horizon:—On the 1st a transit egress of the third satellite at 8h. 20m. p.m., and a transit ingress of its shadow at 11h. 28m. p.m. On the 2nd a transit ingress of the first satellite at 9h. 27m. p.m., and of its shadow at 10h. 44m. p.m. On the 3rd an occultation disappearance of the first satellite at 6h. 47m. p.m., and its eclipse reappearance at 10h. 14m. 34s. p.m. On the 4th a transit egress of the shadow of the first satellite at 7h. 26m. p.m., and an occultation disappearance of the second satellite at 9h. 3m. p.m. On the 6th a transit egress of the second satellite at 6h. 35m. p.m.; a transit ingress of its shadow at 6h. 40m. p.m., and its transit egress at 9h. 3m. p.m. On the 8th a transit ingress of the third satellite at 10h. 26m. p.m. On the 10th an occultation disappearance of the first satellite at 8h. 46m. p.m. On the 11th a transit ingress of the shadow of the first satellite at 7h. 8m. p.m.; a transit egress of the first satellite at 8h. 9m. p.m., and of its shadow at 9h. 21m. p.m. On the 12th an eclipse reappearance of the third satellite at 7h. 17m. 59s. p.m. On the 13th a transit ingress of the second satellite at 6h. 54m. p.m., of its shadow at 9h. 18m. p.m., and a transit egress of the satellite at 9h. 20m. p.m. On the 18th a transit ingress of the first satellite at 7h. 54m. p.m., of its shadow at 9h. 4m. p.m., and a transit egress of the satellite at 10h. 8m. p.m. On the 19th an eclipse reappearance of the first satellite at 8h. 34m. 37s. p.m., and an eclipse disappearance of the third satellite at 9h. 30m. 16s. p.m. On the 20th a transit ingress of the second satellite at 9h. 40m. p.m. On the 22nd an eclipse reappearance of the second satellite at 8h. 26m. 5s. p.m. On the 25th a transit ingress of the first satellite at 9h. 54m. p.m. On the 26th an occultation disappearance of the first satellite at 7h. 15m. p.m., and of the third satellite at 9h. 3m. p.m. On the 27th a transit egress of the shadow of the first satellite at 7h. 41m. p.m. The fourth satellite is in inferior conjunction at 3h. 29m. a.m. on the 16th, and at 11h. 18m. p.m. on the 29th; in superior conjunction at 4h. 37m. p.m. on the 4th, and at 0h. 13m. p.m. on the 21st.

Saturn is an evening star, rising on the 1st at 9h. 27m. p.m., with a southern declination of 7° 1′, and an apparent equatorial diameter of $18\frac{1}{4}''$ (the major axis of the ring system being 42″ in diameter, and the minor 10″). On the 12th he rises at 8h. 41m. p.m., with a southern declination of 6° 46′, and an apparent equatorial diameter of 18·4″ (the major axis of the ring system being $42\frac{1}{2}''$ in diameter, and the minor 10″). On the 31st he rises at 7h. 18m. p.m., with a southern declination of 6° 15′, and an apparent equatorial diameter of $18\frac{1}{2}''$ (the major axis of the ring system being $42\frac{3}{4}''$ in diameter, and the minor $9\frac{3}{4}''$). Titan is at his greatest eastern elongation at 4h. p.m. on the 12th; Iapetus at superior conjunction at 4h. a.m. on the 20th; and Titan at greatest elongation at 2h. p.m. on the 28th. Saturn describes a short retrograde path through a very barren region of Virgo.

Uranus is now an evening star, rising on the 1st at 11h. 34m. p.m., with a southern declination of 16° 2′, and an apparent diameter of 3·8″. On the 31st he rises at 9h. 30m. p.m., with a southern declination of 15° 51′. During the month he pursues a short retrograde path in Libra, to the E.N.E. of α^1 α^2 Libræ.

Neptune is still an evening star, but should be looked for as soon after sunset as possible. He souths at 6h. p.m. on the 1st, with a northern declination of 20° 35′, and an apparent diameter of 2·6″. On the 31st he souths at 4h. 3m. p.m., with a northern declination of 20° 40′. During the month he describes a short direct path in Taurus. A map of the small stars near his path will be found in the *English Mechanic* for December 29th, 1893.

There are no very well-marked showers of shooting stars in March.

The Moon is new at 2h. 18m. p.m. on the 7th; enters her first quarter at 6h. 28m. p.m. on the 14th; is full at 2h. 11m. p.m. on the 21st; and enters her last quarter at 8h. 28m. a.m. on the 29th. She is in apogee at 4h. p.m. on the 1st (distance from the earth 251,620 miles), in perigee at 6h. a.m. on the 17th (distance from the earth 229,230 miles), and in apogee at noon on the 29th (distance from the earth 251,130 miles). At 3m. past midnight on the 16th the $6\frac{1}{2}$ magnitude star ω^2 Cancri will be occulted at angle from the north point of 88°, and will reappear at 0h. 37m. a.m. at an angle of 314°. At 4h. 5m. a.m. on the 23rd the 1st magnitude star α Virginis will disappear at an angle of 123°, and reappear at 5h. 16m. a.m. at an angle of 297°. At 1h. 47m. a.m. on the 24th the $6\frac{1}{2}$ magnitude star B.A.C. 4700 will disappear at an angle of 109°, and reappear at 3h. 1m. a.m. at an angle of 318°. At 2h. 32m. a.m. on the 26th the 5th magnitude star 2 Scorpii will disappear at an angle of 125°, and reappear at 3h. 52m. a.m. at an angle of 282°; the 6th magnitude star B.A.C. 5255 will disappear at 2h. 58m. a.m. at an angle of 130°, and reappear at 4h. 17m. a.m. at an angle of 275°; at 3h. 6m. a.m. the 6th magnitude star 3 Scorpii will disappear at an angle of 85°, and reappear at 4h. 19m. a.m. at an angle of 320°. At 2h. 25m. a.m. on the 15th the 5th magnitude star 136 Tauri will make a near approach to the Moon's southern limb, at an angle of 185°, the star being about 2′ away. On the 21st the $3\frac{1}{2}$ magnitude star β Virginis will make a near approach to the Moon's northern limb, at an angle of 29°, the distance being about $2\frac{1}{2}'$.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of Problem No. 9.

Key-move—1. Kt to B5.

If 1. . . .	K × P,	2. Q to R2ch.
1. . . .	P × Kt,	2. Q to Ktsqch.
1. . . .	Kt × P, &c.	2. Kt to Kt5ch.

Dual after 1. . . . P to B5 by 2. Q to Kt7 (Author) or 2. Q to B2ch.

Unfortunately this dual occurs in the main variation. "Chat" alone has discovered the composer's intention.

Solution of Problem No. 10.

Key-move—1. Q to B3.

If 1. . . .	K to K5,	2. Kt × BPch.
1. . . .	P to QKt5,	2. Q to B3ch.
1. . . .	P to KKt5,	2. Kt to B4ch.
1. . . .	Kt (Rsq) moves,	2. Kt to B7ch.
1. . . .	Kt (Kt6) moves,	2. Q to Q4ch.

Correct Solutions received from the following:—

Seven Points.—Chat.

Six Points.—Kt. J., H. Holmes, Semper, Guy, E. W. Brook, B. G. Laws, A Norseman, A. C. Challenger, J. H. Christie, A. R., L. Bourne, W. T. Hurley.

No. 9 is correctly solved by H. S. Brandreth, and No. 10 by Alpha.

It is satisfactory to find that, in spite of the gaps caused by Nos. 6 and 7, so many solvers are continuing the fight.

With the exception that Mr. Adcock apparently retires, and that "Chat" takes the seventh place, the positions of the leading solvers are practically unaltered.

M. Kaizer.—Thanks for the game, which you will find below.

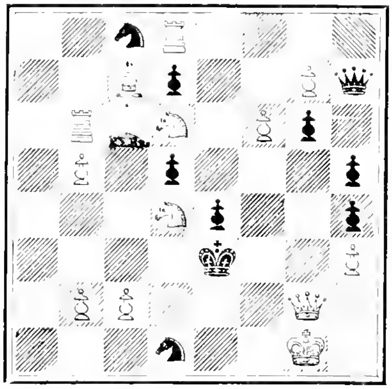
L. Bourne.—We suggested, two months ago, defences to the keys you give for Nos. 4 and 5 (*vide* January number). It is therefore your turn to mate in two moves (if possible) after those defences. If you cannot, the suggested key-moves do not hold good. Black must be allowed to make his best moves.

Semper.—Apart from a curious key and defence to a good "try," we do not remember any particular merit in the problem you mention. Probably many solvers mistook the "try" for the key.

Position No. 11.

"*Pearl of the Garden.*"

Black (10).



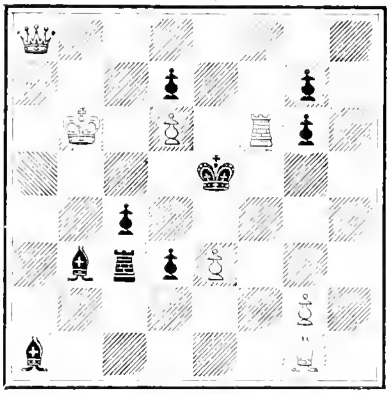
White (11).

White mates in three moves.

Position No. 12.

"*Slender.*"

Black (9).



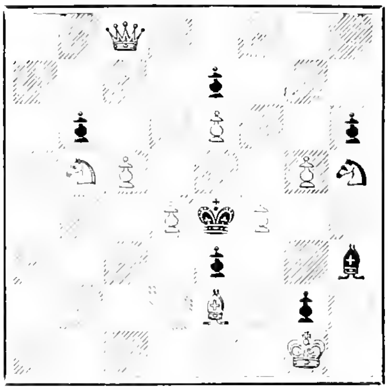
White (6).

White mates in three moves.

Position No. 13.

"*Invicta.*"

Black (7).



White (10).

White mates in three moves.

The following game was recently played in the tournament of the Liverpool Chess Club:—

"Ruy Lopez."

White (M. Kaizer).	Black (F. C. Howard).
1. P to K4	1. P to K3
2. P to Q4	2. P to Q4
3. Kt to QB3	3. Kt to KB3
4. P to K5	4. KKt to Q2
5. P to B4	5. P to QB4
6. P × P	6. Kt to QB3 (*a*)
7. P to QR3 (*b*)	7. B × P
8. Q to Kt4	8. P to KKt3 (*c*)
9. Kt to B3	9. P to QR3
10. B to Q3	10. Q to B2 (*d*)
11. P to KR4	11. P to KR4 (*e*)
12. Q to Kt3	12. Kt to Kt3 ? (*f*)
13. B to Q2	13. Kt to B5 (*g*)
14. B × Kt	14. P × B
15. Kt to K4	15. B to K2
16. Castles (*h*)	16. P to QKt4
17. B to B3	17. Castles (*i*)
18. Kt to B6ch	18. B × Kt
19. P × B	19. B to Kt2 (*j*)
20. Q to Kt5	20. K to R2
21. P to B5 ! (*k*)	21. QR to Qsq
22. P × Pch	22. P × P
23. Q to K3 !	Resigns (*l*)

Notes.

(*a*) The best move, as more than once pointed out in this column. Black reserves the option of capturing the Pawn with either Bishop or Knight, according to circumstances.

(*b*) Some players prefer 7. Kt to B3, or 7. B to K3. The move made compels the capture, and prepares for B to Q3 by preventing Kt to Kt5.

(*c*) Black's play up to the thirteenth move is very weak. He should castle at once, and follow it by the advance of the KBP.

(*d*) Having made his last move he should continue with 10. . . . P to QKt4, with a view to P to Kt5 or Q to Kt3.

(*e*) 10. . . . Kt to Bsq should be better than this.

(*f*) Almost anything would be better, *e.g.*, 12. . . . P to QKt4, or 12. . . . Kt to K2, or 12. . . . B to R2 or K2 with a view to Kt to QB4.

(*g*) And now 13. . . . B to Q2 should have been played.

(*h*) He might have played his next move now, and possibly castled on the other side.

(*i*) Marching straight into the lion's mouth. 17. . . . B to Q2 would enable him to castle on the Queen's side if he castles at all. Probably he feared Kt to Q6ch.

(*j*) There is no time for this. Perhaps his best chance lay in 19. . . . R to Qsq, trying afterwards to bring his Q to KBsq if possible.

(*k*) A pretty finishing touch. White threatens B to Q2.

(*l*) Whether he move the King or not the reply 24. Kt to Kt5 is fatal. Mr. Kaizer played the whole game in good style.

Contents of No. 100.

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LONDON: APRIL 2, 1894.

CONTENTS.

GROUND-SLOTHS.

By R. Lydekker, B.A.Cantab.

SUFFICIENTLY protected from all attacks on the part of the wolf-like marsupials, and such other large carnivorous mammals as may at the same period have roamed over Argentina, the pigmy glyptodont of the Santa Cruz beds of Patagonia could have had difficulty in maintaining its existence against foes of all kinds, and subsequently giving rise to the gigantic mailed monsters which we endeavoured to describe in our last article. Side by side with this well-defended creature there lived, however, another not less remarkable mammal, of nearly similar dimensions, and likewise belonging to the great order of edentates, then, as now, so characteristic of South America. This creature had, however, no such coat-of-mail as that which defended its contemporary (though there is a possibility that some bony granules may have been imbedded in its undefended skin), and as it appears to have been equally devoid of weapons of offence, while it did not derive protection from an arboreal life, it may be a matter of wonder how it managed to fight its way through the struggle for existence. That it did so is, however, perfectly clear, since the pigmy ground-sloth, as the animal in question may be called, is clearly the ancestral type from which were subsequently evolved those gigantic edentates of the Pleistocene deposits of the Argentine scientifically known by the names of *Megatherium*, *Mylodont*, etc., but which may be collectively designated ground-sloths. These, although unprotected by any means of defence, being among the most gigantic of mammals had, it is needless to say, no difficulty in holding their own: and it is only with regard to their pigmy ancestors that we have any cause for wondering how they managed to survive. Possibly, however, these pigmy ground-sloths were burrowing creatures, like the great anteater of the present day, and lived in holes excavated by their powerful claws; and if this should be the case, the difficulty as to their survival vanishes.

Sloths are, however, such essentially arboreal creatures, as characteristic of the Brazilian forests as are squirrels and dormice of our own woods, that our readers will want to know what we mean by using such an apparently contradictory term as ground-sloths.

To justify ourselves, and at the same time to enable our readers properly to understand the structure of these strange extinct edentates, we must enter into a short dissertation on the subject of sloths, and likewise of their distant cousins the anteaters.

The external form and long shaggy hair of the sloths are too well known to require description, and we accordingly pass on to draw attention to certain peculiarities in regard to their skeletons and teeth which will aid in explaining the reason for the term ground-sloths. In the first place, then, sloths (which, as all our readers are doubtless aware, are comparatively small animals) are characterized by their peculiarly short and rounded heads, which have an almost spherical form. If we examine the skull of one of these animals, we shall find, as in those of other members of the same order, a total absence of front teeth; while the cheek-teeth comprise five pairs in the upper, and four in the lower jaw.

Those who recall our article on "Armadillos and Aard-Varks," published in an earlier number of this journal, will not fail to recollect that in all edentates the teeth are devoid of the hard enamel so characteristic of those of other mammals. In the sloths we find that the teeth form short cylinders, of which the outer layer is harder than the central core, in consequence of which their grinding surfaces become slightly cup-shaped. In the three-toed sloths (*Bradypus*) the whole of the teeth are of this extremely simple type; but in their two-toed cousins (*Cholœpus*) the first pair in each are longer than either of the others, and are modified into a somewhat tusk-like form, the upper ones wearing against the front of the lower ones so as to produce by mutual attrition an oblique bevelled surface at the top of each. The limbs of the sloths are remarkable for their length and slenderness, but the front pair are much longer than the hinder ones. The narrow and curved feet terminate in long hooked claws, which in the three-toed species are three in number in each foot, although in the fore feet of the two-toed sloth they are reduced to a pair; in fact, the feet are reduced to the condition of little more than hooks, admirably adapted for suspending the animal back-downwards from the boughs of trees, but forming poor instruments for terrestrial progression, sloths when on the ground walking slowly and awkwardly, with the soles of the feet turned inwards, and the weight of the body supported on their outward edges. It is important to notice that in the skeleton of the feet the terminal bones, or those ensheathed in the long claws, are not longitudinally grooved on the upper surface.

The South American, or true anteaters, one of which is terrestrial, while the other two are more or less arboreal in their habits, are so unlike the sloths that it is difficult to believe they have any near relationship with the latter;

and, indeed, were it not for the extinct creatures forming the subject of the present article, it would have been very difficult to discover how close the connection between these two groups really is. In place of the short and rounded heads of the sloths, the anteaters have the head greatly elongated and very slender, while the thin jaws are totally devoid of teeth, and the tongue is long, cylindrical, and highly extensile. There is, however, some degree of variation in regard to the degree of elongation of the skull, the maximum development occurring in that of the great anteater. If possible, a still greater difference obtains in the structure of the feet, the fore foot of the great anteater having five toes, of which the middle one is vastly more powerful than either of the others; while all but the fifth have strong claws. In walking, the extreme outer side and part of the upper surface of the fore foot are applied to the ground; but in the hind foot, which has the fourth toe the largest, and all the five digits furnished with claws, the whole of the short sole touches the ground in the ordinary manner. An important difference from the sloths is to be found in the circumstance that the bones of the terminal joints of the feet have a longitudinal median groove on the upper surface at their tips.

With these preliminary remarks on some of the leading features of the sloths and anteaters, the reader will be in a position to appreciate the peculiarities in the structure of the ground-sloths, and likewise to understand the appropriateness of the name by which they are designated.

Apparently the first of these extinct animals known in Europe was the giant ground-sloth, or *Megatherium*, of which a nearly complete skeleton was discovered in the year 1789 near Lujan, in the province of Buenos Ayres. This skeleton was soon after sent to Madrid, and described by Cuvier in 1798, who gave to the animal to which it belonged the name by which it has ever since been known. If we desired to be hypercritical, we might convict the great anatomist of not having formed this name according to strict rule, for it ought clearly, as in the analogous instance of *Megalosaurus*, to have been *Megalotherium*, instead of *Megatherium*; but let this pass. Cuvier recognized the affinities of the megathere to the sloths; and other skeletons subsequently obtained from the Pleistocene deposits of Buenos Ayres, and which are now in the museum of the Royal College of Surgeons, the British Museum, and the museums of Milan, Paris, and La Plata, have in their turn served to confirm the general truth of the original determination.

One of the most gigantic of land mammals, measuring somewhere about eighteen feet in total length, the megathere, although having a rather more elongated skull, agrees with the sloths in the number of its teeth. In structure, however, these teeth, of which the four lower ones are represented in the accompanying

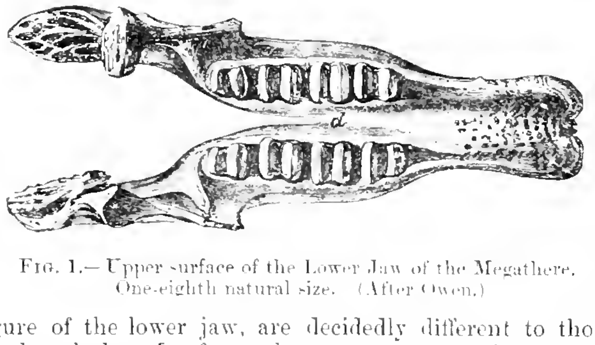


Fig. 1.—Upper surface of the Lower Jaw of the Megathere. One-eighth natural size. (After Owen.)

figure of the lower jaw, are decidedly different to those of the sloth. In form they are square prisms, with a length of over ten inches, and a diameter of fully an inch and a half. The summit of each individual tooth carries a pair of transverse ridges, produced by the alternation of vertical plates of different hardness in the tooth itself; and since the teeth are rootless and grow continuously throughout the life of their owner, this transversely-ridged structure is likewise permanent. To contain such enormous teeth, the lower jaw is remarkably deepened in the middle of its length, where it descends suddenly. The long median channel shown in our figure extending between and in front of the anterior teeth, is evidently for the reception of a large and fleshy tongue, which from its size was probably extensile like that of the giraffe.

If we had only the megathere to deal with, we might have some hesitation, judging from the skull and teeth (which in the group are the only portions of the skeleton showing sloth-like affinities), in regarding the group of animals to which it belongs as closely allied to the sloths. Fortunately, however, the same Pleistocene deposits of Buenos Ayres (to say nothing of the caverns of Minas Geraes, in Brazil) have yielded us remains of other and somewhat smaller ground-sloths, known as mylodonts,

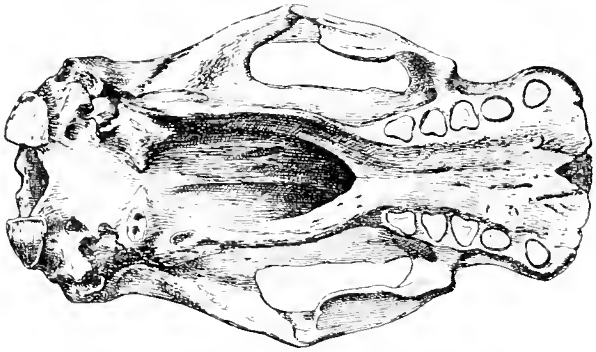
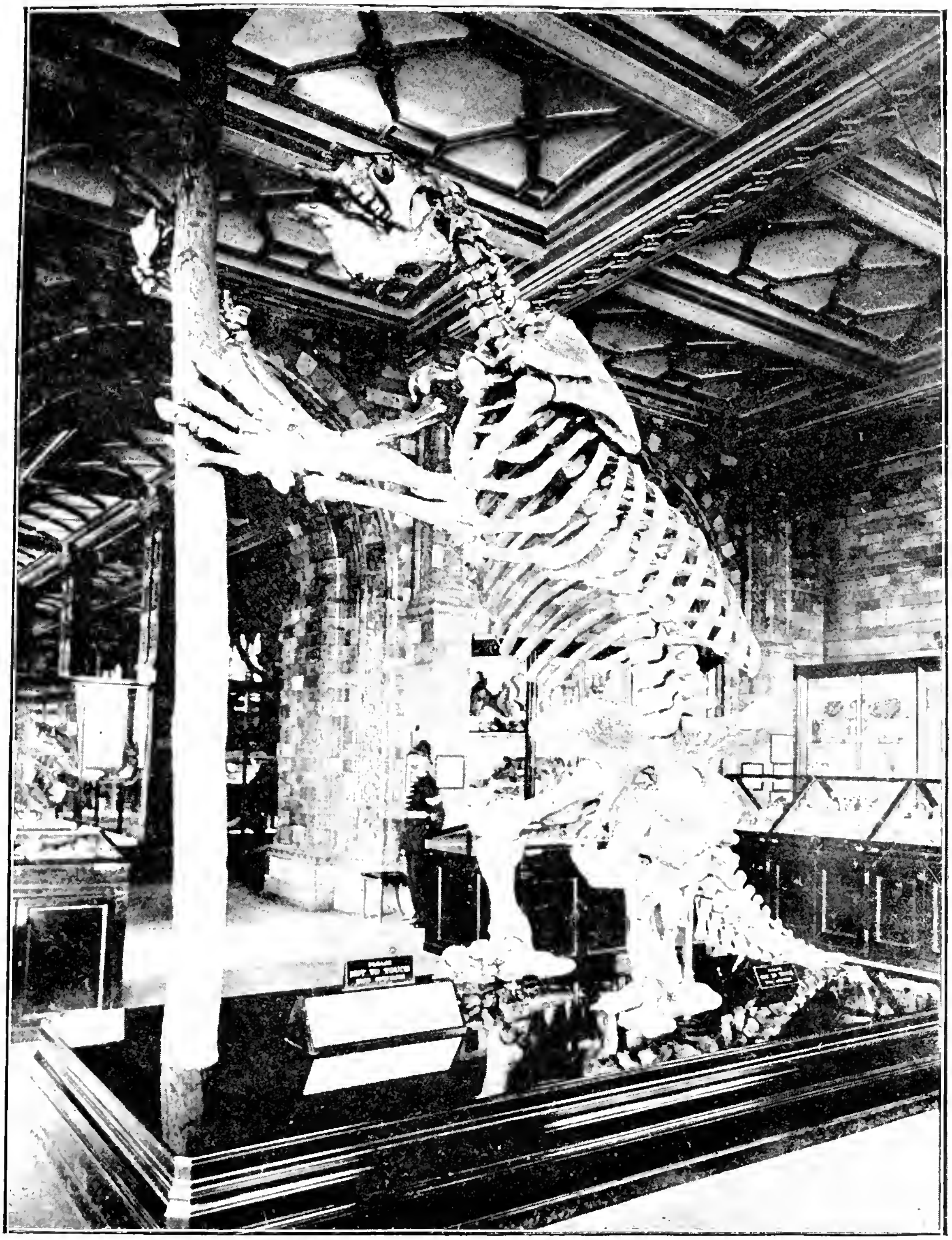


Fig. 2.—Under view of the Skull of a Mylodont. One-sixth natural size. (After Owen.)

which effectually bridge, in these respects, the gap between the megathere and the sloths. In these animals, as shown in our second illustration, the teeth are either cylindical or triangular in section; and from having a harder external coat, wear in the same cup-shaped manner as those of the latter. Moreover, in some mylodonts the front pair of teeth in each jaw have the elongated tusk-like form and oblique wear characterizing those of the two-toed sloth, while in others they resemble the hinder teeth, as in the three-toed sloth. We thus have an exact parallelism in this respect among the mylodonts to the two genera of sloths; and as their skulls in their more rounded and shorter form, and the absence of a descending expansion in the middle of the lower jaw, are likewise more sloth-like than is the skull of the megathere, we can have no hesitation in regarding the ground-sloths, so far as cranial characters are concerned, as closely allied to the sloths. It may be added that the great divergence of the two series of teeth in our figured mylodont skull indicates the presence during life of a tongue of great width and size.

Thus far we have been showing how the ground-sloths are related to the sloths in the characters of their skulls; but other members of the group, known as the scelidotheres (*Scelidotherium*), although still retaining the same number of teeth, show a certain approximation in these respects to the anteaters. Thus their skulls, instead of being short and broad like those of the mylodonts, are very long and narrow, and have the muzzle much produced in advance



SKELETON OF THE GIANT GROUND-SLOTH OR MEGATHERE. From Lujan, Buenos Ayres.

This Specimen, which is in the British Museum, measures about eighteen feet in total length.

of the anterior teeth. Indeed, it would require only a still greater elongation and narrowing of the skull of a scelidothere, coupled with the total loss of the teeth, to produce one very similar to that of an anteater.

So far as we are aware, palæontologists have not yet been able to trace a complete transition from the gigantic ground-sloths of the Pleistocene deposits of Buenos Ayres to their diminutive representatives from the older Tertiary deposits of Patagonia, although it is known that some of the species from the intermediate forms were inferior in point of size to their more recent allies. It is, however, very interesting to find that the pigmy ground-sloths of these Patagonian deposits had transversely-ridged prismatic teeth like those of the megathere, and not the cylindrical or triangular ones of the mylodonts, scelidotheres, and megathere; thus apparently indicating that the former type of tooth is the oldest. The contrast between the pigmy ground-sloth and the giant ground-sloth (*Megatherium*) is, however, most remarkable. The total length of the skeleton of the former was only about three feet; while its skull was less than six inches, whereas the skull of the megathere was over a couple of feet in length. Then, again, the whole series of five upper teeth occupy in the pigmy ground-sloth a space of less than an inch and a half, or less than the diameter of a single tooth of its gigantic relative. That such a diminutive creature, if as naked and undefended as its huge cousin appears to have been, needed some special protection, is pretty evident; and it is the need of such defence from attack that has led us to suggest that the creature may have lived in holes excavated by its powerful claws.

Leaving for a moment the mutual relationships and affinities of all these different animals, we have to direct a short glance at the skeleton of the body and limbs of the ground-sloths. In the first place, this differs from that of the sloths in the shortness and extreme massiveness of the limbs, and especially in the extraordinary stoutness and width of the bones of the hind leg and pelvis. In the general form of the scapula or blade-bone, and more especially in the presence of a complete pair of clavicles or collar-bones, the ground-sloths resemble the sloths and differ from the anteaters; the clavicles of the latter being rudimentary. The skeleton of the fore foot is, however, essentially that of an anteater, the inner toe being rudimental, the next three, and more especially the middle one, being enormously enlarged and furnished during life with huge claws, while the outermost was small and clawless. That during life the creature rested on the outer side of this fifth claw and the backs of the three large ones, in anteater fashion, may, from the structure and arrangement of their bones, be considered certain. Unlike the anteater, in which, as we have seen, it rests upon the sole, the hind foot of the Pleistocene ground-sloths is even more strangely modified than the front one, these creatures walking only on its outer edge, while the enormous middle toe, with its gigantic claw, does not appear to have touched the ground in walking and was thus always kept sharp. The first toe is wanting, and the second rudimentary, while the two outer ones were relatively small and unprovided with claws. Some idea of the gigantic proportions of the megathere may be gathered from the circumstances that its hind foot measures nearly a yard in length. Of the pigmy ground-sloths of Patagonia the complete skeleton has not yet been described; but so far as our recollection of a specimen in the La Plata Museum carries us, we believe that it was not of the extremely specialized type characterizing the gigantic forms. Moreover, while in the larger forms the terminal joints of the feet were neither grooved nor split at the extremities, in the small Patagonian species these were deeply cleft at the end, after the fashion obtaining in the scaly anteaters or pangolins of India and Africa. As regards the structure of the vertebral column, the ground-sloths exhibit certain peculiarities distinctive of the anteaters, and which are only rudimentary in the sloths.

When we add to the foregoing brief survey of the chief structural peculiarities of the skeleton of the extinct edentates forming the subject of the present article the circumstance that, from their enormous size, they must necessarily have been terrestrial in their habits, we are in a position to realize the appropriate nature of the term ground-sloths by which they are designated. These creatures may, in fact, be briefly described as edentates having a skull, teeth, and shoulder-girdle very similar to those of the sloths; while as regards their back-bone and feet they come very close to the anteaters, although in the later and more gigantic forms the specialization characterizing the fore feet of the latter has been extended to the hinder pair.

We now come to the interesting question of the mutual relationships and phylogeny of the three groups of edentates discussed in the course of the foregoing paragraphs. Now, in the first place, we shall have little hesitation in regarding the pigmy ground-sloths, which are the earliest known representatives of the group, as the direct ancestors of the gigantic megathere. A modification in the structure of the teeth would equally well permit of their having likewise been the ancestors of the mylodonts, which, as we have seen, possess sloth-like teeth. This, however, will not permit us to regard the mylodonts as having been the forerunners of the sloths, seeing that the latter have a less specialized type of hind foot; and we must accordingly regard the sloths as being a side-branch derived from the pigmy ground-sloths or some nearly allied form after the acquisition of cylindrical teeth, but before the hind foot had acquired the specialization characterizing the mylodonts and megatheres. Hence the curious structural similarity between the front teeth of some of the mylodonts and the two-toed sloth must be another instance of that parallelism in development to which a special article has already been devoted.

With regard to the anteaters, we have already seen that the fore foot of these animals resembles that of the pigmy ground-sloths in that the terminal joints of the larger toes are marked by a longitudinal groove representing the cleft of those of the latter; and as in both groups the middle toe is the largest, there is no reason why the anteaters should not trace their origin to these same pigmy ground-sloths or a closely allied type. In this case the specialization has resulted in a lengthening of the skull and the loss of the teeth, the hind foot having retained more or less of the primitive type. Here, likewise, we must notice that the resemblance presented by the skull of the scelidotheres to that of the anteaters must be regarded as an instance of parallel development.

From the structure of their teeth, the ground-sloths were evidently vegetarians; and the same may be said of the sloths, which are animals specially modified for the exigencies of a purely arboreal existence. On the other hand, the anteaters, as their name implies, have given up a vegetable diet and taken to living on ants, and to this may be attributed their total loss of teeth. Should germs of teeth ever be found in their jaws during an early stage of existence, we venture to predicate they will approximate in structure to the teeth of the ground-sloths.

Thus ends our survey of the structure and relationships of the extraordinary monsters forming the subject of this article; but we cannot conclude without saying a few words as to their probable mode of life and external appearance. As regards the latter, it may be suggested that since both sloths and anteaters are clothed with a thick covering of coarse hair, it is highly probable that the same held good in the case of their extinct relations. Further, from their massive proportions, and also from their kinship to the sloths, it is most likely that the ground-sloths were as slow and deliberate in their movements as the latter. That such monstrous creatures could not have existed in a treeless country like the Argentine pampas has been already indicated in the first of the series of articles of which the present is the conclusion, and we may hence assume that in the days of the ground-sloths Argentina was much like what Brazil is at the present day. Browsing on the leaves and probably on the smaller branches of forest-trees, the ground-sloths doubtless obtained their food by rearing themselves up against the trunks, supported on the tripod formed by their massive hind limbs and powerful tail, the ponderous structure of the pelvis being eminently adapted for maintaining the body in such a posture. The same massiveness of structure conclusively proves that the creatures were not arboreal, since no tree capable of being climbed could carry such an enormous weight. It was suggested, indeed, by Owen that the megathere was in the habit, when reared up in the manner indicated above, of clasping a tree in its arms and swaying it backwards and forwards until it fell with a crash to the ground; but although such a radical mode of procedure may have been occasionally resorted to, we have no right to assume that such was the ordinary habit of the ground-sloths.

THE MAKING OF DIAMONDS.

By Vaughan Cornish, M.Sc., F.C.S.

The reproduction of the diamond by M. Moissan has put the coping-stone to the work of mineralogical synthesis. For some years past it has been thought that the solution of this problem was merely a matter of time and patience; but it is no little satisfaction to be able to say at last that the thing has been done, for it is indeed a striking illustration of the power over stubborn matter which is won by the patient student of science. In the light of what has now been accomplished, it may not be without interest to refer to what was written in this journal on the subject of the production of diamonds previously to the work of M. Moissan. In Knowledge for May, 1891, at the conclusion of an article on "The Artificial Production of Rubies," the matter was referred to as follows:—

"The great problem in the artificial production of gems is the preparation of the diamond. . . . . . In the case of other minerals the successful production has generally only been achieved after a minute study of the mode of natural occurrence, and this has afforded guidance as to the best means of imitating the natural process of formation. It is only of recent years that the diamond has been found in its original matrix, so that materials have been wanting on which to base experimental methods. The chemical nature of the body, a combustible substance, is so different from that of the ruby and most other gems, which are oxides or oxidized materials, that the methods to be employed for its production will probably involve the application of different principles. There is no reason, however, to regard the problem as insoluble. When sufficient guiding data have been obtained, skill will not be wanting to imitate in the laboratory the conditions under which Nature has worked in the formation of this most beautiful product of the mineral world."

What some of these determining conditions might be was indicated in a subsequent paper on "The Diamond Mines of South Africa," which appeared in Knowledge for October, 1891. "To the mineralogist the chief interest of the South African mines lies in the fact that the 'blue rock' or kimberlite appears to be the original matrix of the diamond . . . . . It is worthy of note that a black shale forms one of the surrounding rocks, and pieces of this shale have been found baked and otherwise altered in the blue rock. The suggestion has been thrown out that the diamonds were formed by the alteration of the carbonaceous matter of the shale *under the influence of a moderately high temperature and great pressure.* Such indications are useful as affording suggestions to the experimentalist, to whom in spite of previous failures we must look to tell us definitely how the diamond is formed."

If the diamond be highly heated in the presence of oxygen it takes fire, as is well known, and burns with the formation of carbonic acid. If it be heated not in contact with oxygen it swells up and blackens, reverting to the ordinary charred form of carbon. But the action of heat upon bodies is in many cases very different when they are subjected to high pressure, a principle established by Sir James Hall more than one hundred years ago in his celebrated research on the conversion of chalk into marble, one of the achievements of experimental geology, described in Knowledge for July, 1891.

As will be seen, M. Moissan invoked the aid of pressure to modify the action of heat in his experiments, and produced diamonds from charcoal, a substance of the same nature as the "shale" which occurs in the Kimberley rock. The formation of crystals is, as a rule, best brought about either by sublimation or by cooling a solution. Carbon, however, cannot be distilled or sublimed, and is insoluble in all ordinary solvents, such as water or aqueous solutions of acids and alkalies, or in liquids such as alcohol, ether or benzene. On the other hand, molten metals can take up or dissolve carbon to a not inconsiderable extent, as happens, for instance, in the well-known process of iron-smelting. The molten iron in the blast furnace dissolves some of the carbonaceous fuel, a part of which, when the iron is allowed to cool and solidify, crystallizes out in plates of graphite.

This is an example of the production of a crystalline form of carbon from a non-crystalline variety, and it is at the same time an instance of the artificial formation of a mineral.

M. Moissan, in his experiments, employed iron as a solvent for carbon, which was in the form of charcoal; but he modified the action of heat and the solvent by subjecting the carbon-saturated iron to considerable pressure. It may be noted here that M. Moissan finds the principal constituent in the ash of the native diamond to be oxide of iron. It is known also that native diamonds often contain liquefied gases in cavities of the crystal, and that they are sometimes liable to spontaneous disruption, owing to a state of strain which is probably due to their having been formed under high pressure.

In an earlier series of experiments, iron melted by means of an electric furnace, and raised to a white heat, was allowed to saturate itself with carbon in the form of strongly compressed sugar charcoal. The crucible in which the operation was conducted was then plunged into cold water, which cools the outer portion of metal so as to form an outer layer of solid iron. While this outer coating is still red-hot the crucible is withdrawn from the water, and the cooling proceeds more slowly. To realize what goes on within the jacket of solid iron, we must remember that the still liquid interior is molten iron, containing a large excess of dissolved carbon, and that iron *expands* in the process of solidifying. Hence, during the process of solidification within the jacket or crust of chilled metal, great pressure is exerted. The process of solidification, therefore, goes on slowly and under great pressure, and examination of the resulting product showed that, under these changed conditions a part only of the surplus carbon had crystallized out as graphite, and that in the residue left after dissolving away all the iron by means of boiling hydrochloric acid and other solvents there was a certain quantity of a denser form of carbon (having a specific gravity of 3 to 3·5), and hard enough to scratch a ruby; and that among these heavier portions of the residue were transparent particles, having a greasy or waxy lustre, and marked with parallel striæ and triangular depressions. These transparent particles burnt when heated to 1050° C. in oxygen gas, and as it appeared, with the formation of carbonic acid; but the particles were too small to allow of a quantitative experiment. Similar results were obtained by the slightly modified method of rapidly cooling an ingot of molten iron saturated with carbon from a temperature of 2000° C. In a few cases small fragments were obtained "*qu'ils ressemblent aux petites fragments de diamant transparents que nous avons rencontrés dans la 'terre bleu' du Cap*" (*Comptes rendus*, February 6th, 1894). The result may be summed up by saying that, up to the date of the experiments described in the above quoted paper, M. Moissan appears to have succeeded in *reproducing that transparent variety of carbon of which native diamonds are composed.* The specimens could hardly be called *diamonds*, although they showed certain characters of the native diamond—*e.g.*, a waxy lustre, and parallel striæ and triangular depressions on the surface.

Since the experiments above described, a happy modification of the method employed has given results of a far superior kind, perfect diamonds being formed, having the distinctive physical peculiarities of the native stone, and of sufficient size for M. Moissan to prove by quantitative chemical experiments upon some of the specimens that they burnt with the formation of pure carbonic acid. In the course of experiments made in former years by other experimenters using other methods, transparent crystalline bodies were obtained which were thought to be diamonds, until their failure to satisfy the carbonic acid test showed that the crystalline particles were not composed of carbon.

Moissan's modified method is as follows:—Iron is saturated with carbon at the white heat of an electric furnace, and under pressure. The crucible containing the molten iron is then quickly lowered to the bottom of a bath of melted lead. This ensures quicker cooling than when the iron is plunged in water, owing to the fact, first, that the white-hot iron does not really come into contact with the water, and secondly, that the lead is a good conductor and carries away the heat rapidly. It seems that the two liquid metals behave towards one another much as oil and water, and the molten iron collects in spherical globules which rise to the surface of the molten lead, the difference in the specific gravity of molten iron and of molten lead being of course very considerable. The surface of the drops of liquid iron which float upon the surface of the lead quickly solidifies, the smaller drops with a diameter of one to two centimètres first, the larger drops after a lapse of a longer time, and the solid little balls of iron are left to float on the molten lead where they cool down. The interior of the balls is of course liquid long after the formation of the solid crust. The tendency of the central parts to solidify is resisted by the solid crust, owing to the fact before mentioned, that iron expands in the act of solidification. Meanwhile a part of the carbon crystallizes out from its solution in the liquid iron. After a time, as the cooling goes on, the lead also solidifies, and the little iron balls are left imbedded in the ingot of lead. Then begins the process of getting at the small quantity of the carbonaceous material which it is desired to examine. The lead which adheres to the iron is dissolved away with nitric acid, the iron itself is dissolved by hydrochloric acid, and further treatment with suitable solvents leaves the sought-for residue, a small quantity of material left after the tedious process of removing by slow chemical means the relatively large mass of metal.

Transparent diamonds are found in the residue having well-defined crystalline faces, striated and marked in the well-known way, and the edges generally curved; they have the high refracting power, the specific gravity, and the hardness of the native stone. The peculiar form known as the *hemihedral* predominates amongst these crystals as in those of native diamonds, and their formation under pressure is found to give rise to the phenomena of anomalous polarization of the light which passes through them, as well as occasionally to spontaneous disruption; characters which, as has been mentioned, are sometimes noticed in the native stone. The diamonds are of course small; one with a diameter of half a millimètre appears to be reckoned a fine specimen. Further practice in working the process will probably enable larger specimens to be obtained, as has been the case with the production of rubies, which are now produced of a size sufficient to be used in the jewelling of watches.

However this may be, the production of diamond is now an accomplished fact, achieved by the patient skill of the same worker who, seven years ago, successfully overcame the great experimental difficulties which had rendered fruitless the many former attempts to isolate the chemical element fluorine.

STINGING INSECTS.—III.

By E. A. Butler.

(*Continued from page* 56.)

ALL the stinging insects hitherto described have carried their weapons at their tail, where they form an instrument more or less closely connected with the process of egg-laying. Our third group of so-called stingers, for in this case the epithet is hardly accurate, comprises those that make punctures with their *mouth* organs, and often cause much pain and inflammation by so doing. The insects, in fact, feed on animal juices, and the "stings" are the necessary results of their attempts to obtain food, and do not form incidents in a hostile demonstration. All the members of this group belong to two orders—the Diptera, or flies, and the Hemiptera, or bugs. Taking the former first, we may remind our readers that we have on former occasions, in the articles on various household pests, discussed at some length the so-called "bites" or stings of some of the greatest sinners in this direction, viz., gnats, mosquitos, fleas, and the stinging house-fly (*Stomoxys*), and these details need not be repeated here. But there are a few other flies that are often very troublesome in the same way, though they do not enter our houses, but only punish us when we invade their domains in woods or marshes. One of the most noted of these has such a blood-thirsty appetite that it has been named *Hæmatopota*, *i.e.*, blood-drinker. It is an inhabitant of damp spots in woods, and though plentiful enough, is hardly likely to be noticed till painful experience in the shape of a sharp and sudden prick on hand or neck awakens us to consciousness of its presence.

It is a cruel-looking, grey-bodied insect, with speckled wings, and somewhat smaller and slenderer than a blue-bottle fly. During life its eyes are strongly suggestive of an evil nature, for they are green, with three or four crimson bands across them. Their brilliancy, however, disappears after death.

This fly, which is sometimes called the cleg, belongs to a family of evil repute, the *Tabanidæ*, which, from their persecutions of farm quadrupeds, have acquired, as a group, the name of horse-flies. Kirby mentions a striking instance of the severity of the attacks of these creatures. He was driving with another entomologist through Cambridgeshire, when the horse became "bathed in blood flowing from minute wounds made by the knives and lancets of various horse-flies." The larger members of the family are also known as gadflies, a name that has the misfortune of being applied to other flies as well, which are troublesome to cattle as internal parasites, and whose life-history, therefore, is totally different from that of the *Tabanidæ*. Much confusion has thus originated, and can only be avoided by using the scientific instead of the popular name. It must, therefore, be clearly understood that throughout this paper, when using the term gadfly, we are speaking of the non-parasitic gadflies of the genus *Tabanus*, and not of the parasitic ones of the genus *Œstrus*, which belong to quite a different family, and have no stinging power at all. The *Tabani* have further acquired the name of breeze-flies, in consequence, it is said, of the loud buzzing they make during their rapid and headlong flight. These larger kinds are not nearly so common in this country as the cleg, and it is fortunate, at least for our cattle, that such is the case, for with their larger size is associated a proportionately severer bite. There is, however, this to be said in their favour, that, in consequence of their buzzing, you know when they are coming, and can be on the look-out. Such is not the case with the wretched little cleg, which has a silent and almost stealthy flight, giving no warning of its approach, but settling on the skin in a calm and determined way, though with so gentle a touch that the victim is quite unconscious of its presence, if its arrival does not happen to have been seen. It does not run over the skin seeking a good place for attack, but sets to work at once at the spot on which it has alighted. By the time the prick is felt, the six lancets with which the mouth is furnished have already been plunged deep into the skin, and are fixed therein so firmly that, unless the fly chooses to withdraw them, some little force is needed to dislodge the creature. The after effect of the puncture seems, as is generally the case with punctures of this sort, to vary with the sensitiveness of the person attacked. To some it causes only temporary irritation, in others it produces swelling and inflammation which do not subside for some days.

In the articles on gnats and mosquitos above alluded to, we pointed out that the persecuting power is characteristic of one sex only; the males are harmless and inoffensive, and it is in the feminine mouth that all the virulence resides. The same is true of the *Tabanidæ*: the males have much smaller mouth organs than their partners, and have two lancets less, the knife-like mandibles being absent, and they regale themselves with sweets from flowers instead of blood. It is not a little remarkable that in the case of all the insects we have already dealt with, whether the power of irritation resides in the head or the tail, it is without exception the females, whether prolific or abortive, that possess the persecuting power. To this rule, however, the Hemiptera, which we shall consider presently, constitute an exception; in them both sexes possess and use the piercing bristles.

Another very brilliant but exceedingly vicious member of the *Tabanidæ* is the "golden eye" (*Chrysops cæcutiens*) (Fig. 6). It is a trifle larger than the cleg; its black body has an orange band at the base, interrupted with black markings; its wings have a dark cloud along the margin, a dark band stretching across the middle, and another smaller one towards the tip. Even in these parts it is a handsome insect, but it is in the eyes that its greatest glory lies. On seeing the creature for the first time one can hardly suppress an exclamation of admiration and delight, as one gazes at the blaze of brilliance with which the eyes sparkle—it is as though the brightest of gems were set in glowing masses over the head; the ground colour is brilliant golden-green, and scattered over this on each eye there are five deep crimson or purple spots. The hind border of the eye also is set with the same intense colour, and then, as with a gem, there is a change of the appearance as it is regarded first from one point of view and then from another. Like the cleg, this fiery creature is silent in its flight, and the first hint of its proximity is its own brilliant self seen calmly resting, perhaps, on one's coat-sleeve. If this be so we can afford to admire it at leisure, but if it should have dropped silently down on to the bare flesh, the first involuntary thought of admiration will soon be banished by a sharp twinge of pain, and we shall hasten to shake or brush off the offender, heedless of its gems and their lustre. The mouth organs in all the female *Tabanidæ* form a vicious-looking beak pointing downwards from beneath the head, and as the antennæ also have a rather cruel aspect, being short and stiff and curled upwards like little horns, the face of the insect forms a pretty good index to its character.

Fig. 6.—Golden-eye (*Chrysops cæcutiens*). Magnified two diameters.

The gadfly of the ox (*Tabanus bovinus*) is a very fine insect, the bulkiest of all our British Diptera. Like its brethren it has a broad, flattish body, each segment of which is dark at the base and pale at the apex; in the centre the pale margins expand into pale triangles, which form a line down the middle, and by their artistic effect take off something of the otherwise awkward breadth of body. The larva of this fine insect is a footless grub which lives underground, where it appears to feed on the roots of plants and vegetable refuse. While still underground it changes into a spiny chrysalis, and when about to become a perfect fly this chrysalis works its way up through the soil by means of its spines and bristles. In this resting stage it is of course blind, like pupæ in general, and how it knows in what direction to move so as to reach the surface must be left to conjecture. The larva is full grown in May, and the perfect fly appears during the summer, when it becomes a great plague to cattle in districts where it is common, by piercing their hides by means of its powerful set of six lancets, and sucking their blood. This is certainly a strange revolution in tastes; that an insect which in early life is a nibbler of roots should become in adult age a sucker of blood is hardly what would have been expected, though it is by no means an alteration without parallel amongst the order Diptera. A change from solid to liquid food is necessitated by the altered form of the mouth organs, but still there are plenty of vegetable juices available, and it would have seemed more natural had some of these been selected. There are several other species of *Tabanus*, which closely resemble the gadfly in form and adornment, and which are sometimes mistaken for it. The true cattle pest may, however, be distinguished by its comparatively gigantic size; it attains a length of about an inch, and has an expanse of wing of at least two inches, and this is a very large size for a British fly. It flies with a loud hum, and wheels round its prey in large circles before commencing the attack. The female lays some four hundred or five hundred eggs, which are deposited on grass stems, and the larvæ when hatched wriggle down and work themselves beneath the soil, where they soon find appropriate food. A degree of fecundity such as this may well cause this insect to become an intolerable nuisance in any district in which it is well-established, not only to cattle, but to human beings as well, for it is quite ready to attack mankind. Fortunately it is by no means common in this country, and we are therefore tolerably free from molestation.

But even the gadflies have had their apologists. In the days when the "apothecary's" chief instrument was the lancet, and blood-letting was regarded as the universal panacea for human ills, it is scarcely surprising that the idea was entertained that the attacks of gadflies on cattle were not altogether an unmixed evil, but that in fact, by their phlebotomy, these insects might even be a valuable preventive of disease in full-fed animals, and that their incessant attacks, by keeping the cattle in constant movement, were useful in giving them needed exercise, and thus holding in check such diseases as might be generated by indolence and repletion.

In this connection may be mentioned that terrible pest of Central Africa, the tsetse fly. Though such a fearful scourge, it is but a small insect far inferior to the gadfly in size, and indeed not much larger than an ordinary house-fly. According to Livingstone, its attack produces no immediate effect on the cattle, and symptoms of constitutional derangement do not appear till a few days after the puncture has been made. The eyes and nose then begin to run, and swellings appear under the jaws; though the animal continues to graze, it becomes thin and starved in appearance, and its flesh becomes flaccid and feeble. Some perish at an early stage with staggering and blindness, as though the brain were affected; others linger on, becoming more and more emaciated, until at last they die of extreme exhaustion, all the organs of the body being more or less diseased.

There is a most remarkable section of the fly order, which contains flies parasitic upon various mammals and birds; some of them, like the bat-louse and sheep-tick, have no wings, and their popular names reflect the mistakes that have thence arisen as to their zoological position. Though their habits are those of lice and ticks, they are yet true flies—very extraordinary ones, it is true, but still none the less members of the order Diptera though they have no wings. Some near relations of theirs may be appealed to in support of this contention; the bird-louse or fly (*Ornithomyia*) and the horse-louse or fly (*Hippobosca*) are in shape of body and general habits very much like the sheep-tick, but they have the usual pair of wings of dipterous insects. These insects live upon the blood of their hosts, which they suck up through a fleshy tube leading into the mouth, composed of the labium and maxillæ and provided with piercing bristles. On the death of their host they forsake it at once, and proceed to seek for another; when on this search the bird-louse is not always particular as to the animal from which it shall elect to take its next draught, and if unlucky man should fall in the way he will become the victim. *Hippobosca equina* is a great pest to horses, settling on them as they pass through woods, and running in spirited fashion over their bodies in search of those parts that are least covered with hair. These found, they plunge their straight beak through the skin and greatly irritate the quadruped. Swishing with the tail, the horse's only method of dislodgment, is not very effective, because the flies cling so tightly, and have such tough bodies. By far the most remarkable facts connected with these insects are those that concern their reproduction. They are not prolific, the female producing no more than a single egg at a time; there is, however, a good reason for this slow rate of increase, for the egg is not actually laid when fertilized, but is retained within the body of the mother, where the larva is hatched and remains during the whole of its larval life. During this time it is fed on a milky secretion furnished within the mother's body, and of course it grows a good deal, and the body of the mother, which is sac-like without evident segmentation, expands to accommodate it. Thus there is no room for more than a single egg. As soon as the immured grub has assumed the pupa state, it is deposited by the mother as a large, soft, white, roundish body which, but for its size, might easily pass for an ordinary egg. As we have seen, however, it is really a pupa, or rather puparium, since, according to fly custom, the real pupa is enclosed in the last larval skin. The apparent eggs, then, laid by the flies of this division are not really eggs at all, but pupæ, and hence the group has been named "Pupipara," *i.e.*, bringers forth of pupæ.

Brief reference may now be made to the Hemiptera. All of these insects possess four piercing bristles in a gutter-like labium, which constitutes a sort of beak, usually carried, when at rest, bent backwards beneath the head. They all feed upon liquids, derived either from animals or plants, the latter being by far the most usual source of supply. As a consequence, only a very few species ever trouble mankind, for even amongst those that are animal feeders it is the rarest thing for man to be the animal selected, and indeed it is usually by accident that such an event happens. Of course there is the bed-bug, which seems to have permanently attached itself to mankind, but beyond this no species can be spoken of as other than quite an occasional and incidental assailant. We have sufficiently discussed our bedroom pest on former occasions, and need now therefore only notice the other species that are likely to trouble us. These are almost entirely to be found amongst water insects, two of which are all that call for notice. The first is the water boatman (*Notonecta glauca*), a well-known inhabitant of ponds, which swims on its back, oaring its boat-shaped body about with the utmost vigour by means of its flat and fringed hind legs, and every now and then resting at the surface with the tip of its body just out of the water for breathing purposes. It is a strong, active, and rapacious insect, wielding an iron rule over the other inhabitants of the pond; of course it does not eat them, since it has no biting jaws, but it hugs them tight, digs its beak into them, and sucks out their juices. It is a bold and enterprising insect, and very much objects to having its liberties curtailed, so that if caught in a net and then taken into the hands, it is not slow to manifest its indignation by a sharp prick with its beak (Fig. 7.) This, however, can hardly be intended for taking food, but must be regarded as a defensive act. The pain is acute at the moment, but it soon passes off, and no after ill effects are perceived.

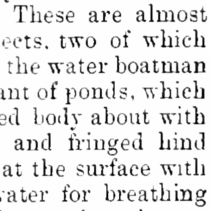


Fig. 7.—Head of Water Boatman, with beak extended. *a*, antennæ; *b*, beak; *e*, eyes. Magnified three diameters.

The other insect is a closely allied species, of a dark olive-brown colour, broad and flat instead of narrow and deep, as the boatman is. It is not so common as *Notonecta*, and as it lurks amongst pond weeds, is rarely seen except when taken in a net; it appears, therefore, to have no popular name, but is scientifically known as *Naucoris cimicoides*. Its behaviour is much the same as that of *Notonecta*, save that it swims back uppermost, and the pain of its prick is at least as acute, if not more so, and hence most persons would instinctively drop it as soon as they felt the prick, under the impression that a real sting had been received.

The only terrestrial species of Hemiptera that has been found to give a painful prick with its beak is a very common insect found amongst low herbage, such as tufts of grass, rushes, stinging-nettles, &c. It is called *Nabis limbatus* (Fig. 8), and is a long, narrow, brownish insect, with long, slender legs, and rudimentary wings. The female has the body considerably dilated, and marked above with pale orange stripes, which contrast prettily with the more sober colouring of the other parts. Like the other members of its genus, it is active and predaceous, feeding on the juices of other insects. Only one instance has been recorded of its attacking man, and that was under the most exceptional conditions, when the equanimity of any insect might be expected to be disturbed. In 1889, Mr. Eardley-Mason wrote as follows to the *Entomologist's Monthly Magazine*:—"On 1st September last, feeling a sharp sting on my neck, I hastily put up my hand to catch the offender, when, instead of a wasp, it proved to be a *Nabis limbatus*. The sensation was precisely that of a wasp's sting, and the appearance also. The swelling, however, was not nearly so great, and in two hours both it and the irritation had subsided. The insect, I imagine, had been trapped between my neck and shirt collar, and had resorted to its rostrum as a weapon of defence." Such an experience is certainly very rare, and I have myself handled hundreds of these insects without ever having been stung. It was no doubt the awkward position in which the insect found itself that led it to behave in such an unprecedented way.

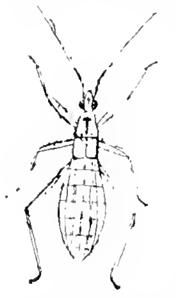


Fig. 8.—*Nabis limbatus*. Magnified two and a half diameters.

Our final group of stinging insects consists of caterpillars with glandular hairs, such as those of the brown tail and gold tail moths, and the processionary moths of the Continent. As we have already described in detail the powers of these insects in the recent articles on caterpillars, it will be unnecessary to enlarge upon the subject here, and we need only remind our readers that these stings of the fourth class are the only ones that are, as it were, accidental, and independent of the will of the insect, being brought about by the mere contact of an external body with the hairs. Nevertheless, in result they are as painful as the bites and stings already referred to, and give rise to even greater irritation. These are the only group, too, in which the effect may be produced without actual contact with the insect itself; merely holding the head over a box containing the caterpillars is sometimes sufficient to produce considerable swellings and much irritation, no doubt because of fragments of the hairs floating about in the atmosphere.

A word may be added with reference to the accompanying plate. The figure of the gadfly, magnified about three and a half diameters, will speak for itself, as we have described it above. The flattened body, the pale margins of the segments, expanding in the middle into pale triangles, and the forked antennæ, will serve to distinguish it from other two-winged flies. This insect, it will be remembered, carries its weapons around its mouth. The three bees, typical of insects whose weapon is in the tail, represent the "sexes" of the hive bee (*Apis mellifica*), magnified about one and a half diameters. The bulky body, meeting eyes, and longer antennæ and wings, at once distinguish the drone or male bee. The queen being monandrous, and one impregnation lasting her lifetime, only one drone is really required for each queen, so that the annual production of drones is far in excess of actual requirements; and as the queen is caught by her partner in the air, the successful suitor is likely to be one of the finest of the brood, and thus the quality of the breed is maintained. Under ordinary circumstances the drones are of course stingless, but since hermaphroditism occasionally occurs amongst bees as amongst other insects, drones with sting and poison gland complete may be met with—in fact, various admixtures of the sexual peculiarities occur, such as specimens with drone abdomen and thorax and worker head, and the converse; or, more remarkable still, with drone abdomen and thorax and one half of the head worker and the other half drone, as well as the converse of this.

THE GREAT SANITARY LESSON OF THE CRIMEAN WAR.

By G. B. Longstaff, M.A., M.D.Oxon., F.R.C.P., &c.

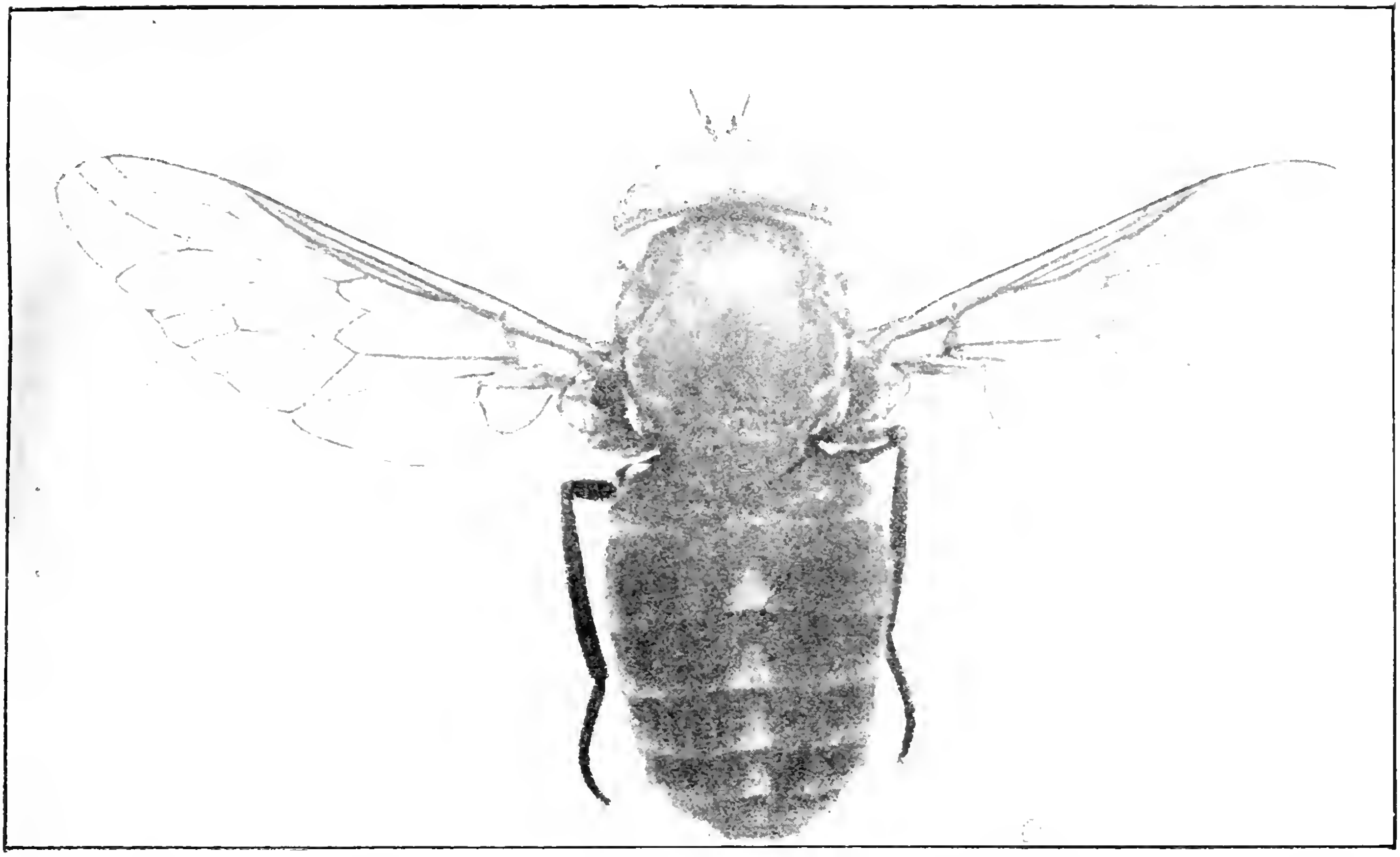
War is a great evil, some would go so far as to say the greatest of all evils; but, bad as it is, horrible as it is, we owe many good things to war, some that few dream of.

It is now forty years since the armies of France and England pitched their camps on the plateau before Sebastopol. The winter of 1854-5 caused unspeakable sufferings to many thousands of brave men. Did they suffer in vain? By no means, but it is quite certain that very few people know in what way we to-day are benefiting from the hardships they endured in those terrible days.

I will quote from one who was there, who studied the object-lesson deeply, who barely escaped with his life, but who lived long after to give to his countrymen in a most practical form the results of his painful studies. J. Netten Radcliffe, late Medical Inspector of the Local Government Board, wrote: "The Crimean war was one of the most important agencies concerned in the development of sound sanitary method and practice in this country"; and he went on to say that its sanitary lessons constitute, probably, the most important legacy left to the nation by that war.*

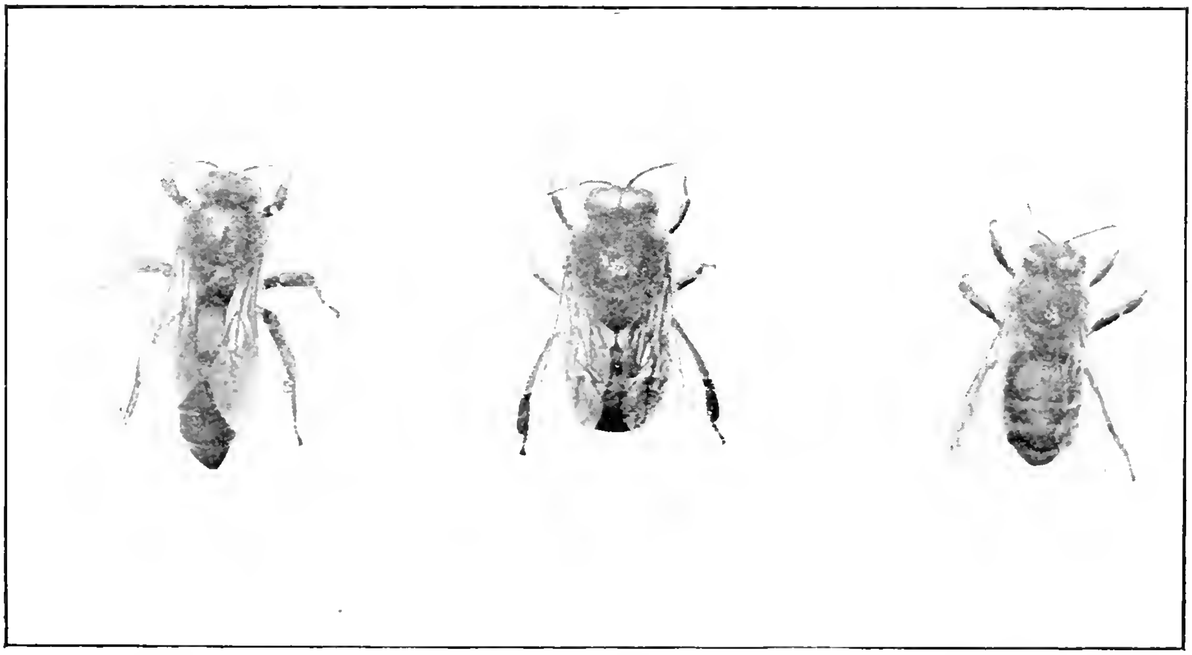
"The great catastrophe which befell the British army in the Crimea during the winter of 1854-5 was no novelty in our military history, but it occurred under circumstances very different from any that had ever before presented themselves in the wars waged by this country. It occurred at a time when the country had been thoroughly aroused [especially by the cholera epidemic of 1849] to a sense of the supreme importance of the health of the population as affecting the welfare of the nation, and was prepared to take an intelligent interest in all questions relating to the subject. It occurred also under circumstances of publicity such as had never attached to an army in the field before. . . . . Then England learnt for the first time how strangely it had misapprehended the requirements of the soldier. By the electric telegraph, the facility of

* "Sanitary Fundamentals." Two lectures delivered at the Royal Naval College by J. Netten Radcliffe, afterwards published in *The Practitioner*.



GADFLY *(Tabanus bovinus)*, **the largest British species of the genus.**

With its strong and well-developed mouth organs, which are beneath the head and cannot be seen in the specimen, it pierces the hides of cattle and sucks their blood. Its enormous masses of compound eyes will be noticed occupying nearly the whole of the surface of the head. The two horn-like objects projecting from the front of the head are the antennæ. The first two pairs of legs were bent under the body in the specimen photographed, and only the knees of the first pair can be seen. One of the halteres, or balancers, the substitutes for hind-wings in the Diptera, can be seen as a knobbed stalk just above the left hind leg.



QUEEN BEE. **DRONE.** **WORKER BEE.**

(Apis mellifica).

The queen is the mother as well as the ruler of the hive, being the only perfectly developed female present: her long, pointed abdomen distinguishes her. She is furnished with a sting. The drone is the male bee, and may be known by his broad, bulky body, and longer antennæ; he has very large eyes, which meet on his forehead, and large and powerful wings. Both of these peculiarities give him an advantage in mating with the queen in the air; by his superior sight he can see her at a distance, and by the strength of his wings he can rise above her. He is stingless, and his legs are not provided with the means of collecting pollen, so that he rarely, if ever, visits flowers. The worker is the smallest of the three, and being an imperfectly developed female, is provided with a sting. The workers have depressions on the hind legs for carrying pollen, and by them all the work of the hive is performed.

correspondence given by steam power, and the marvellous intelligence of the daily press, the most intimate life (so to speak) of the Crimean army was laid open to the English public from the time of its leaving these shores to the time of its return. . . . . The forces had barely landed on a foreign soil, when an uneasy consciousness that all was not as it should be began to possess the public mind. . . . . The suspicion grew with the progress of the war, gaining strength from the events at Varna, and on the beach near Eupatoria, the night after the descent upon the Crimea. The horrible deadlock at Scutari quickly followed, and doubt was at an end. With amazed indignation the British people saw an utter absence of organization in the general hospitals, department clashing with department in hopeless confusion, and official routine setting at nought the dearest interests of the soldier and honour of the country. It witnessed the wounded of Alma, of Balaclava, and of Inkerman, and the rapidly increasing sick from the camp before Sebastopol, crowded together without order or decency, and wanting even the sheerest necessaries amidst an apparent profusion of stores, and within cannon-shot of a great city. It witnessed these gallant men rotting away amidst revolting filth and neglect; the vast buildings in which they were housed converted into foul pest-houses; the medical staff helpless amidst the trammels of senseless regulations; and the military authorities deaf to remonstrance, and placidly replying to all protests that they had no official information of the state of things being such as the public press represented it to be.

"Then the indignation of the people broke forth. It intervened, with a force which could not be said nay to, between the sick and wounded and the authorities. From its abundance the nation poured out whatever was needed to give its maimed and helpless soldiers ease, comfort, and the hope of life." The *Times* organized this spontaneous outbreak of public feeling; and Florence Nightingale appeared upon the scene, and "dispelled the hideous gloom which had gathered around the sick and wounded at Scutari, and extended its shadow to every hearth in the kingdom."

To Miss Nightingale's book, "Notes on Hospitals," we owe scarcely less than to her heroic work at Scutari: but even she could have effected little but for the noble administrative work of Sidney Herbert. The reports of the Barrack and Hospital Improvement Commissioners—of whom Captain Douglas Galton is still with us as an active labourer—laid down principles which must remain true for all time, and which have been of incalculable benefit to civilians no less than to military men in many countries besides our own. It is probably no exaggeration to say that no barrack, workhouse, hospital, infirmary, asylum, or even large school has been erected in the last thirty years that is not indebted in a greater or less degree to the reports of that Commission.

In those days the duties of the army medical officers were officially confined to the treatment of the sick and wounded; as regarded preventive measures they were helpless. Before our troops sailed from England, and again in the early autumn in the Crimea, warnings were uttered by the chief medical officers, who were well versed in the medical histories of earlier campaigns, but they were curtly ordered to mind their own business. Now-a-days the main duty of the army surgeon is held to be the *preservation* of the health of the troops committed to his charge, and the Professor of Military Hygiene is not the least important teacher in the Army Medical School at Netley. English generals, now-a-days, constantly consult their principal medical officers, with the best results for all under their command.

When the pitiless Russian winter fell upon our troops it found them clothed in summer garments, with no better shelter than their bell-tents, in which the men huddled together for warmth. Crowding engendered typhus; the personal uncleanliness, scarcely avoidable under the circumstances, brought forth vermin. The lack of vegetables and delay in serving out lime-juice caused an outbreak of scurvy, and the scurvy-stricken soldiers, with spongy and bleeding gums, could scarcely gnaw the hard biscuit, their only bread. There were no definite sanitary regulations, and matters were aggravated by the men being exhausted by work in the trenches, so that we are told that the camps became "diffused cesspools"; naturally dysentery, camp-diarrhœa, and enteric fever were added to the other plagues.

The cup of misery was filled to the brim before the Royal Commissioners arrived upon the scene. The results which followed the adoption of their recommendations were startling in the extreme. "The hospitals were quickly reduced to order and efficiency, and the health of the men speedily rallied. From month to month the physical vigour of the troops improved, notwithstanding the harassing duties of the siege, and the evil sanitary condition in which, at the best, they were too frequently of necessity placed; and before the end of the war the remarkable spectacle was presented of an army maintaining a higher degree of health in the field, in presence of the enemy, than when comfortably housed in barracks at home during peace."

But who were the Commissioners? and what were their methods? They were Robert Rawlinson and Drs. Hector Gavin, John Sutherland and Gavin Milroy. They came fresh from the sanitary organization of England, under the first Public Health Act (of 1848), and they simply found a state of affairs practically indistinguishable from that prevailing in the slums of London, Liverpool, Leeds, and Glasgow, crowded as they had been by fugitives from the Irish famine of 1847. "There was the like privation, with the like results; the like unutterable filth, again with the like results; the like close packing together of the living, still with the like results; the like squalidity of person, clothing, and surroundings, again and again with the like results"—typhus, scurvy, diarrhœa, vermin.

"With the introduction of proper food, scurvy presently ceased, and with the cleansing and better ordering of the camps and hospitals, typhus, dysentery, and diarrhœa practically vanished: by the adoption, in fact, of the same sort of sanitary measures which it was sought to make common in our towns and villages at home, diseases which were at that time and still, although happily to a less extent, are the curse of our crowded communities, disappeared from the army, and the men reached the remarkable pitch of health which I have already described. And this result, it must be remembered, was brought about with the troops occupying the same positions which they had occupied since the beginning of the siege—positions around which of necessity had been deposited the accumulated filth of the occupation, and all the dead, human and brute, for which a resting-place had to be found."

It was at that time the tradition of the Navy to allow the naval surgeon more discretion in preventive measures, and it is satisfactory to be told that the naval brigade suffered much less than the soldiers; it never got into so deep a slough, and recovered it more rapidly when better times came.

But it will be asked, How about the French? Put very shortly, this is what happened. At the commencement of the operations the French troops settled down to camp life much better than ours; they showed a greater capacity for adapting themselves to the new conditions, although in this respect they fell short of our sailors; they were more provident in proceeding at once to make good roads from their landing-place to the front; they were conspicuously better cooks, and it is even said that they feasted upon what our men threw away. Once more, I cannot do better than quote Mr. Radcliffe's words. "Yet there was still another tragedy to be enacted in the Crimea before the war ceased. I have already spoken of the French army as suffering less than the British from the sicknesses incident to the campaign during the winter of 1854-55, and I have more than once referred to the better organization of our allies, in view of field service, at the beginning of the war. There can be little doubt that to this better organization, and to the greater adaptability for campaigning displayed by the French soldier during the first period of the war, the comparative immunity of our allies from the sufferings which crippled the British forces was owing. But after the termination of the first winter, and during the time that the British army was recovering from the state into which it had been plunged, and was proceeding step by step to that extraordinary pitch of health and efficiency I have described, the strange spectacle was presented of the French army gradually sinking into a state of misery and disease, which eventually, in the winter of 1855-56, equalled, and indeed, if it were possible, surpassed what had been witnessed in the British army the preceding winter. A more startling contrast was never contemplated than that presented by the English and French camps and the English and French hospitals during the winter of 1855-56. On the one side—the French—was to be seen a gallant army melting rapidly away from privations and from typhus, dysentery, scurvy, camp-diarrhœa, and other deadly ailments; camps degenerated to the lowest depths of negligence and filth; hospitals from which all semblance of hospital care and order had gone, and which were equally deadly to patients and attendants. As in the Crimea, so in the Bosphorus; the scenes which had been enacted in the British hospitals at Scutari in the winter of 1854-55 were now re-enacted in the French hospitals in Constantinople in the winter of 1855-56. But there the resemblance ended. With the coming of the spring of 1856 there was no arrest of the diseases which were sapping the marrow of the French army, such as there had been in the case of the British army the preceding year; and when peace was declared, the entire disablement of the French forces from privations and sickness appeared to be imminent."

Towards the close of the siege the Russians suffered also very severely from typhus, and when the army after the conclusion of the war was distributed over the country, it carried the fell plague with it to every halting-place, causing a wide-spread mortality among the civilian population, which probably far exceeded one hundred thousand.

Incidentally, a lesson in pathology (the science which treats of the nature of disease) of lasting importance was finally driven home by this campaign. Hitherto the French doctors, who at that time held a very high position in the scientific world, had been destitute of experience of typhus fever, and combated the views of Jenner, Murchison and Budd that 'continued fever' comprised at least two diseases which were fundamentally distinct, alike in symptoms, causes, and mode of propagation. The French army surgeons had ample opportunities on the plateau before Sebastopol of seeing the behaviour of the two diseases side by side, and from that time there was no disagreement as to the distinctness of typhus, which is invariably associated with overcrowding and is propagated directly from man to man, from typhoid or enteric fever, which is associated with conditions of excremental filth and propagated for the most part indirectly by means of polluted water or milk.

True sanitary method necessitates a foundation of exact knowledge of the nature of disease.

Mr. Radcliffe adds with great force: "If it had been possible for any doubt to have rested upon this great result and its causes, the spectacle of the French army sinking into the slough out of which we had escaped, and the conditions under which this happened, would have put an end to it. Here, then, was a lesson in hygiene, having the precision and force of a scientific experiment, as applicable to civil as to military life, and which exercised a less obvious but hardly less important part on the progress of civil hygiene in this country than it did upon military hygiene."

THE THERMAL RADIATION FROM SUNSPOTS.

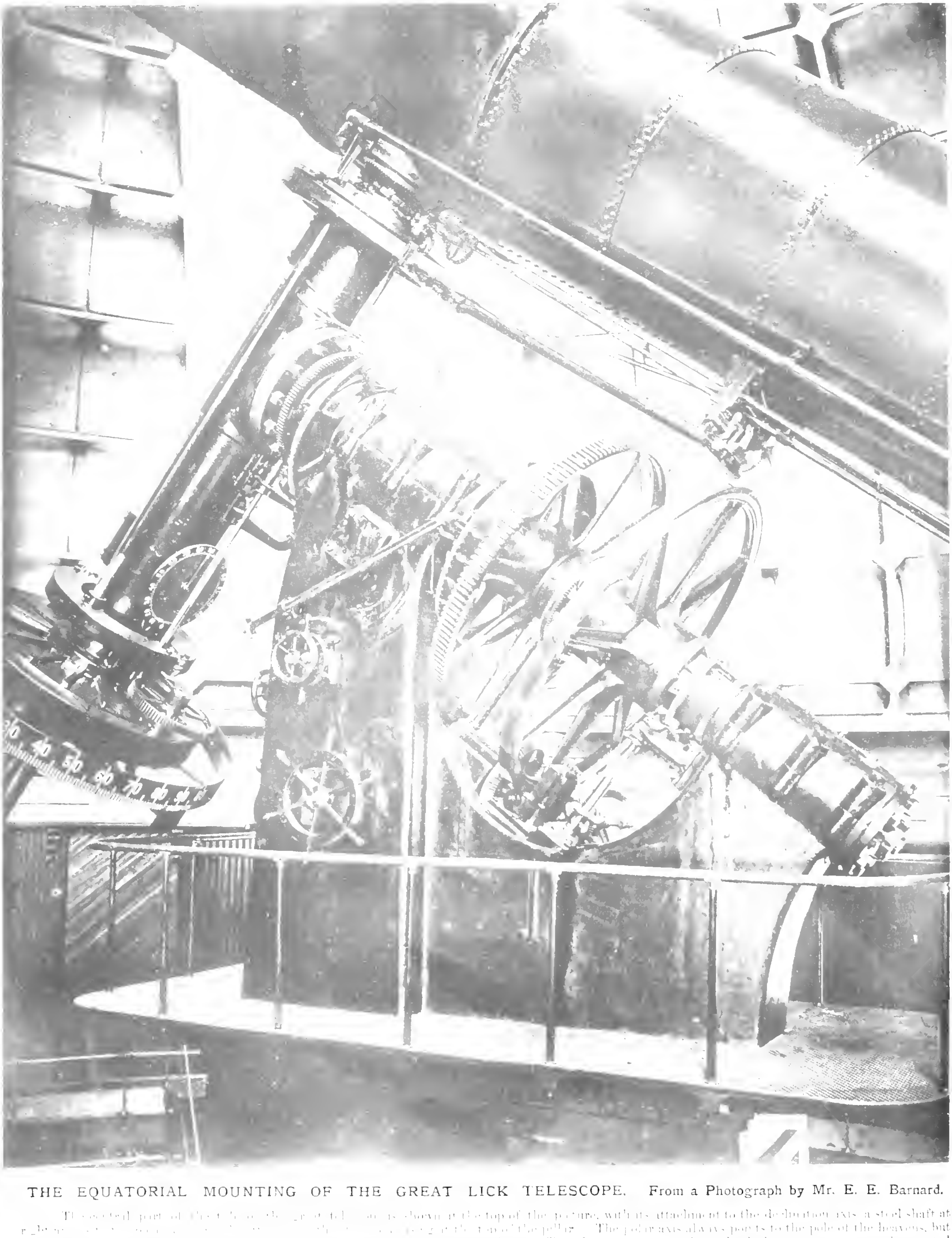
By W. E. Wilson, M.R.I.A.

Communicated to the Royal Society, January 1th, 1894.

These observations were made by means of a large heliostat, lent by the Royal Society, and a Boys' radio-micrometer. The heliostat consists of a plane silver on glass mirror of 15 in. aperture. It is mounted equatorially, and driven by a clock. When in use, it is adjusted to reflect the sunlight to the north pole, and as long as the driving clock is kept in motion the beam of light remains fixed in that position. In the track of this beam, and about 12 ft. from the plane mirror, is mounted a concave silver on glass mirror of 9 in. aperture, and about 13 ft. focus. Its axis points to the south pole, so that the cone of rays formed by it strikes the centre of the plane mirror at a short distance inside the focus. A small plane mirror mounted on the end of an arm is then so placed as to intercept the cone of rays, and reflect it horizontally into the observatory window; an achromatic lens enlarges the solar image which is formed on a screen in the room to 4 ft. in diameter.

Behind this screen, and standing on a pier of concrete, is mounted the radio-micrometer. The aperture through which radiant heat reaches the sensitive thermo-couple is a round hole drilled through a thick sheet of brass, and is only 1 mm. in diameter. A white cardboard screen is placed in front of the brass one to cut off heat from falling on the latter, and is provided with a hole slightly larger. A beam of lime-light is thrown on the mirror of the radio-micrometer, and reflected on to the scale in the usual way. The diagonal mirror of the heliostat is provided with slow motions in two directions, which are moved by long rods and hook joints inside the observatory. Thus any part of the sun's disc can be placed on the small aperture of the radio-micrometer, and the driving clock will then keep it there.

The observations are taken in the following manner. A small screen is placed over the aperture of the radio-micrometer, and the zero position of the spot of light on the scale noted. The screen is then removed, and the umbra of a sunspot placed on the aperture. The reading is then taken and entered in column *u*. The image is then moved, so that a part in the neighbourhood of the spot, but at *the same distance from the centre of the solar disc*, is placed on the aperture. This reading is entered in column N. Finally, a reading is taken at the centre of



THE EQUATORIAL MOUNTING OF THE GREAT LICK TELESCOPE. From a Photograph by Mr. E. E. Barnard.

[illegible] part of the [illegible] is shown at the top of the picture, with its attachment to the declination axis, a steel shaft at [illegible] the top of the pillar. The polar axis always points to the pole of the heavens, but can turn [illegible] carrying the declination axis with it. The telescope can turn about the declination axis so as to be pointed [illegible] of the picture is the declination circle, which gives the angular distance from the equator [illegible] The divided circle about the polar axis gives the position of the telescope in right ascension. [illegible] motion of the earth, and keep a star in the field of the telescope.

the disc, and entered in column C. The throws of the instrument are then got by subtracting the figures in columns u, N, and C from the zero. The deflections of the instrument have been experimentally proved to be *strictly proportional* to the amount of radiant heat falling on the thermo-couple. The following is a typical observation taken August 7th, 1893, of a large sunspot then visible. The *umbra* of this spot measured 0·8 in. across on the screen, so that the aperture of the radio-micrometer was only covering about $\frac{1}{400}$th of that of the umbra.

Zero.	u.	N.	$u-z$.	N $-z$.
15·8	17·1	20·4	1·3	4·6
15·6	16·9	20·2	1·3	4·6
15·5	16·8	19·9	1·3	4·4
15·3	16·7	19·8	1·4	4·5
15·2	16·6	19·6	1·4	4·4
15·1	16·4	19·5	1·3	4·4
14·9	16·1	19·4	1·2	4·5
		Means	1·31	4·49

$$\text{The ratio}\ \frac{\text{umbra of spot}}{\text{neighbouring photosphere}} = \frac{1·31}{4·49} = 0·292.$$

Five concordant readings gave a mean deflection of 4·57 for the centre of the sun, which gives for the ratio $\frac{\text{umbra}}{\text{centre}} = 0·287$.

This spot was at a distance from the centre of the disc of about 0·4.

As the radiation from the photosphere falls off from the centre to the edge of the disc, it seemed an interesting point to determine if any change in the ratio of u/C would take place as a spot was carried across the disc by the sun's rotation. If the spot is, as has been generally thought, a depression, the absorption of heat ought to increase as it is carried towards the limb, on account of the increased depth in the solar atmosphere through which the radiation would have to pass. On the other hand, if the spot was floating *above* the absorbing atmosphere the radiation from it would remain constant in any position on the solar disc.

The following is the value of the heat radiation from the photosphere taken along a radius of the sun, where 0 = centre and 100 is the distance of the centre from the limb. The radiation R equals 100 at the centre.*

D.	R.	D.	R.
0	100·0	70	87·8
10	99·8	75	85·3
20	99·5	80	82·5
25	99·3	90	72·0
30	98·9	95	61·8
40	97·2	98	51·5
50	95·3	100	42·9
60	92·2		

It will be seen by the following observations of spots, taken from August 5th to November 9th, that there is distinct evidence that the radiation from the spot does not fall off as rapidly when near the limb as the radiation from the neighbouring photosphere; in fact, the ratio u/C remains nearly constant, whereas the ratio u/N gets nearer unity as the spot approaches the limb. The spot observed on October 22nd is a good example, as the same spot was observed again on the 26th, 29th, and on the 30th, when it had reached within a distance, D, of 95 from the centre. It will be seen that on these four dates the ratio u/C was respectively 0·338, 0·360, 0·313, 0·356, whereas the ratio u/N was 0·349, 0·110, 0·706, 0·783.

Date.	$\frac{u}{C}$	$\frac{u}{N}$	D.
1893			
Aug. 5	0·370	0·427	60
7	0·287	0·292	40
8	0·286	0·323	50
8	0·339	0·377	40
8	0·418	0·542	90
14	0·361	0·373	50
19	0·368	0·375	50
Sept. 2	0·509	0·309	10
3	0·298	0·298	10
4	0·420	0·450	30
4	0·430	0·446	30
7	0·287	0·355	85
Oct. 1	0·398	0·401	30
1	0·489	0·570	80
22	0·338	0·349	52
26	0·360	0·410	40
29	0·313	0·706	90
30	0·356	0·783	95
Nov. 8	0·365	0·800	97
9	0·339	0·848	85

Langley,† in 1874 and 1875, measured the radiation from the sun and the radiation from spots. He used a thermopile and galvanometer, and obtained as the mean of his results a ratio of 0·54±0·05.

His method was first to take a reading in the neighbourhood of the spot, but between it and the centre of the disc. He then took a reading in the umbra, and, finally, a third reading in the neighbourhood between the spot and the edge of the sun.

The mean of the two photospheric readings he used as a divisor for the umbral reading. He then says, "The decrement of heat as we approach the limb is, though not exactly, yet so very nearly, in the same ratio for photosphere and spots, that no correction is needed on this account for the present observations."

If Langley failed, through want of instrumental means, to notice the difference between the absorption in a spot and the photosphere near the limb, his method would make his umbral readings too high. The mean of twenty observations here equals 0·356, against Langley's 0·54. This is a serious difference, and, I think, can only be accounted for either by the use of superior instrumental means, or by a possible variation in the radiation of spots in different years of the sunspot cycle.

It is difficult to see how *too low* a value for umbral radiation could be got, whereas too high a one might be found by want of definition and trembling in the image, so that some of the penumbral radiation would reach the thermo-couple.

THE NORTH POLE OF THE MOON.

By A. C. Ranyard.

WHATEVER may be the temperature of the equatorial regions of the moon, it will not be disputed that the moon's polar regions must be exceedingly cold, for no clouds float above the moon's surface, and many phenomena go to prove that if the moon has an atmosphere it must be a very thin and scanty one compared with our own, so that such an atmosphere would afford but a poor covering to

* "The Absorption of Heat in the Solar Atmosphere," by W. E. Wilson and A. A. Rambaut, *Proceedings of the Royal Irish Academy*, 3rd series, Vol. II., No. 2.

† *Monthly Notices*, Vol. XXXVII., No. 1.

prevent the radiation of heat from the body of the moon. Added to this, the poles of the moon never advance as far into the sunlit lunar hemisphere as the poles of the earth advance into the earth's sun-lit hemisphere.

It will be remembered that the earth's poles enjoy a period of six months of continuous sunshine, during which they advance into the sun-illuminated hemisphere to a distance of more than twenty-three degrees from the zone of sunset tints which continually encircle the earth, dividing the sunlit half from the starlit half.* But the moon's poles never advance as much as one and a half degrees into the sun-lit hemisphere, for the lunar equator makes an angle of only 1° 28′ 45″ with the ecliptic. The north and south poles of the moon are consequently never very far from the terminator or zone of sunrise and sunset on the moon.

Our plate illustrates very well the sort of illumination which objects near to the lunar terminator enjoy. The steep sides of the lunar mountains are brightly lit up, but the valleys and hollows and the lunar plains are left in darkness, or are only faintly illuminated by very slanting rays. A region constantly within a degree and a half of the terminator would therefore receive very little heat, though it would radiate as freely as any other part of the moon, and we should expect to find it relatively colder as compared with the lunar equator than the earth's polar regions are compared with our equatorial regions. Judging by analogy, therefore, if there is any water-vapour in the lunar atmosphere, we should expect to find it condensed in greater quantities in the lunar polar regions than in regions with a higher average temperature, but there are no distinguishing white caps to mark the place of the lunar poles, and we must conclude, either that the lunar poles are not covered with snow, or that the polar snow-caps extend as far as the lunar equator, and that the only difference between the equatorial and polar regions is that the layer of condensable vapour is thicker at the poles than in the neighbourhood of the lunar equator.

There is some evidence which tends to show that there is some kind of condensable vapour in the lunar atmosphere, for the mountainous regions and higher parts of the moon's surface are always whiter than the low-lying land. This is well illustrated by the beautiful lunar photograph of the Brothers Henry, reproduced in our plate. The limb or sharp edge of the moon is shown in it (as well as in all other good photographs of the lunar crescent) as very white, distinctly whiter than the lunar surface at a little distance from the limb. At the limb we are looking tangentially at the lunar surface, and only the tops of the lunar mountains and high ground would be visible to us, valleys and low-lying land being eclipsed by nearer regions at a higher level. But the smooth limb of the moon is always whiter than other parts of the disc, whether the moon is gibbous or presents a thin crescent form. In the crescent phase shown in our plate we are looking at the shadow side of the mountains on the limb, and not at the slope which lies in the full glare of sunlight. It might be argued that the white band along the limb of the gibbous moon is due to the fact that we are looking at the sun-illuminated sides of the mountains on the limb, and that these appear relatively bright as compared with less vertically illuminated surfaces. The relative brightness of objects near the terminator (or region of lunar sunrise) evidently very materially depends on the slope which they present to the slanting rays of the sun; but as the sun rises and the shadows grow shorter, the slope of the surface makes less and less difference, until at the full moon, when no lunar shadows can be seen from the earth, the differences of brightness of different parts of the lunar surface must be due to actual differences in the albedo or light-reflecting power of the lunar surface. In the case of the mountains and cliffs seen along the limb of the crescent moon, the slope of the surfaces seen from the earth is away from the direction in which the sun's rays are falling, and any appearance of greater whiteness must be entirely due to the actual whiteness or light-reflecting power of the mountains.

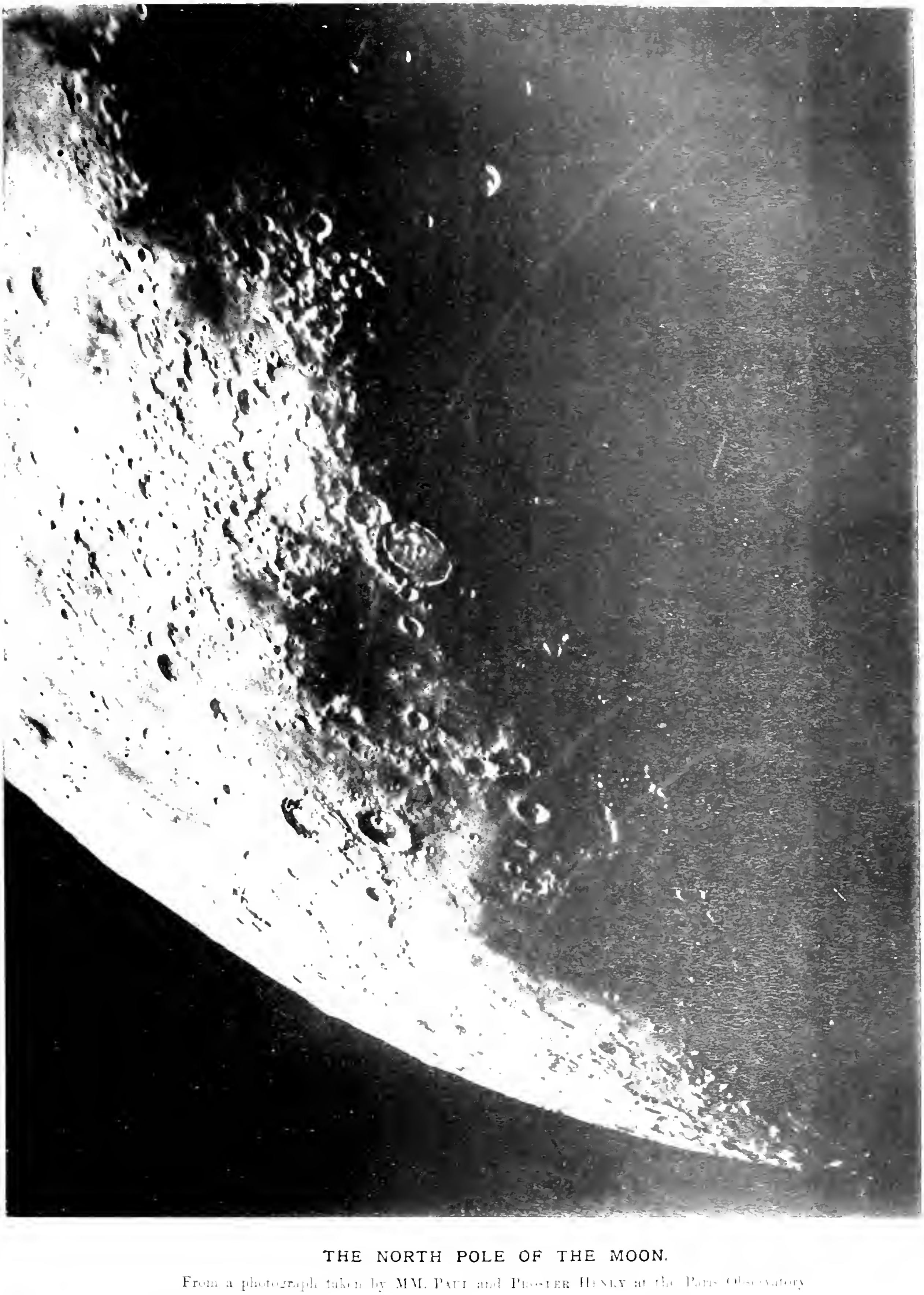
We consequently have in this band of whiteness along the lunar limb very forcible evidence that the lunar mountain tops are white as compared with the average whiteness of the lunar surface. The whiteness, and consequent brightness, of this band along the limb is so considerable that in lunar photographs it is the first part to become over-exposed, and it then hides the irregularities of the limb, which are well shown in the comparatively under-exposed photograph of the Brothers Henry reproduced in our plate.

The white material which condenses on the lunar mountain tops need not necessarily be snow. Any vapour which condenses in small transparent crystals would look snow-like and white, on account of the way in which such crystals break up the light. Thus, the feathery crystals formed from carbonic acid vapour, in the well-known lecture experiment, look snow-like and white, and probably crystals of frozen air would have a similarly snow-like appearance.

But if we accept the concurrent testimony of Profs. Langley and Very, the Earl of Rosse, and Prof. Boys, the temperature of the surface of the equatorial regions of the moon during sunshine is not very far from 0° Centigrade, or the freezing point of water. At such a temperature, crystals of carbonic acid or of atmospheric air would evaporate with extreme rapidity; and it is not conceivable that such rapid evaporation could go on during the fortnight of the lunar day without giving rise to a gaseous envelope about the moon, which would be easily detectable by the distortion of the sun's image during a solar eclipse, and by the phenomena observable during the occultation of stars at the moon's limb. For there is no recognizable change of whiteness from sunrise to sunset at the lunar equator—that is, the white covering is not entirely evaporated away, and the continuity of colouring from the moon's poles to its equatorial regions shows us that if there is any polar capping of condensable vapour, the polar white caps extend from the pole to the equator, and that they are not even materially diminished in extent in the lunar equatorial regions during the fortnight of unclouded sunshine passed through in every lunation.

We have therefore to choose between two alternatives: either the general whiteness of the moon is caused by an extensive snow-like covering, which is not evaporated away in the lunar equatorial regions during a fortnight of temperature not far removed from the freezing point of water, or the moon's whiteness is due to the natural colour of its surface rocks, and we are then forced to assume that all the lunar mountain tops are formed of white rocks, while the plains and low-lying areas are formed of a darker material. The latter assumption will not be seriously maintained by anyone who considers the great disturbances

* The zone of sunset tints glides over the earth always touching two parallels of latitude. At midwinter and midsummer it lies between two small circles, with a radius of about twenty-four degrees described about the northern and southern pole. It is never a "great circle," but always lies a little within the dark hemisphere, for the sun in setting is raised by the refraction of the earth's atmosphere more than half a degree. A little before the autumn equinox and a little after the spring equinox it passes through the poles, and then as seen from the outside would appear to spin round the parts of the zone where the tints of morning and evening meet.



THE NORTH POLE OF THE MOON.

From a photograph taken by MM. Paul and Prosper Henry at the Paris Observatory

Direct Photo Co., 9, Barnsbury Park, N.

to which the lunar crust has been subjected. If there had originally been such a bridecake-like stratification, it must long ago have been disturbed by the action of the forces which have built up and levelled again gigantic lunar craters and mountain chains.

The steep precipitous cliffs and tall pinnacles of rock which are to be seen on so many parts of the moon are standing evidence that the moon has a gaseous envelope around it sufficiently dense to protect such rocky pinnacles from being levelled by meteoric bombardment, for the moon must encounter as many meteoric particles in its annual journey round the sun as a similar area of the earth's atmosphere encounters. But not a millionth per cent. of the meteoric bodies encountered by the earth's atmosphere reach the earth's surface ; they are, in nearly every case, entirely driven into vapour before they reach a height of fifty miles above the earth's surface. If the lower hundred miles of the earth's atmosphere were condensed or done away with, it is evident that the earth would be subjected to a very serious bombardment, for even a particle as large as a mustard seed, projected with a velocity of eighteen miles a second against a cliff face, would bring down a portion of rock much larger than itself, probably shattering the rock for a considerable distance round the place of impact ; for we know that the force of a blow increases proportionally to the square of the velocity of the projectile, and the damage done by meteors meeting the earth with a motion in a contrary direction to the earth's motion round the sun would be even more considerable.

Such considerations seem to render it probable that the moon has an atmosphere of some sort which acts as a protecting shield, or otherwise, in the course of geologic ages, cliffs and pinnacles would have been shattered, and they could not have retained their precipitous forms.

Most of the meteors which we see consumed in our atmosphere become visible at a height of less than one hundred miles, and they are generally entirely driven into vapour before they reach a height of fifty miles above the sea level. Such an atmosphere as surrounds the earth at a height of fifty miles above the sea level would consequently be sufficiently dense to enable the moon to preserve the sharp outlines of its geologic features. If we assume that the earth's atmosphere continues to halve in density with every increase of three and a half miles by which we rise above the earth, the density of our atmosphere at a height of fifty miles would be about one fifteen thousandth part of the density at the sea level.

The observations with regard to lunar occultations and solar eclipses, referred to above, enable us to say that the moon certainly is not surrounded by an atmosphere of similar material to our own, which is one two-thousandth part as dense as the earth's atmosphere at the sea level.

But it may very possibly be surrounded by an atmosphere which is one ten-thousandth part as dense. Assuming that it is surrounded by such an atmosphere, the absence of white caps about the lunar poles would seem to show that the cold, even in the polar regions, is not sufficiently intense to freeze the lunar atmosphere. If the lunar air is similar in chemical composition to our own, this would enable us to affirm that the temperature of the lunar poles has not yet fallen below about -180° Centigrade. It is evident that at some period, the geologic record of which is not yet effaced, there were considerable volcanic displays at the lunar poles, for both the northern and southern lunar polar regions are thickly crowded with crater rings—indeed, the volcanic activity at the lunar poles seems to have been greater than in the lunar equatorial regions.

Science Notes.

Prof. Dewar, in a recent lecture at the Royal Institution on the scientific use of liquid air, and the study of the properties of matter under very low temperatures, demonstrated that in low temperatures the tensile strain of metals is stronger, and their colour also is less brilliant.

Some interesting details have been published in the *Transactions of the Texas Academy of Science*, concerning rain-making and the rain-makers. For the problem of overcoming the severe drought in such districts as the United States, or New South Wales, has, at irregularly recurring intervals, engaged the attention both of men of science and various impostors, who have endeavoured to persuade the Government to make trial of their schemes. The problem that has to be solved is the cooling of the upper layers of the air to such an extent that some of the moisture contained in it shall be precipitated. One of the theories on which several rain-makers based their suggestions was that if a rapidly ascending current of air could be produced, on reaching a great height this would expand under the conditions of diminished pressure, and in expanding would cool, and so precipitate some of its moisture. But the production of this ascending current is in itself the first difficulty. The scheme that Prof. Espy proposed in 1837 was to kindle great fires, thus producing a rising current of hot air. It would be better for the success of the scheme if the air could be induced to rise before first heating it, as the object of the theorists is to produce cooling in the upper strata.

It is a well-known fact that a shock of some kind given to a supersaturated atmosphere will sometimes precipitate the excess of moisture held in suspension, and it seems to be some distortion of this fact that has actuated some of the schemes of the rain-makers ; for they appear to have thought that a severe shaking was all that was necessary to induce the atmosphere to render up its aqueous vapour. Mr. Powers, of Wisconsin, published in 1870 an ingenious collection of random statistics entitled "War and the Weather," in which he endeavoured to prove that battles were followed by heavy rainfall. The same idea moved another rain-maker, and having obtained a Government grant of a considerable sum, he proceeded to make war upon the elements in true military style. Ground explosives were fired off at some advancing rain-clouds, then balloons, charged with explosives, were fired inside them, shells were projected at them, but the clouds sailed away in unruffled serenity, regardless of the rain-maker and his challenge.

A more scientific scheme was afterwards patented, which consisted in freeing liquefied carbonic acid in the air ; this liquid, by rapid vaporization, producing great cold. But as a frequent expedient, this plan is marred by the fact that the cost of one inch of rainfall over a square mile would be four hundred thousand dollars.

Some curious mechanical devices have been seriously proposed for rain-making, such as Mr. Pitkin's large sheet of canvas, which was to be hung in the air with the object of deflecting upwards warm air currents into a colder strata. Mr. Astor's invention is a tower, up which air is to be pumped by an engine, such a tower having presumably to be about the height of the Eiffel tower, and therefore similar in cost. The engine too would probably require much more water than the whole apparatus would conjure out of the atmosphere.

Notices of Books.

Celestial Objects for Common Telescopes. By the Rev. T. W. Webb. Fifth Edition, revised and greatly enlarged, by the Rev. T. E. Espin. Vol. I. (Longmans, Green & Co.) This is a new edition of a book which has probably made more astronomical observers than any other book that has been published. It is fourteen years since the fourth edition appeared, and nine years since Mr. Webb's much-lamented death; and considering the rapid advances which have been made in every branch of observational astronomy during the past decade, a new and enlarged edition of the Celestial Objects was much needed. The astronomical public owe a debt of gratitude to Mr. Espin for the trouble and care he has spent upon its production. The bulk of the book has been considerably increased. It will now be issued in two volumes, only the first of which has as yet appeared. The first volume contains an appreciative little memoir of Mr. Webb by his friend and executor Mr. Espin, which is followed by Mr. Webb's chapter on the use of the telescope, to which notes on celestial photography and the use of the spectroscope have been added; and the old chapters by Mr. Webb on the sun, the moon, the planets, comets and meteors, to which more or less extensive notes have been added by Miss Brown, Mr. Elger, Mr. Stanley Williams, Mr. Waugh, Mr. Freeman, and, last but not least, Mr. Denning. The second volume refers to double stars, clusters, and nebulæ, and to its enlargement and bringing up to date Mr. Espin has especially given his attention, greatly adding to its value by his additions.

The Theory of Heat. By Thomas Preston, M.A. (Dublin). (Macmillan & Co., 1894.)—This is a companion volume to Professor Preston's admirable book, "The Theory of Light," published four years ago. It is a still larger volume, extending to over 700 pages, and embraces a wider range of subjects, which Professor Preston endeavours to deal with historically as well as theoretically. No scientific inquiry is more full of human interest than the study of the nature of heat, for no branch of science is, as Professor Preston remarks, so intimately connected with the every-day occupations of life. Professor Preston is a lucid exponent of the theoretical parts of his subject, and an interesting writer, who gives a living interest to every subject he touches. All the chapters are methodically arranged and broken into convenient paragraphs. He gives, wherever possible, the classical experiments which have led to the discovery of new facts and important advances in theory, and leads the reader to take a personal interest in the work of Lavoisier, Rumford, Pictet, Herschel, Dalton, Davy, and Gay-Lussac. His chapters on the early theories of Heat, on Matter, and on Energy, with which the book commences, are particularly to be recommended.

Life and Rock: a Collection of Zoological and Geological Essays. By R. Lydekker, B.A. (Cantab.), F.G.S., F.Z.S. London: The Universal Press, 326, High Holborn. 1894. —Our readers will be glad to see this collection of essays, many of which they will remember in the pages of Knowledge, though they are now in a slightly altered form, having been carefully revised, and in some cases further illustrated by the author. Mr. Lydekker's articles are always interesting and instructive; probably no other palæontological writer deals with the problems of evolution and development in so attractive a manner; he has the gift of putting before his readers multifarious facts and details about dry bones in a way that makes them see the living animal, and follow with interest the logical conclusions to which he desires to lead them.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

A BLACK AURORA.

To the Editor of Knowledge.

Sir,—The appearance of the great sunspot which was visible from February 20th till the beginning of March lends interest to a curious meteor seen by me on January 25th last, about 8 p.m., at Croydon. It consisted of five dark rays or streamers, which emanated from a point over the northern horizon at or near the true north, and radiated like the spokes of a wheel towards the zenith, or it might be the magnetic zenith. The rays were clearly defined against a hazy sky, which was faintly illuminated by the glare of the metropolis, and resembled five blades of a black outstretched fan. As I looked, the whole system wheeled slowly through an arc of 30° or 40° towards the east, and then faded out. The rays did not seem to quiver or change colour, but remained black or smoky, and reminded me of streaks made by a hair pencil dipped in Chinese ink. I regard the phenomenon as a black aurora, because of its behaviour and the collateral phenomena. Black or smoky pillars and patches have been observed in auroras, but although I have examined the records of hundreds of displays, I have seen no account of a similar effect.

I may add that on the evening of February 28th, about 8 p.m., an aurora was seen in Croydon by me and many others. Two white luminous patches, one waxing while the other waned, appeared in the clouded sky near the Great Bear, and several more near the constellation Orion. A dirty greenish arch of diffused light over a dark segment also showed above the northern horizon, and gradually spread up the sky nearer to the zenith. The display lasted an hour or more, and was also seen with better effect in other parts of the country, where red streamers emanated from the greenish arch. As the black aurora seems to have heralded the sunspot, and the green display to have followed it, perhaps you will consider these observations of some interest.

Croydon. Yours, J. Munro.

[If we suppose with Mr. Munro that the dark rays radiating "from a point over the northern horizon" were sufficiently opaque to cut out the light reflected by the atmosphere from the gas lamps of London, we must assume that they were foggy semi-opaque regions in the lower atmosphere, an assumption which entails a considerable strain on the imagination, especially when we remember that the haze-producing particles which reflect the glare from a town probably float at no great height above the ground.

It seems to me easier to assume that the dark rays were narrow interspaces between broad bright rays. Readers of Mr. Munro's book, "The Romance of Electricity," will congratulate him upon his good fortune in witnessing so curious and interesting a phenomenon.—A. C. Ranyard.]

To the Editor of Knowledge.

Beechfield, Heswall, Cheshire,
19th March, 1894.

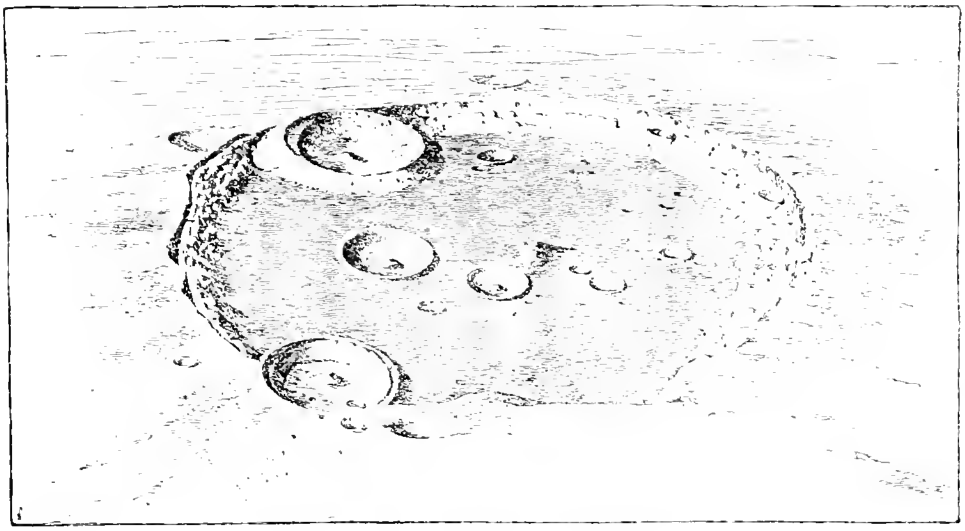
Dear Sir,—On the 15th of March last, from 6.30 to 7 p.m., I observed what, to me at all events, was an unusual appearance, as the sun rose over the lunar crater Clavius.

The ridges of the two principal inner craters, being illuminated, showed a brilliant red colour in very marked contrast to the general surface of the moon. The colour was of precisely that hue with which we are familiar in our terrestrial morning and evening skies, and prompts me to ask the question whether it is a phenomenon often observed in regard to sunrising on the moon, and whether or not it may be held to be evidence of a lunar atmosphere possessing a certain amount of absorptive power similar to that of our own air.

I may say that, not being familiar with such an appearance, I at once attributed it to instrumental dispersion, and took considerable pains to ascertain whether the colour could arise from such a source, but, after trying several powers both upon Clavius and other parts of the moon, I was unable to connect the colour with any such cause; and whether the eye-piece was in proper focus or not, the red colour still remained conspicuous in the imperfect image so produced.

The atmospheric conditions, I might add, on that occasion were, from the unusual amount of detail and steadiness perceptible, apparently better suited for observation of the moon than it has usually been my fortune to find.

I am, Sir, yours truly,
Charles MacIver.



Clavius, from a drawing by G. K. Gilbert.

[I am unable to suggest any optical illusion which would account for Mr. MacIver's observation. He seems to have taken ample precautions to test whether the brilliant red colour was due to the eye-piece used.

Sunrise upon Clavius is a magnificent spectacle, which has been watched with wonder and delight by many generations of astronomers; Beer and Madler, Webb and Neison, all speak of it with enthusiasm. At first the sun lights up the western wall of the great crater, which is one hundred and forty-two miles in diameter. As the sun rises it presents the appearance of a great bay of darkness penetrating into the illuminated portion of the moon; then some small bright points appear in the bay—these are the summits of the rings of craterlets on the floor of the great crater; as the sun continues to rise, the craterlets appear as bright rings, like golden atolls in a sea of ink; at last the sunlight reaches the floor of the great crater, and the long shadow of the western wall of the crater slowly recedes till the whole of the crater floor is lit up.

Mr. MacIver's observation seems to have been made at the time when the sun's light had reached the ridges of the inner craters; they then appear as intensely brilliant rings on a dark background, and any chromatic defect of the telescope would be more recognizable upon them than on a bright object upon a bright background. Sunset and sunrise tints are certainly not generally recognizable upon the moon's terminator, and it is doubtful whether there are any half-tints, or region of crepusculum, such as would probably be seen upon the earth in the regions of sunset and dawn. The parts of the moon just beyond the parts lit up by the first rays of the rising sun would be illuminated by the light of the corona and chromosphere, but I have not been able to trace any coronal or chromospheric lines in the light from the dark region just beyond the terminator when examined with a spectroscope. M. Thollon and Mr. Lockyer have similarly searched for evidence of coronal light at the lunar terminator, but have failed to find it. It seems, therefore, improbable that the ruddy tints observed by Mr. MacIver could have been due to illumination by the red light of the chromosphere. If the little craters shone with a red-hot glare we should expect to see them glowing on the dark side of the moon before the lunar sunrise, and possibly retaining their red colour after the sun had risen.

The only suggestion that occurs to me is that Mr. MacIver's eyes may be very sensitive to strong light, and that he sees coloured images for some time after looking at a bright object. The brighter parts of the moon are very dazzling when looked at in the telescope without a dark wedge to subdue their light, and they are relatively very bright compared with objects on the lunar terminator.—A. C. Ranyard.]

To the Editor of Knowledge.

Sir,—Mr. Lynn on page 7 calls 1899 the "last year of the present century." I should call it the last but one. The comet due therein, he says, has "only hitherto been seen in the winter of 1865." But I submit it was seen in the summer of 1366, and recorded so that its perihelion has been reckoned the 21st of October, or four hundred and ninety-nine years seventy-two days before the last perihelion. This divided by fifteen gives 33·281, instead of the 33·18 of Oppolzer's reckoning from 1866 only. Apart from all perturbations by Jupiter and Saturn, we might therefore expect it early in May, 1899. That is the least likely time of year for it to be seen, we being on the opposite side of the sun. The effects of Jupiter and Saturn seem eminently worth computing in this case.

Yours truly,
E. L. Garbett.

[Mr. Garbett is obviously right about the year 1899 not being the last year of this century; but it is a common oversight, into which I inadvertently fell. No great reliance can be placed on an orbit determined from observations made in 1366, whilst Le Verrier's theory that the Leonid meteors were introduced into our system by Uranus cannot be proved, though it remains probable that their introduction took place at a comparatively recent date. Neither their period, nor that of the small comet which moves in nearly the same orbit, is known very exactly.

That the comet is identical with the one recorded in the Chinese annals five centuries before is exceedingly doubtful: a glance at the elements of the orbit of the latter as computed by Peirce will at once show how uncertain they are, as is remarked by Mr. Hind in his "Comets." Oppolzer's determination of the orbit of the comet of 1866 is probably as accurate as could be made from observations which extended over an interval of less than a month. To compute its perturbations with much accuracy would not be a very hopeful task at present: after the return in 1899 (which will probably take place in March) this will be more practicable.—W. T. Lynn.

WEIGHING THE EARTH.

By J. J. Stewart, B.A., B.Sc.

(*Continued from page 32.*)

The method adopted by Prof. Poynting in his earth-weighing experiments, concluded a year or two ago, is a modification of that of Cavendish, in which the balance is directly made use of, and the force of attraction due to a sphere is found by placing it beneath a scale pan, and then balancing the disturbance of the beam produced by the sphere in this position, by adding weights to the other pan.

"In using the common balance to find the attraction between two masses, perhaps the most direct mode of proceeding would consist in suspending a mass from one arm of a balance by a long wire, and counterpoising it in the other pan. Then bringing under it a known mass, its weight would be slightly increased by the attraction of this mass. The increase would be the quantity sought if the attracting mass had no appreciable influence before its introduction beneath the hanging mass, and if, when beneath it, the effect on the balance could be neglected. This is very nearly the principle of the method used by Von Jolly."

Prof. Poynting used a differential method. A spherical mass was placed first under one of two masses suspended from the beam of a balance, and then placed under the other, the tilt produced in the beam being observed. Then the suspended masses were raised to a higher position, and the attracting mass placed under each alternately as before: in this last case the attraction on the beam is the same as in the first experiment, and this attraction can thus be eliminated, for the difference between the two observations of the increase of weight on one side is caused solely by the alteration of the positions of the suspended masses with reference to the attracting sphere below them: the attraction on the beam remains the same in each case. From the observed effect of a known alteration of distance, the attraction at any distance can be arrived at.

The attracting mass used in the experiments consisted of a metallic sphere. This was placed on a turntable, and could thus be gently moved into its position below the balance or away from it. The experiments were commenced at the Cavendish Laboratory, Cambridge, in a room in the basement. The apparatus was afterwards moved to Birmingham, and the experiments continued at the Mason College there. The balance room was in the basement of the building, and observations were taken by a telescope placed in the room above through an opening in the floor. The balance used was of the large bullion balance type, and was made specially for the experiment with extra rigidity of beam. The movement of the pointer of the balance was shown by reflection from a suspended mirror. Both the attracting and attracted masses were made of an alloy of lead and antimony for the sake of hardness, and their surface was gilded.

Errors were detected due to alteration of the slope of the floor on moving the weight. There was also a slow gradual change. Another mass, half as great as the attracting mass, was placed on the opposite side of the turntable and twice as far from the axis. This arrangement caused the resultant pressure to be always through the axis. A second set of experiments was made with the masses turned over, to get rid of any error which might arise owing to want of symmetry, the mean of the two sets of experiments being taken.

Errors due to air currents were the most difficult to get rid of. In warm, quiet weather the air was steadiest. Prof. Poynting says the opening or shutting of a door anywhere in the building had a visible, though transient, effect on his apparatus, doubtless through the production of an air wave. In a high wind the balance was always unsteady, partly owing to rushes of air into and out of the case with sudden changes of pressure, and partly through changes of ground level with variations of wind pressure against the building.

The law of universal gravitation states that when two masses m m^1 attract each other the attraction is $\frac{K\, m\, m^1}{d^2}$, K being the gravitation constant, which is the same for all masses, and d the distance between the masses.

When the gravitation constant K is known, the mean density Δ of the earth can be found immediately; for if V = volume of the earth considered to be a sphere of radius R, the weight of any mass, M^1 being the attraction of the earth upon it, is $\frac{K\, V\, \Delta\, M^1}{R^2}$; but if g denotes the acceleration produced by gravity the mass is also $= M^1\, g$. Therefore $\Delta = \frac{g\, R^2}{K\, V}$.

Prof. Poynting finds as the mean value of Δ from his experiments 5·493. In one set of his experiments the value found was less than that got by Cavendish, in another set it was greater, the mean being as above.

It has been suggested that a good way of finding the earth's mass would be to observe the change of deflection produced in the plumb line by the filling and emptying of an estuary by the periodic movements of the tides. The quantity of matter occupying the space of the estuary or arm of the sea would undergo regular periodic changes, and by observations of the changes of latitude every six hours a good determination of the constant required might be obtained.

A method very similar to this, and of a very interesting character, has quite recently been employed by M. Alphonse Berget, who described his experiments in the *Comptes rendus* of the Paris Academy of Sciences last year.

The experiments consisted in artificially causing a change of level in the waters of a lake. The level was raised or lowered through a distance of a little over three feet, and the effect of this alteration on a hydrogen gravimeter, such as that which was employed to measure the diurnal variation in gravity, was observed. The lake on which these trials were made is in Luxemburg, and has an area of seventy-nine acres. Its level could be raised or lowered by the above-mentioned amount in a few hours, and the variation in the column of mercury of the observing instrument was determined by a very delicate method, which consisted in noting the appearances and changes in Fizeau's interference fringes, formed *in vacuo* between the surface of the mercury and a flat sheet of polished glass placed at the bottom of the observing tube. Two sets of readings were taken, the one on lowering the level of the lake by about twenty inches and forty inches, the other on raising the level through the same distances. The results obtained are given in centimetres; the displacement of the columns for a change of level in the water of one metre was ·0000000126 centimetres. From this the gravitation constant, K, *i.e.* the attractive force in dynes produced by a mass of one gramme upon another equal mass placed one centimetre from it in air was found to be $6{\cdot}80 \times 10^{-8}$, *i.e.* ·000000068 dynes. The mass of the earth was found to be $5{\cdot}85 \times 10^{27}$ grammes, and its density 5·41, which differs but little from previous results.

The numbers above are deduced thus:—Put in the value of $K = 6{\cdot}80 \times 10^{-8}$ in the formula $g\,\mu = K.\frac{\mu\,M}{R^2}$,

in which M = mass of the earth in grammes.

R = radius of the earth in centimetres = $6{\cdot}37 \times 10^8$.

g = intensity of gravity = 981.

Hence M is found to be $5{\cdot}85 \times 10^{27}$ grammes, and the value of the density follows at once as 5·41 compared with water.

Another determination of the density has in recent years been carried out by Von Sterneck at Freiberg. These experiments were made in the years 1882 to 1885 and were similar in character to the pendulum experiments of Airy. The times of swing of the pendulums at the surface and at a depth within the earth were obtained by observing the coincidences with the same clock, which gave electrically, at the same instant, half-second signals at the two stations. The results, however, tend to confirm the opinion that the pit method is not a suitable one for determining the mean density of the earth, though it may throw light on the composition of the strata near the surface.

In conclusion, the different values found for the density of the earth in the principal experiments made for determining it may be given.

Plumb line at Schiehallien (Maskelyne and Playfair)	4·713
,, at Arthur's Seat (James)	5·316
Pendulum at Mont Cenis (Carlini and Giulio) ...	4·94
,, at Harton Coal Pit (Airy) ..	6·565
Torsion balance (Cavendish, 1798) ..	5·48
,, (Reich, 1838)	5·49
,, (Baily, 1843)	5·66
,, (Cornu and Baille, 1872) ...	5·5—5·56
Method of Weighing (Von Jolly) ..	5·58
,, (Poynting, 1891)	5·493
,, (Wilsing, 1887-1888) ..	5·58
Rise of Water Level (Berget, 1893) ...	5·41

Note.—On page 30, column 1, fifth line from bottom, instead of "the earth," *read* "the latter."

THE PHŒNICIANS, OR PALM-TREE PEOPLE.

By J. H. Mitchiner, F.R.A.S.

The authorities at the British Museum have recently completed an important re-arrangement that must prove of the greatest interest to the student of early civilizations.

Some two thousand years before the Christian era, a branch of the Semitic race, emigrating from the direction of the Persian Gulf, settled on the eastern shores of the Mediterranean Sea. The territory occupied was not large, comprising a coast-line of some three hundred miles, with an average width of about fifteen. But if the area was restricted in size, in character it was most diversified—a land of mountain and flood, possessing a Lebanon (white mountain) range, its highest peak rising ten thousand two hundred feet above the level of the sea. Seen from the Mediterranean, the distinctive feature of the landscape was the luxuriant palms that everywhere flourished indigenous to the soil. Hence the old pre-Homeric mariners from the Ægean named the country "Phœnicia," or "the Land of Palms," and to the people who inhabited it they gave the name of "Phœnicians," or "the Palm-tree People." Here, on this strip of Syrian shore-land, on the slopes of its great southern headland Mount Carmel, on the plains of Samaria and Sharon, and on the banks of the Nahr-el-Litani (Lion River), which rises a short distance from the celebrated ruins of Baalbek, collected, and prospered beyond precedent, this remarkable branch of the Semitic race.

In character, instincts, and prevailing habits the Phœnicians seem to have been the very opposite of the militant Semitic of ancient history, as the belligerent Babylonian, the cruel Assyrian, or that "bitter and hasty nation" the Chaldæans.* Instead of prosecuting wars of conquest and aggression, they were essentially an industrious and peaceable people, everywhere pioneers of civilization, whose whole genius and energy seemed absorbed in commercial activity. Ships, colonies, and commerce formed the ultimate aim of their political constitution, and their cities, Tyre, Sidon, and Aradus, became centres for the business of the then known world. Phœnician colonies multiplied, extending to Spain and Africa. The present city of Cadiz constituted the ancient Gades of Phœnicia, while Carthage, the daughter of Tyre, was founded on the African coast about 800 B.C. The strength of Phœnicia lay in her navy. "Ships of Tarshish" (ancient *Indiamen*) explored the Adriatic, Ægean, and Mediterranean Seas, sailed through the Straits of Gibraltar, and facing the perils of the Atlantic, effected the circumnavigation of Africa.

According to general testimony it is to the Phœnicians that the world is indebted for the invention of the alphabet;† but whether by them derived from the Egyptian hieratic system or from monumental phonetic symbols remains at present a debateable question. M. de Rougé maintains that the primitive form of almost every Semitic letter can be deduced from its normal hieratic prototype. Doubtless the exigencies of increasing commercial intercourse necessitated some simplification of the imperfect and laboured ideographic writing in vogue. A figurative method would dispense with the use of a multitude of tedious phonetic signs. Simplicity was the object to be attained, and we may be quite sure that in the construction of the alphabetical system necessity was the mother of its invention. In common with other Semitic alphabets constructed subsequently on the Phœnician model, it consisted of twenty-two letters, all consonants, and it may be said to have furnished the basis of nearly all other alphabets. The Hebrew is more closely allied to the Phœnician than to any other language; it might, indeed, almost be considered as a dialect of the same tongue. Both alphabets contain twenty-two letters, are without vowels, and the writing reads from right to left. In religion the Phœnicians acknowledged a single deity—one Supreme Power—but the names by which he was known varied with the locality of the temples. El (great) Ram or Rimmon

* Habakkuk i., 6.

† Lucan *Pharsalia*, iii., V., 220, 222. Lemornant, i., 84. Herod, V., 58. Diod. Sic., V., 24. Pliny, H N., V., 12, VII., 56. Tacitus, Ann XI., 14. Eusebius, Chron. Can.

(high), Baal (Lord), Moleck (King), and Adonai (My Lord). As Sun-god, Baal had temples at Baalbek, Tyre, Tarsus, Carthage, and Ekron.

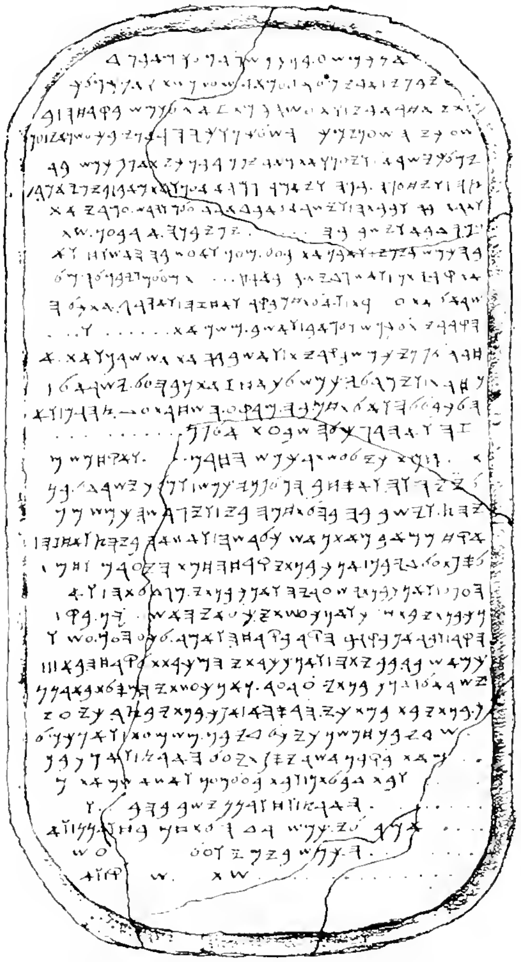
The Phœnician relics in the British Museum—the classification and re-arrangement of which has just been completed—occupy three rooms in the Northern Gallery of the building. The archaic Cyprian sculptures (B.C. 650) are for the most part crude in conception and conventional in execution. The country being destitute of marble, the figures are cut from a calcareous limestone, abounding in holes and fossil shells, quite unfitted for purposes of sculpture. Generally speaking, the bas-reliefs are superior in execution to objects in the round. Most of the faces are depicted with remarkably sharp-pointed noses—a feature even more marked in the terra-cottas. Several heads testify to Assyrian and Egyptian influence; while in the later works (B.C. 150) the results of Hellenistic intercourse is manifest in improved artistic execution.

One of the oldest known alphabetical inscriptions is that of Mesha, King of Moab (B.C. 896), and is known as the Moabite Stone. The original is in the Louvre, but an excellent cast will be found in the Second Room. The stone was discovered by Mr. Klein, a Prussian, at Dibân, a village on the east of the Dead Sea. It is of basalt, rounded at both ends, about three and a half feet in height by two feet in thickness and breadth, having on one face thirty-four lines of inscription, each line about an inch apart. When first seen by Mr. Klein it was in a most perfect state of preservation, not a single piece being broken off. As soon as open efforts were made to secure the treasure, difficulties with conflicting authorities unfortunately arose. Negotiations for its possession were *not* judiciously managed, and ultimately, rather than surrender the stone to the Turkish Government, the Arabs determined to destroy it. They lighted a fire round it, and when sufficiently heated threw on its surface cold water and vinegar, thus causing it to crack and split into fragments. Fortunately a "squeezing" of the inscription had previously been taken by a young *attaché* of the French Consulate, M. Ganneau. In the woodcut are reproduced the first three lines of the inscription. The words are divided from each other by means of points, and the lines or verses by vertical strokes. The whole inscription gives evidence of great fluency, and of long habituation in the use of written characters. Of the undoubted age and genuineness of this interesting relic of antiquity there can be no reasonable doubt. An article by the Rev. A. Lowry on "The Apocryphal Character of the Moabite Stone" appeared in the *Scottish Review* for April, 1887, but the conclusions of the writer are not accepted by other European Semitic scholars.

The stone was erected by Mesha, King of Moab, to commemorate his successes against Omri, King of Israel, and his descendants. This is the same Mesha whose resistance to the united forces of Jehoram, Jehoshaphat, and the King of Edom is recorded in the third chapter of II. Kings. Omri became King of Israel B.C. 929. The date of the stone would be about thirty-nine years afterwards—that is, 890 B.C. The characters of the inscription are Phœnician of the Moabite dialect. The last four lines are undecipherable. There is great similarity between the Moabite and ancient Hebrew writing, which sufficiently explains how it is that in all Biblical references to communications between these people there is no reference on any occasion to an interpreter.

We append a transcription of the whole of the thirty-four lines of writing.

In June, 1880, an important discovery was made in Jerusalem, in the ancient conduit which conveys the water through the hill and under the Mosque of Omar to the Pool of Siloam. The length of the tunnel is one thousand seven hundred and eight feet (five hundred and sixty-nine



The Moabite Stone. B.C. 900.

Analysis of the first three lines.

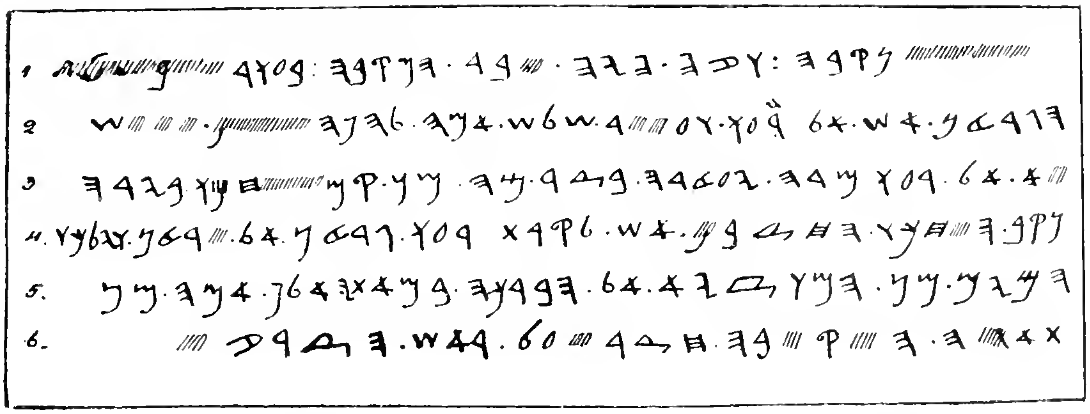
ANoKi MeShA. BeN. KaMoShGaD. MeLeK. Mo'AB [He] D—
—IBoNI | 'ABI. MaLaK. 'AL. Mo'AB ShLishiN. ShaT V'ANoKi. MaLaK—
TI. 'AChaR. 'ABI.

Translation.

1. I am Mesha, son of Kamoshgad, King of Moab, the D-
2. ibonite | My father reigned over Moab thirty years, and I reign-
3. ed after my father.

yards). It is not straight; the passage winds considerably, and reveals several *culs-de-sac*, showing that the engineering was defective. The inscription (of which a cast will be found in the Second Room in the British Museum) was found in a niche in the wall, about nineteen feet from the mouth of the tunnel where it opens into the Pool of Siloam. A spot, twenty-seven inches by twenty-six, had been prepared in the solid wall on the right hand side of the tunnel as one enters from the Pool, and made smooth to receive the inscription. Being below the water-line, before it could be copied it became necessary to lower the water in the conduit.

According to Prof. Sayce, some of the characters, as *waw*, *zayin*, and *Zsadhê*, are more archaic in shape than the corresponding letters in the Moabite inscription. He therefore regards the tunnel inscription as older than the Moabite Stone, and assigns it to the age of Solomon. It is, however, more generally held to date from about 750 B.C., the time of Hezekiah.



Copy of Inscription of Siloam.

Translation.

1. *Behold the* excavation ! Now this is the history of the tunnel. While the excavators *were using*
2. the pick each to his neighbour, and while there were yet three cubits *to be excavated* the voice of one call-
3. ed to his neighbour, for there was *an excess* in the rock on the right. They arose . . . . . they struck on the west of the
4. excavation, the excavators struck each to meet his neighbour, pick to pick, and there flowed
5. the waters from the outlet to the Pool for the distance of 1000 cubits, and . . . . .
6. of a cubit was the height of the rock at the head of the excavation here.

We have here the experience in constructing the Mont Cenis tunnel anticipated by two thousand six hundred years. It is clear the tunnel to the Siloam Pool was commenced simultaneously from both ends ; that in consequence of imperfect engineering skill the workmen nearly missed meeting in the centre and overlapped, but, directed by the sound of the picks, altered their course until they joined, and the water flowed throughout the conduit. As might be expected from the difficulty in determining many of the half-obliterated letters, the translation given by Canon Taylor differs somewhat from that of Prof. Sayce, but the general meaning is in no way affected thereby.

An object of considerable interest in the Third Room is the large bronze Lion-weight, of some twenty manehs, engraved with the inscription in Phœnician characters: "Verified in presence of the supervisors of the silver." In the Babylonian Room, close by, are several of these weights, evidently of Phœnician manufacture, of from one to ten manehs each. These were found in Babylonia, and are stamped with the official stamp in both Phœnician and cuneiform characters, and were probably cast exclusively for the Babylonian trade. We know the commerce of the Phœnicians was most extensive. They carried on an active export and import trade with Syria, Judæa, Egypt,

Arabia, Babylonia, Assyria, Mesopotamia, Armenia, Central Asia Minor, Ionia, Cyprus, Hellas, Spain, the Scilly Isles, and the coast of Cornwall. British tin was highly prized, and appears to have secured a monopoly of the markets within Phœnician influence.

There are many other objects and inscriptions also of great interest, as the sarcophagus of the King of Sidon, B.C. 350, the ancient Coptic, Himyritic, Palmyrene, and Hebrew inscriptions, all of which are admirably arranged, and form a deeply instructive chapter in the book of the past.

THE ROOT-TUBERCLES OF PEAS AND BEANS.*

Part II.—*Continued from page 70.*

By J. Pentland Smith, M.A., B.Sc.

The life-history, so far as it is known, of the organism that is the cause of the formation of these tubercles has been worked out by Prof. Marshall Ward, Prazmowski, and others, while Lawes and Gilbert, Berthelot, and Warrington have studied its life-history from the chemical standpoint.

The nodules vary in size. Last month we gave a photograph of the roots of a pea with badly-developed tubercles. Fig. 1 shows a well-grown tubercle on the root of a bean. This is seen in transverse section in the next illustration (Fig. 2). At *a* the cells of the tubercle are still growing, and almost free from the irritating organism; lower down in the tissues are found thread-like bodies (hyphæ), and still further towards the base the parasite has been very active. Fig. 3 is a partly diagrammatic section of a root with a tubercle on one side, and with a rootlet arising from another portion. In the centre of the root is the axile vascular bundle of the usual type, composed of alternating patches of xylem (wood) and phloëm (soft bast); around this is the cortex (bark), through which the root has pierced. The lateral root arises opposite a xylem strand. Two stages in the development of the tubercle-causing organism are seen in the nodule. On the outside is the cortex, continuous with that of the root, and exhibiting a zone of merismatic tissue—that is, a tissue composed of cells dividing up to form new cells. In the cells internal to this, hyphæ are seen from which minute corpuscular bodies are being budded off. This process will be seen more distinctly in another figure. Still nearer the point of

I.

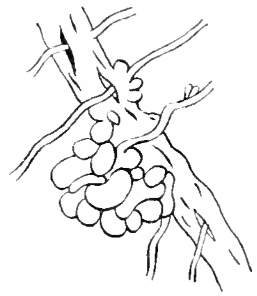
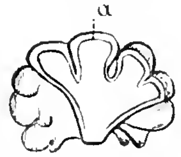


Fig. 1.—Tubercle on the root of a Bean.

a



II

Fig. 2.—Vertical section of Tubercle on root of Bean.

* I am indebted to Prof. Marshall Ward, F.R.S., etc., for his kind permission to copy the figures illustrative of his monograph on the "Root-Tubercles of the Leguminosæ," in the *Transactions of the Royal Society* for 1887.

origin from the root the cells are filled with small corpuscles, which have been called bacteroids, from their resemblance to bacteria. If the specimen under examination is fresh, these corpuscles are to be seen in active motion, but a high power of the microscope is necessary to observe them properly. The corpuscles are of various forms, as shown in Fig. 4; some are spherical, others are larger and shaped like the letter Y. The spherical corpuscles were found in tubercles formed some time ago; the Y-shaped in the freshly-formed nodules. A much magnified view of some cells filled with bacteroids is given in Fig. 5. They were taken from the inner portion of the tubercle shown in Fig. 3. The densely granular nature of the cell contents is due to the enormous development of the bacteroids. These have preyed upon the cell contents, causing a flow of nourishing matter to the cells, resulting in their abnormal enlargement. The open spaces in the cells are termed "vacuoles"; they are filled with a watery fluid. The black body is spoken of as the "nucleus."

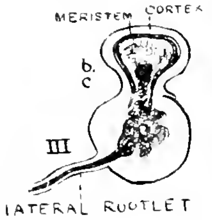


Fig. 3.—Cross section of Tubercle on root of Bean.

Tubercles have been found on the roots of all leguminous plants when grown in the open; but under certain experimental conditions the tubercles are not to be found. Thus when the seeds are germinated in sand or cocoanut fibre (sterilized), and are then carefully washed and watered with distilled water, containing nourishing salts in solution, the young plants will grow, if well provided with all the elements necessary for their development. But no tubercles will be formed when these precautions are carefully observed, and the water used has been properly sterilized. If, however, the plant is infected by contact with other tubercles, or a small quantity of garden soil be introduced into the culture medium, the formation of nodules at once takes place, and it has been shown by Prof. Marshall Ward that the act of infection is a perfectly definite one. Figs. 6, 7, and 8 show that the infection consists in the distortion of the cell-wall of a root-hair at one portion where a brilliant dot is noticed. From this point a fine tube passes down the cavity of the root-hair. It then passes through the cell-wall and into the underlying cortical cells, its tip ultimately reaching the innermost cells of this portion of the root. There it branches into the neighbouring cells, and the irritation set up causes them to renew their activity; they divide up and form the mass of the tubercle. In the cell-wall of one of the cells depicted in Fig. 6 the hypha is first seen to branch, and it is not an uncommon thing to find, as in one of these branches, the hypha attached to the nucleus. Where the hyphæ penetrate the walls of the cells peculiar trumpet-shaped widenings may be noticed, suggesting the idea that after the hyphæ had passed through them the cell-walls of the still growing cells had stretched out. Referring to Fig. 8, we see a peculiar "trumpet-shaped widening" of the cell-wall of the root-hair where the organism has obtained an entrance into the interior.

Fig. 4.—Bacteroids from cells of Tubercles.

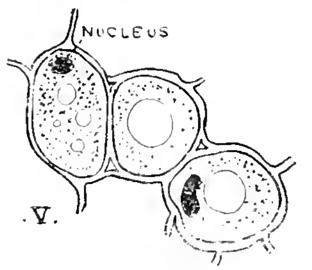


Fig. 5.—Much magnified section of cells containing Bacteroids.

So far, then, we have seen that peculiar brilliant spots are noticeable on certain of the root-hairs of plants affected by this organism; that from these a tube passes down into the tissues of the root; that it branches in the inner layers of the cortex, and stimulates the attached cells much in the same way as does *Plasmodiophora brassicæ*, the cause of the disease known as club-root, or fingers and toes on the turnip and allied plants. We have also seen that in the outer cells of a still healthy tubercle hyphæ are present along with minute corpuscular bodies, which are termed "bacteroids," and that, further, the bacteroids found in a tubercle of the current year are peculiarly shaped, whilst those found in old tubercles are spherical.

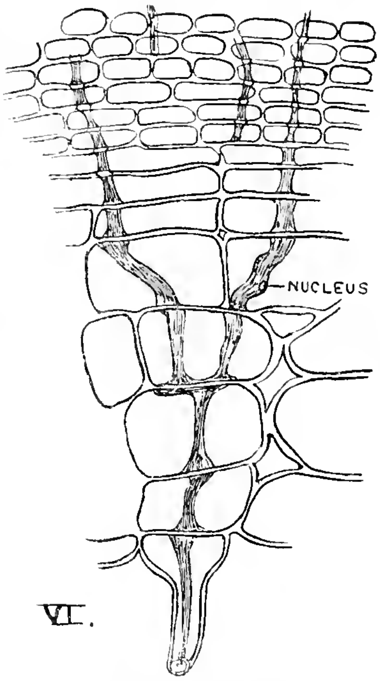


Fig. 6.—Section of root showing hypha penetrating cells.

We now come to the examination of a preparation which helps to throw some light on the formation of the bacteroids. If we turn to Fig. 9 we shall see a very much magnified view of a few cells from the dark shaded portion of the tubercle of Fig. 3. The protoplasm of the cells is very granular with bacteroids, and in the majority of cases contains many vacuoles. Furthermore, two branching hyphæ are visible, which appear to be budding off from their tips minute bacteroids. At this stage it appears that starch often accumulates in the cells of the tubercle, and that the nucleus occasionally undergoes a fatty degeneration. The widening of the hypha in its passage through the cell-wall is more clearly seen in the next figure (Fig. 10), and in the subsequent ones, Figs. 11 and 12, we have a more enlarged view of the process of budding off of the bacteroids at the tips of the hyphæ.

In the *Botanisches Centralblatt* for 1888 there is a paper of Prof. Prazmowski's which confirms in the main the statements of the life-history as worked out by Prof. Marshall Ward, from whose paper in the *Philosophical Transactions* we have borrowed our illustrations, but he differs in some details. Marshall Ward, for example, states

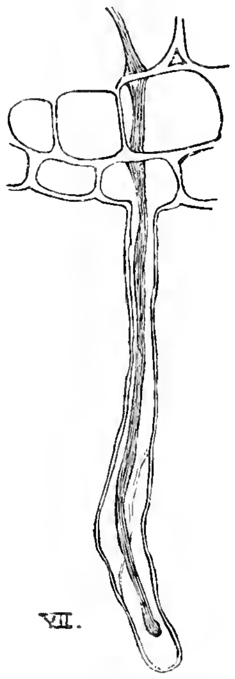


Fig 7.—Section of root-hair and cells, with penetrating hypha.

that the bacteroids are budded off from the hyphæ, whereas Prazmowski conjectures that they are formed from their contents inside them; this, however, is a mere supposition. Prazmowski states that he has not observed their development directly, although he has taken the trouble to cultivate them in very different nourishing media and under the most variable conditions; but this is not to be wondered at when we consider that these organisms are amongst the most minute in the vegetable kingdom.

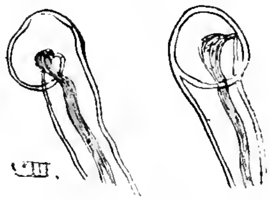


Fig. 8. — Root-hair with trumpet-shaped widening.

Experiments were afterwards instituted (in 1888) by Marshall Ward for the purpose of determining what relation existed between the tubercle-forming organism of the bean and pea respectively, and they resulted in the conclusion that they were one and the same. It was also noticed that the young root-hairs, with delicate cell-walls, are especially liable to be attacked; that at the place of infection a brilliant spot makes its appearance, as previously stated. If this is not one of the bacteroids it is difficult to say what it is. The resulting tube grows down the cavity of the root-hair, developing at the expense of the cell contents.

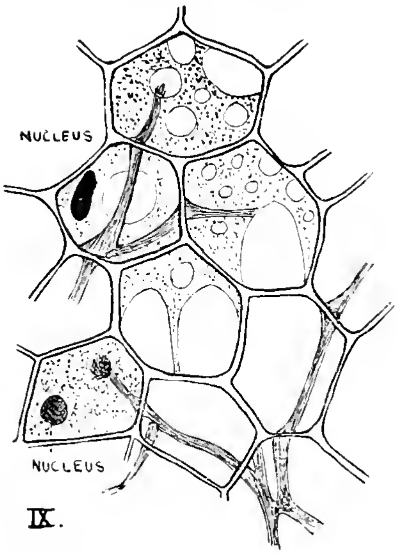


Fig. 9. — Magnified view of cells from tubercle with branching hyphæ

In the lichens we have a fungus and an alga growing together, the well-being of the fungus dependent on that of the alga, and *vice versâ*. The fungal portion alone produces the sexual organs of the lichen; the fungus extracts nourishment from the substratum, while the algal portion decomposing the carbonic acid of the air provides at least a large amount of the carbon necessary for the growth of the compound organism. Two organisms growing together in this fashion are said to live a symbiotic existence. There are many examples of such partnerships in the vegetable kingdom, though sometimes the partnership is only helpful to one of the symbionts, as in the case of all parasites.

From researches conducted in 1888 and 1889, by Prof. Marshall Ward, we have learnt more about the conditions which rule the development of the tubercle and the relations of the organisms to them. It was proved that the relation between the organism and the host plant are of the most intimate kind, and that the well-being of the one depends upon that of the other. For instance, if the growth of the plant were so modified that no more carbonaceous material was assimilated than it required for its own development, then that of the tubercles was arrested, and they were found to be very deficient in bacteroids. In one experiment a stream of air was passed through the water in which the plants were being cultivated. This caused the plants to grow rapidly, but the amount of carbon assimilation being disproportionate to their growth, either no tubercles were formed or only very small specimens made their appearance.

It may be interesting to note a number of experiments actually made in this connection by Prof. Marshall Ward in 1889:—

"Six peas were placed in garden soil.

"Six peas were placed in silver sand with cultural salts including a nitrate.

"Six peas were grown similarly in silver sand with cultural salts but *without* a nitrate.

"Six peas were placed in sand with traces of soil washings or with pieces of tubercle added.

"Six peas were placed in sand sterilized by heating.

"Six peas were placed in sand to which salts (including a nitrate) were added."

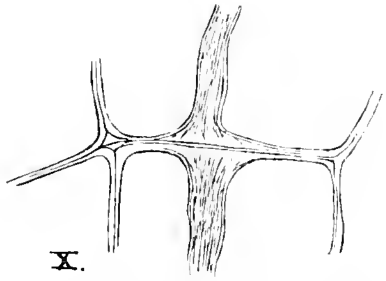
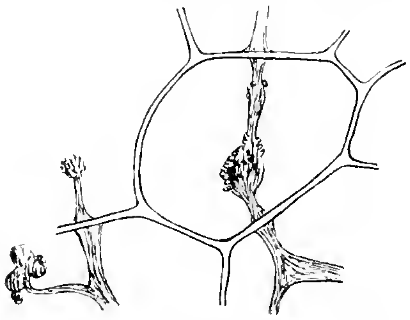


Fig. 10.—Section showing the widening of the hypha on passing through cell-wall.

On all the plants grown, with the exception of those in the sterilized media, tubercles made their appearance. It was also shown that if the plant and cultural medium is regarded as one system, there is a gain of nitrogen either in the crop or in the medium surrounding the roots. This nitrogen must have been taken from the air. So far as we know, the green plants themselves are unable to effect such a gain, and we must conclude that its assimilation was due to the tubercle-forming organism; but where does it get the energy to enable it to perform this operation? This seems to be derived from the protoplasm of the cells of the green plant upon which it lives, and which it in turn benefits by the nitrates assimilated. The precise method in which the assimilation of the nitrogen of the air is effected is still a mystery. When an element is liberated owing to the decomposition of a compound, it is said to be in a nascent condition. Now it is known that hydrogen when in this state possesses especially powerful properties, enabling it to effect unions with other elements, or to decompose compounds which it could not under ordinary circumstances attack; and it has been recently asserted by Windogradsky that in this condition hydrogen unites with nitrogen in the living protoplasm of the bacteroids. If so, the result would probably be the formation of ammonia, which would unite with salts derived from the soil, and thus the nitrogen would become a source of food to the green symbiont.



XI

Fig. 11.—Section showing bacteroids budding off from hyphæ.

Prazmowski asserts that he has succeeded in cultivating the bacteroids in nourishing media, and that they divide indefinitely, appearing as minute motile rods, and he accordingly places them amongst the Schizomycetes or fission fungi, the group to which bacteria belong. But it should be mentioned that Prof. Marshall Ward has not confidence in his cultures, and does not seem inclined to give these minute bodies a similar place in his classification of organisms.

It may be noted in conclusion that the leguminous plant, being the stronger of the two symbionts, directs the growth. It provides space in which the bacteroids may develop by means of the zone of merismatic cells, and it encloses them in a corky tissue, so that their development may go on undisturbed by external influences.

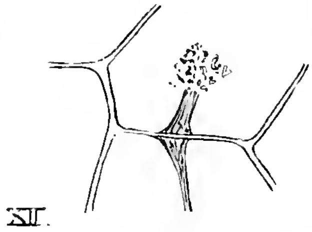


Fig. 12.—Section showing bacteroids budding from tip of hypha.

At the death of the bacteroids the plant absorbs the nourishing matter provided by them, and thus is a distinct gainer in the matter of assimilated nitrogen. Further, the tubercles being situated near the vascular bundle, a ready source of nutrient material, in the form of carbo-hydrates (elaborated in the leaves), is always open to bacteroids, and at the same time the products of decomposition of their bodies can be conveyed to the green plant as required.

THE FACE OF THE SKY FOR APRIL.

By Herbert Sadler, F.R.A.S.

A MAGNIFICENT group of sunspots has lately been visible on the Sun's disc. An annular eclipse of the Sun will occur on the 5th, but no portion of it will be visible in these islands. Conveniently observable minima of Algol occur at 11h. 6m. P.M. on the 6th, at 7h. 55m. P.M. on the 9th, and at 9h. 37m. P.M. on the 29th.

Mercury is a morning star in the sense of its rising before the Sun, and is at his greatest western elongation (27½°) on the 10th, but as during the whole month he does not rise more than forty minutes before the Sun, he cannot be detected by the naked eye.

Venus is a morning star, but is decreasing in apparent diameter and brilliancy, her brightness at the end of the month being about two-thirds of what it was towards the end of March. She is at her greatest western elongation (46¼°) on the 27th. On the 1st she rises at 4h. 3m. A.M., or 1h. 35m. before the Sun, with a southern declination of 8° 57′, and an apparent diameter of 33½″, $\frac{33}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was on January 21st. On the 11th she rises at 3h. 48m. A.M., or 1h. 27m. before the Sun, with a southern declination of 7° 32′, and an apparent diameter of 29½″, $\frac{4}{10}$ths of the disc being illuminated, and the brightness of the planet being about equal to what it was on March 11th. On the 21st she rises at 3h. 32m. A.M., or 1h. 23m. before the Sun, with a southern declination of 5° 16′, and an apparent diameter of 25½″, $\frac{46}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was on March 7th. On the 30th she rises at 3h. 17m. A.M., or 1h. 20m. before the Sun, with a southern declination of 2° 39′, and an apparent diameter of 23″, $\frac{51}{100}$ths of the disc being illuminated. During the month Venus pursues a direct path through part of Aquarius into Pisces. On the morning of the 4th she is very near the 4½ magnitude star θ Aquarii, and on the following morning the 5½ magnitude star ρ Aquarii.

Mars is, for the purposes of the amateur observer, invisible.

Jupiter is an evening star, but is so rapidly approaching the Sun that we only give an ephemeris of him for the first half of the month. While visible he pursues a direct path in Taurus, through a region barren of naked eye stars. On the 1st he sets at 11h. 1m. P.M., with a northern declination of 19° 23′, and an apparent equatorial diameter of 34½″. On the 15th he sets at 10h. 23m. P.M., with a northern declination of 20° 8′, and an apparent equatorial diameter of 33″. The following phenomena of the satellites occur up to the 15th, while the planet is more than 8° above and the Sun 8° below the horizon :— On the 2nd an occultation disappearance of the second satellite at 9h. 16m. P.M. On the 3rd a transit ingress of the shadow of the first satellite at 7h. 23m. P.M., a transit egress of the second satellite itself at 8h. 38m. P.M., and of its shadow at 9h. 36m. P.M. On the 5th an occultation disappearance of the second satellite at 9h. 24m. P.M. On the 6th a transit ingress of the shadow of the third satellite at 7h. 32m. P.M., and its transit egress at 9h. 37m. P.M. On the 7th a transit egress of the shadow of the second satellite at 8h. 53m. P.M. On the 10th a transit ingress of the first satellite at 8h. 25m. P.M., and of its shadow at 9h. 18m. P.M. On the 11th an eclipse reappearance of the first satellite at 8h. 49m. 57s. P.M. On the 13th a transit ingress of the third satellite at 8h. 6m. P.M. On the 14th a transit ingress of the shadow of the second satellite at 9h. 6m. P.M.

Saturn is an evening star, rising on the 1st at 7h. 14m. P.M., with a southern declination of 6° 14′, and an apparent equatorial diameter of 18·7″ (the major axis of the ring system being 43″ in diameter, and the minor 9¾″). On the 15th he rises at 6h. 13m. P.M., with a southern declination of 5° 50′, and an apparent equatorial diameter of 18·7″ (the major axis of the ring system being 43″ in diameter, and the minor 9½″). On the 30th he rises at 5h. 8m. P.M., with a southern declination of 5° 26′, and an apparent equatorial diameter of 18·6″ (the major axis of the ring system being 43″ in diameter, and the minor 9″). On the evening of the 11th the 6½ magnitude star 72 Virginis will be about ½′ south of Saturn, and at 10h. P.M. there will be a conjunction of this star with Rhea. Iapetus is at his eastern elongation on the 9th, and in inferior conjunction on the 27th. Saturn is in opposition on the 11th, at a distance from the earth of about 808 millions of miles. During the month Saturn pursues a retrograde path in Virgo, being about 23′ south of 74 Virginis, 5th magnitude, on the 6th.

Uranus is an evening star, and but for his southern declination would be favourably placed for observation. On the 1st he rises at 9h. 26m. P.M., with a southern declination of 15° 51′, and an apparent diameter of 3·8″. On the 30th he rises at 7h. 26m. P.M., with a southern declination of 15° 30′. During the month he pursues a retrograde path in Libra, up to and beyond α^2. He is in conjunction with α^2 Libræ (3·0 magnitude) at 1h. P.M. on the 27th, of course in bright sunlight, and at 10h. P.M. he is only 3·0s. *p.* and 4′ 20″ north of it. At 8h. P.M. on the 28th he is in conjunction with α^1 (5·3 magnitude) at 6h. P.M., 2′ 15″ to the north, but the asterism does not rise till about 7h. 30m. P.M. At 10h. P.M. that evening he will be 1·7s. *p.* and 2′ 23″ north of α^1. As α^1 and Uranus are nearly of the same magnitude and colour, this, if the weather be clear, will prove a very interesting phenomenon, especially as the Moon will be absent. α^1 α^2 Libræ form a wide double, not, however, divisible with the naked eye on account of the inequality of the stars, 231″ apart in the direction of 314½°. A map of the stars near the path of

Uranus, and a diagram of the conjunction, will be found in the *English Mechanic* for March 23rd.

Neptune is an evening star, but should be looked for as soon after sunset as possible. He sets on the 1st at 11h. 57m. P.M., with a northern declination of 20° 40′, and an apparent diameter of 2·5″. On the 30th he sets at 10h. 11m. P.M., with a northern declination of 20° 48′. A map of the small stars near his path will be found in the *English Mechanic* for December 29th, 1893.

Shooting stars are fairly plentiful in April, the best marked shower being that of the Lyrids, with a radiant point in R.A. 18h. + 33°. The radiant point rises on the evenings of the 19th and 20th, when the maximum occurs, at about 6h. 27m. P.M., and souths at 4h. 8m. A.M.

The Moon is new at 4h. A.M. on the 6th; enters her first quarter at 0h. 33m. A.M. on the 13th; is full at 3h. 2m. A.M. on the 20th; and enters her last quarter at 3h. 20m. A.M. on the 28th. She is in perigee at 3h. A.M. on the 11th (distance from the earth 229,280 miles), and in apogee at 8h. A.M. on the 26th (distance from the earth 251,330 miles). At 4h. 19m. on the 2nd the 6½ magnitude star 29 Aquarii will disappear at an angle of 66° from the north point (the star being below the horizon at the time), and reappear at 5h. 27m. A.M. (10 minutes before sunrise) at an angle of 252°. At 7h. 4m. P.M. on the 9th the 5½ magnitude star χ^1 Tauri will disappear at an angle of 67°, and reappear at 8h. 4m. P.M. at an angle of 278°. At 10h. 54m. P.M. on the 10th the 6½ magnitude star B.A.C. 1746 will disappear at an angle of 92°, and reappear at 11h. 44m. P.M. at an angle of 273°. At 8h. 40m. P.M. on the 11th the 5½ magnitude star 49 Aurigæ will disappear at an angle of 76°, and reappear at 9h. 37m. P.M. at an angle of 305°. At 10h. 52m. P.M. on the 12th the 6th magnitude star 76 (*c.*) Geminorum will disappear at an angle of 111°, and reappear at 11h. 49m. P.M. at an angle of 286°. At 8h. 42m. P.M. on the 16th the 4th magnitude star σ Leonis will disappear at an angle of 78°, and reappear at 9h. 29m. P.M. at an angle of 357°. At 4h. 28m. A.M. on the 19th the 6th magnitude star B.A.C. 4394 will disappear at an angle of 106°, and reappear at 5h. 25m. A.M. (the star being below the horizon) at an angle of 306°. At 3h. 2m. A.M. on the 29th the 5th magnitude star κ Capricorni will disappear at an angle of 53°, and reappear at 4h. 13m. A.M. at an angle of 264°.

ERRATA.—In KNOWLEDGE for February, page 47, column 2, *for* "The Moon . . . on the 3rd" *read* "The Moon . . . on the 5th." In KNOWLEDGE for March, page 70, column 1, last line, *for* "19° of arc" *read* "19′ of arc"; page 71, column 1, three lines from bottom of column, *for* "5h. 16m." *read* "5h. 13m."

Chess Column.

By C. D. Locock, B.A.Oxon.

COMMUNICATIONS for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of Problem No. 11.

Key-move—1. R to B6.

If 1. . . . P×R,	2. Q×KPch.
1. . . . K to B5 (or Kt×Kt &c).	2. Q to Kt5ch.
1. . . . Q moves, &c.	2. Kt (Q6) to B5ch.
1. . . . Kt (Q8) moves	2. Q—B2 mate.

Solution of Problem No. 12.

Key-move—1. P to Kt4.

If 1. . . . K×R,	2. Q—Q5
1. . . . P×R,	2. B to R2ch.
1. . . . P to Kt4,	2. Q to R5ch.
1. . . . Anything else,	2. Q to K8ch.

Solution of Problem No. 13.

Key-move—1. Q to K8.

If 1. . . . RP×P,	2. Kt—Kt3ch.
1. . . . KtP×P,	2. Kt to B3ch.
1. . . . B×P,	2. Q×P
1. . . . B to Kt5	2. Q to B6ch.
1. . . . B to B4,	2. Q to B6 or R8 mate.

Dual after 1. . . K to B4 by 2. Kt to B3 or B to B3.
Also after 1. . . K to Q4 by 2. Kt to Kt3 or B to Q3.

We congratulate the three solvers (*not* the leading triumvirate) who discovered these duals.

As explained fully in the February number, the dual *short mate* does not count.

CORRECT SOLUTIONS received from the following:—

Eleven Points.—A. C. Challenger, E. W. Brook.

Ten Points.—H. Holmes.

Nine Points.—J. H. Christie, L. Bourne, Chat, Alpha, B. G. Laws, Semper, Guy, W. T. Hurley. Kt. J.

Six Points.—A Norseman.

The correct keys were also sent by A. R., but unfortunately too late for competitive purposes.

H. S. Brandreth.—Your solutions this month are painfully incorrect. In No. 11. After 1. R to K8, Kt×R; 2. B×Kt, Q to R3 (!). In No. 12. After 1. Q to KB8, P×R, Black has the better game, though White may draw. In No. 13. After 1. Q to KB8, Black may play almost anything except B×P, KtP×P, and of course B to B4.

H. Holmes.—In No. 11, we would suggest 1. . . . K to B5 in reply to 1. P Queens. If then 2. Q×QP, Q to R3. Unless you can *prove* that your move solves the problem, the deduction of one point for the incorrect claim must hold good.

A Norseman. — In reply to (No. 11) 1. Kt to QKt7 1. . . . P to Q3 looks a strong defence. The post-card referred to has not been received.

A. R.—The adverse decision in your case seems necessary, though much to be regretted. Your presence on the "Jury" will be most desirable; it is to be hoped, therefore, that with this end in view you will send solutions of the remaining six problems.

LEADING SOLVERS' SCORES.

Guy	51	H. Holmes	41
B. G. Laws	51	J. H. Christie	39
Semper	51	A. R.*	35
A. C. Challenger	50	E. W. Brook†	35
Kt. J.	48	A Norseman	34
W. T. Hurley	47	L. Bourne	31
Chat	45		

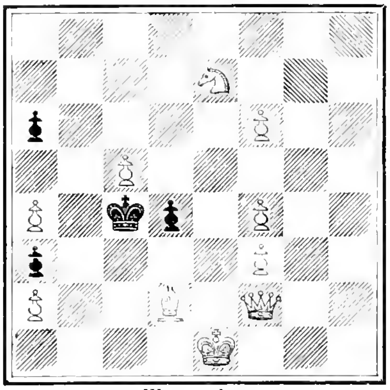
* Three solutions too late to count. † Did not send solutions of Nos. 1 and 2.

It is satisfactory to note that the supremacy of the three leaders is not allowed to continue unchallenged. One of them remarks on the singularity of the fact that they missed two duals in the first eight sound problems. But four duals missed in eleven problems is still more strange, and certainly unusual.

Position No. 14.

"*Enrichetta.*"

Black (4).



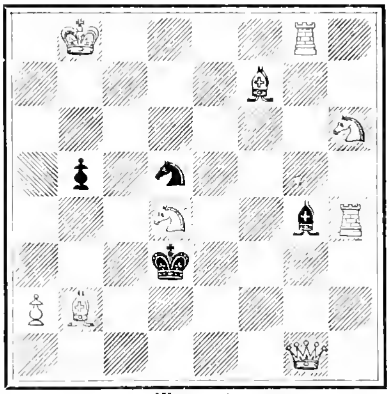
White (10).

White mates in three moves.

Position No. 15.

"*The Circle.*"

Black (4).



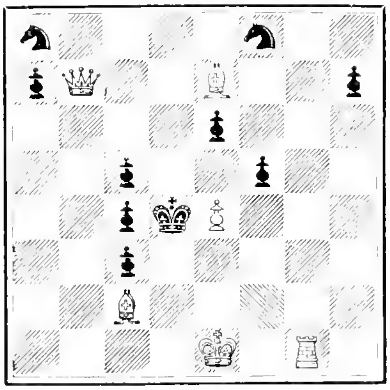
White (9).

White mates in three moves.

Position No. 16.

"*A Norseman's a Chess-Piece.*"

Black (10).



White (6).

White mates in three moves.

[The three Problems in the May number will conclude the series.]

CHESS INTELLIGENCE.

The long-discussed match between Messrs. Steinitz and Lasker for the championship of the world has not only been arranged, but no sooner arranged than begun. The match goes to the winner of the first ten games, draws of course not counting. The first portion of the contest takes place at New York.

In the Southern Counties' Chess Union, Sussex defeated Kent, at Redhill, without very much difficulty. The match between Hants and Surrey is still undecided, the result depending on the interpretation of the time-limit rule in the case of the game played at the top board.

The Inter-University Chess Match took place at the British Chess Club on March 16th, Cambridge winning by a bare majority. The following was the score :—

Oxford.	won	Cambridge.	won
G. H. Higginbotham, Pembroke	0	H. E. Atkins, Peterhouse	1
R. G. Lynam, St. Catharine's.	½	P. H. Dyke, King's ...	½
P. W. Sergeant, Trinity	½	H. J. Snowdon, Queen's	½
W. Poynton, Exeter ...	0	L. W. P. Lewis, Peterhouse	1
E. Lawton	1	A. B. Ramsay, King's	0
G. H. Cooper, Oriel ...	0	H. V. Naish, Emmanuel	1
J. H. Wetherall, Exeter	1	G. Varley, Christ's ...	0
Total ..	3	Total ...	4

On March 14th took place what was intended to be the decisive battle for the London Club Championship. The teams opposed were the City of London Chess Club and the Metropolitan Chess Club, both of which had won all their previous matches in the competition. The teams as usual consisted of twenty players a side, and when time was called after three hours' play it was found that the only five games finished had resulted in draws. After some discussion of this most unsatisfactory result, it was finally decided that the match should be replayed at some future date. Obviously three hours' play is insufficient for an important contest between equally matched teams. If both sides take their full time, only thirty moves can be played in each game, a number which is seldom quite decisive between fairly even opponents.

The North *v.* South match of one hundred and ten players a side takes place at the Portman Rooms, W., on April 7th. On the day before, the annual match between Old Oxonians and Old Cantabs takes place.

Contents of No. 101.

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LONDON: MAY 1, 1894.

CONTENTS.

MAGNIFYING POWERS MOST USEFUL IN OBSERVING WITH LARGE TELESCOPES.

By Prof. E. E. Barnard, of the Lick Observatory.

MR. RANYARD is quite right about the superiority of small powers for planetary work with a large telescope. I have always used the full aperture of the thirty-six-inch in my work. It is possible, however, that planetary detail might be somewhat improved with a slight reduction of aperture.

My experience with the higher powers has been principally in the measurement of a list of close and difficult double stars which I am observing at the request of Mr. Burnham. What experience I have had with the thirty-six-inch has been very varied. It has consisted in the observation of the double stars referred to, the measurement of the positions of very faint and distant comets, observations of nebulæ, of planetary details, and the positions of satellites.

On double stars I have found it always satisfactory to use one thousand diameters if the night will stand it, because of the greater scale and ease of measurement. I have used two thousand six hundred with perfect satisfaction, but this requires a perfect night and is only useful where the stars are bright and not too unequal. With very close stars I should always prefer this power when the night will permit its use.

Mr. Burnham's great experience in this line would, however, make him far more competent to speak of the powers useful for this class of work with the great telescope than I am.

In reference to the planets, I can never get any satisfaction from the surface markings of Jupiter with as high a power as one thousand, not even on the best nights. Only the coarser details can then be made out. I find it seldom satisfactory to use even five hundred and twenty. The lower power of three hundred and fifty is always preferable on this planet, and a similar remark also applies to Mars. Five hundred and twenty gives a fine image of Saturn, and sometimes one thousand diameters is useful, though the lower power is to be preferred. This singular peculiarity has always been apparent to me with all telescopes in observing Jupiter and Saturn. Saturn will stand a much higher power than Jupiter, the latter becoming vague and vapory with high powers. The moons of Jupiter, however, readily stand one thousand, giving clearly-defined discs with more or less stray light. The newly-discovered fifth satellite does not stand magnifying well and is lost with the higher powers.

I have lately been measuring the dimensions of the asteroids Ceres, Pallas, and Vesta. They present well-defined measurable discs and are very satisfactorily observed with one thousand diameters, and on a good night I would much prefer this power.

I think Mr. Ranyard's estimate of the powers that can be used on the planets with the thirty-six-inch—forty or fifty diameters to the inch—is, if anything, too high, twenty or thirty would more nearly represent the values, and for Jupiter ten to fifteen, in my opinion, would be nearer the mark.

In comet observations much will depend on the comet. A small comet, with a definite condensation, is best seen with powers of two hundred and sixty or three hundred and fifty, and sometimes with five hundred and twenty and seven hundred. It is surprising how some comets will stand magnifying. If the comet is large and diffused it had best not be observed with the thirty-six-inch at all, as the great separating power of that instrument would diffuse it into nothing. I remember one night Mr. Burnham and I tried to observe a nebula which was quite noticeable in the finder, and we finally gave it up in despair without having seen the slightest trace of it in the thirty-six-inch with any power. But for the planetary and small indefinite nebulæ the great telescope is pre-eminent.

There is a very large eye-piece belonging to this instrument that is very seldom used. The field lens is six inches in diameter, and it will take in the entire moon. Where one would expect this to be specially useful—for faint objects—it is very disappointing. The sky becomes whitish and milky in it, and one thus loses a delicate faint object for want of blackness of field. I tried comets 1889 I. and 1889 V., when very distant from us, with this eye-piece, but could not see a trace of them on account of the brightness of the field; but with powers of three hundred and fifty and five hundred and twenty I followed the first of these objects over one hundred million miles beyond the orbit of Jupiter, and the other I observed nearly a year after it was lost to all other telescopes. A view of the Orion nebula through this large eye-piece is, however, very fine.

In reply to Mr. C. Robinson's letter published in Knowledge for March, p. 64, I would remark that the blue colour about Jupiter or a bright star in the thirty-six-inch is much greater than in a good six-inch telescope. The secondary spectrum is much more pronounced in the thirty-six-inch than in the twelve-inch.

In speaking of the Orion nebula, there is a feature in connection with some of its details that I have never seen mentioned, and which, though I first saw it with the large eye-piece referred to, is well seen in the twelve-inch. The southern sharply defined edge of the great bright area in which is located the trapezium is distinctly bordered by a dull red. There are other parts about it also that show this colour. It is best seen in strong moonlight. The three hundred and fifty eye-piece shows it also distinctly. I am not prepared to say just what this phenomenon is. I hardly think it is a telescopic effect, because I have never seen it connected with any other of the nebulæ. I first saw it some three or four years ago.

Mount Hamilton, California,
April 6th, 1894.

Remarks by Mr. S. W. Burnham *on the same subject.*

Referring to the note on the powers that can be usefully used on large telescopes, which appears in the March number of Knowledge, in which reference is made to me and to my friend Mr. Barnard, I would say that the highest power used by us on the thirty-six-inch refractor at Mount Hamilton was two thousand six hundred. The focal length of this eye-piece was given as one-fifth of an inch, and its power was therefore originally called three thousand three hundred, but a subsequent careful measurement reduced this to two thousand six hundred. The other powers in general use on the micrometer were one thousand nine hundred, one thousand five hundred, one thousand seven hundred, five hundred and twenty, and three hundred and sixty. The lowest power was very rarely used by me and, aside from the measurements of nebulæ, probably not half a dozen times a year. The eye-piece next to that was used in the measures of very wide couples, where a large field was necessary, and occasionally for extremely faint companions to bright stars, where the distance was several seconds. Most of my measures were made with powers of seven hundred, one thousand, and one thousand five hundred. My practice has always been, in measuring close pairs, to use the lowest power which will give the separation necessary for good measures. The nights are not frequent, even at Mount Hamilton, when the highest power can be used to advantage; but there are many very close double stars which cannot be measured with anything else, and one must wait for a favourable opportunity for such work. I kept on my working list most of the very close pairs known to be in rapid motion, and those which for a long time had been regarded as single. Where the distances were 0·15″ or less, the measures were made with the two highest powers, and the closest of these were always measured with two thousand six hundred. Occasionally I have examined a doubtful object, under exceptionally favourable conditions, with one lens of the highest eye-piece removed. This, of course, gave a higher power—I do not know what it would be—but the use of a single lens was only an experiment, as the micrometer could not be used in that way.

So far as my experience goes, these very high powers are useless for anything but extremely close double stars. I have looked at Saturn, Jupiter, and other planets many times with high powers, and under no circumstances could as much be seen in the way of surface details as with moderate powers. For all ordinary purposes, I should say the range of useful eye-pieces would be within the limit suggested—viz., about fifty to the inch of aperture.

Of course, I always used the full aperture of the thirty-six-inch refractor in all my double star work. After using a large instrument, one does not voluntarily take a smaller one, nor reduce the aperture for any visual purpose. Nothing is gained with any condition of the air by cutting down the objective; but there are some nights so poor—and I have never seen worse ones than we had at Mount Hamilton at times—when a small instrument is as good as a large one, but these are occasions when no one would think of attempting to make any measures.

Chicago.

ON THE MOUNTING OF LARGE REFLECTING TELESCOPES.

By Sir Howard Grubb, F.R.S., &c., &c.

Whatever may be said as to the relative merits and demerits of reflectors and refractors, there can be very little doubt that, for the present, we must look to reflectors as offering the most likely form by which to increase, to any very large extent, the light-grasping power of our telescopes. The difficulties in obtaining optical glass have of late years been considerably reduced, and at the present time discs of thirty inches diameter are not much more difficult to obtain than discs of half that diameter were twenty years ago. There does not, however (in spite of recent advances), seem to be much chance of obtaining discs of optical glass which will enable us to construct an objective which would equal in light-grasping power such an instrument as Lord Rosse's six-foot reflector, which has been in existence for half a century.

It seems strange that fifty years have been allowed to elapse without any attempt being made to develop the power of the reflector. This is not due to any optical imperfections, or any great difficulty in making the optical parts perfect, as is clearly proved by the splendid work accomplished with reflectors by Draper, De la Rue, Common, Roberts and others. Modern astronomical research, however, requires that all instruments should be mounted with an accuracy and delicacy which it was scarcely possible to obtain, even if it had appeared necessary, at the time when Lord Rosse's six-foot mirror was mounted. Whenever the reflecting telescope has been mounted with the rigidity and stability required for stellar photographic work, when the clock-driving has been sufficiently accurate, and when the correcting slow motions have been sufficiently delicate, the mirror has held its own against the object-glass; and, at the present day, if the six-foot mirrors of the late Lord Rosse were properly mounted on equatorials which would carry them with the accuracy required for modern work, it cannot be doubted that they would do magnificent work in the hands of present-day astronomers.

There appears to be some probability that an attempt will be made by our neighbours on the other side of the English Channel to make a distinct advance in this direction. In view of the rumours of a ten-foot reflector to be constructed and mounted for the great exhibition in Paris in 1900, it may be interesting to consider some of the difficulties that will probably arise in the construction of such an instrument, and how such difficulties might possibly be overcome.

I do not propose to deal here with the optical difficulties, feeling quite satisfied that they can be successfully dealt with, if a disc of glass of sufficient size can be obtained; and if not, then by the use of speculum metal. Dr. Common, who has a most intimate knowledge of the difficulties to be overcome in making such large instruments, is of opinion that a silver-on-glass mirror of eight or nine feet aperture is now possible.

It is, however, to the mechanical difficulties of construction that I wish to address myself, as I believe, up to this time, this matter has not been very seriously treated. The problem is indeed one of enormous difficulty, and the working out of the details will be a serious matter.

Speaking generally, it may be taken that the whole weight of the tube, mirror and cell will probably be some forty or fifty tons, and in the present state of engineering skill it does not at first sight appear to be so very difficult to mount this on a simple universal stand, which will enable it to be pointed to all parts of the heavens. But such a mounting would be insufficient unless the telescope is to be used simply for getting transitory glimpses of celestial objects. It would be practically useless for all serious work, bearing in mind the requirements of the future ; for the chief hope of progress in astronomical research lies undoubtedly in the application of photography. It would appear to be not only useless (except to satisfy mere popular curiosity), but an absolute waste of money and energy to build an instrument of such large dimensions, unless its light-grasping power can be utilized for celestial photography.

The mounting must be of the equatorial form, and the problem to be solved is how to carry the enormous weights involved with all the *accuracy and delicacy* which are so essential for stellar-photographic work, while at the same time the instrument must also be readily available for general visual work. To satisfy the latter condition, it is necessary above all things, as has been pointed out by Dr. Common, that the eye-piece of the instrument should not be at any great distance from the centre of motion. This, in the ordinary Newtonian form, necessitates serious modifications, for there would have to be a considerable distance between the centre of motion and the centre of gravity of the essential parts. The telescope would thus be considerably out of balance, and dead-weight would have to be added to correct this. The instrument, no matter what its length and weight may be, must be carried as evenly and accurately as any of the smaller instruments specially constructed for stellar photography, and this may be expressed by saying that the pointing of the telescope must never be in error by an amount greater than the motion of a star in one-twentieth of a second of time.

It was, no doubt, in view of the very great difficulties of fulfilling these conditions that Dr. Common was led to believe that it would be necessary to revert to the alt-azimuth form in mounting such large reflectors.

Now, when we consider that the lowest magnifying power of an eight-foot reflector is about four hundred and eighty, and of a ten-foot (such as is proposed for the next Paris Exhibition) six hundred, it will be understood how very unsatisfactory such a mounting would be for large-size telescopes.

To view objects in a telescope satisfactorily, it is necessary to bring them into or near to the centre of the field of view ; but even suppose we are satisfied to view them while in *any* part of the field of an ordinary eye-piece, the object could only be viewed in the eight-foot telescope for about fifteen seconds, and in the ten-foot telescope for twelve seconds at a time. This would render the instrument practically useless.

The larger the telescope the more important it is to have it equatorially mounted, and driven correctly by clockwork, so that the observer may watch for a favourable opportunity for distinct vision. It is to be remembered that, in the case of very large apertures, it is only in glimpses on a fine night that good definition is to be obtained ; and therefore it is all the more important that the observer should have the opportunity of watching for and taking advantage of these favourable moments.

I have ventured, in a paper read before the Royal Dublin Society on February 21st, to shadow forth what I believe will be the most hopeful principle on which to mount a monster reflecting telescope.

Dr. Common himself has made a splendid advance in adopting the system of flotation of the polar axis ; this principle of flotation appears to me to be capable of further development, and I have given some thought to the matter. It is perfectly possible to make a tube for a Newtonian reflecting telescope (which is necessarily closed at the lower end) of such a weight, and with its weight so distributed, that it will not only float submerged in water to a certain point (preferably near the upper end), but will be in a state of equilibrium when placed at any or in every position down to a certain angle, the angle depending on the exact outside form of the tube. For instance, Fig. 1 shows the tube closed at its lower end and perfectly symmetrical round its axis. The total weight of the tube must be equal to the weight of water which is displaced when the tube is sunk to the centre of the sphere; the weight of the different sections along the axis can be so distributed that the tube will equally well remain in any position, except it be so far turned over that the cylindrical part of the tube is lifted out of the water at one end and dipped at the other.

By making the spherical part of about the proportions of the figure, the tube can be depressed to within twenty-five degrees of the horizon, and still remain in perfect equilibrium.

Now suppose the tube to have a pair of trunnions attached at the water-line, and these to be carried on a polar axis of, say, the English type (see Fig. 2). We then

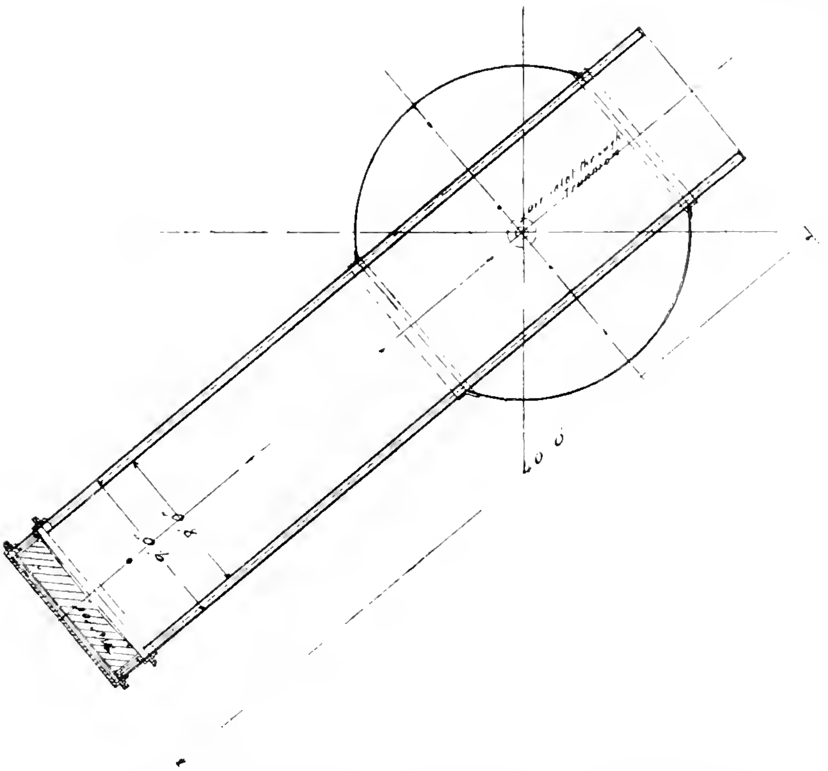


Fig. 1.—Section of the Telescope Tube, showing the double sides, and the direction of the air currents which will be produced by the fan or blower.

have an equatorially-mounted telescope of any size, without any weight whatever on the bearings of the declination axis; or, the tube may be lightened by an amount nearly equal to the weight of the polar axis, and there will then be practically no weight whatever on the bearings of that axis. So here we have a case of, say, an eighty ton telescope mounted and carried by an equatorial, but without throwing any weight whatever on the equatorial mounting and the force necessary to drive the instrument is then independent of the weight of the telescope, and dependent only on the friction necessary to be overcome in carrying the tube at an exceedingly slow rate through the water.

The spherical protuberance of the tube being fixed near the upper portion, and the water-line being made coincident with the centre of the sphere, which is the centre of motion, it follows that the eye end of the telescope can be brought to within about fifteen feet of the centre of motion, and the movement of the observer need never be more than three feet per hour. To approach the eye end I would arrange a stage independent of the telescope, and mounted on rails round the tank shown in Fig. 2. Two flights of steps would enable the observer to be always within reach of the eye end.

To overcome the inconvenience to the observer due to the rotation of the tube as the telescope moves in right ascension I would perforate the circumference of the tube at intervals of thirty degrees, attaching adapters for eye-pieces at each place, and arrange the "flat-mount" in a collar, so that the flat could be turned through angles of thirty degrees, and the image of the celestial object to be observed would be thrown through the perforation of the tube which was most convenient for observation.

Let us inquire into any possible disadvantages that may be urged against this form of mounting:—

First—That the temperature of the water will often be different from that of the air, and consequently there will be a detrimental mixture at the mouth of the tube, of air from inside the tube (which will partake of the temperature of the water) and the cooler or warmer outside air.

This I would propose to avoid by making the tube double, with a space of some three inches between the inside and outside tubes, hermetically closed except at the lower end, where there would be apertures in the inside envelope.

The space between the two tubes would be connected through the trunnions with an air pump, worked by a gas or other motor, which would continually exhaust the air from between the two tubes, and thus cause a current of the outside air to pass continually down the inner tube and to the pump through the space between the two tubes. This would keep the temperature of the inside tube and the air in the tube constant with that of the outside air.

A velocity of motion of the air of one foot per second would perhaps be quite enough to entirely overcome this difficulty.

To avoid dewing of the mirror when the air outside was warmer than the temperature of the water, I would propose to warm the mirror by electric arrangements at its back, always keeping the mirror one degree above the temperature of the air.

Second—The limited range of the equatorial. I have stated that the instrument would be in perfect balance down to twenty-five degrees from the horizon. If desired, though no longer perfectly balanced, it can be used lower by employing a chain or wire rope connected between the lower end of the tube and the upper end of the polar axis, and the amount which the instrument would be out of balance, between twenty-five and twenty degrees, would be very trifling.

Again, it will not be convenient to use the instrument within some fifteen degrees of the pole. It could be planned to go somewhat closer, but when it is considered

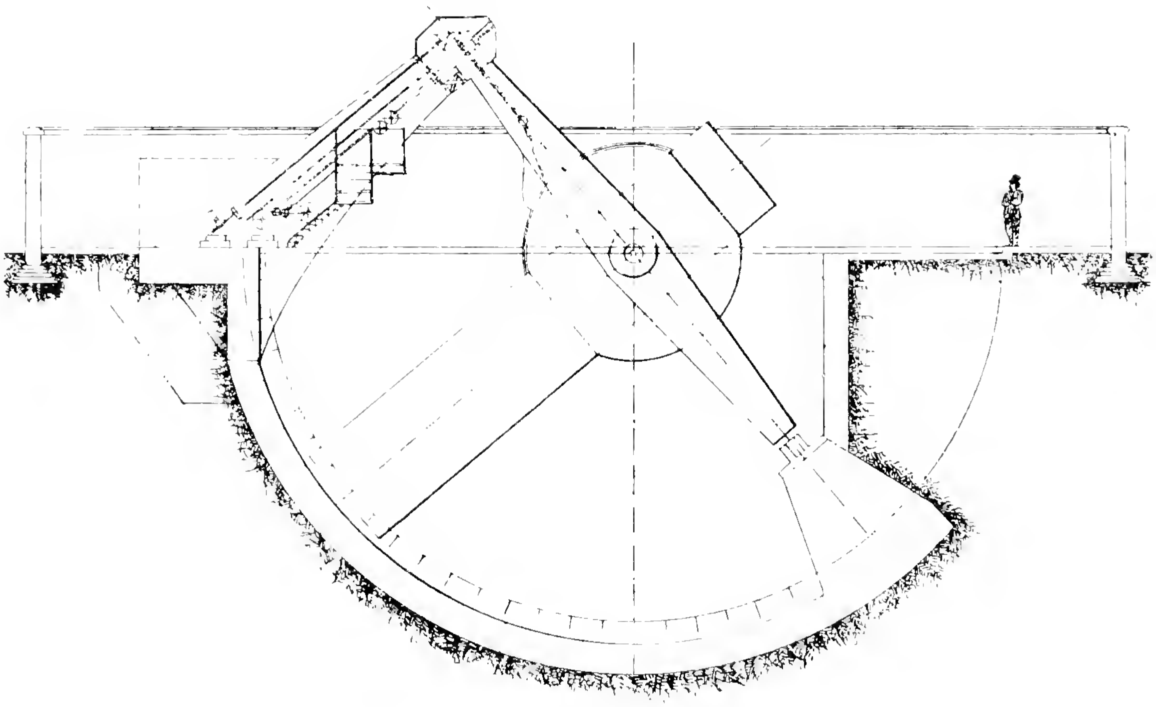


FIG. 2.—Section of the whole Instrument, showing the tube, polar axis and tank, together with the motors for producing the necessary motions.

that nine-tenths of the work required to be done can be commanded by this instrument, it is clearly better to design it to do that nine-tenths well than to strain it into

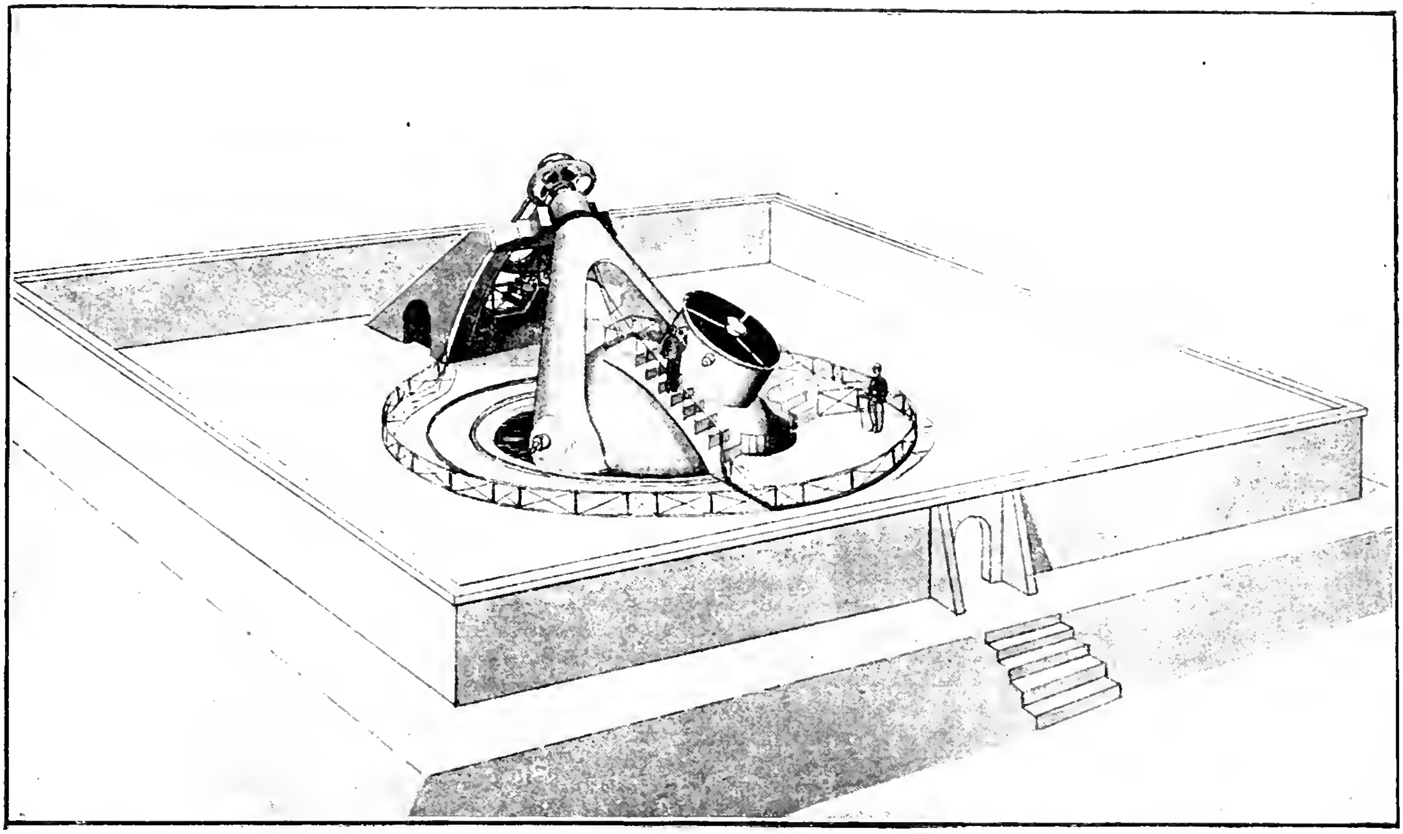


Fig. 3. Perspective view made from the model of the proposed Instrument. It shows the movable gallery to which the steps are attached, by means of which the observer obtains ready access to the eye end.

doing another five degrees that would only be useful on very rare occasions.

Third—It may be urged that the friction of the water will prevent the rapid setting of the instrument.

In a telescope of this size all the motions would be effected by motors of some description, guided by the observer from a commutator board at the eye end, and there would be no difficulty in setting the telescope quite as quickly as could be expected considering its great size.

Fourth—It may be objected that currents will be set up in the water by the moving of the telescope, which currents will affect the steadiness.

No doubt this will be the case to some extent, but these will quickly subside, and the motion necessary for following the stars will be so slow that no perceptible effect of this kind will be felt from it.

I would make all the motions of the telescope and observing stage by electro-motors, controlled from a commutator board at the eye end of the telescope. A one-horse power gas engine would give all the power required to work this telescope. This could be fixed some distance from the telescope so as to avoid vibration. During observations it would be used to work the air pump, which would be either some form of fan such as the Blackman, or some blower like Root's or Beale's. During the day the gas engine would be used to charge storage cells for the motors, of which four would be required, all of them being under the control of the observer at the eye end. One motor would be required for the observing stage, one for the quick motion in right ascension, one for the setting in declination, and the fourth instead of the usual clock for following the stars.

STREAMS OF STARS IN THE MILKY WAY.

By A. C. Ranyard.

I AM indebted to Dr. Max Wolf, of Heidelberg, for the beautiful photograph which accompanies this note. It represents a very rich region of the Milky Way to the north of Sagittarius, and lies on the edge of the great dark rift which divides the Milky Way into two streams through about half its circuit round the heavens. The region photographed is not very far removed from the part of the Milky Way on the borders of the constellation Hercules, towards which the sun is drifting in space, certainly at the rate of ten miles a second. At such a pace, if the sun continues his course in a straight line and his motion is not disturbed by the attraction of some enormous mass of matter of whose existence we are at present ignorant, it will in the course of eighty thousand years have passed over a space equal to the distance separating us from α Centauri, our nearest neighbour amongst the stars. In a million years the sun will have passed over twelve and a half times that distance, and if this region of the Milky Way is twelve and a half times as distant as α Centauri, the larger stars shown in this photograph must be very large or very bright compared with our own sun.

The plate has been etched so as to show numerous streams of very faint stars whose images are not as dense and black as the images of the larger stars, and in bringing out these very faint objects it has been impossible to avoid showing a slight fogging and other small photographic defects, which are most evident near to the bottom of the plate. But the general nebulosity on the left hand of the plate—a nebulosity which is densest where the stars are most thickly distributed—represents true nebulosity as shown on Dr. Max Wolf's photographs.

The cluster near to the centre of the plate exhibits several radiating and branched streams of very faint stars somewhat similar to the branching streams which are shown radiating from the Hercules cluster in the photographs reproduced in Knowledge for June, 1893, but it must be remembered that this photograph is on a very small scale compared with the pictures of the Hercules cluster above referred to. I should like to draw the reader's attention to two curious undulating streams or strings of stars, which extend from the cluster towards the south or left hand side of the plate.

A somewhat similar series of curves of stars will be found about two inches higher up on the plate—that is, on the preceding side of the stream of stars trending to the south from the cluster in the middle of the plate. Fig. 1 shows them, and also shows a brighter line or

Fig. 1.—Triple Arch of Stars.

channel running alongside the strings of stars. There are several such bright channels or lanes (which on the sky mean dark channels) in the nebulosity, very distinctly traceable in Dr. Max Wolf's photographs, and also in those of Prof. Barnard. If these channels were due to a photographic defect, we should expect to find a nebulous band joining the star images of a stream of stars rather than a breach in the nebulosity lying on one side of the star stream. It is easy to conceive that, owing to imperfections of the optical image representing a star, the central spot of light might be surrounded by a nebulous haze, which in the case of a row of stars would merge together, and possibly in a photograph cause the stars to appear to be linked together by a nebulous band. But it is difficult to conceive of any optical reason for this reversed effect, especially as the brighter channels are not always coincident with or parallel to lines of stars.

I would invite the reader's attention to the curious small bright channels, as well as streams of faint stars, in the region of the plate reproduced in Fig. 2. It represents an area near to the top of the plate just below the beginning of the word "preceding."

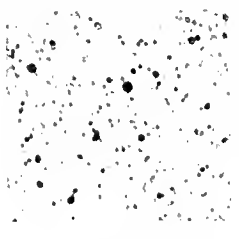


Fig. 2.—Curving Streams of Stars.

Some of the streams of fainter stars in this region are very striking, and must convince the most sceptical of their reality.

It is possible to draw an arc of a circle through any three stars, and a conic section through any five; but where we find ten or twenty stars falling into line, not once, but in many cases, and that there is a curious similarity between the strange curves and branching streams which these phalanges of stars mark out on the heavens, there is no room left for doubt that the mind is not being led away by a tendency of the imagination similar to that which finds faces in the fire, or sees a man carrying sticks on the face of the moon.

If it is proved that a group of stars is arranged in line or marshalled in any order, it would follow that the individuals of the group must be actually as well as apparently close to one another, and that they form some kind of system, having all of them had a common origin, or been subject to some common influence. What these streams and curves of stars mean, and what forces have marshalled them in lines, forms one of the grandest problems of the future, one that I trust I may live to see unravelled.

Science Notes.

Mr. Worthington P. Smith, in his new book, "Man the Primeval Savage," summarizes in a vivid chapter the surroundings and general appearance of the palæolithic men. The forests which then so extensively covered the British Isles harboured animals against which they had ever to guard; the lion, wild cat, bear, wolf, rhinoceros, and hyæna were among the most terrible to them, and the elephant, mammoth, hippopotamus, and bison were no doubt also to be feared.

From the bones that have been found it is noticeable that these earliest known men were shorter in stature, broader in the back, and less upright than the man of the present age; but it is not so clear how Mr. Worthington Smith has discovered that the hair which covered them was probably of a bright chestnut red. The forehead receded, and the heavy overshadowing brow-ridges suggest a creature but little removed from the arboreal ape in his habits.

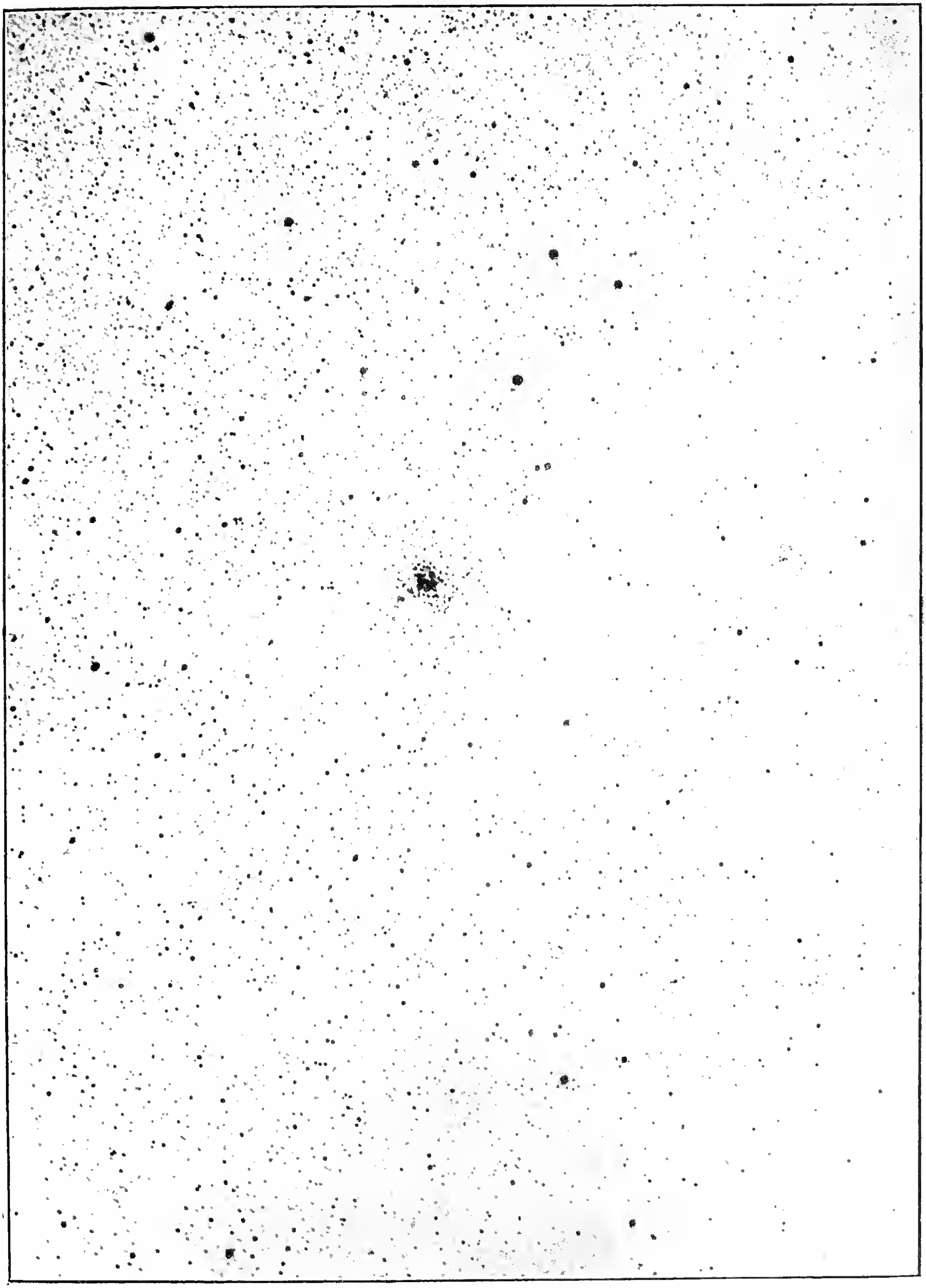
Fear of their common enemies, those animals which would attack stray men who were isolated from their fellows and therefore helpless, obliged them to live in social communities, and to give one another aid and protection to some extent. But, reasoning from the condition of existing savages, Mr. Smith infers that the feebler among them were recognized by the rest as being useless to keep and unprofitable to provide for, so that if any one of their companions was badly injured by accident or attacked by disease, he was hunted away by the rest for the wolves to rid them of him, or deliberately killed.

Another marked resemblance to animal habits is seen in their apparent neglect of their dead, unless they burnt them; for if any deliberate burial occurred, it is singular no traces have survived. Possibly, as Mr. Smith hints, they were cannibals, and not only the dead but the weaker living among them became at times victims to the stronger. Their chief labour was the manufacture of their implements of flint, which were chipped out of the stones in the shape of knives, arrow heads, and such weapons. It is curious to notice that these were entirely fashioned by dexterous chipping, and this was a matter of considerable difficulty when the projected implement was to have a keen knife edge; the idea of rubbing one flake on another stone to produce a sharp edge did not occur to man till the neolithic time. These, with branches of trees cut as sticks, formed their only tools and weapons against wild animals. With such flint tools they could hunt only the smaller animals for food, but would possibly also devour the larger ones when they found them already dead.

At the last meeting of the Royal Meteorological Society, Mr. Inwards, the president, gave an account of various balloon ascents which had been undertaken with the object of making meteorological observations. In 1850 Messrs. Barral and Bixio, when they had ascended to twenty thousand feet, found the temperature had sunk to 15° Fahr., but this was in a cloud, and on emerging from it three thousand feet higher, the temperature fell as

PRECEDING.

SOUTH.



NORTH.

REGION OF THE MILKY WAY ROUND THE CLUSTER NEAR β SCUTUM SOBIESKI.

Enlarged from a Photograph taken by Dr. MAX WOLF, of Heidelberg, on the 28th July, 1892, with a camera of six inches aperture, by Voigtlander, and an exposure of three and a half hours.

low as *minus* 38°, or 70° below freezing point. In 1862 Mr. Glaisher and Mr. Coxwell made their famous ascent, when they reached an altitude of about seven miles from the earth. A short time ago a balloon, without an aeronaut, but having a set of self-recording instruments attached, was sent up in France, and from the records obtained it is shown that a height of about ten miles was attained, and that the temperature fell to *minus* 104° Fahr.

Clouds are simply a form of water made visible by the cooling of the air which previously held the water in the form of invisible vapour. Every cloud may be regarded as the top of an invisible warm column or current thrusting its way into a colder body of air. The comparative altitude of a cloud may be judged, when there is no time or opportunity to make exact measurements, from its form and outline, its shape or shadow, its apparent size and movement, its perspective effect, and the length of time it remains directly illuminated after sunset. By the last method Mr. Inwards states that some clouds have been estimated to have been at least ten miles above the surface of the earth. The cloud velocities at high altitudes have been carefully noted at the Blue Hill Observatory, Mass., U.S., and show, practically, that at about five miles in height the velocities are three times as fast in summer and six times in winter as the velocities of the currents on the earth's surface.

Dr. Hume, in his thesis for the Doctorate of Science, has given geologists a minute and exhaustive account, chemical, mineralogical, and biological, of the zones of the upper Cretaceous in the south of England. With regard to the vexed question of the origin of the chalk, so interesting in its bearing upon the permanence of the great oceanic troughs, Dr. Hume is of opinion that the organic remains point to an ocean which, if not abysmal, was at least far deeper locally than many prominent marine areas. The opinion which M. Cayeux formed from a study of the minute derived minerals in the chalk, that this rock is after all a shallow-water deposit, is contested by Dr. Hume, and he hints not obscurely at ice and ocean currents to explain the mineralogical difference between the chalk detritus and the corresponding constituent of the globigerina ooze now accumulating in the Atlantic.

INSECT SECRETIONS.—I.

By E. A. Butler, B.A., B.Sc.

As a group, insects are remarkable, when compared with the other great divisions of the animal kingdom, for the number and variety of the secretions they produce, whether it be for protection against their numerous enemies, or for constructive or other purposes connected with their own economy. Not only are these secretions useful adjuncts to the creatures from which they emanate, but they are also the source from which most of the valuable products obtained by man directly from the insect world are derived. Such materials as wax, silk, lac, cochineal, all of which are of the nature of secretions, will at once occur to the mind and serve to exemplify the variety mentioned above, and the commercial advantage that may accrue when man can take under his own control the wonderful secreting power of these little beings. But these four products, though amongst the chief of what we have found it profitable to employ for our own purposes, and therefore by far the best known are but a very small proportion of the multitude of substances secreted by insects; and we propose in the present series of papers to try to give some idea of the immense number and variety of these products of insect vitality. The subject will open up, to such of our readers as possess the requisite qualifications and care to pursue the inquiry, a wide field of investigation, for in many cases but little is known of the exact composition of the substance secreted, and the discoveries of the last few years have shown that in all probability many more exist than are yet known or even supposed.

It may be premised that such secreted substances as we are here speaking of will, in their primitive condition, be liquids, though these may afterwards, when stored or brought into actual use, either solidify or vaporize; and further, that the presence of a secretion implies the existence of a special apparatus for the purpose of elaborating it. To this apparatus the general name of "gland" is applied, whatever may be its exact structure. To constitute a gland, all that is essential is a cell, or a group of cells, which shall have the power, under nervous stimulus, of elaborating from the materials with which they are supplied the secretion in question. There will in most cases also be some means by which the secretion, when formed, can be conveyed to the spot where it is required, and this will frequently be in the form of a tube or tubes called "ducts." There may also be superadded to these parts a storage reservoir, especially when the secretion, though tolerably constant in its formation, is used only at intervals. Of course such substances as bile, saliva, &c., which occur in many groups in the animal kingdom, are of the nature of secretions, but we do not propose to deal here with such as are common to many classes of animals, but only with those that, with one or two slight exceptions, are characteristic of the class Insecta. These secretions are not confined to any particular group of insects, and in fact, of all the eight or nine orders into which the majority of insects naturally fall, not more than one or two will be omitted from our enumeration as being of insignificant importance in this direction. By far the most extensive group thus excluded is the order Diptera, or two-winged flies, to which we look in vain for any noteworthy secretions of the kind we are speaking of. Even the formation of silk, which is so common amongst other insects with a complete metamorphosis, is practically absent from this order. One good reason for this will readily occur to the mind. One of the chief uses of silk to insects in general is to protect them in their helpless pupal condition; but a large number of the flies, it will be remembered, form their chrysalis inside the last larval skin, which hardens into a barrel-shaped receptacle, the whole structure thus formed going by the name of "puparium." Thus the chrysalis, being already protected by the hard barrel-like skin of the larva, requires no other envelope, and the silk-forming power is consequently absent.

In silk we have the chief secretion which is shared by animals outside the limits of the class Insecta; spiders, in making receptacles for their eggs (Fig. 1) (the so-called cocoons), and in building up their snares, use a gummy secretion drawn out into a fine thread, which is sometimes scarcely distinguishable from the silk of insects. The silk of which their egg-cases are formed is most like that of insects, as is evidenced by the application of the term "cocoon" to them, though they shelter eggs and not pupæ. The silk of which the

Fig. 1.—Spider's cocoon suspended from twig.

snares are made is less like that of insects, inasmuch as it remains more or less viscid after exclusion, while insect silk hardens at once on exposure to the air. If the silk of spiders' webs did not retain its viscosity, it would be of little use for entrapping victims to supply the larder; and, on the other hand, a permanent viscosity in the silk of cocoons, whether the egg ones of spiders or the chrysalis ones of insects, would be a drawback rather than an advantage, as the cocoon would become encumbered with rubbish which would adhere to it, and consequently we find no such property developed in this connection. The position of the silk glands, too, is quite different in spiders from what obtains in insects. In the former they are situated in the abdomen, and the silk issues from innumerable minute orifices situated on papillæ under the tail end of the body; whereas the silk glands of insects are placed in the anterior part of the body, and the ducts open by a single orifice on one small papilla just beneath the lower lip and outside the mouth.

Early in the last century, Réaumur made some inquiries as to the comparative value of the silk of spiders and that of silkworms for manufacturing purposes. The inquiries were suggested by the achievement of a certain M. Bon, of Languedoc, who had succeeded in making stockings and mittens of spider silk. Réaumur found that the thread of the spider's cocoon had about eighteen times the strength of that of the web, and further, that it would take about five of the spider's strongest threads to equal one of the silkworm's. He calculated also that it would require nearly thirteen times as many spiders as silkworms to make the same amount of silk, and since only the cocoon silk would be available, of course all of these must be females. The superiority of insect silk was thus unmistakably demonstrated; while the further difficulty, that the natural ferocity of spiders rendered it impossible to keep large numbers of them together, put the idea of profitably using their silk out of the question.

We have already pointed out that the power of secreting silk is possessed by insects in their larval state only, the glands by which it is secreted being aborted in the adult. The commercial importance of the silk derived from the Chinese silkworm leads us, no doubt, to mentally associate silk most closely with the caterpillars of moths and butterflies, but its production is not confined to the order Lepidoptera, though what is produced by insects outside that order has no commercial value. Amongst the Hymenoptera, for example, we find saw-flies and ichneumon flies making cocoons just as successfully as any lepidopterous insect. The larvæ of some ants also make a silken cover within which to become pupæ, and those of bees and wasps cover the entrance to their cells with a silken cap, so that they may pass into their resting condition undisturbed. Some beetles, too, make neat little network or papery cocoons, which are attached to the food-plant. The caddis worms, again, which are the larvæ of caddis-flies, members of the order Trichoptera, line their curiously-constructed cases with silk, so as to form a smooth and comfortable chamber. The same material is used to fasten together the shells, grains of sand, bits of stick, or dead leaves by which the case is ornamented outwardly, as well as to make the grating by which the end of the case is guarded when the enclosed insect becomes a pupa. Lastly, even the common flea envelopes itself in a little silken ball when it changes from a wriggling maggot into a restful, dumpy chrysalis. Thus we see that the power of secreting some sort of material to which the name "silk" may fairly be applied is found in at least four orders, though in only three of them is it widely prevalent.

As one of the chief uses of silk is to construct cocoons for protecting the chrysalis, silk glands must not be expected to be present in insects whose metamorphosis is incomplete, and in which there is no such thing as a chrysalis: so that to dragon-flies, grasshoppers, crickets, earwigs, bugs, &c., silk spinning is an unknown art. And as we have seen, even amongst those insects whose metamorphosis is complete, there are many that pass through their changes without the assistance of silk. It is unquestionably in the order Lepidoptera that the silk glands reach their highest perfection, and here the uses of the secretion are manifold. Many larvæ of moths hang suspended by a silken thread when suddenly shaken from the trees on which they are feeding; others construct shelters by fastening leaves together or building fixed galleries or movable tubes, while social caterpillars employ their silk to fabricate a nest which all may use in common. There is a curious little moth which is a great pest in chocolate warehouses, and which, living in enormous swarms together, sometimes covers the whole of a wall with a thin sheet of silken webbing to facilitate the movements of the members of the colony. The same secretion, too, helps to bind together the cocoa-nibs, and prevent them from shifting as they become disturbed by the ravages of the insects. It is of this destructive pest that Curtis speaks in his "Farm Insects," when he draws the following horrifying picture: "I have known bushels of cocoa-nuts which were, every one, worm-eaten and full of maggots, with their webs, excrement, cast-off skins, pupæ, and cocoons, all ground down to make chocolate, flavoured, I suppose, with vanilla."

Should a caterpillar wish to change its skin, it will often spin a little raft of silk upon a leaf to serve for foothold for the "claspers," while it crawls out of its old skin through a slit in the neck. The hooks with which the claspers are furnished being inserted firmly amongst the meshes of the silken structure, a position of vantage is gained, and the creature can use all its strength to pull itself out from its old skin, which will be left collapsed on the raft. And then, when the pupating time comes round, the results of the use of silk are of the most varied description. In some cases a distinct cocoon is made, smooth and even inside, and more or less rough outside, either white or of some shade of yellow or brown, the texture varying from that of a thin and brittle papery film, or a hard and chippy layer in which no threads can be traced, to the loosest possible network of distinct threads. If the caterpillar adopts a subterranean retreat, either a cell is excavated in the loose earth, and the fragments of soil in its walls cemented together by silk, or a complete and tough silken lining is made, which easily comes away from the surrounding earth when it is dug up. Such subterranean cocoons may often be found round the roots of trees, especially where the soil is bare and affords easy ingress to the burying caterpillars.

A third method of utilizing the silk for pupation is to be met with amongst the larvæ of butterflies. These insects are very chary of their silk, expending an exceedingly small quantity of it on their pupating arrangements, and rarely making even so much as a loose web. Sometimes there is merely a small button of silk to serve as a support for the tail of the chrysalis, which thus hangs head downwards from the underside of a leaf or a ledge of some sort. The beautiful butterflies known as *Vanessidæ*, and popularly called tortoiseshells, admirals, peacocks, &c., pupate in this way, as also do the lovely spotted fritillaries. The process of suspension by the tail is a difficult one, and is carried out in a remarkable fashion. The button of silk is first formed, the caterpillar laying down layer after layer, each one over a smaller area than the preceding, so that a conical mass is formed. Then the hooks of the last pair of prolegs are entangled in the mass, and the caterpillar swings down into a vertical position. It has now to cast its skin, in order to appear as a chrysalis. The head is bent round in a curve and after a while the skin splits along the back, and the contained chrysalis appears through the opening. By various contortions it manages to push the old skin gradually backwards towards the point of suspension. The tail of the chrysalis is not yet attached to the support, though the old skin is: but before the skin is pushed quite off, it is necessary for the chrysalis to secure itself. This it does by working itself gradually upwards by means of the still partially investing skin, and stretching out its tail till it can reach the button of silk. The tail is provided with a large number of hooks (Fig. 2), and by means of these the chrysalis fastens itself to the silk, and hangs securely while the skin is completely pushed away.

Fig. 2.—Hooks at end of chrysalis of Red Admiral Butterfly.

The white butterflies and their allies, as well as the swallow-tails, make a more elaborate arrangement. For some reason or other, they elect to lie parallel to the surface of support instead of hanging freely suspended. They therefore add to the tail button a thin loop round the anterior part (Fig. 3), fastened on each side to the object of support, but not in any way adhering to the chrysalis, which therefore lies free in the loop. The loop is made either by the caterpillar bending backwards and running its threads from side to side over its body, or by constructing the loop first and afterwards getting into position.

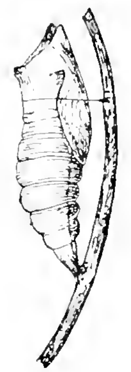


Fig. 3.—Chrysalis of Swallow-tail Butterfly, suspended by button and loop.

The ancients were sorely puzzled as to the origin of the silk of commerce. For many centuries it reached Europe only as a raw product, or a manufactured article coming from the East, where it was cultivated, a region which to an average European might as well have been, for aught he knew about it, in another world. Thus, never having seen the thing in its natural condition as produced by the silkworm, they trusted to rumour for the explanation of its origin, and, as usual, rumour grotesquely mangled the tale as it travelled from mouth to mouth many times over. Silk had some sort of connection, it was understood, with the animal kingdom and some with the vegetable, but what was the precise share of each was by no means clear. Certain insects and trees had a kind of partnership in its production, but only the vaguest notions were current in many places as to the sort of insects and trees that were between them responsible for the lovely product. Perhaps we cannot do better, in order to show the absurdity of the ideas held on this subject even by educated people some eighteen centuries ago, than quote a passage from the naturalist Pliny, who flourished during the golden age of Latin literature; and as the crudity of the ideas will find a better match in an antique English version than in the literary language of the nineteenth century, we will adopt the rendering of an old translator. The passage is as follows: "They build their nests of earth or clay, close sticking to some stone or rock, in manner of salt; and withall so hard, that scarcely a man may enter them with the point of a spear. In which they make also wax, but in more plenty than bees; and after that, bring forth a greater worme than all the rest before rehearsed. These flies engender also after another sort namely, of a greater worme or grub, putting forth two hornes after that kind: and these be certain canker-wormes. Then these grow afterwards to be Bombilii, and so forward to Necydali: of which in six months after come the silke-wormes Bombyces. . . . . . It is commonly said, that in the Isle Cos there be certain silkwormes engendered of flowers, which by the meanes of rain-showers are beaten downe and fall from the cypres tree, terebinth, oke and ash; and they soon after doe quicken and take life by the vapor arising out of the earth. And men say, that in the beginning they are like unto little butterflies, naked, but after a while (being impatient of the cold) are overgrowne with haire: and against the winter, arme themselves with good thick clothes; for being rough-footed, as they are, they gather all the cotton downe of the leaves which they can come by, for to make their fleece. After this, they fal to beat, to felt and thicken it close with their feet, then to card it with their nailes; which done they draw it out at length, and hang it betweene branches of trees, and so kembe it in the end to make it thin and subtill. When al is brought to this passe, they enwrap and enfold themselves (as it were) in a round bal and clew of thread, and so nestle within it. Then are they taken up by men, put in earthen pots, kept there warme, and nourished with bran, untill such time as they have wings according to their kind; and being thus well-clad and appointed, they be let go to do other businesse."

With such a ridiculous collection of nonsense had the *élite* of Roman society to be content, if they wished to know anything of the origin of the soft and brilliant fabrics which they so much prized as a novel article of clothing. It is plain that the author writes simply from hearsay, and has jumbled up together notions derived from different insects and embellished them with freaks of the imagination. And yet there was nothing so very extraordinary in the production of silk by silkworms. The counterpart of the process was going on every season in wild nature in hundreds of places in the country districts all round the Western folk as well as in the remoter regions of the far East; and one would have thought that they might have recognized enough resemblance between the cocoons of the wild Lepidoptera of their own regions and the silk of commerce to have made a nearer guess at the origin of the latter, had they but had eyes to observe more carefully what was going on in the woods and fields close to their own doors. Another account was even more ludicrous, for it was gravely stated that silk was the entrails of a spider-like creature which was fed for four years on a kind of paste, and then with willow leaves, till it actually burst with fat.

The silk-glands of the silkworm are, as might be expected, exceedingly well developed, and may be taken as the type of the organs for the order at large. On opening the body of a silkworm, the glands may be seen as twisted tubes lying partly by the side of, and partly underneath the stomach. Each consists of three parts. The central, which is the most prominent, is a stout, yellowish tube, bent into folds; this is prolonged behind into a much-twisted but narrower tube, and in front into a very fine straight one. The straight tubes of the two glands unite to form a common canal, which leads to the spinneret or papilla placed beneath the mouth. The gummy secretion which is elaborated in the lower divisions of the glands passes as fine threads into the common canal, where another secretion from small glands at the sides unites the two threads into one, at the same time giving the combined thread the beautiful gloss which is one of its strongest attractions: and finally, the composite fibre thus made issues at the pore of the papilla and speedily hardens. In forming the more compact portion of the cocoon, the caterpillar, which is of course inside at the time, bends its head over its back and sways it backwards and forwards, tracing out with its silk a series of figures of eight which adhere to one another by reason of the stickiness of the thread when fresh formed. When a patch of silk has thus been laid down in one position, another is similarly placed elsewhere, and so on till the cocoon acquires the requisite thickness all over. The amount of silk used depends upon the amount and nature of the food on which the insect has been reared. Sometimes as much as half a mile of silk may be unwound from a single cocoon, and it is easy to see what a vast amount of work the laying down of such a length entails upon the caterpillar, and what an enormous number of times it must sway its head backwards and forwards through the narrow limits of its silken envelope before its toils are over.

(To be continued.)

ANCIENT AND MODERN HIPPOPOTAMI.

By R. Lydekker, B.A.Cantab.

The popular conception of hippopotami is that they are clumsily-built creatures of enormous size and bulk, spending the greater portion of their time in the rivers and lakes of Africa, where they are more at home than on land, diving with the readiness of a crocodile, and even walking on the river bed with their bodies submerged many feet below the surface of the water. As regards the common hippopotamus (*Hippopotamus amphibius*), which is the one that has alone been exhibited in our Zoological Gardens, and portraits of which we are enabled by the courtesy of the Secretary of the Zoological Society to present to our readers, this conception is a perfectly true one. As, however, is so frequently the case in popular zoology, this conception, excellent as it is so far as the common species is concerned, does not cover the whole ground, for it happens that there exists in Liberia a second species of the genus, known as the pigmy hippopotamus (*H. liberiensis*), differing not only in size, but likewise in habits from the one with which we are all familiar. In place of attaining a total length of about eleven feet, measured in a straight line, and weighing probably some three or four tons, the pigmy hippopotamus is not larger than a good-sized wild boar, although it has the short and stout limbs of its gigantic cousin, with which it also agrees to a certain extent in the relatively large size of its head. As regards its mode of life, this species differs, however, *in toto* from the common one. Instead of passing at least as much of its time in the water as on land, and never living away from rivers or lakes, the pigmy hippopotamus is an inhabitant of the dense tropical forests of that part of western Africa which is its home, where it apparently leads a life very similar to that of wild pigs, wallowing in swamps after the manner of those animals, but apparently not habitually frequenting rivers, though it is doubtless, like almost all mammals, able to swim well when the necessity arises. Moreover, in place of associating in large herds after the manner of the common species, and never moving far from one particular locality, the Liberian hippopotamus is a comparatively solitary creature, going about at most only in pairs, and wandering long distances through the woods, where it seems to have no definite place of abode.

Out of a large number of representatives of the genus once widely spread over the Old World, the common and pigmy hippopotami, both of which are confined to Africa, are the only species which have survived to the present day; and the reader will at once see, when we have to take into consideration the probable habits of the extinct kinds, how fortunate it is that these two widely different forms have been preserved to us. Were there only the common species, we should have had no conception that any hippopotamus possessed the habits characterizing the smaller kind, and might thus have been led into drawing very erroneous inferences as to the mode of life and habitat of fossil hippopotami.

The general appearance of the common hippopotamus is so familiar to all, and is so well portrayed in our illustrations, that we need not spend much time in discussing it. We may observe, however, that the enormous size of the head, and especially the great width of the mouth, the prominent position of the eyes and nostrils, the minute ears, bulky body, short and stout limbs, and short tail, are among the most striking external features of the creature. The presence of hoofs (four in number on each foot) shows that the hippopotamus belongs to the great order of hoofed, or ungulate, mammals, and the thickness of its nearly naked hide led the older naturalists to place it among what used to be called the pachyderms. It has been shown, however, by anatomical investigations that the group thus designated, which included such totally different forms as elephants, rhinoceroses, and hippopotami, is an entirely artificial one, and that hippopotami, together with their near relatives the pigs, are much more closely connected with the ruminants, the distinctive characters of which have been already indicated in an article in this journal.

The young hippopotamus represented in the full-page plates was born in Antwerp in September, 1891; while the large female depicted in our third and fourth illustrations is of English birth, having been born in the Zoological Gardens on November 5th, 1872, and accordingly named "Guy Fawkes." In both instances, Mr. Ranyard, by whom the photographs were taken, has been successful in showing the characteristic form of the head.

If the reader desires to know why zoologists place such very dissimilar-looking animals as the hippopotamus and the giraffe in the same great group, while they sunder from the former the apparently more similar rhinoceroses, we reply that this is largely due to the difference in the structure of the feet of the two groups. In that the bones of the skeleton of the two middle toes are symmetrical to a line drawn between them, the hippopotami and pigs resemble the ruminants, whereas the rhinoceroses agree with horses in having the middle toe (which is alone present in the latter) symmetrical in itself. Those of our readers who read the article above referred to may recollect that one of the essential characteristics of the ruminants is the circumstance that in the lower part of the leg the two middle toes are supported by a single bone known as the cannon-bone, which consists anatomically of two originally distinct elements welded together, while the supporting bones of the small lateral toes are incompletely developed. If, on the other hand, we examine the skeleton of a hippopotamus, we shall find that in each foot the four nearly equal-sized toes are severally supported by four complete and distinct bones, known in the fore limb as the metacarpals and in the hind limb as the metatarsals; and it will be obvious that this is a much simpler or generalized type of foot-structure than that which characterizes the ruminants. If, again, we contrast the foot of a hippopotamus with that of a pig, we

SIDE VIEW OF YOUNG MALE HIPPOPOTAMUS.

Born at Antwerp in September, 1891; now in the Gardens of the Zoological Society, Regent's Park, London.

shall find that whereas in the latter the lateral pair of hoofs are considerably smaller than the middle pair and do not touch the ground when the animal is walking on a hard surface, in the former the two pairs are nearly equal in size and are all applied to the ground in walking. In this respect the hippopotamus is the most primitive of all the even-toed hoofed mammals that have survived to the present day, and is, therefore, a creature of special interest to the believer in evolution. It is, indeed, a member of the great group from which the ruminants are considered to have originated; although, if the reader should be led from this statement to jump to the conclusion that a hippopotamus was in any sense an ancestor of the giraffe, he would be led into a grievous error. As is the case with nearly all existing animals of a primitive type, the hippopotamus, in place of being an ancestral form, is a side-branch from the original stock, which has developed certain specialized features not found in the latter. To show that this is the case, we have but to study the teeth of the various species of hippopotami, which are of such a nature as to show conclusively that those of the ruminants could not have been derived from them.

It will be remembered that in the group of animals last mentioned the molar teeth have crescent-shaped columns on their grinding-surfaces; and those of our readers who recall an article which appeared some years ago in Knowledge under the title of "Teeth and their Variations,"* may recollect that extinct animals show a complete passage from such teeth to a simple type not unlike that now found in the pigs. The molar teeth of the hippopotami, though of the same general plan as those of the latter, have, however, their four main columns, when partially worn, with a distinctly trefoil-shaped pattern; and it is quite evident that such a tooth could never have given rise to the crescent-teeth of the ruminants. The hippopotamus molar is, indeed, quite peculiar, and its structure is is so well marked and characteristic that any person who has once seen a figure like the one here given could immediately identify any example that might come under his notice.

Fig. 1.—Molar Tooth of Hippopotamus, showing the trefoil-shaped surfaces on the crown. Actual size.

Whereas, however, all the members of the genus have molar teeth almost exactly alike, there is a considerable amount of difference with regard to the front or incisor teeth of the different species, and as these differences are of considerable interest from an evolutionary point of view, they may be considered in some detail.

In the first place, it may be mentioned that all hippopotami have an enormous pair of curved tusks or canines in each jaw, these being shown on the sides of the two lower jaws represented in our second figure. In the common species, between these huge tusks are two pairs of incisors, those of the upper jaw being of nearly equal size, whereas in the lower jaw, where these teeth are cylindrical and project nearly horizontally forwards, the central ones are very much larger than the lateral pair, as shown in Fig. 2 (A). If, however, we examine the lower jaw of the pigmy Liberian species, we shall find that normally there is but a single pair of incisors between the tusks, which would lead to the conclusion that this animal is a more specialized type than its larger relative. The truth of this inference is curiously confirmed by the circumstance that individuals of the Liberian hippopotamus are occasionally met with in which there are two incisor teeth on one side, while on the other there is but the single tooth; this being an excellent example of what evolutionists term reversion or atavism. This, however, by no means brings us to the end of the variation in the number of these teeth obtaining in the group under consideration; but before proceeding further it is necessary to remark that, since in ordinary mammals the typical or full complement of incisor teeth consists of three pairs, it is natural to suppose that one pair has been lost in the common species. That such is really the case is demonstrated by the extinct Siwalik hippopotamus (*H. sivalensis*) of the Pliocene deposits of the outer ranges of the Himalaya, of which the extremity of the lower law is shown in Fig. 2 (B). Here it will be seen that between the two large tusks there are three pairs of incisor teeth, which differ from those of the common species in being all of nearly equal size; and if we were to examine the upper jaw, we should find that in this also there is the same number of teeth. In the presence of these three pairs of incisors the Siwalik hippopotamus resembles the pig, from which it departs less widely than does the common species in that these teeth are relatively smaller and also of nearly equal size. The Siwalik hippopotamus must accordingly be regarded as a less specialized species than either of its living cousins; and since, together with an allied species from the Irrawady valley known as the Burmese hippopotamus (*H. iravaticus*), it is the oldest representative of the genus, its generalized features are precisely what evolutionary considerations would have led us to expect.

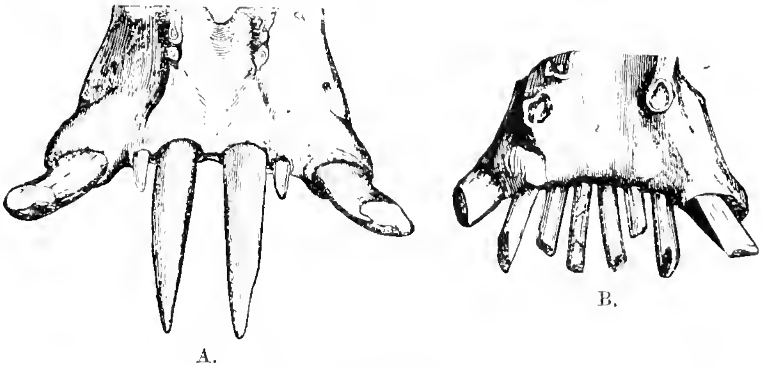


Fig. 2.—Extremity of the Lower Jaw of the Common (A) and Siwalik (B) Hippopotamus.

There is, however, yet another curious point in connection with these teeth demanding a moment's notice. From the evidence of the two specimens represented in Fig. 2, it is quite impossible to determine which of the three pairs of lower incisors found in the Siwalik hippopotamus have disappeared in the common species.

* Reprinted in "Phases and Forms of Animal Life." Longmans & Co.

Fig. 3 Front view of full-sized female Hippopotamus, born 5th November, 1872, in the Zoological Gardens, London.

Fortunately, however, palæontology here once more comes to our aid, showing not only which pair has been lost, but how the loss was brought about. From the gravels of the Narbada Valley in central India, which are probably intermediate in age between the Pliocene deposits yielding remains of the Siwalik hippopotamus and the brick-earths of our own country in which occur those of the common African species, there are found two extinct members of the genus, one known as the Narbada hippopotamus (*H. namadicus*), and the other as the Indian hippopotamus (*H. palæindicus*). In the former of these the lower incisors are similar in size and number to those of the Siwalik species; but in the latter, while the inner and outer pairs are very large, there occurs on each side between them a minute and rudimentary tooth, squeezed out from the general line to the upper margin of the jaw, and evidently just about to disappear altogether. We have thus decisive evidence that the missing pair of lower incisor teeth in the common hippopotamus is the second; and we further see how a complete transition can be traced, as regards the number of these teeth, from the Siwalik species through the common one to the Liberian hippopotamus. While it is quite possible that the African hippopotamus may have been directly derived from the Siwalik species, it is quite clear that the pigmy hippopotamus is not the descendant of its giant existing cousin.

With regard to the geographical distribution of the genus, we have already said that the two living species are confined to Africa, to which it may be added that there is no record of their having ever occurred in the districts lying to the north of the Sahara during the historic period. They are, therefore, essentially inhabitants of what naturalists term the Ethiopian region, although they are quite unknown in the island of Madagascar, which belongs to the same zoological province. So far as we are aware, there is no evidence that the pigmy species ever ranged beyond its present habitat of Liberia, although the case is very different with regard to the range of the common species. At the present day this animal is found from the Cape Colony northwards to the cataracts of the Nile, and it extends westwards to Senegal; but while for several centuries it has been very seldom met with on the Nile below the entrance of the Atbara and Blue Nile, there is abundant evidence that in the time of the Pharaohs it was common in Egypt, where in the temple of Edfu, as well as several other buildings, there are frescoes representing the mode in which it was hunted and speared. That the hippopotamus is the animal indicated in the book of Job under the name of behemoth is, according to Canon Tristram, undoubted, but there is no evidence that the Jews were acquainted with it otherwise than during their sojourn in Egypt. It is true, indeed, that the writer just mentioned suggests that its range may have extended eastwards as far as Palestine, but this is mere conjecture, and had the creature ever lived there the expeditions which have from time to time explored that country ought to have found some of its remains. In the Pleistocene and upper Pliocene deposits of southern and central Europe there occur, however, numerous remains of a hippopotamus which cannot be specifically distinguished from the existing African form, although it was generally of rather larger size. This difference in size was at one time thought to indicate that the fossil form was a distinct species, but the discovery many years ago of a half

FRONT VIEW OF BABY HIPPOPOTAMUS.

Two and a half years old, now in the Zoological Gardens; showing the small size of the ears, the prominence of the eyes, and the slit-like nostrils, the latter being nearly closed.

fossilized jaw in the alluvium of the Nile near Kalabshi, in Nubia, showed that in former times the African hippopotamus attained dimensions as large as the European form. In England the hippopotamus ranged at least as far north as Leeds, and it is a remarkable circumstance that in many places its remains have been found in association with those of the reindeer. How animals now inhabiting countries with such totally different climatic conditions as tropical Africa and Lapland could have lived in the same country at the same time, is very difficult to understand. If the hippopotamus had been different from the living African one, we might have regarded it as a terrestrial species like that of Liberia, and thus perchance capable of standing a colder climate; but being identical with the former, we are perforce compelled to believe that its habits were similar, and that in its habitat the rivers must have been more or less free from ice throughout the year. Whatever may be the true explanation of the difficulty, it is pretty clear that no theory of summer and winter migrations will hold good, as the hippopotamus is essentially a resident animal.

Returning once more to Africa, we may notice that in Algeria, where the genus is now unrepresented, a small species (*H. hipponensis*) flourished during the Pleistocene period; this species being distinguished by having three pairs of lower incisor teeth, which differed from those of other members of the genus in having their enamel smooth and their extremities somewhat expanded, thus approximating to the corresponding teeth of the pigs. Equally noteworthy is the occurrence of another species, Lemerle's hippopotamus (*H. lemerlei*) in Madagascar, where its remains are common in the great marsh of Ambulisatra. Somewhat intermediate between the common and the Siwalik species, this rather small hippopotamus had sometimes three and sometimes two pairs of lower incisors. Certain traditions current among the Malagasy, suggest that this species may have lived within the historic period, and it may even be one of several mysterious animals alluded to by an early European voyager.

In addition to the common species, southern Europe, inclusive of Malta and some of the other Mediterranean islands, was the home of one or two smaller varieties or species, which seem to pass imperceptibly into one another until they dwindle down to the proportions of the Liberian species. Possibly these small forms may have been more or less completely terrestrial in their habits.

The three Indian species have been already sufficiently discussed, while mention has been likewise made of the Burmese hippopotamus. The latter species, by the way, was decidedly pig-like in many parts of its structure, and may well, therefore, have been a marsh-haunting animal. It was at one time thought that one of the later Indian hippopotami was an unknown animal referred to in Sanscrit literature, but further investigation has shown this view to be untenable. Eastwards of Burma, we are unaware that there is any evidence of the existence of these animals, and they appear to have been always unknown in the New World.

Although it is possible that in Madagascar Lemerle's hippopotamus may have been exterminated by human agency, such an explanation will not hold good with regard to the other fossil species. So far as we can see, India and Burma are now in every way as well fitted to be the dwelling-places of hippopotami, giraffes, and ostriches as they were during the Pliocene period, when those animals either wallowed in their lakes and rivers, or stalked over their plains; and as the former countries have not been completely swept during the interval by a glacial period, it seems impossible to divine the reason why these creatures should have so completely vanished from the one area and have survived in full strength in the other.

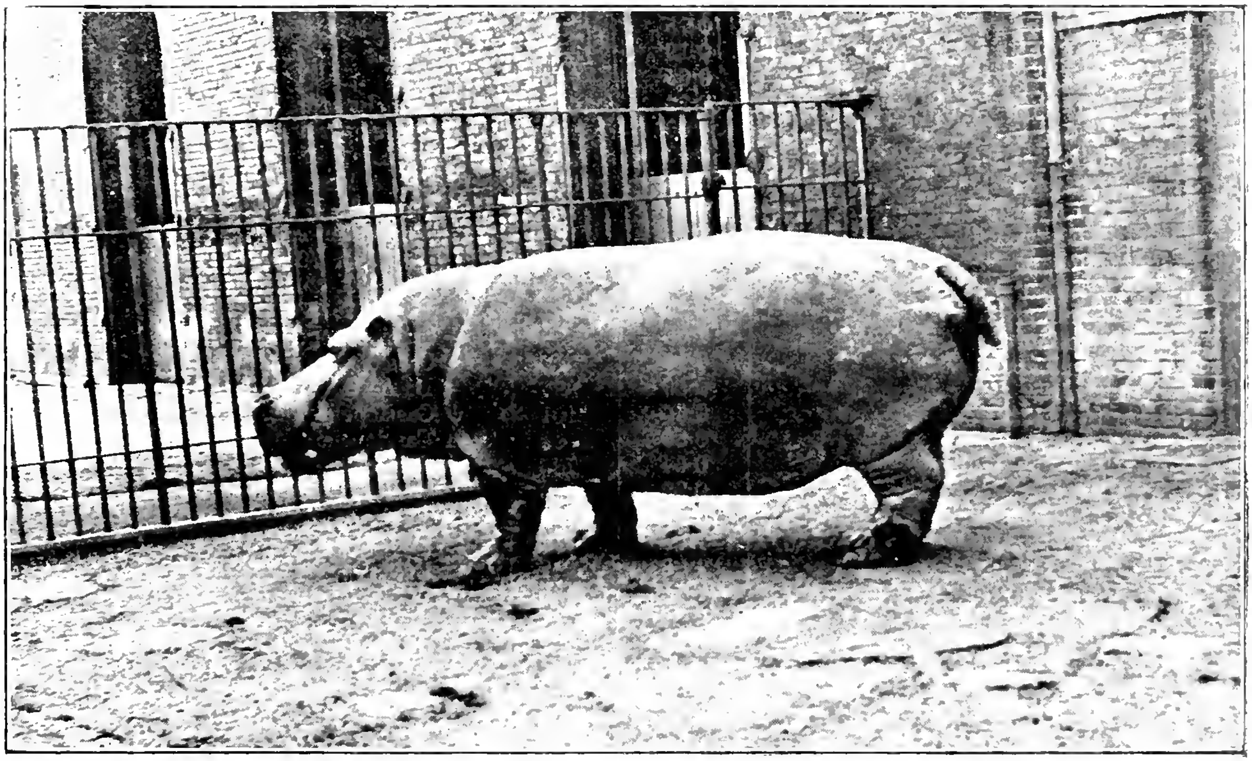


FIG. 4.—Side view of "Guy Fawkes," the large female Hippopotamus, in the Gardens of the Zoological Society. Now twenty-one years old.

NAKED EYE DOUBLE STARS DISCOVERED BY BURNHAM.

Mr. BURNHAM has been especially successful in discovering two new classes of double stars—namely, naked eye stars with close companions, and naked eye stars with faint companions.

Both classes of stars form excellent, though mostly very difficult, test objects, and a list of them will, no doubt, be valued by readers of Knowledge who possess instruments of good quality. The numbers on the left hand are the numbers in Mr. Burnham's catalogues. These will enable observers to verify their observations when they have independently made their measures or estimates of the position, angle and magnitude of the companion.

Close Pairs.

β	Star.	Dist.
1147	2 Andromedæ	0·23″
1212	24 Aquarii	0·55
172	51 Aquarii	0·68
1220	ψ¹ Aquarii (B C)	0·22
755	Argus 34	0·77
101	9 Argus	0·22
1240	26 Aurigæ	0·16
328	Canis Majoris 139	0·51
1099	B. A. C. 255 ...	0·12
518	48 Cassiopeiæ	0·58
414	Centauri 315	1·00
1176	48 Cephei H	1·18
395	Ceti 82	0·75
1163	Ceti 199	0·19
220	Crateris 22	0·65
1129	Gr. 2829	0·34
64	1 Delphini	1·00
151	β Delphini	0·50
962	26 Draconis	0·62
744	Eridani 299	0·79
311	Eridani 315	0·98
881	46 Eridani	1·29
1241	3 Geminorum	0·53
1058	4 Geminorum	0·30
1008	η Geminorum	1·08
1192	ν Geminorum (B C) ...	0·15
587	15 Hydræ	0·59
341	Hydræ 348	0·66
239	59 Hydræ...	0·86
694	Lacertæ 4	0·64
1076	55 Leonis...	0·99
314	Leporis 3	0·82
766	θ² Microscop.	1·06
16	3 Monocerotis	1·88
241	Ophiuchi 74	0·75
1117	24 Ophiuchi	0·58
1118	η Ophiuchi	0·36
631	Ophiuchi 255...	0·36
1125	68 Ophiuchi	0·89
1032	σ Orionis	0·23
989	κ Pegasi	0·2
1144	η Pegasi (B C)... ...	0·29
718	61 Pegasi	0·69
720	72 Pegasi	0·33
733	85 Pegasi	0·79
1170	χ Persei (B C)	0·27
524	20 Persei	0·15
1179	34 Persei	0·68
535	38 Persei	0·87
1029	ξ Persei	0·85
1164	95 Piscium	0·39″
506	η Piscium	0·99
5	103 Piscium	1·07
947	β Scorpii	1·03
120	ν Scorpii	0·80
416	Scorpii 185	0·58
391	κ Sculptoris	0·94
348	2 Serpentis	0·76
619	Serpentis 55	0·59
547	47 Tauri	0·91
1007	126 Tauri	0·2
1077	α Ursæ Majoris	0·97
932	Virginis 550	0·51
612	B. A. C. 4559	0·31

Wide Pairs.

β	Star.	Dist.
1095	28 Andromedæ	2·42
999	ω Andromedæ	2·28
717	8 Andromedæ	7·43
1034	7 Aquarii	2·09
279	ω² Aquarii	5·86
287	ξ Aquilæ	5·63
757	Argus 101	2·57
1061	κ Argus	9·98
1063	ξ Argus	4·63
1064	19 Argus	1·84
878	66 Arietis	1·29
1046	9 Aurigæ	6·29
888	σ Aurigæ	8·60
901	65 Aurigæ	11·14
1086	47 Bootis	6·03
750	γ Cæli	2·69
1043	3 Camelopardis...	3·92
1187	5 Camelopardis...	12·89
930	B. A. C. 4389	2·67
608	17 Canes Ven.	1·22
753	λ Canis Majoris	1·29
21	η Canis Majoris ...	3·99
668	B. A. C. 7080	4·64
492	B. A. C. 201	2·11
497	B. A. C. 239 (B C) ...	0·76
1098	ν¹ Cassiopeiæ	12·79
1028	γ Cassiopeiæ	2·15
396	B. A. C.	1·28
1101	ψ Cassiopeiæ	2·93
1103	44 Cassiopeiæ	1·73
785	49 Cassiopeiæ	5·40
343	Centauri 219	1·70
1160	B. A. C. 230	1·19
399	Ceti 211	1·66
7	58 Ceti	2·63
1080	17 Comæ	1·79
1081	37 Comæ	5·15
1087	τ Coronæ	3·10
1245	ξ Corvi	4·81
600	Crateris 36	1·23
1131	θ Cygni	3·79
980	η Cygni	7·21
675	51 Cygni	2·99
677	T Cygni	9·91
65	13 Delphini	1·54
946	B. A. C. 5248	1·43
1090	β Draconis	4·04
11	ρ² Eridani	2·64
877	γ Fornacis	12·03
1193	36 Geminorum	10·81
1009	τ Geminorum	1·75

β	STAR.	DIST.
1194	65 Geminorum	13·91″
1062	82 Geminorum	4·06
771	σ^2 Gruis	2·46
1198	τ Herculis	6·70
625	ω Herculis	1·76
816	31 Herculis	5·28
818	32 Herculis	3·64
627	52 Herculis	1·62
954	54 Herculis	2·56
130	90 Herculis	1·63
590	29 Hydræ	10·95
1075	ϕ^3 Hydræ ...	3·03
940	52 Hydræ	1·27
105	κ Leonis	2·79
599	65 Leonis	1·78
913	50 Leonis Min.	12·27
320	β Leporis ...	2·89
94	Leporis 61	2·61
106	μ Libræ...	2·01
618	ι^1 Libræ (B C)	1·40
648	B. A. C. 6480	1·29
16	3 Monocerotis	1·88
17	4 Monocerotis	3·21
1124	67 Ophiuchi	6·79
290	34 Pegasi...	2·71
874	5 Persei...	5·40
875	9 Persei...	11·64
276	η Piscis Australis	1·61
772	δ Piscis Australis	4·78
286	8 Sagittarii	6·03
760	η Sagittarii	3·51
1033	ν^2 Sagittarii	1·37
654	52 Sagittarii	3·00
763	κ^2 Sagittarii	1·33
36	2 Scorpii	2·86
39	11 Scorpii	3·25
1013	δ Sculptoris	3·31
32	6 Serpentis	2·41
1031	Aldebaran (C D)	1·83
1045	99 Tauri	6·21
1067	o Ursæ Majoris	7·01
1071	θ Ursæ Majoris	5·15
1082	78 Ursæ Majoris	1·46
924	31 Virginis	3·94
248	2 Vulpeculæ	1·92
1130	9 Vulpeculæ	9·53

THE LUMINIFEROUS ETHER.

By J. J. Stewart, B.A.Cantab., B.Sc.Lond.

In the earlier theories of electricity and magnetism, "action at a distance" was considered a sufficient explanation of the mutual influence of electrified bodies or magnets upon each other. Bodies charged with electricity were stated to attract or repel each other with a force varying inversely as the square of the distance, and no account was given or inquiry made as to the mechanism whereby these attractions and repulsions were excited, though actions of material systems on each other at a distance without any intervening medium seems an unthinkable hypothesis.

To Faraday is due the fruitful theory that these electrical actions are caused by stresses and strains in a medium surrounding and interpenetrating the electrified bodies, and he mapped out the surrounding space by a set of curving lines of force. He showed that the actual phenomena may be explained by supposing a tension along the lines of force, combined with a pressure at right angles to them. This theory has been further developed by Clerk Maxwell, who showed that it gave a consistent explanation of the behaviour of electrified bodies and of magnets.

But the existence of some medium filling interplanetary space is demanded by the undulatory theory of light, in order to account for the transmission of light-waves from the heavenly bodies, and from all luminous objects to our eyes. Many facts go to prove that the dark radiations, which do not affect our sense of sight but which produce heat in the matter on which they fall, are conveyed by the same medium, and that the heat-producing waves differ only from the luminous vibrations in having a greater wave-length; the two radiations therefore seem to be essentially the same, but when the waves are shorter and more rapid than the luminous ones, they do not affect our nerves of sight, though their chemical effects may be observed and their existence made manifest by their photographic action.

The existence of a medium capable of conveying radiation by some sort of periodic vibration being abundantly confirmed by the various phenomena of light, the question arises whether it is not the very same medium whose stresses and strains may account for the observed electric effects. It would simplify matters much if we had not to suppose separate ethers to account for the various phenomena in the different departments of physical research. These various effects are considered by us separately and placed in different categories because they manifest themselves to us in differing ways, but they may all be due to different forms of energy exerting influence through the same medium. To reduce the explanation of physical phenomena to as few forces as possible is simpler and more satisfying to the mind, and the tendency of physical research and modern speculation is to form wider and more comprehensive generalizations, which enable us to include various and apparently disconnected phenomena under the same far-reaching laws. For the departments of electricity and light this has been to a great extent done by the famous electro-magnetic theory of Clerk Maxwell, which considers light as an electro-magnetic phenomenon, and explains the vibrations of light as consisting of some sort of alternate electric polarizations of the particles of the luminiferous ether.

Let us consider a little what is known of this all-pervading medium, through which are manifested all the remarkable effects of electricity and light and radiation.

Maxwell's theory has recently received a striking confirmation and illustration by the brilliant experiments of Dr. Hertz, who has investigated the behaviour of long electro-magnetic waves and has not only found that they are capable of reflection, refraction and polarization, but measured their wave-length. He finds that their behaviour is quite analogous to the behaviour of light-waves, and that they differ merely in having a greater length.

It is possible that the attraction of gravitation may also be due to stresses in the ether, though the cause of gravitation no one has yet been able to explain. It is highly probable that if we were acquainted with all the properties of the luminiferous ether, the knowledge would include an explanation of the mechanism of gravitation.

Newton emphatically rejected the idea of action at a distance. He says in his *Letters to Bentley*: "You sometimes speak of gravity as essential and inherent to matter. Pray do not ascribe that notion to me; for the cause of gravity is what I do not pretend to know, and therefore would take more time to consider of it. It is inconceivable that inanimate brute matter should, without the mediation of something else which is not material, operate on and affect other matter without mutual contact, as it must do if gravitation, in the sense of Epicurus, be essential and inherent in it. . . . . That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a *vacuum*, without the mediation of anything else by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws, but whether this agent be material or immaterial I have left to the consideration of my readers."

Newton explained the phenomena of light as due to luminous corpuscles emitted with great velocity from shining bodies. He rejected the undulatory theory because he could not explain by it the propagation of light in straight lines, but some of his ideas closely resemble and agree with those of the theory of undulations; and he also supposed the existence of an all-pervading ether, and used the undulatory theory to account for the occurrence of reflection and refraction.

He imagined that his luminous corpuscles on striking surfaces produced waves in the ether, and by the action of these waves alternate fits of easy reflection and easy transmission were communicated to the luminous particles, so that sometimes they were in a state to be reflected and sometimes in a condition to be refracted at a transparent surface. He applies his observations on the colours of thin plates to this hypothesis, and develops it with extraordinary ingenuity. Many of his notions as to the waves produced in the ether agree far more closely with the undulatory theory than has been generally supposed. He compares the waves in the ether to those produced on throwing a stone into water. He says: "What kind of action or disposition this is—whether it consists in a circulating or a vibrating motion of the ray, or of the medium, or something else—I do not here inquire." He considered that vibrations or tremors were excited in the reflecting or refracting medium at the point of incidence, that they were propagated to great distances, and that they overtook the rays of light and successively put them into the fits of easy reflection and easy transmission. In the queries at the end of his *Opticks*, he asks: "Is not the heat of the warm room conveyed through the *vacuum* by the vibrations of a much subtler medium than air? And is not this medium the same with that medium by which light is refracted and reflected, and by whose vibrations light communicates heat to bodies, and is put into fits of easy reflection and easy transmission?" He gave as a possible explanation for gravitation that the ether was much rarer within the dense bodies of the sun, stars, and planets than in the spaces between them; that it grew denser and denser as the distance from these bodies increased, and thereby caused the gravitation of the bodies towards each other, every body tending to go from the denser parts of the medium towards the rarer. Again he asks: "Is not vision performed chiefly by the vibrations of this medium excited in the bottom of the eye by the rays of light, and propagated through the solid, pellucid, and uniform capillamenta of the optic nerves into the place of sensation?"

The ether must be of extreme tenuity and imponderable. Its presence cannot be detected by our senses, and its properties must be discovered by a process of reasoning founded on its behaviour, as manifested, for example, in the transmission of luminous vibrations. Its properties are to a great extent at present unknown. We know that it must fill the celestial spaces as far as the most distant stars; and from the propagation of light through transparent material we judge that the ether must evidently interpenetrate solids and fluids, for the matter of the solid body itself is incapable of transmitting vibrations with the enormous rapidity of those of light. From phenomena such as the polarization of light it is seen that the direction of the vibrations must be transverse to the direction of propagation.

As fluids cannot give rise to transverse vibrations, the ether was supposed to behave like an elastic solid, or at any rate to possess some property analogous to rigidity or resistance to change of shape. As a first step, the vibrations constituting light were regarded as actual periodic displacements of the particles of the ether in the wave front, and transverse to the direction in which the wave is moving. A solid gives rise to longitudinal vibrations as well as to transverse ones, and to get rid of the complication arising from the existence of the former the ether was supposed incompressible; then the velocity of propagation of the longitudinal disturbance would be infinite. Sir G. Stokes has pointed out that though the ether may act as a perfect fluid for large and comparatively slow displacements, those occurring in the propagation of light may be so small and so rapid that for them the ether behaves like an elastic solid.

The ether must be supposed to freely pervade all material bodies. As all bodies are compressible, their constituent molecules cannot be in contact, and the ether may be regarded as surrounding and bathing them, the molecules floating as it were in an ocean of ether. But the ether is affected by the presence of the molecules of matter, and this is shown by the bending or refraction of rays of light when they enter transparent substances. This refraction is accounted for in the undulatory theory by the difference of the velocity of the light-waves through a vacuum and through ponderable matter. The presence of the particles of matter causes the speed of transmission of light to be less. At first sight it appears difficult to believe that a dense solid substance like glass should have its molecules so far apart as to allow of a free penetration of the ether amongst them, and that this contained ether should also be free to vibrate and thus transmit the periodic disturbances producing light. But we know that a magnet can act through a plate of glass and attract a mass of iron on the other side, and this magnetic influence must be conveyed through some medium from the magnet to the iron. Neither the magnetic influence nor the ethereal medium is directly observable by our senses, but the existence of both is inferred by our intellect from the effects produced.

From the fact that ether is capable of transmitting with a finite velocity the vibrations which convey light, it would seem to follow that it must be endowed with inertia, or some property answering to mass in ordinary matter. As these vibrations are transverse, it must also possess a quasi-rigidity or an elasticity analogous to that by which a solid body resists a force tending to change its shape, or opposes the gliding of its particles over one another. It may be continuous; at any rate, if it has a molecular structure it must be different from that of gases, which cannot transmit transverse vibrations. If it be supposed to consist of molecules at a distance from each other, the same difficulty as to action at a distance between these separated particles would occur, for action at a distance across empty space is not more easy to understand when the distance is extremely small than it is when the distances are those we have to deal with in astronomy.

BROOKS' COMET. Enlarged from a Photograph by Prof. E. E. Barnard,

Taken October 21st, 1893; exposure 16h. 37m. to 17h. 12m., Standard Pacific Time. The arrow from the nucleus shows the direction of motion of the Comet, and the distance passed over in the succeeding twenty-four hours.

WHAT IS A COMET'S TAIL?

By A. C. Ranyard.

No bride was ever covered by such a transparent gauzy veil as that which trails behind a comet as it comes to do obeisance to the sun, or as it backs like a courtier out of the solar presence, keeping its train behind it. It has frequently been noticed that the light of small stars is not sensibly dimmed when the tail of a large comet sweeps between the earth and the star; therefore, to compare the matter of comets' tails with a white mist, or a silver fog in space, is too gross a comparison. A few hundred yards of the thinnest fog or mist we are familiar with, cuts down very materially the light of objects seen through it, but the light of a star in passing through the tail of a large comet must have travelled through hundreds of thousands of miles of the nebulous material which is streaming away from the nucleus. The thickness of light-absorbing material traversed by a ray of light makes a greater difference than would at first sight be suspected in the amount of light transmitted through a fog or haze, or other absorbing medium, for the light lost increases in geometrical proportion as the thickness of the light-absorbing medium increases in arithmetical proportion; thus, if a haze ten miles thick reduced the light of an object seen through it by one half, a similar haze twenty miles thick would absorb three-quarters of the light that would otherwise be transmitted, for the second ten miles of haze will halve the light that has been transmitted through the first ten miles. Thirty miles of such haze will reduce the light to an eighth, and two hundred miles of such haze will reduce it to about one millionth, for two to the power of twenty is a little more than a million.

On the clearest summer day the brightness of objects at a distance of ten miles on the horizon is reduced to less than one half by the absorption of the intervening atmosphere—a fact that becomes very evident to photographers who attempt to photograph distant objects, and who find that long exposures are necessary to obtain upon their plates any trace of the blue distance which so charms the eye. The tail of a comet must consequently be far more transparent than the earth's atmosphere; indeed, a mass of gas as bulky as the tail of a large comet would—even if it were a thousand times more transparent than air—act as an opaque screen in space, cutting out the light of the stars, and probably even eclipsing the light of the sun itself, if such a cometary tail should pass between the earth and the solar disc.

The light derived from the tail of a comet is generally found to give a bright line spectrum in the neighbourhood of the nucleus, and to be more or less polarized at a greater distance from the nucleus. The bright lines seem to point to the presence of incandescent gas, and have frequently been taken to indicate a high temperature in the region about the nucleus; but the spectrum of the aurora which glows in the cold upper strata of our atmosphere is also characterized by narrow gaseous lines, and many comets begin to glow and throw out tails in regions of the solar system where they can derive but little heat from the warming effect of the sun's rays.

Thus, according to Mr. Marth, comet Brooks, at the time of the photograph reproduced in our plate (October 21st), was at a distance 1·02 times the earth's mean distance from the sun—that is, it was at a little greater distance from the sun than the earth ever is.* We may therefore compare the temperature of the comet as derived from the sun's rays, at the time that its photograph was taken by Prof. Barnard, with the temperature of the moon, and it was shown in the article in the April number that the temperature of the moon's equatorial regions during the lunar day probably does not exceed the temperature of melting ice. Consequently, if the ebullition which was evidently going on in the nucleus of Brooks' comet at the time the photograph was taken was due to the rapid driving into vapour of matter by the sun's heat, the material that was being vaporized must have had a very low melting point, such as is possessed by carbonic acid or substances which freeze at a still lower temperature, such as hydrogen, nitrogen, and other forms of matter which in terrestrial laboratories we are, under ordinary circumstances, only familiar with in their gaseous state.

The way in which comets' tails, as a general rule, slowly develop in size as they approach the sun, and again diminish as they recede from him, would seem to point to the conclusion that the growth of comets' tails is principally due to the intensity of the sun's heat, or to some other cause which varies with the distance of the comet from the sun. But the rapid variations in form and brightness which many comets have exhibited seem to show that the evolution of gas from the nucleus, and the repulsion of matter in the tail, is influenced or in some way partly controlled by some more irregularly varying conditions, such as collisions with meteors, or dust in space, or the passage of the cometary nucleus through a mass of gas. The rapid variations in form and brightness which a comet sometimes undergoes are well illustrated by the four photographs of Swift's comet, taken by Dr. Max Wolf, which are reproduced in our second plate. A still more striking instance of a rapid increase of brightness was afforded by Holmes' comet, which, at more than double the earth's distance from the sun, seems to have suddenly brightened up.

Before attempting to speculate on the causes of these irregular variations in brightness, it may be well to give an account of the phenomena which are usually observable. A comet when it is first seen as it approaches the sun, and also when last seen as it recedes from the sun, generally appears as a small roundish patch of faintly luminous nebulosity, sometimes with a brighter patch or stellar point near the centre. As the comet brightens on approaching the sun it generally begins to emit jets or streamers, or to form more or less symmetrical envelopes on the side next the sun, and develops a tail on the side remote from the sun. In the great comet of 1858, usually known as Donati's comet, the action was most symmetrical, one envelope after another rising from the nucleus and expanding, as if the material forming the envelopes was repelled by the nucleus, and was also repelled by the sun, till it was ultimately driven away within a hyperbolic envelope or stratum which formed about the nucleus.

The tail in this and other comets seemed to be composed of hollow cones slightly bent backwards in the plane of the orbit. The backward curvature is easily explained, because particles repelled from the comet's head would still retain their original orbital motion, and would fall behind the line drawn from the sun through the comet's nucleus, as they were driven into a larger and larger orbit. The amount of backward curvature of the tail evidently depends on the velocity with which the particles are driven away from the sun, and we find in this and other comets multiple tails, indicating that the different branches of the tail are composed of different materials which are repelled from the sun with different velocities.

But in Dr. Max Wolf's photographs of Swift's comet we

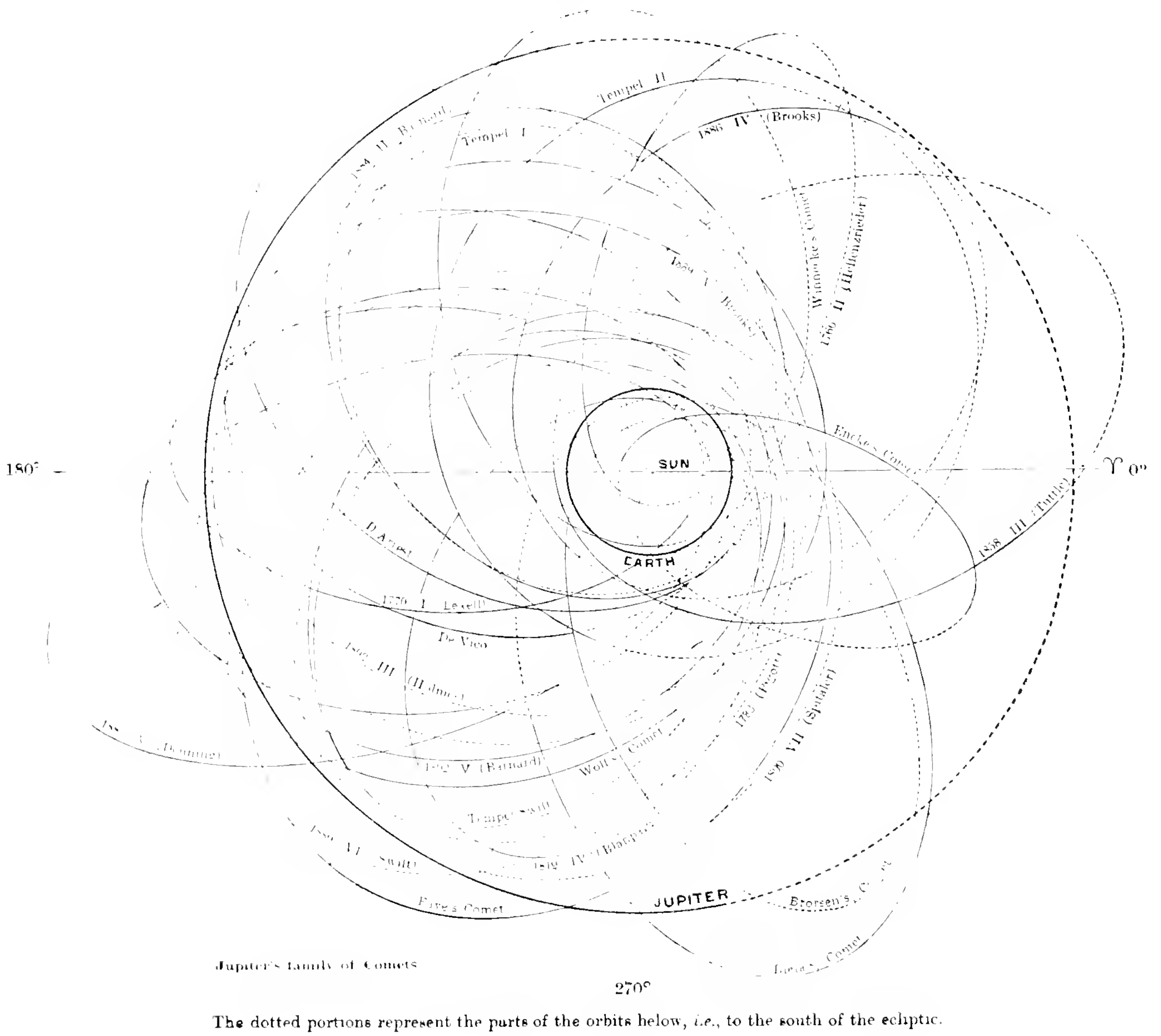
* During our summer in the Northern Hemisphere the earth attains a distance of 1·01677 times its mean distance from the sun.

find no such hyperbolic strata enveloping the nucleus; the matter seems to be driven directly away from the nucleus, and not in the first instance to be driven into an envelope about the nucleus prior to its being driven away from the sun. Perhaps the discrepancy may be explained by the repulsion from the nucleus being comparatively feeble, so that the envelopes about the nucleus are small and are hidden by the nebulosity about the head of the comet. In Swift's comet, the streams of matter radiating from the nucleus all seem to be bounded by straight lines, though they radiate in slightly different directions from the nucleus. In the photograph of Brooks' comet there are similar straight rays radiating from the nucleus in addition to the curious curved and branching structure which forms the brightest part of the tail. If we look for an analogy with the more regular structures of Donati's comet, it would seem that the great branching structure corresponds to one of the jets which issued from the head of Donati's comet, while the small straight rays in Brooks' comet correspond to the streams which formed the bulk of the tail in Donati's comet.

The plate of Brooks' comet has been produced from a dense collodion enlargement, made from a glass positive sent over by Prof. Barnard. It is entirely untouched, and shows the great variations of brightness in different parts of the tail. The spectral lines observed in the light from the heads of different comets indicate that the chemical constitution of one comet differs from another, and it is perhaps to be expected that the general appearance of comets, and the phenomena they exhibit, should also vary according to the materials of which they are composed.

The light from the remoter parts of the tail is usually more or less completely polarized according to the position of the comet with respect to the sun and earth, in a manner which indicates that the matter of the comet's tail disperses the sun's light as fine dust would do. It seems, therefore, probable that the remoter parts of the tail of a comet consist of very minute particles, whose average diameter is small compared with the wave-length of light, and that the material of which it is composed has been precipitated from the gaseous matter driven off from the nucleus.

In 1872 the medal of the Astronomical Society was given to Prof. Schiaparelli, of Milan, for showing that there was an intimate connection between certain meteor



The dotted portions represent the parts of the orbits below, *i.e.*, to the south of the ecliptic.

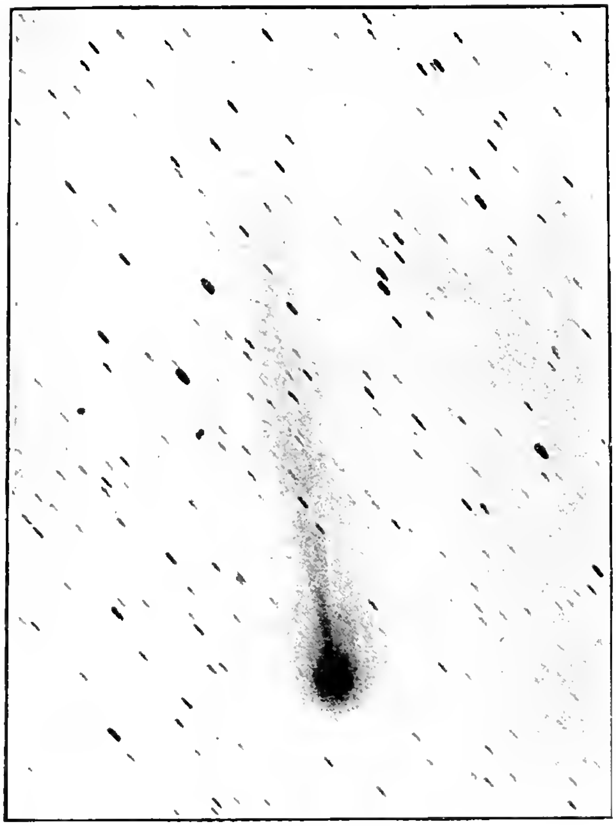


FIG. 1. 26th May, 1892

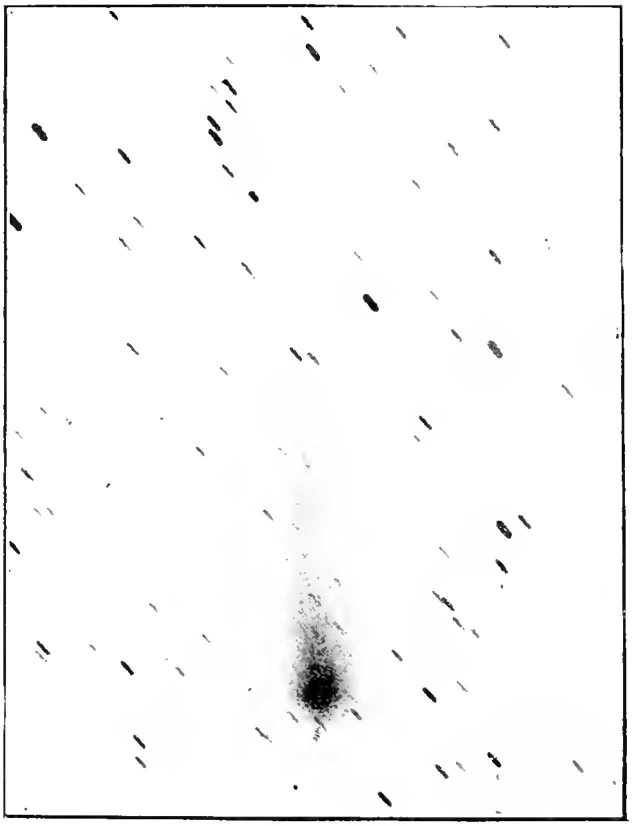


FIG. 2 27th May, 1892.


FIG. 3. 28th May, 1892.

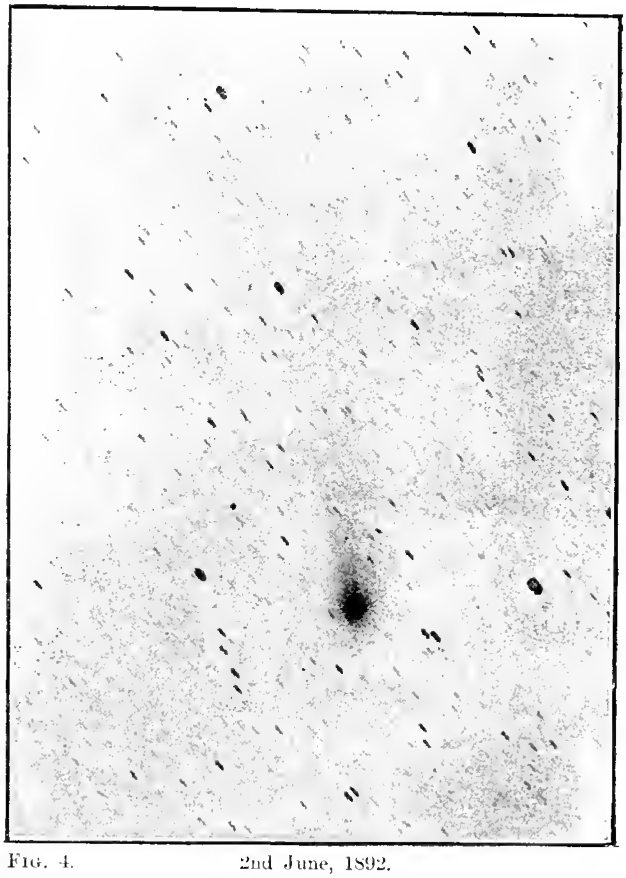


FIG. 4. 2nd June, 1892.

PHOTOGRAPHS OF SWIFT'S COMET.

Taken by Dr. MAX WOLF, of Heidelberg, showing the rapid changes taking place.

streams and comets. He showed that the August meteors revolve in an orbit which is, as near as can be determined, identical with the orbit of Comet II. 1862, usually known as Tuttle's comet, and that the November meteors move in an orbit which is practically identical with the orbit of Comet I. 1866, known as Tempel's comet. A few years later it was shown that the Andromid meteors are revolving in a track which is practically identical with the orbit of Biela's comet, and that the April meteors are also associated with a cometary orbit. In view of this evidence, it seems highly probable that the nebulous matter which renders comets visible is evaporated from meteor swarms as they approach the sun, and that the matter thus separated from the meteors is repelled by the sun, never to be regathered by the meteor swarm. It would follow that the meteor swarms which are associated with comets are wasting away and losing a portion of their substance every time that they approach the sun. Possibly some of the particles driven away may fall upon the planets and go to augment their atmospheres, taking the place of carbon, oxygen, and other elements which have been absorbed or added to the solid substance of the planet by the processes of life, oxidation, and other chemical changes continually going on; and it would seem to follow that comet-producing meteor swarms cannot last for geologic ages, and that those which are now associated with comets must have been introduced into the solar system within a comparatively recent period—a conclusion which is opposed to Mr. Proctor's and Sir Robert Ball's ejection theory, which assumes that comets and meteors had their origin within the solar system, and were ejected from the sun and the larger planets at an early period when these bodies were in a sun-like state.

The accompanying diagram (page 114) has been copied from a drawing made by Mr. A. G. Sivaslian, of Northfield, Minnesota. It represents Jupiter's family of comets, and was originally published in an interesting article by Prof. W. W. Payne in the October number of his "Popular Astronomy."

It will be noticed that nearly all the farthest points of these orbits (the aphelia) are on one side of Jupiter's orbit, and that the places where the dotted portions of the orbits join the continuous ones are in nearly every case close to the orbit of Jupiter. The dotted portions of the orbits are below the ecliptic, while the continuous portions are to the north, so that one of the nodes of the comet's orbit is in every case near to the orbit of Jupiter. If Jupiter were at that part of his orbit at the time when the comet was passing its node, the two bodies would really be near to each other, and Jupiter by his great mass would have a very marked influence in changing the orbit of the comet. It seems, therefore, probable that all these comets have at some time been considerably perturbed by Jupiter.

The sun and the whole solar system is moving through space towards a point in the constellation Hercules, having a right ascension of about 269° and a north declination of about 35°. The bottom of the plate corresponds to right ascension 270°; consequently, a vertical line on the page approximately corresponds to the direction in which the solar system is moving—probably at a rate of some ten miles a second.* Jupiter is moving in his orbit with a mean velocity of a little more than eight miles a second, in a direction contrary to the hands of a watch when looked at from above the ecliptic, as in the diagram; consequently, when Jupiter is in the part of his orbit which lies on the left hand side of the diagram he is moving very rapidly through space, with a maximum velocity of about eighteen miles a second, while in the part of his orbit which corresponds to the right hand side of the page he is moving in a direction about the sun nearly contrary to the sun's motion in space, and when going slowest he is only moving through space with a velocity of about two miles a second. The distribution of the aphelia of the cometary orbits shows that Jupiter has caught many more comets when moving rapidly through space than when he is moving slowly. But this is only what might be expected if the comets were all originally caught from outside the solar system, and it forms an interesting additional piece of evidence tending to prove that the sun is actually moving in space, and that the comets of Jupiter's family were not originally members of the solar system.

A similar piece of evidence tends to show that the meteors we encounter were not originally members of the solar system. It has long been known that the earth encounters a larger average number of meteors in the autumn half of the year than in the spring half, from midwinter to midsummer; that is, when the earth is moving most rapidly through space it encounters fewest meteors. Exactly the contrary of this would be the case if the majority of meteors were sporadic—that is, if they came from outside space. But with meteor streams captured by the larger planets in the way in which Jupiter has annexed his comet family, we should expect to find the earth most involved amongst the perihelia of such elliptic streams on the opposite side of its orbit from that on which the larger planets are most successful in capturing such streams. The observed facts can therefore be best explained by supposing that the majority of meteors are now moving in closed orbits, which are arranged in a manner that shows that meteors as well as comets were originally captured from outside space.

* This is the velocity determined by Prof. Vogel from his observations of the motion of stars in the line of sight. It seems to be the most trustworthy determination of the velocity of the sun's motion in space that we at present have.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

MOONLIGHT PHOTOGRAPHS.

To the Editor of Knowledge.

Dear Sir,—It seemed to me that the best way to test your theory as to the markings on Mr. Levingston's photograph, published in Knowledge for December, 1893, would be to repeat the process as an experiment. I therefore recently took the opportunity of a bright moon to expose a plate to a landscape for one hour, and then to point the camera directly to the moon; the result shows a tracing made by the moon.

The camera had a focal length of four and a half inches, with an aperture in stop of 0·4 of an inch.

I forward the plate for you to make use of as you like.

Yours truly,

Cranleigh, Surrey. J. P. Maclear.

[Admiral Maclear's photograph shows a band or knotted trace which is very similar in appearance to Mr. Levingston's supposed lightning flash.—A. C. Ranyard.]

METEORS IN THE LUNAR ATMOSPHERE.

To the Editor of Knowledge.

Sir,—In your interesting article on the moon, in the April number of Knowledge, you infer that it is probable the moon has an atmosphere comparable in density with that which surrounds the earth at a height of somewhere about fifty miles above sea level, and that it is sufficiently dense to vaporize meteoric showers. If this is so, should we not see occasionally, either during observations made with the telescope, or on photographs, some slight streaks of light caused by a mass of meteorites, or a large aerolite, passing obliquely across the dark portions of the moon's surface?

Lewisham, S.E., Yours truly,
April 15th, 1894. A. E. Whitehouse.

[In the earth's atmosphere we only occasionally see meteors which appear, as seen from a distance of one hundred miles, many times brighter than a star of the first magnitude. As seen from a distance of one thousand miles, such a meteor would only appear one hundredth part as bright as when seen from a distance of one hundred miles; and when seen from the distance of the moon, the apparent brightness of such a meteor would be reduced to less than one five hundred millionth part of its brightness as seen from a distance of one hundred miles, so that probably the brightest meteors in the lunar atmosphere would escape attention, as seen from the earth.—A. C. Ranyard.]

To the Editor of Knowledge.

Donville (Manche), France.

Dear Sir,—Some doubts have recently been expressed about the visibility of the whole ball of Venus, especially when it has been observed during the daytime near to inferior conjunction.

I do not wish to state that the phenomenon is a real one, but I would offer an observation which tends to show that it is not an optical illusion. I was observing Venus on January 24th, 1894, at 1h. p.m., and noticed that the entire ball of the planet was vaguely seen, of an indefinable colour, but it was impossible for me to ascertain if it was brighter or darker than the surrounding sky. It was of a kind of reddish-grey, and was much more visible with the strong eye-pieces than with the weak (the eye-piece principally employed magnified about two hundred and forty times); that is to say, as the light of the sky grew darker, by employing strong magnifying glasses, the ball of the planet and its slightly different colour from the sky became more marked. Would not an optical illusion, on the contrary, be more visible with a weak eye-piece—that is to say, one giving a brilliant image?

I am, dear Sir, yours truly,
L. Rudaux,
Membre de la Société Astronomique de France.

[The higher magnifying power would, of course, decrease the light derived from the body of the planet just in the same proportion as it decreased the light derived from the surrounding sky; but the contrast may appear more evident when the brightness of both areas is decreased. I feel no serious difficulty in assuming that the body of Venus may shine, when it is not illuminated by the sun, with a light which is comparable in brightness with the light derived from the dust in the earth's atmosphere, when illuminated by the sun's rays. This dust forms a semi-transparent veil, sufficient to hide the planets when looked for with the naked eye, but not sufficient to hide them in the telescope.

On the 24th of January, about one-seventh of the disc of Venus was illuminated by the sun. A curious fact is that the phenomenon observed by M. Rudaux seems to become more and more apparent as the planet approaches the sun, and is seen through the brighter parts of the atmospheric veil, for the general brightness of the sky increases rapidly as we approach the sun.

I have on more than one occasion, when Venus has been nearer to the sun than it was on the 24th of January, seen what appeared to me to be the whole body of the planet, clearly distinguishable on the background of sky. It may be that the light from the illuminated crescent of Venus lights up the dust in our atmosphere in the immediate neighbourhood of the planet's place, so as to render it more opaque than it is rendered by the less direct illumination of the sun's rays. The patch of illuminated atmosphere round the brighter stars is well known to all telescopic observers. With a large instrument, the brightened appearance of the sky before a large star enters the field of the telescope has been frequently compared to the light of approaching dawn. —A. C. Ranyard.]

THE AURORA AND ZODIACAL LIGHT.

To the Editor of Knowledge.

Dear Sir,—The zodiacal light has been a prominent object every clear evening of the first three months or so of each year I have spent here—nearly twenty of them. December 17th is, I think, the earliest date I have seen it, and I do not remember it later than the middle of April, with very varying extension. For the first time, yesterday I saw it in daylight, *i.e.*, immediately after sunset, of a pretty rose-colour, somewhat like the wondrous after-glows of ten years ago, but distinct in this respect, that those generally had the sun's place for centre, whereas this had not, but was an oblong, rounded mass, with its major axis lying along the ecliptic.

About 9.30 I found an aurora pervading the northern sky, chiefly in the true (not magnetic) north; low down pale green, then a bank of cloud, and above that, to within ten degrees of Polaris, rose-colour, with shootings of pencilled rays, and the complementary colours thus evenly distributed above and below the nimbus. These colours lasted only a short time, but all night I suppose (at least till 2 a.m.) the whole lower northern sky was brilliant with yellow radiance, like a summer dawn or early night, but its centre was the magnetic north. Its beauty was much enhanced by masses of cloud (looking black like nimbus, though probably they were only cumulus).

The zodiacal light is usually supposed to belong to the sun, the aurora borealis to the earth; yet last evening's displays seemed to point to a real connection or sympathy, such as is also pointed to by the connection between solar disturbance and magnetic storms. May not the sun's corona extend in an *invisible*, attenuated condition beyond our own orbit, so that we are always within it, but when the sun is more than usually active we see it at our poles as well as along the ecliptic? Would not this explain what now seems inexplicable, viz., the immediate magnetic sympathy between the earth and the sun?

I once asked Mr. Proctor to give us a monograph on the zodiacal light, putting together all the known facts and probable theories. I wish that I could induce you to take the matter up. Yours faithfully,
A. P. Skene.

Pornic, Loire Inf., France, March 31st, 1894.

I am collecting facts with regard to auroral displays, which I hope to put together for publication. I have recently had an opportunity of examining some very interesting photographs of the aurora, taken during the past year by Dr. Martin Brendel. I may, perhaps, be allowed to reproduce them in Knowledge. Mr. Skene will find a short paper "On the Connection between Sunspots and Magnetic Storms" in Knowledge for April, 1892. I still hold to the theory there advocated. It assumes that magnetic storms, as well as auroral displays, are caused by the passage of the earth through a dust-laden region or stream of matter projected from the sun beyond the region ordinarily occupied by the coronal streamers.—A. C. RANYARD.]

THE FORMATION OF DIAMONDS.

To the Editor of KNOWLEDGE.

DEAR SIR,—The following remarks of Dr. Joly, of Dublin, who has been engaged in measuring the rate at which diamonds expand on being heated, may interest your readers. Commenting upon the fact that the co-efficient of expansion increases very rapidly at about 750° C., Dr. Joly remarks, in a recent communication to *Nature*, that "the sudden increase in volume at high temperatures suggests that the diamond is a form of carbon which has been subjected to high pressure when crystallizing. Such changes we may expect to be reversible, and it is supposable that equilibrium at the higher density is only preserved by crystalline forces which will require to be brought into play by external conditions of pressure. It is probable that this is therefore an essential condition of success in its artificial production. It is perhaps of interest, adds Dr. Joly, that this reasoning gave rise to experiments—as I had leisure for them—which I only laid aside finally upon hearing of M. Moissan's success. I did not seek the aid of solution in a metal, but used an apparatus to compress graphite, as well as carbon prepared from sugar, between iron plates kept at a red heat and urged together by the alternate heating and cooling of the bars of an iron yoke. I am not without hope," says Dr. Joly, "that the use of high pressure at a high temperature may ultimately prove sufficient, without resort to solution in a metal, to produce diamond." Yours faithfully,

VAUGHAN CORNISH.

BROOKS' COMET.

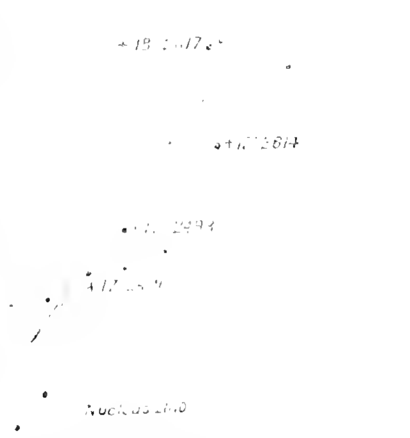
To the Editor of KNOWLEDGE.

SIR,—Has anyone tried to make out the correspondence between the details of the two photographs of Brooks' comet in the February number of KNOWLEDGE? They are so very different that it is not easy to see the connection between them. It is a pity if no photographs were obtained in the intervening twenty-four hours, as with such a rapidly changing object as this comet was, more frequent photographs are very desirable.

I made an eye observation in the interval, but scarcely any of the detail shown in the photographs was visible to me. The difference between the amount that could be seen and that photographed is indicated by the fact that I traced the tail to a distance of just 2°, whereas in the photographs the total length is 3·7° on the 21st, and on the 22nd, including the detached portion, 4·4°.

It may be well to give my description at that time, viz., Oct. 22nd, 16h. 40m., G.M.T.: "With power 20 on a $4\frac{1}{4}$in. refractor, at first sight the tail seems strongly curved (concave to preceding side), but on closer examination this is found to be caused by the following part being brightest to some distance from the nucleus, viz., to near the star B.D. + 17°, 2496, when it fades rapidly, and a portion further preceding brightens—B.D. + 17°, 2493 being at the brightest part—this part seeming to be straight, and continuing to be the axis to the end. The central line of this part of the comet is at B.D. + 17°, 2496, or perhaps slightly preceding it, and passes B.D. + 17°, 2493 and $\frac{2}{3}$ from B.D. + 18°, 2614 to B.D. + 18°, 2617, going a little beyond. The brightening of the tail about B.D. + 17°, 2493 is an unusual feature, reminding me of the photographs of comet I. 1892 in KNOWLEDGE, &c. With field glasses, power 4, the comet is faintly visible, and the tail strongly curved, the details above described not being discernible. The tail, however, is visible to the same distance as with power 20."

There can be no doubt that the bright patch I saw about B.D. + 17°, 2493, although very indefinite, must have been a similar one to the two striking ones shown in the photograph on Oct. 22nd, though it is singular I saw but one instead of two. At the time of my observation, allowing for the motion of the nucleus in the interval, the star B.D. + 17°, 2493 would be in the axis of the south one in the photograph, about $\frac{1}{3}$ from its south to its north extremity. Assuming that this was the one I saw, and that the star was then in the middle of its length (though this is uncertain owing to its indefiniteness to me) the patch must have moved 17′ in the $8\frac{1}{4}$ hours between my observation and the photograph. If, however, the north patch was the one I saw, a much more rapid motion is indicated; but this seems improbable, that patch not being in the same line from the nucleus.



Stars traced from Barnard's photograph of 21st October, 1893. ———— Axis according to T. W. Backhouse, 22nd October, 16h 40m. G.M.T. ………… Axis of bright patch.

Fitting my drawing to the scale of the photograph, the bright ray emanating from the nucleus and forming the main part of the tail for a long distance fits accurately, as far as it goes, on to the same in the photograph; but it had evidently grown considerably in the $8\frac{1}{4}$ hours' interval, for it is brilliant in the photograph to a distance of 0·83° from the apex of the head, while I could not trace it at all more than 0·53° from the nucleus, thus indicating a growth of at least 18′ in the interval. But it is singular that the preceding side of the tail, joining the bright patch to the nucleus, is scarcely perceptible in the photograph, while it was quite plain to me.

Allowing for the motion of the nucleus, it is remarkable that the further part of the axis of the tail, as seen by me, lies from 2′ to 3′ preceding the preceding edge of the tail in the photograph on the 22nd, excepting that there appears to be therein a very faint ray further preceding, in continuation of the preceding edge of the south bright patch.

Yours truly,

T. W. BACKHOUSE.

West Hendon House, Sunderland.
April 6th, 1894.

METHOD BY WHICH A PATIENT MAY OBSERVE A CATARACT IN HIS OWN EYE.

To the Editor of KNOWLEDGE.

DEAR SIR,—I see from newspaper reports that the eyes of Signor Crispi, Prime Minister of Italy, are in the same condition as those of Mr. Gladstone, and that the eyes of

Sir William Vernon Harcourt are nearly as bad. The Czar's favourite Minister of Finance is also said to be in the same plight. With such a visitation of cataract in the eyes of public men, your readers may possibly be interested in the following account of a simple method I have discovered which enables a patient to see a cataract in his own eye and note its growth and development, probably better than any oculist can observe it for him.

Cataract is said to be due to the gradual deposition of oxalate of lime in the substance of the crystalline lens, at first in small spots or streaks, sometimes in one part and sometimes in another. The deposit gradually increases until it penetrates the whole of the lens, causing blindness. The remedy, then, is to remove the lens, and after its removal the patient needs a substitute in the form of highly magnifying spectacles.

All that is necessary to enable a patient to see his own cataract for himself is a piece of card and a needle—a visiting card will do very well. Pierce a clean round hole near the middle of the card and hold the card up to the light close to the eye, looking preferably in the direction of a piece of blue sky. With the card near to the eye, the patient will not see the small hole pierced by the needle, but he will see a comparatively large faintly illuminated field with his cataract projected upon it. He is, in fact, observing the shadow cast by his cataract on the retina at the back of his eye. With a small puncture in the card the shadow so thrown is comparatively sharp. But with a normal eye an evenly illuminated field or clean disc will be seen. The patient may thus map down his own cataract, and settle for himself whether it is extending and whether he will have an operation or not. None of the oculists I have seen have known of the method, and there may, consequently, be some advantage in making it public. I enclose for your inspection drawings, which I have made at intervals during the last three years, of a cataract which is slowly developing in one of my eyes. If you accept this communication please not to publish my name, as it might be a disadvantage to me in my business if it was thought that my sight was defective.

Yours truly,
J. S.

THE PHYSIOLOGICAL EFFECTS OF CITY AND SEASIDE AIR.

To the Editor of Knowledge.

Sir,—In your very valuable article in the March number of Knowledge on "Sewer Gas and Zymotic Disease," you refer to the mysterious difference in the physiological effects of city and seaside or mountain air. I venture to think that this difference is for the main part non-existent, and that the effects which are attributed to it spring mainly from other causes. Leaving out of sight the changes in the mode of life, and comparative freedom from care and worry, to which a great deal of the good influence which those experience who leave the city to take a holiday in the country is doubtless due, a great deal is also to be attributed to changes in the physical surroundings other than the quality of the atmosphere. In hot weather, the most important of these, I believe, is the greater practical coolness of the country, especially of mountains. In a large town, the effect of the heat of the air is greatly added to by the radiation of heat from bare roads, pavements and walls, and not diminished to the same extent as in the country by the movement of the air, which is impeded by the rows of houses.

It is during periods of excessive heat that the healthiness of towns falls most below that of the open country, except in very large towns where there are dense smoke-laden fogs. In cold weather, even when there are no such fogs, the air of large towns is commonly so much more smoke-laden and cloudy than that of the country as to shut out a great deal of the light and warmth of the sun, and thus gives rise to a lowering of vitality and spirits.

Close observation for many years has convinced me that these circumstances, and not any supposed difference in the quality of the air, are the source of the benefit derived from "a change into the country."

I am, Sir, yours truly,
Tunbridge Wells. Edw. G. Gilbert, M.D.

[Dr. Gilbert would have added to the interest of his letter if he had shown how he manages to distinguish between the beneficial effects produced by the various concurrent circumstances alluded to as generally accompanying the dose of fresh air.—A. C. Ranyard.]

THE FACE OF THE SKY FOR MAY.

By Herbert Sadler, F.R.A.S.

Several large groups of sunspots have of late appeared on the solar surface.

Mercury is invisible during May. He is in superior conjunction with the Sun on the 20th.

Venus is a morning star, rising on the 1st at 3h. 15m. a.m., with a southern declination of 2° 19′, and an apparent diameter of $22\frac{3}{4}''$, $\frac{52}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was on January 25th. On the 16th she rises at 2h. 47m. a.m., with a northern declination of 2° 34′, and an apparent diameter of $19\frac{3}{4}''$, $\frac{59}{100}$ths of the disc being illuminated, and the apparent brightness of the planet being about equal to what it was on February 1st. On the 31st she rises at 2h. 21m. a.m., with a northern declination of 8° 37′, and an apparent diameter of $17\frac{1}{4}''$, $\frac{65}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was on February 3rd. During the month Venus pursues a direct path through Pisces to the borders of Aries.

Mars is, for the purposes of the amateur observer, invisible; and Jupiter and Neptune have left us for the season.

Saturn is an evening star, and is well situated for observation. On the 1st he rises at 5h. 4m. p.m., with a southern declination of 5° 21′, and an apparent equatorial diameter of 18·6″ (the major axis of the ring system being 42·8″ in diameter, and the minor 9″). On the 16th he rises at 4h. 0m. p.m., with a southern declination of 5° 5′, and an apparent equatorial diameter of 18·4″ (the major axis of the ring system being 42·3″ in diameter, and the minor 8·6″). On the 31st he rises at 2h. 58m. p.m., with a southern declination of 4° 53′, and an apparent equatorial diameter of 18·0″ (the major axis of the ring system being 41·1″ in diameter, and the minor 8·2″). Titan is at his greatest eastern elongation on May 14th and 31st, and Iapetus at his greatest western on the 17th. During the month Saturn describes a short retrograde path in Virgo, but does not approach any naked-eye star.

Uranus is an evening star, and but for his southern declination would be well placed for observation. He is in opposition to the Sun on the 3rd, at a distance from the earth of about $1637\frac{1}{4}$ millions of miles. He rises on the 1st at 7h. 23m. p.m., with a southern declination of 15° 29′, and an apparent diameter of 3·8″. On the 31st he rises at 5h. 13m. p.m., with a southern declination of 15° 8′. During the month he describes a short retrograde path in Libra, to the north west of $\alpha^1\alpha^2$ Libræ. A map of the stars near the path of Uranus will be found in the *English Mechanic* for March 23rd.

There are no very well marked showers of shooting stars in May.

The Moon is new at 2h. 41m. P.M. on the 5th; enters her first quarter at 6h. 21m. A.M. on the 12th; is full at 4h. 43m. P.M. on the 19th; and enters her last quarter at 8h. 4m. P.M. on the 27th. She is in perigee at 4h. A.M. on the 8th (distance from the earth 226,280 miles), and in apogee at 1h. A.M. on the 24th (distance from the earth 251,930 miles). At 7h. 55m. P.M. on the 12th the 6th magnitude star 37 Leonis will disappear at an angle of 88° from the north point, and reappear at 8h. 51m. P.M. at an angle of 340°. At 10h. 36m. P.M. on the 14th the $6\frac{1}{2}$ magnitude star B.A.C. 4043 will disappear at an angle of 76°, and reappear at 11h. 21m. P.M. at an angle of 355°. At 11h. 50m. P.M. on the 15th the $6\frac{1}{2}$ magnitude star B.A.C. 4294 will disappear at an angle of 120°, and reappear at 0h. 58m. A.M. on the 16th at an angle of 305°. At 2h. 19m. A.M. on the 19th the 6th magnitude star B.A.C. 5023 will disappear at an angle of 46°, and reappear at 2h. 53m. P.M. at an angle of 350°. At 10h. 58m. P.M. on the 19th the 6th magnitude star B.A.C. 5311 will disappear at an angle of 134°, and reappear at 0h. 14m. A.M. on the 20th at an angle of 271°. At 2h. 20m. A.M. on the 20th the 5th magnitude star B.A.C. 5347 will disappear at an angle of 164°, and reappear at 2h. 59m. A.M. at an angle of 223°. At 1h. 56m. A.M. on the 31st the $4\frac{1}{2}$ magnitude star ξ Piscium will disappear at an angle of 96°, and reappear at 2h. 40m. A.M. at an angle of 207°.

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

COMMUNICATIONS for this column should be addressed to C. D. LOCOCK, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of Problem No. 14.

Key-move—1. P to B5.

If 1. . . . P to R4, 2. B to Kt4.
1. . . . K × P, or K to Q6, 2. B to R5.
1. . . . P to Q6, 2. Q to R4ch.

Solutions of Problem No. 15.

Six Keys, viz.—Q to B2 (Author's), Q × B, Q to Ksq, either R × B, B × Kt
(For if 1. . . . P to Kt5, 2. Q to QBsq !).

Some apology is due for the insertion of so unsound a position. The problem was sent in by a well-known composer almost at the last moment, and was therefore accepted without due examination. One solver quaintly remarks that just as there is no end to a "circle," so for some time there seemed to be no end to its keys. Probably it would be difficult to "square" this "circle," which might be described as the "double nine-point circle," being worth eighteen points to some of our more persevering solvers.

Solution of Problem No. 16.

Key-move—1. R to Kt4.

If 1. . . . P × R or P to B5, 2. P to K5.
1. . . . Kt moves, &c., 2. P × Pch.
Dual after 1. . . K to K4 by 2. B to B6ch or Q to B6.
Also after 1. . . K to K6 by 2. P × P or 2. B × Pch.

CORRECT SOLUTIONS received from the following:—

Twenty-five Points.—Semper, Guy.

Twenty-three Points.—B. G. Laws.

Twenty Points.—A. C. Challenger.

Fourteen Points.—A Norseman.

Thirteen Points.—J. H. Christie.

Eleven Points.—Chat.

Ten Points.—A. R., Kt. J.

Nine Points.—Alpha, H. Holmes, E. W. Brook.

L. Bourne.—"No solution" to No. 15 ?! The others are correct.

H. G. Brandreth.—Solution to No. 14 correct. G, not S.

H. Holmes.—Thanks. The reply to you in last number was evidently an oversight.

A. E. Whitehouse.—None of your solutions are quite correct, though in No. 14, 1. B to Kt4 nearly solves the problem. We have no space this month for a detailed reply.

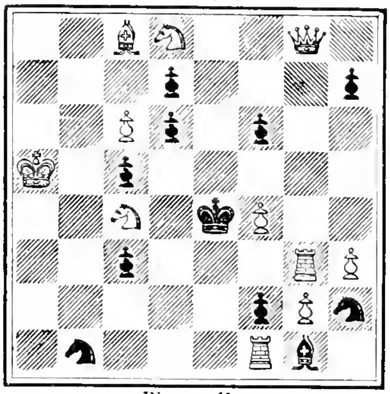
W. T. Hurley.—Your compulsory retirement is much to be regretted.

A Norseman.—Your solutions this month are even more unintelligible than usual. You are credited with three solutions to No. 15, but a fourth commencing 1. "QKtBB6" (whatever that may mean) is quite incomprehensible, the deduction of one point being the only course.

POSITION No. 17.

"*Posuit ultimum lapidem.*"

BLACK (11).



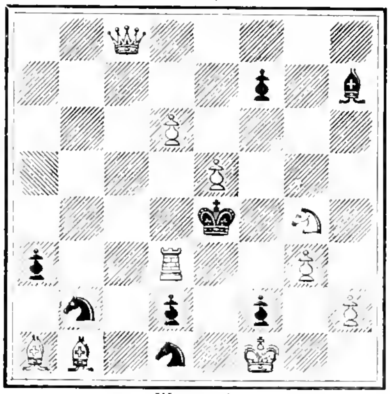
WHITE (11).

White mates in three moves.

POSITION No. 18.

"*Fortes Fortuna juvat.*"

BLACK (8).



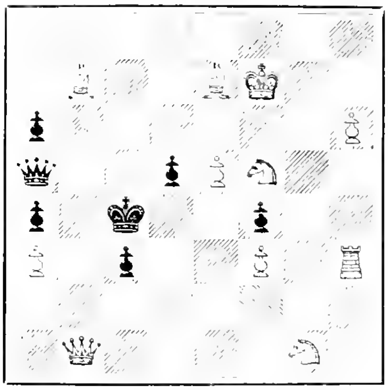
WHITE (10).

White mates in three moves.

Position No. 19.

"*East Harling.*"

Black (7).



White (11).

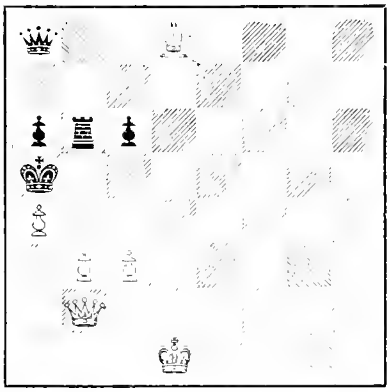
White mates in three moves.

[The above problems conclude the current tournament.]

CONDITIONAL PROBLEM.

By W. De Morgan.

Black (5).



White (6).

White mates in three moves, on condition that no piece may make two consecutive moves. [In order to prevent such solutions as 1. P to Kt4ch, K × P; 2. Q to Kt3 mate (!), it seems necessary to make an exception in favour of the Black King.] Solutions will be acknowledged.

Readers of Knowledge will be interested to know that the composer of the above is the son of the distinguished Prof. De Morgan.

CHESS INTELLIGENCE.

The first portion of the Steinitz-Lasker match is now over. Eight games were played at New York, resulting in four wins for Lasker, two for Steinitz, and two games drawn. The play, so far, has been of a brilliant character on both sides. Mr. Lasker has played the Ruy Lopez consistently, an opening in which Mr. Steinitz has succeeded in discovering just the cramped awkward defence that he revels in. Mr. Steinitz has of late years always done badly in the earlier stages of his matches. Under stress of urgent necessity he may possibly abandon the defence referred to; in any case, he is sure to play his best as the match enters on its final stage. The next instalment of the match is just commencing at Philadelphia.

The North *v.* South match was played in London on April 7th, with one hundred and seven players on each side. The result, after five hours' play, was a rather decisive victory for the South by sixty-four and a half games to forty-three and a half. No doubt the Northern team were severely handicapped by the long distances which many of them had to travel, and also by the absence of Mr. Skipworth and many of the leading Lancashire players. On the Southern side notable absentees were Messrs. Chepmell, Guest, Hunter, Mortimer, and Wayte, not to mention Mr. Donisthorpe, who deserted to the Northerners.

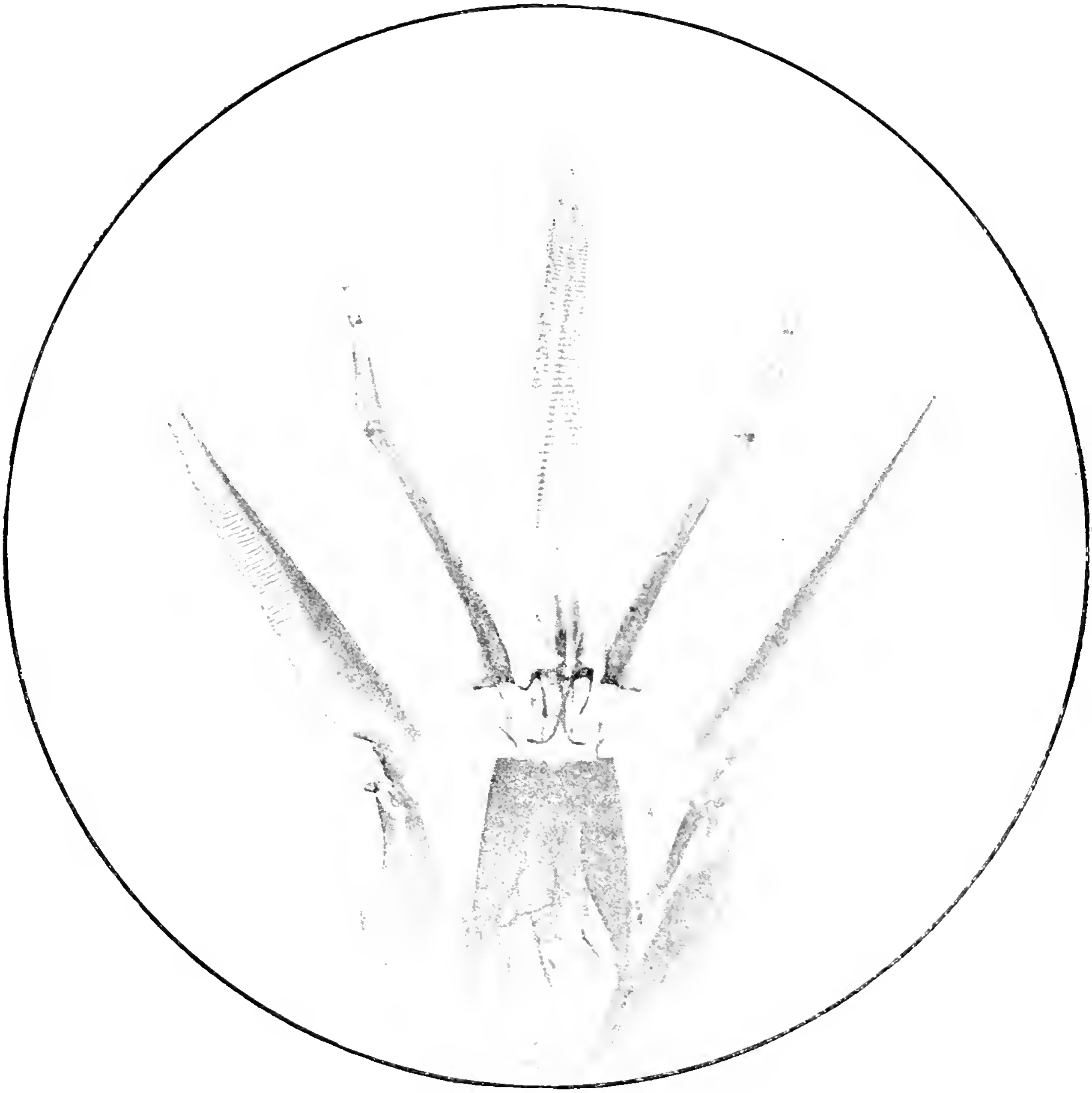
After the match the two teams were entertained at supper by the Reception Committee. The arrangements throughout were excellent. Mr. Blackburne again acted as umpire.

An analysis of the Southern score shows that the County players came out with a better average than the Metropolitan; Surrey, Sussex, and Somerset contributing in a large measure to the victory of the side. At the same time, it should be mentioned that most of the Surrey players are practically Londoners and members of London clubs. Last year no game was lost on the first twenty Southern boards; this year only one game on the same boards was lost. The Northern successes were almost entirely on the middle boards (Nos. 33 to 87). Here they obtained a slight majority, but not sufficient to balance the failure of the two ends of the team.

Late News.—Mr. Lasker won the ninth game.

Contents of No. 102.

NOTICES.



MOUTH ORGANS OF HIVE BEE.

At the sides are the blade-like maxillæ, or secondary jaws. Their palpi are exceedingly short, jointed organs, placed at the junction of the blade with the basal part. Between the bases of the maxillæ is the labium, which is prolonged as a long pointed organ, the ligula or tongue, which is very flexible, ridged, and beset with hairs. Branching from the labium at each side of the ligula are the long, jointed labial palpi. These and the maxillæ close round the ligula and enable the honey to be passed up into the mouth. Between the labial palpi and the ligula, at the base of the latter, are faintly traceable two small organs, the paraglossæ, which in some bees become proportionately much larger. The mandibles, or biting jaws, are not shown in this specimen.

KNOWLEDGE
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CONTENTS.

INSECT SECRETIONS.—II.

By E. A. Butler, B.A., B.Sc.

(*Continued from page* 106.)

FOR wax, our second illustration of insect secretions, we must go first of all to the order Hymenoptera, as yielding that variety of animal wax which is best known and most widely used in the Western world. But the production of waxy substances is not confined to hymenopterous insects; for example, while European wax is the produce of the hive bee, the white insect wax of China owes its origin to an entirely different insect, belonging to the order Homoptera, and to that section of it called *Coccidæ*, or scale insects. And, in fact, the power of secreting matter varying from a waxy to a more or less silky consistency is widely diffused throughout this latter order; the makers of these substances, however, do not use them, as bees do their wax, for constructive purposes, but the secretions generally exude in the form of long threads, which remain adherent to the insects as personal appendages of either a protective or ornamental character. The production of waxy and other allied substances is, therefore, associated with two very distinct types of insect life—the hymenopterous, typified by the hive bee, and the homopterous, typified by the scale insects. We will first turn our attention to beeswax.

It was long thought that the honey bee produced its wax from the pollen of flowers, which was supposed to be worked up and kneaded by its feet to the requisite consistency. Nor was this idea unnatural, though erroneous. In the hive were to be found stores of honey and wax; the former it was known that the bees manufactured from the nectar of flowers, and it remained, therefore, to account for the wax in a somewhat similar way. On the bees' legs were seen the masses of pollen they had also gathered, and as the wax seemed more nearly akin to the solid pollen than to the liquid honey, it was an easy supposition that the two were related to one another as raw material and manufactured product. So we find an old writer stating that "from the flowers they gather the wax with the hairs which cover their bodies, and when they return from the fields you may see their hairs full of small particles of wax like dust." This idea prevailed for a long time, and it was not till late in the last century that it became generally recognized that wax was not a gathered substance, but that it originated in the form of scales on the under side of the abdomen of the worker bee.

One of the earliest detailed accounts of the discovery of its true source is contained in a book on bees, called "Melisselogia, or the Female Monarchy," published in 1744. The author, J. Thorley by name, who had for some years devoted himself to bee-keeping, was anxious, as he says, to "find out how or where they brought home their wax," but for some time his efforts were baffled; at length, however, the favourable conjuncture of circumstances occurred, and the problem was solved. This is how he announces his discovery:—"Viewing a hive of bees very busy at labour, I observed one bee among the rest as she fixed upon the alighting place, of an unusual appearance; upon which I seized her directly, before she had time to enter the hive, where, with very sensible pleasure, I found what I had (till then) been in vain searching for. Upon the belly of this bee, within the plaits, were fixed no less than six pieces of solid wax, perfectly white and transparent, like gum; three upon one side and three upon the other, appearing to the eyes equal in bulk and gravity, so that the body of the bee seemed duly poised, and the flight not in the least obstructed by any inequalities. Here have I found it at other times, and once I took away eight pieces together, and I knew that it was wax and nothing else. Will not this pass for demonstration?" This observation showed that wax was not merely pollen worked up—and was, therefore, chiefly valuable as negative evidence—but there was much more to be learnt; for, as Thorley himself says, "how they manufacture the wax, fix it to the hive, and fashion it in so curious a manner into combs and cells, we cannot easily account for."

Thorley's discovery does not seem to have attracted much attention, and in fact apparently remained unknown to the scientific world; for twenty-four years afterwards, Wilhelmi wrote to Bonnet informing him of what was evidently regarded as an interesting novelty, that a Lusatian peasant, who was an ardent bee-keeper, had found wax scales attached to the abdomen of worker bees, and had thus revealed the source of this useful product. A somewhat similar observation had been recorded in Germany even before Thorley's time, so that the truth was independently discovered in several places and at different times. In the *Philosophical Transactions* for 1792, John Hunter gives some very pertinent observations in refutation of the previously accepted notion of the origin of wax from pollen. Thus, while the "farina," as pollen was then called, was often of different colours on the legs of different bees, the newly-made wax was all of one colour; it was gathered with more avidity for old hives, in which the combs were complete, than for those in which the comb was still in course of construction, which could not have been the case if "farina" was the material out of which wax was made, Again, at the beginning of a new hive, the bees seldom brought in any spoil on their legs for two or three days, although cells were in course of construction all the time; and lastly, in wet weather, when the bees do not go out, yet much new comb was formed. It thus came to be seen that wax was not to be thought of as a gathered substance, but as a true secretion, and subsequently some careful series of experiments by various observers revealed the fact that it was produced as a result of the digestion of honey. But though honey is the essential ingredient, a little pollen eaten in addition considerably increases the yield. Thus Gundelach showed that it required seventeen pounds of honey alone to produce one pound of wax, while when honey and pollen were both eaten only ten pounds were required for one pound of wax. In Tegetmeier's experiments, from twelve to fifteen pounds of dry sugar were consumed by a hive of bees in producing one pound of wax. These figures serve to show what an enormous amount of the nectar of flowers needs to be collected for wax construction alone, apart from what may be used as food, and sufficiently explain the unflagging industry of working bees.

Let us now follow a bee throughout those operations which result in the secretion of wax. The construction of the comb must be one of the first operations carried out when a swarm takes possession of new quarters, and to meet this demand the worker, before passing out with the swarm, will have taken its fill of honey. This, whether imbibed direct from flowers or from stores already accumulated, must be taken up by means of the complex apparatus to which the name "tongue" is usually given. The whole tongue really consists of several organs fastened together, as will be seen from the accompanying photograph (Plate 1). The central piece, transversely ridged and beset with hairs, is the real tongue, or *ligula*. It is very flexible and extensile, being moved by special muscles situated in the large dark piece at its base (*mentum*.) The pair of organs at the side of the ligula are the labial palpi, each consisting of four joints—two large and two minute. The outermost pair of organs are the maxillæ, or secondary jaws. The whole of this apparatus is used in taking liquid food, and while it is being employed the biting jaws, or mandibles, which are not shown in the photograph, cannot be used, though they have to be called into requisition when anything solid has to be bitten, in which case the "tongue" must be folded back out of the way. The maxillæ and labial palpi close around the ligula and form a channel, within which it can move up and down so as to assist the passage of liquid towards the mouth.

There has been a great deal of controversy as to the exact method by which this apparatus secures the passage of nectar to the mouth, which, it must be remembered, is situated a considerable distance from the tip of the fully extended tongue. As the whole thing is on a small scale, and therefore needs close watching under a lens, and as the movement of the liquid takes place within a closed space, the evidence is mainly circumstantial, and it is hardly surprising that different interpretations have been put upon it. At the extreme tip of the tongue is a rounded part, less thickly supplied with fine hairs and called the spoon. When honey is to be taken up, the bee extends its tongue, and bending the tip under, applies the concave surface of the spoon and part of the hairy tongue to the liquid, and moves it quickly backwards and forwards. In consequence the sticky liquid adheres and spreads amongst the hairs, the immense number of which is shown in photograph No. 2; the withdrawal of the ligula carries the nectar into the space enclosed between the maxillæ and palpi, up which it is drawn partly, no doubt, by the capillarity of the small grooves and interstices amongst which it finds itself, and partly by suction. The syrup taken in this way is swallowed into a temporary receptacle or crop at the base of the gullet, which is often called the honey stomach or honey bag. Between this and the true stomach lies a small apparatus called the stomach mouth, which, by opening and closing at intervals, acts as a regulator to the passage of the honey into the true digestive cavity.

The bee whose fortunes we are following having swallowed honey till its crop is completely distended, passes out with the swarm, and partakes in the general movements until the whole tribe is safely housed. Now will come the business of wax secreting, and for this a restful position and a temperature of from 30° to 37° C. is necessary. The latter condition is attained by the bees clustering together, but the former is achieved in a very curious manner. A bee takes up its position at the highest part of the hive, hanging from the roof by her fore legs; another then clings to this one's hind legs by her fore legs, the pair of hooks with which each is, as usual, provided enabling this to be done with ease. Several others follow suit till a whole chain is produced, all depending directly or indirectly upon the fixity of hold of the originator of the chain. Two chains hanging near together effect a junction by the end bees of each clinging to one another's hind legs, and so festoons of living beings are made, hanging about in all directions. In this way all the workers who are to secrete wax hang themselves up and remain in festoons for some twenty-four hours. Meanwhile the honey has been gradually passed into the true stomach and has been digested. In consequence of this, certain cells lying just underneath the skin of the under surface of the abdominal segments begin to form within themselves a liquid substance, which in due course passes out through the skin by means of a network of minute polygonal openings. Thus a liquid begins to collect on certain white, transparent and slightly depressed portions of four of the abdominal segments, one on each side of each segment; these are arched over by the free edges of the preceding segments, which mould the liquid into a thin plate, and this soon hardens by exposure to the air, appearing as yellowish-white scales. The flattened depressions in which they lie are called wax-pockets (Fig. 4), and are found only in the workers.

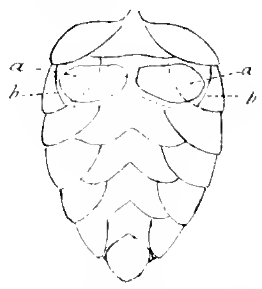
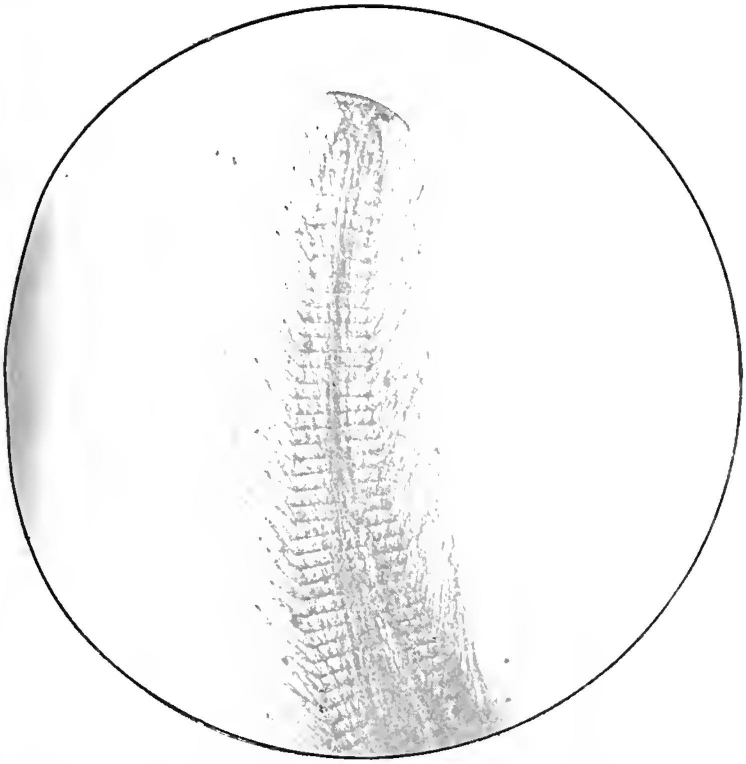


Fig. 4.—Under side of abdomen of Worker Bee. Part of the plates of the second segment has been removed to show (*a*) wax-pockets, (*b*) cut edge of plates. The dotted lines show the position of the removed parts. Magnified five diameters.

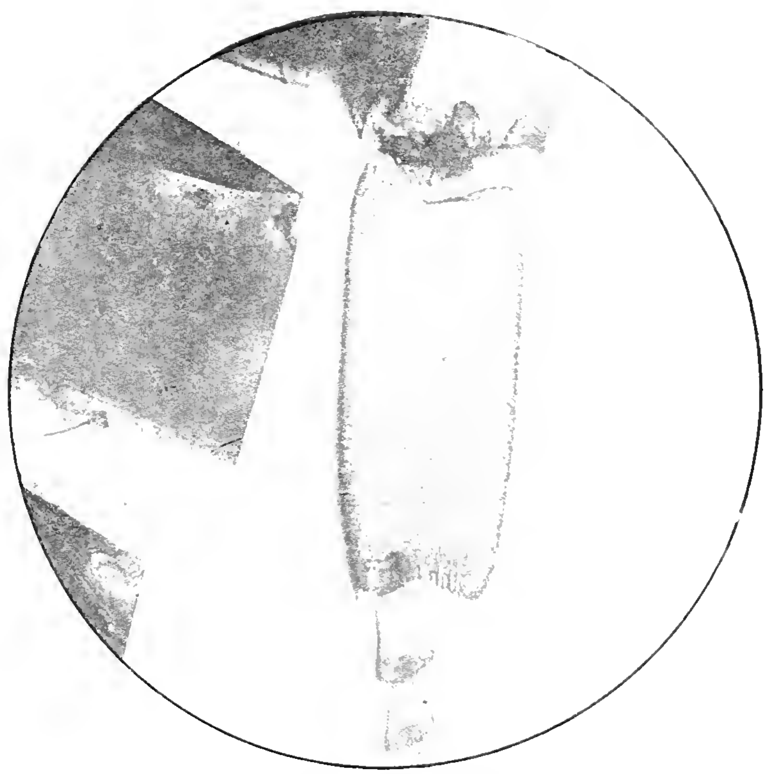
The substance thus secreted and collected in the form of four pairs of thin scales under the abdomen, though containing the essential constituent of wax, is not yet in a proper state to be used for building purposes. It has to be chewed up and mixed with saliva. Our bee, therefore, when its wax scales are all ready, extricates itself from the festoon and goes to the place where building operations are to be commenced. In order to understand what follows, we must look for a moment at the bee's hind legs. Here we find nothing remarkable till we reach the end of the broad tibia or shank. At this point, if we were dealing with any other kind of British bee, we should find on the *inner* side a pair of stout, sharp-pointed spurs, as may be seen in Fig. 5, showing the hind leg of a humble bee; but in the hive bee these are absent, as photograph No. 3



No. 2.—Tip of Worker Bee's Tongue (*ligula*), showing its ridged appearance and thick clothing of hairs.

No. 3.—Hind Foot of Worker Bee, showing the ridged *planta*, with its auricle and comb.

No. 4.—Junction of tibia and planta on Worker Bee's Hind Leg, more highly magnified, showing auricle and comb.



No. 5.—Hind Foot of Queen Bee, showing absence of auricle and comb.

The above are reproduced from Photographs taken by Dr. E. J. Spitta.

shows, and we find instead, on the *outer* side, an apparatus which can be used as pincers. The first joint of the foot proper, or *planta*, is very broad, as much so as the tibia itself, and on the inner face it is furnished with rows of hairs which give it a ridged appearance (see photograph No. 3); outside it is quite smooth. Now the outer and upper corner of this planta is excavated and broadened, so that a spoon-shaped depression is formed, which faces the outer angle of the tibia and is called the "auricle." The edge of the tibia opposite the auricle bears a row of stiff bristles, called collectively the "pecten" or comb (see photographs 3 and 4). This apparatus of auricle and comb is found only on the hind legs of the worker bees, as will be seen by comparing the photographs of the worker's (3) and queen's (5) feet. By these two structures the waxen scales are seized as they project from the abdomen and pulled off; they are then passed on to the front pair of legs, by which they are held up to the jaws to be masticated and mixed with saliva. As a consequence of this treatment the wax becomes ductile and plastic, and can easily be moulded and shaved down or excavated to the required shape. Beyond this point the scope of our paper does not permit us to follow its history.

FIG. 5.—Hind leg of Humble Bee. *p*, planta; *s*, spurs.

When freshly built into combs, wax is generally of a pale yellow colour, but other shades are met with, and variations of this kind are due to the pollen which the bees have consumed in addition to the honey that forms the basis of the secretion. White pollen, such as that of the heather, has the effect of whitening the wax, while dark orange pollen intensifies its natural yellowness.

The value of beeswax to man arises from its plasticity and combustibility. Its uses are manifold, and many of them may be traced back to a very remote antiquity. The readiness with which wax receives impressions and the accuracy with which, owing to its lack of elasticity, it retains them, early led to its adoption as the most suitable material for coating writing tablets, and the same property made it a valuable adjunct of the law courts for use either in the form of tablets or seals. In ancient times it was also employed in the arts, as a medium for the mixing of painters' colours. Pliny has left an account of the method of its preparation for this purpose. Ordinary beeswax was boiled three times in sea-water with a small quantity of nitre, and by this means it was purified and bleached. After careful drying it was fit for mixing with all kinds of colours, and was then called Punic wax.

When we try to form some idea of the quantity of wax that must have been annually consumed in the ancient world for such purposes as those mentioned above, as well as for the many other uses to which it was put, it becomes evident that we have in wax secretion an excellent illustration of the wonderfully great total that can be reached by accumulated littles. For, though individually each wax scale as produced by the bees is a minute object no larger than about one-fifteenth of an inch long by about two-thirds as much in breadth, the gross amount produced season by season to supply the needs of the civilized world must have been very large, and must have necessitated the formation of millions upon millions of wax scales. And although some of its ancient uses have become obsolete, others have taken their place, and wax still remains to man a valuable product of insect agency, and the labours of the bees are still of the utmost importance not only in the economy of Nature, but also in the service of man. If we try to estimate the enormous quantity annually consumed at the present day, in the form of wax candles, in those countries in which the burning of candles forms an essential part of all ecclesiastical observances, and if we remember the great disproportion that exists between the quantity of honey consumed and that of wax secreted—the ratio being sometimes as great as seventeen or eighteen to one, as already mentioned—we see that for this purpose alone there must be vast multitudes of bees hard at work day after day, pilfering from the flowers of the hillsides, gardens, and meadows of Europe that nectar which is to serve as the raw material for so huge an amount of secreted wax. And when we add to this the amount of honey that is not devoured for wax secretion, but stored for future use, and brought into the market before its conversion into wax, we need no further evidence of the incredible activity and industry which these small insects display, and which have been the admiration of the world from time immemorial. Their eagerness for gathering honey indeed is so great that they become reckless and infatuated in its pursuit. The following scene, described by Dr. Langstroth, will illustrate this:—"No one can understand the extent of their infatuation until he has seen a confectioner's shop assailed by myriads of hungry bees. I have seen thousands strained out from the syrup in which they had perished; thousands more alighting even upon the boiling sweets; the floor covered, and windows darkened with bees, some crawling, others flying, and others still so completely besmeared as to be able neither to crawl nor fly—not one in ten able to carry home its ill-gotten spoils, and yet the air filled with new hosts of thoughtless comers."

The secretion of wax is not confined to the hive bee amongst the Hymenoptera; the humble bees also have the power of producing a similar substance, although in very inferior degree, since no definite comb is made, and the wax is used only to strengthen the cocoons, and stop up cracks and crevices in the roof. They differ from the hive bee also in not being provided with wax-pockets. The economy of these *Bombi* is much less elaborate than that of the hive bee; they have, as it were, advanced less far along the path of civilization, and are therefore satisfied with more primitive and less refined arrangements, especially in the accommodation of their larvæ. Thus, while the hive bee provides each of its grubs with a separate cell in which to live and undergo its transformations, the *Bombi* simply deposit their eggs here and there on a shapeless heap of pollen, which constitutes the stored provision of the establishment, and each larva as it hatches begins to eat from the store immediately around it, thus excavating a hollow which serves it as a cell. When the larva is full fed, this is lined with silk, and its walls may then be strengthened with wax by the old bees.

(*To be continued.*)

THE LUMINIFEROUS ETHER.

By J. J. STEWART, B.A.Cantab., B.Sc.Lond.

(*Continued from page* 112.)

IT becomes an interesting question whether moving bodies, such as the earth in its course through space, carry the ether with them or pass through it without causing any motion of the ether in their direction. Do the matter molecules drag the ether along with them or not? Dr. Young, to whom the advance of the undulatory theory of light owed so much at the beginning of this century, supposed that the motion of the ether was not affected by the passage of gross matter through it, but that the ether passed through solid masses such as the earth or the planets freely like the wind through a grove of trees, or water through a wide-spaced net dragged through it. The earth, according to him, moved on its path, but the ether within it and around it remained fixed in space. Experiments have been made to test this question of the relative motion of the ether, but it still remains unsettled. Some experiments seem to point to one conclusion, some to the other.

The phenomenon of aberration, which consists in a periodic displacement of the position of a star as seen from the earth, the period of the displacement being a year, is usually explained as due to the composition of the velocity of light with the velocity of the earth in its orbit. Owing to aberration, in order to observe a star in the direction A C or B D a telescope must be pointed in the direction A D, if in the figure A C represents the velocity of light and A B the velocity of the earth. The apparent position of a star is always in front of its true position. A ray entering the telescope tube at D will travel with the velocity of light and reach the other end of the telescope while this latter has travelled with the earth from A to B, so that the direction of the ray in the telescope is along D A. Thus aberration is satisfactorily explained. But if this is the true explanation, the amount of aberration must depend on the medium which is contained in the tube if the ether is not affected by the moving matter, for the velocity of the light considered is its velocity through the medium filling the telescope.

The effect of filling the telescope tube with different substances has been tried by Sir G. B. Airy at Greenwich, and he found that the aberration was the same whether the tube contained air or water. Now, in the wave theory the index of refraction of a substance is the ratio of the velocity of light in vacuum to its velocity in the substance, and as the index of refraction of water is one and one-third, the velocity of light in air is four-thirds of its velocity in water, and the aberration with a telescope containing water should be four-thirds of its value under ordinary conditions, on the supposition that ether is not dragged along with moving matter.

To account for the fact that the aberration remains constant it has been suggested that moving matter carries the ether, or a portion of it, along with it. M. Fizeau has made experiments to investigate how far the velocity of light is affected by the motion of the medium, *i.e.*, the matter through which it passes. If we imagine a luminous object and an observer to be fixed in position relatively to the ether, then if the medium intervening is moving towards the observer and it carries the ether with it, the velocity of the waves towards the observer will be increased, but if the ether does not move with the matter of the medium the velocity of light will not be affected by the motion.

In Fizeau's experiment a pencil of rays from a narrow slit was sent through two parallel tubes containing water and reflected back again to the observer. The water was made to flow through the tubes, in an opposite direction in each, with a velocity of over twenty feet per second; and one half of the beam of light went through one of the tubes travelling in the direction of the flow of water and back through the other still in the direction of flow, while the other half of the light went in a direction against the flow of the water, entering through the second tube and returning by the first. The rays of light which had traversed similar paths were brought to a focus by a lens, and if the velocities of the rays were affected by the moving water they would be affected in opposite directions, and thus a difference in the time of transit would be caused and a phase difference produced which should give rise to interference fringes. By altering the direction of the stream of water in the tubes displacement of the fringes should take place if the ether is dragged along by the water, and this is what Fizeau found was the case. The fringes were displaced towards the right or towards the left of the observer according as, in the tube placed at the right of the observer, the movement of the water was towards the observer or in the opposite direction.

Interference consists in the crest of one wave coinciding with the trough of another and thus producing an absence of resultant effect, or in two crests coinciding and thus producing heightening of effect. When a beam of light is split into two portions which are made to traverse slightly differing paths, and these two portions are made to meet again and overlap, in some places crests may fall on troughs and cause there an absence of light, and thus lines of darkness or interference fringes may be produced. This is the principle involved in Fizeau's experiment, and by measuring the amount of shifting of the interference bands he obtained a measure of the change produced in the velocity of the light by the motion of the medium traversed. From his experiment he concluded that Fresnel's theory was correct, according to which the ether is partly dragged along by the surrounding matter in proportion to its refractive index, so that the velocity of the matter need not be taken into account, or added to or subtracted from the velocity of the light, but that the excess of the ether within the medium over that outside is alone carried along. According to Fresnel's theory, if V is the velocity of light, and v the velocity in a transparent medium, and the index of refraction of the medium is n, then the velocity of light in the direction of the motion of the medium will be $V + \frac{n^2 - 1}{n^2} v$. This closely agrees with Fizeau's result.

Messrs. Michelson and Morley, in America, a few years ago made experiments to test if there was any relative motion between the luminiferous ether and the earth, and the conclusion they came to was that if there was any it was small—that is, that the ether is carried along with the earth on its course through space. This result is in contradiction to the ordinarily accepted explanation of aberration. The nature of the experiment consisted in sending light along two paths, one in the direction of the earth's motion, and the other at right angles to it, and by reflection causing the rays to fall on the same point, and produce interference owing to the difference in path. By sending the ray which went in the direction parallel to that of the earth's motion first with this motion and then against it, displacement of the interference fringes should take place if there is relative motion between the earth and the ether, and the amount of the displacement which would occur can be calculated. Mr. Michelson found that the displacement was probably less than the fortieth part of what it would have been if the ether was at rest and the earth moved relatively to it, and certainly less than the twentieth of this value. The observations were made with great accuracy, and Michelson reckoned that he could detect an alteration of one part in four thousand millions, if it existed. This is equivalent to detecting an error of less than one-thousandth of an inch in fifty miles, and the experiments point to the conclusion that the earth carries the ether with it.

Prof. O. J. Lodge has recently been making experiments to find if he can detect any motion of the ether caused by that of neighbouring matter. He uses two steel discs about a yard in diameter, clamped together with a space of one inch between ; these are made to spin round very fast. Then a parallel beam of light is split into two by a semi-transparent mirror, *i.e.*, a piece of glass silvered so thinly that it lets half the light pass through, and reflects the other half, and the two portions of this divided beam are sent by successive reflections round and round the space between the discs, in opposite directions. After traversing thus a distance of from twenty to forty feet, they are finally made to meet and enter a telescope. In general, the lengths of the paths of the two portions of the beam differ very slightly, and thus they interfere. It is observed whether the motion of the discs is able to cause displacement of the interference bands, but Prof. Lodge could detect no true shift of the bands. He says : "Of real reversible shift, due to motion of the ether, I see nothing. I do not believe the ether moves. It does not move at a five-hundredth part of the speed of the steel discs." Circular saws, railway trains, &c., he thus concludes, do not carry the ether with them ; their motion does not seem to disturb it at all. The presumption is that the same is true of the motion of the earth. Prof. Lodge thinks that "if moving matter disturbs ether in its neighbourhood at all, it does so by some minute action comparable in amount, perhaps, to gravitation, and possibly by means of the same property as that to which gravitation is due—not by anything that can fairly be likened to ethereal viscosity."

Prof. Lodge has recently been able to increase the velocity of his discs to three thousand revolutions per minute, but even with this rapid rotation nothing which can be attributed to a drag of the ether has been detected.

On the other hand, Mr. Michelson concludes from his experiments that the relative velocity of the earth and the ether is probably less than a sixth of the earth's orbital velocity, and certainly less than one-fourth. Thus the question of the connection of the ether with gross matter, and the relation of its motion to that of the earth and the heavenly bodies, is still by no means settled.

Not only has the luminiferous ether been applied to account for the propagation of waves of light, and for the phenomena of electrification by supposing this to be due to stresses set up in it, but Lord Kelvin has suggested that the ultimate atoms of matter may consist of vortices or whirlpools in the ether. He has pointed out that by means of motion alone, in a fluid destitute of elasticity, a virtual elasticity may be produced. It is well known that a quasi-rigidity may be conferred on a limp chain by causing it to rotate rapidly. If when rapidly revolving the chain be struck, a permanent kink or bend is made in it which retains its form while the rotatory motion lasts. Moreover, two smoke rings when they collide rebound from each other as if they were elastic, this appearance of elasticity being conferred on them by their motion. Thus Lord Kelvin's hypothesis in his kinetic theory of matter is that atoms are not hard and solid, but that they consist of rotatory rings or whirls in an incompressible frictionless fluid which is perfect and homogeneous, this fluid being the ether, and differences in the elementary atoms are due to differences in the character and behaviour of these vortices, which may be linked together in various ways. A serious objection to the kinetic theory of gases, by which they are represented as consisting of hard solid spheres flying about and colliding with each other, has been pointed out by Lord Kelvin. It is that the effect of the collisions must be to gradually convert the energy of translation into shriller and shriller vibrations of the molecule, and that finally all the translational energy will be changed into this form. Thus on the elastic solid hypothesis of the atom the result is not much different from what it would be if there was imperfect elasticity. If there is no tendency of this sort in the case of the vortex atoms, a serious difficulty would be got over. Such atoms, moreover, would possess the properties of unchangeability and indivisibility ; they cannot be cut, for they would simply wriggle away from the cutting instrument. They are capable of vibrations, and mutual action at a distance can be explained by continuous action through the intervening ether.

THE GENESIS OF FLOWERS.

By the Rev. Alex. S. Wilson, M.A., B.Sc.

The flowers most generally known are brightly coloured blossoms adapted for insect fertilization ; only these require to attract insects, which is the end served by the perfume and conspicuous colouring. Very many plants, however, bear blossoms so small and obscurely coloured that they are commonly either entirely overlooked or not reckoned as flowers at all. The wind-fertilized flowers of the dock and nettle have no occasion for the services of insects, and are destitute of honey, odour, and brilliant petals. Still more insignificant in appearance are the little self-fertilizing cleistogamic flowers which, towards the end of the season, are produced on the dog-violet. All three kinds possess stamens and pistils, and are therefore recognized as flowers by botanists. Besides stamens and pistils, which are the essential organs of a flower, petals and sepals are usually present. The petals collectively compose the corolla, the sepals the calyx ; both together being spoken of as the floral envelopes or perianth. Occasionally, as in the ash, the flower is reduced to its essential organs, the floral envelopes being absent. Plants bearing flowers, whether with or without floral envelopes, are designated phanerogams or flowering plants ; they constitute the highest division of the vegetable kingdom. Ferns and mosses, again, are examples of the cryptogamic or flowerless class ; they never bear flowers or seeds, but are propagated by minute reproductive bodies termed spores. This class is divided into thallophytes and vascular cryptogams. The organization of a thallophyte is very simple ; the plant-body of a fungus or sea-weed, for example, consists entirely of similar cells, and externally shows no distinction into root, stem, and leaf. The structure of a vascular cryptogam, such as a club moss, horsetail, or fern, is more complicated ; both cells and vessels enter into the composition of its tissues, and externally the distinction of stem and leaf is apparent. Phanerogams also admit of a twofold division into gymnosperms and angiosperms ; conifers, cycads and yews are gymnospermous, having naked seeds, exposed either on the ends of branches or on the surface of open scales. All ordinary flowering plants produce their seeds in the interior of a closed ovary, as the lower part of the pistil is called ; from this peculiarity they are termed angiosperms.

Only the remains of thallophytes have hitherto been discovered in the oldest Palæozoic rocks. Vascular cryptogams appear in the Silurian strata, attain their maximum in the Carboniferous age, and in succeeding formations are gradually displaced by gymnosperms. The latter occur as early as the Devonian period, but the prevailing type of vegetation down to the close of Palæozoic time continued to be cryptogamic. Angiosperms possibly existed as far back as Permian times, but it is only in the chalk that their remains begin to be abundant; the vast majority of Mesozoic plants seem to have belonged to the gymnospermous type. Plants with conspicuous flowers only date from Tertiary times: they increase in number and importance as we approach the present day.

Although the plants entombed in the rocks are only an inconsiderable fraction of the numbers that formerly existed, the general succession just indicated is fully made out, and as the palæontological evidence accumulates it tends more and more to establish the view that coloured blossoms are, geologically speaking, of comparatively recent origin. The vegetation of the earlier geological epochs was marked by a singular uniformity of character; not only were there fewer species than now, and these widely distributed over the globe, but the monotonous green of Palæozoic and Mesozoic forests was unrelieved by gay blossoms such as adorn our fields and orchards. We are indebted to geology for another important fact; fossil plants occur which have no near relatives in the existing flora. Intermediate forms which cannot properly be classified with any living family are met with; in others the characters of several modern groups are blended. Although these generalized forms rather upset our systems of classification, they have an important bearing on the origin of living plants. But what a different aspect, when the coal plants were growing in primeval luxuriance, the landscape must have worn from that on which we are accustomed to look! Odd, uncouth lepidodendra of arborescent growth, huge reed-like calamites, gigantic ferns stretched in interminable forests, clothed in one unvaried tint of sombre green. How different is the scene which Nature now presents!—mountains glowing with the purple bloom of heather; hillsides where the furze has spread its cloth of gold; meadows bright with daisies, ranunculi, and cuckoo-flowers; banks where the wild thyme and bluebell grow! The contrast affords a hint of the transformation in our world effected by the introduction of flowers.

Our knowledge may not enable us to describe all the minute steps which led to this remarkable change, but we can at least indicate with great probability the nature of the process and some of the agencies which contributed to bring about this result. To suppose that each species of plant was independently created as we now see it, implies not one creation merely but many successive creations; moreover, it leaves unexplained all the curious affinities which exist among the members of the vegetable kingdom. The gradations of structure, the geological succession and the peculiarities of plant growth are much more intelligible when we view the plants which now inhabit the earth as the lineal descendants of those which lived during the earlier ages of geology. From the nature of the case, the theory of development does not admit of actual demonstration; still the evidence in support of it is such that its advocates are entitled to claim a verdict on the mass of indirect and circumstantial evidence.

Among palæozoic cryptogams we have evidence of the existence of structures which, with comparatively little modification, might be converted into what we now regard as flowers. The abundant remains of lepidodendra in the coal measures testify to the important place attained by the group of lycopods, or club mosses, in the Palæozoic flora. To this family might very well have belonged the archetype from which our modern blossom-bearing plants have come. Our knowledge of this group is derived both from fossil remains and from forms still extant. The selaginellas, so commonly cultivated in greenhouses, are examples; also the little club moss, *Lycopodium selaginoides*, of our highland moors. The last mentioned, though a diminutive form, possesses special interest, being one of the few vascular cryptogams native to this country which produce two kinds of spores. This heterosporous character was, however, a common feature of extinct lycopods; both large and small spores have been detected in great numbers in coal.

The internal anatomy of the lycopodiaceæ is somewhat complex, but their external organization is simple. A club moss consists of a cylindrical stem covered with overlapping leaves, spirally arranged, of small size relatively to the stem, and always simple or undivided. The stem branches in a peculiar forked manner, which gives the plant its characteristic candelabra-like form. Existing lycopods are creeping plants, seldom exceeding two feet in height, but many extinct species attained the dimensions of large trees. On the ends of certain branches the leaves are crowded together, giving the terminal portion of each shoot some resemblance to a pine-cone. The crowded leaves on this portion bear, on their upper surfaces, little sacs called sporangia. Certain of these sacs contain very numerous small rounded bodies, the microspores; others have fewer spores of larger size, distinguished as macrospores. Sacs containing the small male spores are termed microsporangia; those having the large female spores, macrosporangia. When ripe, a sporangium bursts and discharges its spores, which are scattered by the wind. Should a spore alight on a favourable spot, it germinates after a time and gives rise to a structure called a prothallus, which is really an independent plant. This stage in the life-history of a cryptogam is, however, much better seen in ferns, where the prothallus is extirely expelled from the spore and attains a higher degree of independent development. The prothallus throws out root-hairs, nourishes itself and grows, but the leaf-like form it assumes bears not the remotest resemblance to the parent fern from which it sprang. This phenomenon, characteristic of the higher cryptogams, is known as the "alternation of generations." Similar phases are observed in certain animals, the medusæ or jelly fishes for example. In the course of its development a fern passes through two distinct phases; first, the spore-bearing stage or sporophyte, represented by the fern frond; secondly, the egg-bearing stage, the oöphyte or prothallus. As we ascend in the scale of vegetable life, the egg-bearing or sexual generation diminishes in importance, while the sporophyte preponderates more and more. In club mosses the prothallus has all but lost its independence; in the case of selaginella it is formed almost entirely within the spore, only a small part being extruded when the spore ruptures. Some of the lycopods are isosporous—that is, they have, like the ferns, but one kind of spore. Where this is the case, the prothallus developed from the spore bears two sets of sexual organs; the prothallus of one of the heterosporous cryptogams, on the other hand, produces sexual organs of one kind only. Antheridia appear on the prothallus developed from a small spore; archegonia on that from a large one. The former are the male organs, and from them are emitted numerous antherozoids, minute ciliated bodies, which swarm over damp surfaces in all directions. The archegonia are microscopic flasks, each containing an egg-cell or oösphere; they are entered by one or more of the locomotive antherozoids, which coalesce with the egg-cell; the latter is thereby fertilized, and soon grows by cell division into a plant resembling that from which the spores were originally obtained. The life-history of a vascular cryptogam is, so to speak, a story completed in two volumes.

Microscopic research has revealed a most interesting relationship between flowering plants and the heterosporous cryptogams. When the development of the pollen grain in the anther of an ordinary flower is studied and compared with that of a microspore, the two are found to agree in a remarkable manner. The sporangium corresponds in all essential points with the pollen-sac, and its generating tissue develops in similar fashion to that from which the pollen grains originate. In both cases an archesporium is produced by the division of a hypodermal cell; this tissue next divides into a tapetal layer and a row of mother-cells; the tapetal layer dissolves, isolating the mother-cells, each of which then forms in its interior four daughter-cells, which are the spores or pollen grains as the case may be. Not only are the antecedents of microspores and pollen grains alike, but their subsequent histories offer many points of resemblance. Pollen grains are known in numerous instances to form in their interior one or more vegetative cells, which can hardly be regarded as other than a rudimentary male prothallus, such as is commonly developed by a microspore.

There is another bond of connection between flowering and flowerless plants of equal or even greater importance. In the interior of the ovule, or young seed, both of angiosperms and gymnosperms a special cell is developed, called the embryo-sac. When the history of this cell is traced back its development is found to be exactly that of a spore. Certain structures are also formed in its interior bearing the closest analogy to the internal prothallus observed in the macrospore of selaginella. These are most obvious in the embryo-sacs of gymnosperms, where the prothallus is represented by the endosperm, while the corpuscula, or secondary embryo-sacs, arising on this are the undoubted equivalents of the archegonia of ferns and other cryptogams. The gymnosperms thus stand midway between vascular cryptogams and angiosperms; but even within the embryo-sac of the latter, in the so-called antipodal cells, may still be detected vestiges of the oöphyte or sexual generation, that structure so characteristic of the flowerless class.

An alternation of generations can thus be traced throughout the greater part of the vegetable kingdom, from the lowest scale mosses through the urn mosses, ferns, horsetails, lycopods, and conifers, up to the highest members of the phanerogamic division. But of more importance for our present purpose is the certain identification of the pollen grain and embryo-sac of flowering plants with the microspore and macrospore of the older cryptogams. The stamen of a flower turns out to be simply a peculiar form of microsporangium, while the ovule is a macrosporangium, containing but one macrospore, or occasionally developing several. It follows, therefore, that we have only to enlarge our conception sufficiently to see in the spore-bearing cones of the lycopods structures of essentially the same nature as flowers. All the materials that go to the making of a flower could thus have been furnished by the flowerless flora of Palæozoic ages.

An important change, which marked the transition from cryptogams to flowering plants, must now be mentioned, and to this the animal kingdom furnishes a striking analogy. The lowest vertebrates, such as fishes, are oviparous; the ova are discharged and afterwards incubated. Mammals, on the other hand, are viviparous; the young are hatched within the body of the parent. The young of the kangaroo and other marsupials, which constitute the lowest order of mammals, are still very immature at birth. Analogous conditions are found among plants. Cryptogams are all oviparous; the macrospore, which may be regarded as the ovum or egg, separates from the parent plant before fertilization. Phanerogams, on the other hand, may be described as viviparous, since they retain the macrospore or ovum until it has developed an embryo. The presence of an embryo constitutes the distinction between a seed and a spore. Unless an embryo be present a seed cannot germinate, since germination is simply the emergence of the embryo from the coats of the seed. An extreme case of this retention is seen in the mangrove, where the seed germinates while still attached to the tree; the embryo sends down its long radicle into the mud, and only quits its hold of the parent when it has become firmly established. Orchids and many parasitic plants have seeds with exceedingly minute and imperfect embryos, recalling the undeveloped offspring of the marsupials.

The retention of the egg is attended with a manifest advantage; plainly the viviparous method of reproduction, which obtains in the higher divisions of the two organic kingdoms, is much more economical than the other. By the change to the viviparous condition several structures present in the cryptogams are rendered useless, and a disused organ invariably degenerates; the prothallus and its adjuncts, having no longer any function to perform, must inevitably begin to atrophy. The rudimentary structures appearing in the embryo-sac of phanerogams can in this way be accounted for. The life-history of a cryptogam extends, as we have seen, to two volumes; it now appears that the life-history of a phanerogam is a second edition of the same story, somewhat abridged and completed in a single volume.

The life-history of certain ferns occasionally undergoes a corresponding abbreviation. In the phenomena of apospory and apogamy we have departures from the ordinary course of development, closely akin to what would be required for the conversion of a cryptogam into a phanerogam. Apospory occurs when the production of spores is omitted, the prothallus growing immediately on the fern frond; apogamy, when the female organs are not developed, and the frond is formed by vegetative growth directly from the prothallus.

There is another fact of which account must be taken. In different groups of plants, in proportion to the complexity of their organization, the female cell tends to increase in size and importance. This is probably accompanied by a chemical or physiological enrichment of the substance of the egg-cell, rendering a higher degree of protection desirable. The enclosure of the embryo-sac within the ovule becomes in these circumstances an advantage. But by this investment, and by the ovule remaining attached to the parent plant, the microspore is of necessity reduced to the condition of a parasite, and the conversion of the male prothallus into a pollen tube becomes intelligible as a case of degeneration.

The closed seed-vessel of angiosperms, there can be little doubt, has in like manner been acquired for the purpose of excluding fungus spores, bacteria, and other destructive germs from the ovules. Van Tieghem found that when the pistil of a flower was opened the ovules could not be directly fertilized, but were invariably attacked by bacteria. The resinous secretions of conifers act as a germicide, rendering less essential the protection of the seeds, which is the *rôle* of the pistil in angiosperms.

The gradations between stamens, petals, and sepals seen in the water lily, and the conversion of stamens into petals in the garden rose, suggest a possible variation which would explain the first appearance of the floral envelopes.

The nectary may not improbably be a transformed water gland, turned to account as an attraction to visitors, and so of use in promoting cross-fertilization. Every new character tending directly or indirectly to secure this advantage would be perpetuated; the colours, perfumes, mechanism, and most of the peculiarities of flowers become intelligible when viewed as results due to the selective agency of insects. But the steps by which the mutual adaptations of flowers and insects have arisen is a subject demanding treatment by itself, and on which we cannot enter at present.

IS BETA LYRÆ A DOUBLE STAR?

By Miss A. M. Clerke, *Authoress of "The System of the Stars" and "A Popular History of Astronomy during the Nineteenth Century," &c., &c.*

On the 10th of September, 1784, John Goodricke, of York, discovered a bright white star in the Lyre to be variable. He was a deaf-mute, scarcely twenty years of age, and died before he was twenty-two; but he contrived to ascertain the main features of its light-change. They are very peculiar. In a period of twelve days and nearly twenty-two hours, four phases of approximately equal duration are comprised. The light-curve represented in Fig. 1 is perfectly symmetrical. The twin-maxima are situated just midway between the unequal minima, and the measure of their brilliancy is, time after time, filled to the brim, without overflow or defect. Neither an abortive nor an excessive maximum has ever been recorded in Beta Lyræ. The intensity of the chief minimum is also—within observational limits—absolutely constant. So that the entire compass of variation, from 4·4 to 3·4 magnitude, is a fixed

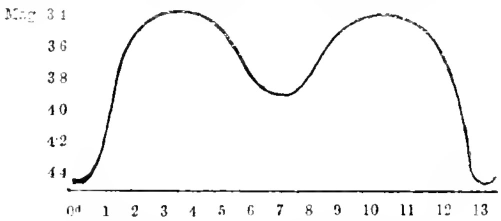


Fig. 1.—Light-curve of β Lyræ (Argelander).

quantity. The secondary minimum, however, does not show the same immutability. Its occasional exaggeration, by which the period is threatened with bisection, is balanced by recurring deficiencies of emphasis. But the flow of change is always smooth; it is interrupted by neither zigzags nor dead-level passages. Intervals of stedfastness, no less than flickerings in lustre, seem foreign to the character of this remarkable object, which traverses its cycle without ever, so to speak, getting off the rails. No single phase encroaches upon the next; anticipated maxima, retarded minima, are unknown. Nevertheless, the entire period is lengthening, and has been lengthening during the past hundred years, at the average rate of about one-third of a second at each recurrence. We have yet to learn whether this perturbation is of a compensatory nature. In either case, we can scarcely refrain from connecting it with disturbed orbital revolution.

Beta Lyræ displays an exceedingly curious and beautiful spectrum. The bright lines noticed in it in the first days of stellar spectroscopy by Father Secchi, were found, by M. Von Gothard in 1883, subject to what seemed like fits and starts of invisibility. Visual observation proved, however, altogether inadequate to the investigation of a highly complex phenomenon; and it was not until the aid of the camera became available that even its most essential characteristics were recognized. The duplex nature of this star's spectrum was detected at Harvard College Observatory in 1891. Mrs. Fleming's examination of twenty-nine Draper Memorial plates showed all the chief bright lines to be coupled with dark ones. This, at the time, unprecedented arrangement was repeated in Nova Aurigæ, and again last year in Nova Normæ. All three spectra, too, were of the Orion type, and in all three the great solar prominence-line, K, was bright and broad. But while the bracketed rays continued, in the "new stars," relatively fixed, they execute in Beta Lyræ certain mutual evolutions unmistakably connected with the periodicity of the object. The relation, it is true, is not direct or immediate; yet the processes of light-change and line-change cannot be regarded as otherwise than, in the long run, concurrent. Prof. Pickering accordingly suggested that the Lyra variable is really a binary system composed of a gaseous mass revolving in a period of nearly thirteen days round a star of the same physical constitution with Rigel. The opposite motion-displacements of the bright and dark lines indicated, according to his estimate, a relative velocity of three hundred miles a second in a circular orbit, the moving bodies being fifty millions of miles apart. No attempt was made to explain the fluctuations of their joint brightness. Father Sidgreaves, however, who has made this star the object of an interesting research, favours the theory of an alternate eclipse by and of its supposed gaseous attendant, combined with tidal action producing both spectral and luminous variations. But the *rationale* thus offered is hampered by serious, perhaps by insuperable, difficulties.

Let us look steadily for a moment at the conditions of the problem. It is admitted on all hands, to begin with, that the star's telescopic variability depends wholly upon the waxing and waning of its continuous spectrum—representing, presumably, its photospheric emissions. The fading of brilliant rays, or the deepening of dark ones, has no perceptible effect upon the sum-total of light. The observed changes in its *quantity* and *quality* are, then, correlated effects of a single cause. The former are perfectly definite, both as to time and amount; the latter, amid many seeming caprices, obey fundamently the same law of recurrence. If the law be prescribed by orbital motion, then the two kinds of variability must be capable of explanation through the known results of such motion, to the exclusion of contradictory conditions. But attempts to provide, on this basis, a complete explanation of the phenomena have hitherto led to nothing but entanglement in a mesh of baffling inconsistencies.

The possible alterations through orbital movement in the light reaching us from a binary system may be classified as optical and physical. Occultation-effects, distortion-effects, and line-shiftings produced by radial velocity are of the first kind. They represent no actual changes. They are compatible with an absolute constancy in the state of the system, since they depend merely upon the varying relations to the line of sight of the bodies forming it. With the physical consequences, as regards luminous emission, of close duplicity, we have only a speculative acquaintance. It may be that the tidal disturbance at a periastral rush-past would occasion eruptive outbreaks associated with sudden accesses of brightness; but the "tidal theory" of temporary stars does not apply to the object of our present discussion. For two reasons: First, because the path of the stars thus affected should be a

* *Monthly Notices*, Vol. LIV., p. 96.

long ellipse, while that of Beta Lyræ can be inferred from the equal duration of its phases to be sensibly circular. Next, because the ebb and flow of light displayed in them is so tranquil as to exclude the possibility of their connection with any kind of explosive action.

We seem, then, thrown back upon some description of optical *rationale*. The most obvious is that of a double eclipse, the brighter object being obscured at the principal minima, the satellite at the subsidiary minima. This view has in fact been adopted both by Father Sidgreaves and by M. Belopolsky.* Yet the light-curve of Beta Lyræ is totally different from those of Algol and other ordinary eclipse stars. It represents continuous change, instead of a settled maximum, interrupted at fixed epochs by a comparatively swift decline and recovery. It would thus appear that the Lyra variable can be associated with Algol and its congeners only on one condition—that it is made up of two enormous orbs circulating in such exceedingly close contiguity that their mutual occultations form an almost unbroken series. If each were of the solar mass, the distance from centre to centre would then be roughly six and a half million miles. Admitting further the separation of their surfaces by an interval of one million, the diameter of each of the conjoined bodies, which, for the sake of simplicity, may be taken as equal, would be six millions of miles. They would accordingly be three hundred and thirty times rarer than the sun, their density exceeding that of air at the sea-level only about three and a third times. That globes thus tenuous should shine with stellar brilliancy does not seem probable, but one should hesitate to pronounce it impossible.

Assuming their existence, we can safely assert that, although they might escape eclipse, they could not escape distortion through the inequalities of their mutual attraction. They would, in fact, not be globular, and their persistent extension along the line joining their centres, and corresponding compression in the opposite direction, would cause them to present to our view (if the plane of their orbit made only a small angle with the visual ray) a larger luminous area when *broad-side-on* than when *end-on*. And since the range of variability in Beta Lyræ is of one magnitude, the joint extent of surface visible respectively at the elongations and conjunctions of the pair should be in the proportion of two and a half to one. The disparity of their alternate minima would, indeed, offer a difficulty, but it might be successfully met by an ingenious contriver of hypotheses. All that we are at present concerned to establish is that the periodical loss the entire orbital velocity is directed along the line of sight, but coincide when it is directed across it. These regularly alternating effects are, nevertheless, very imperfectly, if at all, recognizable in Beta Lyræ. The extraordinarily complex nature of the problem with which astronomers are thus confronted is emphasized by the splendid series of spectrograms taken at Potsdam, mainly by Dr. Wilsing, in 1892-3, and discussed, in his usual masterly style, by Dr. Vogel.† The prismatic section depicted in them lies between wave-lengths 450 and 380, so that they include the remarkable line at λ 447 together with a considerable extent of the ultra-violet radiations. They are, besides, unprecedentedly numerous, and appear to be of pre-eminent definition, constituting altogether a stock of materials of the very highest importance.

The spectral changes in this star are particularly well-accentuated in the line H ζ, as the first member of the ultra-violet hydrogen-sequence is termed in the new system of nomenclature introduced by Dr. Vogel. The accompanying figures, reproduced by his kind permission, show its characteristic aspects at the four critical epochs of light-fluctuation. In Fig. 3 we see its condition at the principal minimum. A brilliant wide ray lies on the red or less refrangible side of an equally wide dark ray. The ensuing maximum (Fig. 4) brings little alteration; only a slight brightening comes in on the violet side of the absorption. At the second minimum, however, a totally different state of things is seen to prevail (Fig. 5). The black line is projected upon a much broader bright band. And the next maximum (Fig. 6) unexpectedly follows suit. The chief minima of the star, then, take place when the H ζ lines are furthest separated; and the remaining hydrogen and other lines tell the same story. This is as much as to say that these mysterious obscurations are *not* due to eclipses, which are, of course, geometrically impossible except when the occulted and occulting bodies are travelling straight athwart the line of sight. An additional circumstance of great perplexity is the spectroscopic correspondence of adjacent, and not, as would naturally be looked for, of opposite phases of luminous variation. It obliges us to discard utterly the supposition of motion-displacements in a nearly circular track; unless, indeed, we are permitted to bring to the rescue a swift translation through space of the entire system. This would also account for the unsymmetrical character of the recorded line-shiftings, for the bright lines travel very much further from the dark ones towards the red than towards the blue, the compensatory swing being almost null. But we can arrive at no

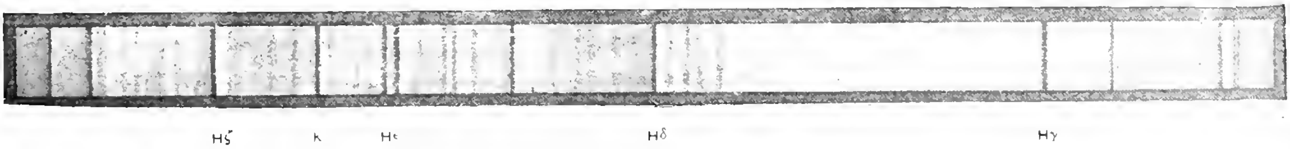


FIG. 2.—General Spectrum of β Lyræ from wave-length λ 380 to λ 450. Reproduced from paper of Dr. Vogel, published in the *Sitzungsberichte* of the Berlin Acad. d. Wiss., February 8th, 1894.

of light in this star, if an optical effect of revolution in an orbit, can only occur when its components are crossing our line of sight.

The spectroscopic evidence on the same point may now be glanced at. Visually indivisible binaries, moving in a plane passing nearly through the earth, show a double spectrum at elongations, a single spectrum at conjunctions. That is to say, the coupled lines in the dispersed light of the companion-suns are separated to the utmost when reliable conclusion on this point until Dr. Vogel carries out his intention of measuring these shiftings with the help of a comparison-spectrum. Information as to their absolute values, their progress and plan, will then be forthcoming. It is true that the width and close juxtaposition of the lines interpose serious obstacles to the success of such operations; but at Potsdam, if anywhere, they will be overcome.

An inspection of Dr. Vogel's beautiful drawings suggests,

* *Memorie degli Spettroscopisti Italiani*, t. XXII., June, 1893.

† *Sitzungsberichte*, Berlin, 8th February, 1894.

however, a further complication. Light emanating from a double source can, under certain circumstances, be distinguished spectroscopically from light derived from a single source. Appearances impossible in the one case expound themselves naturally in the other. Reflecting for a moment upon the origin of a double spectrum composed of contiguous bright and dark lines, we see plainly that the

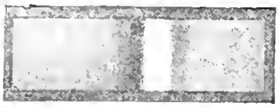


FIG. 3.—Principal Minimum.

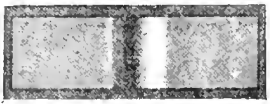


FIG. 4.—First Maximum.

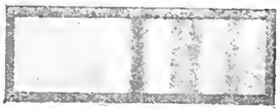


FIG. 5. Secondary Minimum.

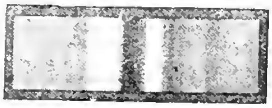


FIG. 6. Second Maximum.

Changes in the $H\zeta$ Region of the β Lyræ Spectrum. The red end of the Spectrum is to the right hand.

corresponding sets can show separately only through the effects of relative displacements, in the absence of which the combined spectrum should represent the simple summation, wave-length for wave-length, of all the rays received into the telescope. Not an algebraic summation. There are no negative quantities. The darkest ray cannot sink below the zero-level of light. Hence the vivid rays lose none of their brightness by subtraction; they must, on the contrary, show more distinctly on an obscured background. Dark lines, accordingly, can never be seen projected upon bright ones emitted by a companion luminary. But look at Figs. 5 and 6. They exhibit an absolute cutting-out, at the second maxima and minima of Beta Lyræ, of part of the brilliant $H\zeta$! They exhibit, in fact, a phenomenon entirely inconsistent with the hypothesis

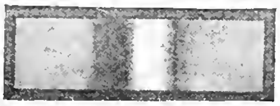


FIG. 7. The $H\zeta$ line at the Principal Minimum.

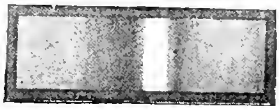


FIG. 8.—λ 447 at the Principal Minimum.

that the superposed bright and dark bands originate in separate stars. The effect is almost demonstrably due to real absorption by a cooler overlaying an intensely glowing stratum of hydrogen in the atmosphere of a single body. It would seem to be perfectly analogous to the double reversals of the calcium K-line in Prof. Hale's photographs of solar prominences. In the Lyra variable, then, double reversals must be held to play a part in producing spectral change. Motion-displacements are doubtless also present, although they cannot be solely effective. There are other items of evidence, too, proving the variations in this wonderful spectrum to be in part optical, in part physical.

Recapitulating, we find that the eclipse theory of light-change, in itself applicable only with extreme difficulty to the circumstances of this star, is directly negatived by patent spectroscopic facts. The incompatibility is fully recognized by Dr. Vogel. He gives, indeed, a general assent to the view that Beta Lyræ is a binary combination, the period of which dominates the variations in the kind and amount of its light, but prudently refrains for the present from attempting to explain the detailed peculiarities and irregularities disclosed on about one hundred and thirty of his spectrographic plates. Before these can all be included under a common formula, knowledge must obviously be greatly and variously increased—a consummation only to be brought about by working diligently and waiting patiently.

THE FATIGUE OF METALS, AND MUSCULAR FATIGUE.

By D. S. SMART.

IN common language we use the words *weariness* and *fatigue* almost indiscriminately, and as synonymous terms to describe physical exhaustion. To the engineer, however, the term *fatigue*, as applied to metals, carries a technical significance which the expression *weariness* does not cover; but it would appear from the following facts that the technical word *fatigue*, as applied to metals, may with equal propriety be applied to muscles.

Fatigue of metals is a phrase which has only come into use within recent years, and it describes a condition of the material not previously understood. The expression stands for a straining of the relationship to each other of the molecules of which the metal is constituted, a meaning which the term *weariness*, or literally *worn-ness*, does not convey.

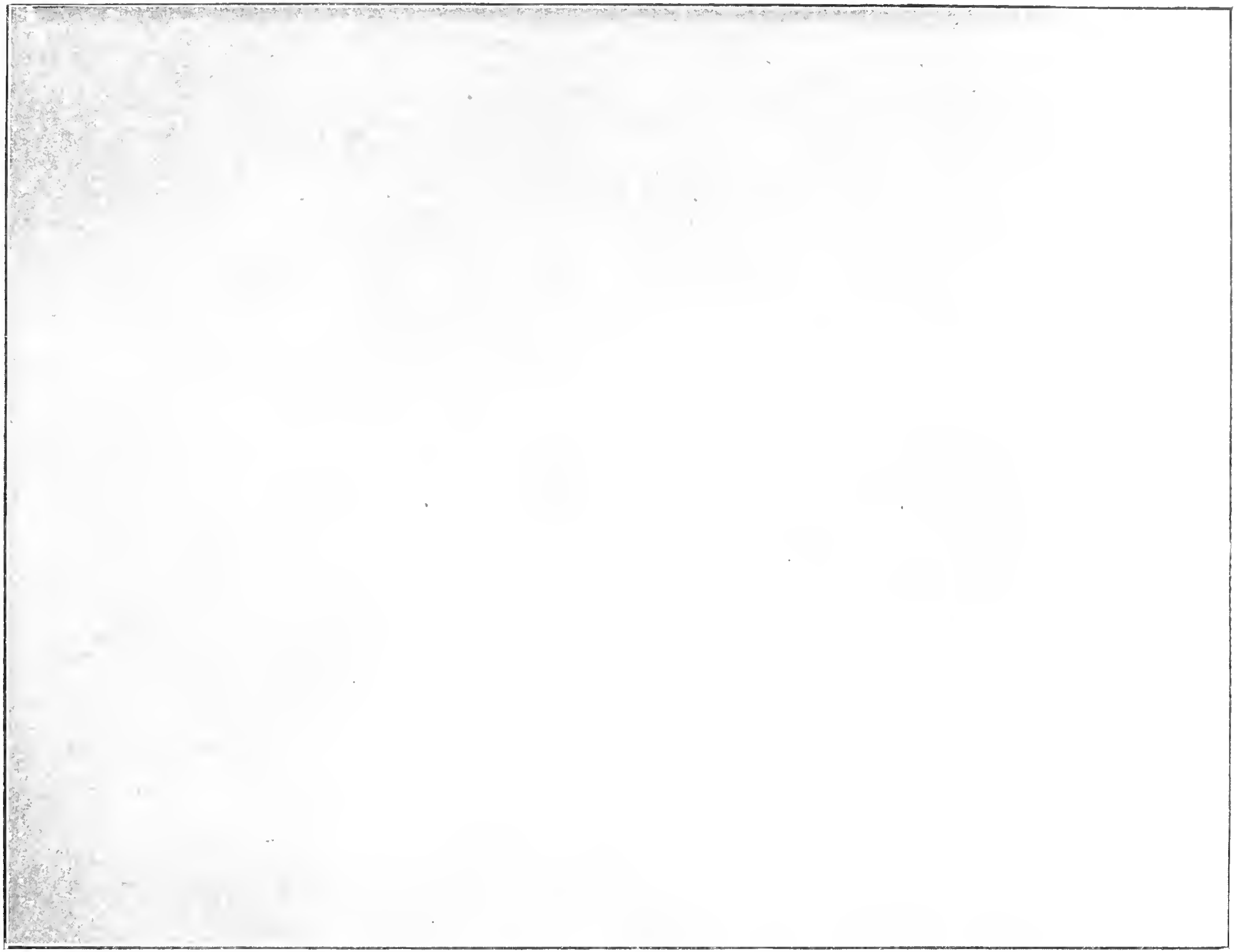
It is a matter of constant experience amongst engineers that parts of machinery break down after having worked satisfactorily, and apparently with safety for months, or it may be for years—ten, fifteen, or even twenty years. The cause of such breakages was long a mystery, but is so no more; they are the result of *fatigue*. We take advantage of this principle when we break a piece of wire; we bend it backwards and forwards until rupture takes place—from *fatigue*.

In the metals there is a point in their resistance to pulling, bending, or crushing, known as the elastic limit, the point at which permanent strain commences. The elastic limit of iron or mild steel, for example, in their normal condition, is reached, roughly speaking, when about half the breaking load is applied. If the stresses brought to bear upon a piece of metal are within this limit it will sustain these stresses without injury, however long they may be applied. If the stresses exceed the elastic limit, in however small a degree, *fatigue* of the metal will result, and, if they are continued, breakage sooner or later will inevitably take place. To guard against accident from such insidious *fatigue*, it has now become usual, in the best practice, to withdraw permanently from use parts of machinery, such as railway crank and carriage axles, upon the soundness of which the safety of many lives may depend, after they have performed a certain number of revolutions, even although no flaw or sign of injury can be detected.

If, however, metals are strained beyond the elastic limit, but not broken, and if the straining is not continued, the material will recover its elasticity by rest alone. Some years ago, Prof. B. W. Kennedy demonstrated by many experiments the recuperative property of metals after *fatigue*. Bars of iron and steel, strained in a testing machine beyond the elastic limit, and so weakened thereby that if they were tested again the following day they would take permanent set at one-third or less of their former load, would, if allowed to rest for about two years, be found not only to have recovered their original elastic

NORTH

FOLLOWING



PRECEDING

PHOTOGRAPH OF THE η ARGÛS NEBULA.

Taken by Mr. H. C. Russell, Director of the Sydney Observatory, with Astro-Photo-telescope of thirteen inches aperture, and eleven feet three and a half inches focal length. Exposure of five hours forty-three minutes.

Direct Photo Engraving Co., 9, Barnsbury Park, N.

limit of strength, but to have exceeded it, and to have become stronger than before in the direction in which they had been pulled. If the period of rest was materially shortened, the restoration of strength was found to be incomplete.

Now let us consider how far *fatigue* in this technical sense is applicable to muscles as well as to metals. Prof. Michael Foster, in his Cambridge University Rede Lecture last year, pointed out that the muscles in the leg of a frog severed from the body, and caused under electrical stimulus to exert themselves in work until thoroughly *wearied*, to use his own expression, and no longer able to respond to the electrical excitement, will, with rest alone, recover their elasticity and be able to resume work as before. Prof. Foster demonstrated that the weariness was in the muscle and not in the nerve. These severed muscles were cut off from any new supplies of strengthening material, and also from any replenishing of vital force, and yet they recovered tone by rest alone. It is therefore evident that this renewed vigour was due solely to the readjustment or rearrangement of molecules—to their recovery to a state of repose. The worn tissues we know could not be restored, but from the *fatigue* the muscles did recover, and it is therefore clear that the fatigue which we experience in our own bodies must be largely *fatigue* in the technical sense in addition to *weariness* proper, or *worn-ness*. Rest is therefore required, not only to enable wasted tissues to be restored by fresh material from the blood, and by the carrying away of waste material, but also to afford opportunity for the strained molecules to recover a state of repose.

In iron or steel which has been strained, a more rapid restoration of the molecules to a state of repose is effected by heating to redness and cooling slowly. This process is termed annealing, and is regularly adopted to take the *fatigue* out of chains, the strength of which has been taxed, and out of any piece or plate of iron or steel which has been much mauled in getting it to shape. In copper, the same result is accomplished by heating to redness and quenching in water.

If a piece of machinery is of ample strength for its work it does not undergo *fatigue*, and is safe for any length of time if not worn out by friction or by rust. In like manner it is only those parts of our bodies which are too light for their work which become really *fatigued*. If one is accustomed only to very light work, he becomes *fatigued* when he undertakes heavier work. His muscles are unfitted for it, and are consequently strained. In fact, all heavy work is *fatiguing*, because our bodies are only fitted for the average work of the race, and if heavy work were to be done without excessive *fatigue*, special training through many generations would be required. For work only a little above the average, a course of training is necessary. If, as in the case of machinery, the bodies of men and animals were unprovided with a sensitive nervous system to register *fatigue* and demand rest, we should continually be having sprained and ruptured muscles and broken bones. But some of the muscles, such as the heart and the muscles of the chest used in breathing, although in practically continuous action, are yet fairly equal to their work, and unless exercised in an exceptional manner, experience little or no actual *fatigue*. They, however, of course, share in the drain of vital force which accompanies *fatigue* and *weariness* in any part of the body. It has been pointed out that, although the heart appears to work continuously, it really does its work expeditiously, and finds time for a considerable amount of rest between the beats, especially during sleep. The necessity for such rest, however, is apparent, quite apart from any theory of *fatigue* in the technical sense, as the rest is evidently required in which to repair the waste of tissue and of unguent which must continually be going on.

Prof. Foster further showed that if the severed but still palpitating heart of a tortoise were washed with water containing salt, some constituent of its strength would be washed out, and the palpitations would cease, but that on the application of a little lime-water the strength would be restored, and the heart would again commence to beat. Such recovery of tone cannot be due to the addition of living cells such as might take place in the living heart when incorporated in the living body, or the carrying away of waste material, and can only result from change in the muscular tissue, such as is involved in the absorption by the impoverished molecules, through chemical affinity, of their required nourishment. But such absorption is not a property of muscular tissue alone. A similar process takes place when iron becomes converted into steel by the absorption of carbon in the case-hardening process. Strips of iron can also be converted by this process into strips of steel, their strength being about doubled. The iron is simply heated and kept in contact with carbonaceous matter until the absorption is complete.

STAR CLUSTERS IN THE η ARGÛS REGION OF THE MILKY WAY.

By A. C. Ranyard.

The great nebulous stream which stretches across the heavens in the Northern and in the Southern Hemisphere is far from being a uniform ring of nebulosity spangled with stars. When different regions of the Milky Way are examined in detail, they are found to exhibit local peculiarities which are not recognized on a survey of the heavens with the naked eye.

Such differences of nebulosity and stellar condensation seem to indicate that the different parts of this immense cosmical structure are not identical in constitution, or, if we assume that the various chemical elements are uniformly distributed in space, such a want of homogeneity tells a tale of vast differences in the conditions under which the various parts of the galactic system have assumed their present form.

That the Milky Way is far from homogeneous was distinctly recognized by Sir John Herschel during his telescopic survey of the heavens, and now that, with the aid of the camera, we are able to place accurate pictures of different parts of the Milky Way side by side for comparison, the characteristic differences exhibited by different regions of the nebulous stream become still more apparent. In speaking of the η Argûs region of the Milky Way shown in our plate, Sir John Herschel (in the *Cape Observations*, p. 33) described it as composed of stars of larger average magnitude than other parts of the Milky Way, grouped into a series of clusters separated by a number of darker patches and lanes. In other parts of the Milky Way the nebulosity is comparatively uniform; in others, again, it is flocculent, as Sir John Herschel described it, "like clouds passing in a *scud*." The whole of the southern half of the Milky Way appears to be rather more coarse-grained than the northern half, and it is rather more thickly spangled with naked-eye stars.

Such differences of constitution in different directions is alone sufficient to negative the supposition that the Milky Way is the projection on the heavens of a stratum of stellar condensation, which corresponds, as it were, to a stellar ecliptic plane in which the sun and the majority of the stars are moving. If we were looking through a vista of stars which extended to a great depth in every part of the Milky Way, such differences of constitution in different directions would indicate a radial distribution of the different types of structure about the sun's place, and would involve the assumption that the sun occupies the centre of the system, and that the material of the universe is arranged symmetrically in sectors about it, an assumption which is abhorrent to modern ideas, and irreconcilable with what we know of the proper motions of the sun and stars.

The assumption that the Milky Way corresponds to a stratum of stars also involves other difficulties, for we must account for the fact that the galactic stream of nebulosity and thickly clustered stars is split into two streams through half of its course round the heavens, and also for the fact that the main streams are again divided and branched. If we hold to the assumption that these streams and branches correspond to a stratum of considerable thickness in a direction radial to the sun's place, the form of the galactic system becomes very complicated. It is evidently altogether simpler to assume that the streams have a thickness which does not differ greatly from their apparent breadth.

The photographic evidence which we now possess does not indicate that the streams have the definitely defined boundaries which they were thought to possess by Mr. Proctor and the old school of map makers, who had to rely chiefly on drawings made with the naked eye. If the Milky Way pictures which have been published in Knowledge are examined, they will be found to show no very definite outlines of the galactic streams, and no clearly recognizable central core, dark lanes or streams of stars running parallel with the axis of the galactic stream. In our second plate, reproduced from a photograph of the region about the η Argûs nebula taken by Mr. Russell with a large camera, the general axis of the Milky Way stream runs horrizontally across the page, but there is no marked condensation of stars or nebulosity at the centre of the stream, and the curiously contorted stream lines of stars which are recognizable seem to be inclined at all angles to the axis of the great stream of the Milky Way.

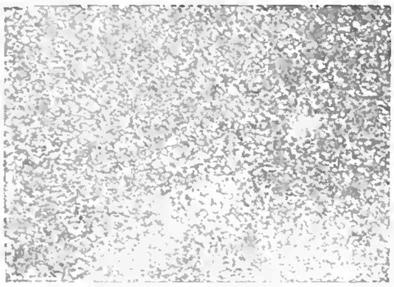


Fig. 1.—Cluster with radiating streams of Stars on the left or following side of the η Argûs Nebula.

There can be no doubt about the general parallelism of arrangement over the heavens of certain classes of objects with respect to the Milky Way; thus the smaller nebulæ are grouped around the galactic poles, and there is a marked absence of them in the neighbourhood of the Milky Way. The larger nebulæ and clusters, on the other hand, are intimately associated with the distribution of the lucid matter and stars of the Milky Way. The aggregation of star clusters upon the Milky Way, especially along its central region, is very strikingly shown in the map published by Mr. Proctor and Mr. Waters in the *Monthly Notices* of the Royal Astronomical Society for August, 1873. The stars exhibiting a bright line spectrum are also distributed along the central axis of the Milky Way; and it has long been known that the brighter stars all over the heavens show a general arrangement with respect to the Milky Way, and a general tendency to cluster towards it, so that they, or a large proportion of them, must be in some way connected with the Milky Way system.* It is evident, therefore, that a large proportion of the matter which our sense of sight reveals to us is controlled by, or at all events is symmetrically arranged with respect to, matter distributed along the axis of the Milky Way.

In the photograph of the region we have before us, we have an opportunity of studying clusters and streams of stars which probably are actually as well as apparently in close proximity to the axis of symmetry around which the visible universe, or a large part of it, is symmetrically arranged, and we naturally look for evidence of condensation along the central axis, or for some evidence indicating motion around the central axis, but we look in vain.

In the star clusters which we are able to study in various parts of the heavens, a central condensation is not always to be detected. Thus the Pleiades and Hyades hardly show any evidence of condensation towards a centre; the clusters in the sword hand of Perseus may be taken as an intermediate type in which there is partial condensation or

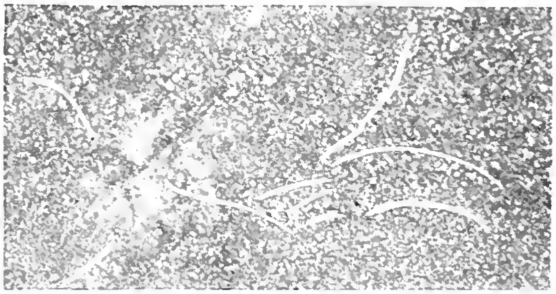


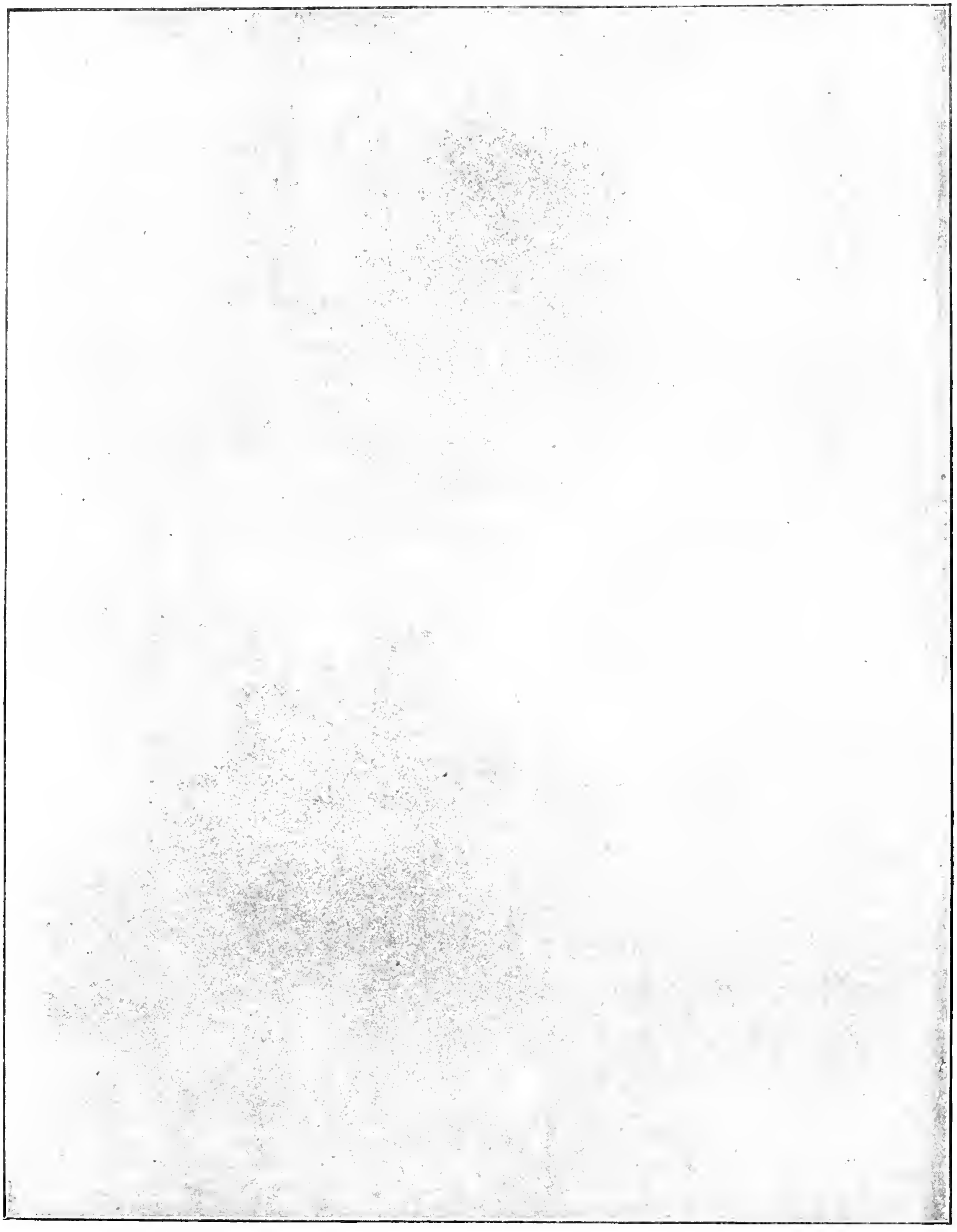
Fig. 2.—The η Argûs Nebula with radiating Star Streams, the position of which has been roughly indicated by scratches on the block.

crowding towards a centre, and at the other end of the scale we have clusters like that shown in Fig. 1, or like the still more centralized cluster in Hercules, photographs of which were given in the May and June numbers of Knowledge for last year (1893.)

In the cluster shown in Fig. 1 and in the Hercules cluster, as well as in the photographs of all similarly condensed clusters which I have had an opportunity of examining, the central mass or group of stars is surrounded by radiating streams of stars which branch in a direction away from the centre of the cluster, and the central mass is associated with dark structures or light-absorbing masses evidently situated between the eye and the nebulous background or haze about the central stars.

The presence of an attracting mass at the centre of a cluster is evidenced not by curves of stars concentric with the centre, but by streams of stars which appear to spring from the centre and break into branches in a direction away from the centre. Similarly we should expect to find the presence of an attracting mass, or attracting masses, arranged along the centre of the Milky Way stream evidenced by chains of stars associated with dark branching structures. If the streams of stars and dark structures were arranged radially with respect to the axis of the Milky Way, we should expect to find the best evidence of the radiating structure at the edges of the stream and not at its centre, where we should look down upon such radiating streams vertically.

* Our own sun, and other swiftly moving stars, may not be so connected.



THE REGION OF THE MILKY WAY ABOUT η ARGÛS, SHOWING NEIGHBOURING CLUSTERS AND ASSOCIATED STAR STREAMS.

From a photograph taken by Mr. H. C. RUSSELL at the Sydney Observatory, with a Dallmeyer six-inch portrait lens of thirty-two inches focus, and an exposure of eight hours. Scale of reproduction 1° = 0·65 inch.

Direct Photo Engraving Co., 9, Barnsbury Park, N.

That we fail to find such a parallel arrangement of diverging streams on either side of the Milky Way seems to indicate that the stream of the Milky Way bears a closer analogy to an open star cluster than to a cluster of the centrally condensed type.

The nebula about η Argûs is a very fine specimen of a nebulous cluster with a central condensation associated with dark structures and radiating streams of stars. Fig. 2 shows several streams of stars diverging from the central mass. (I have indicated the place of some of the most remarkable of these streams by scratches on the block.) The streams are in most cases accompanied by narrow black channels in the general nebulosity, which run parallel to and alongside of the star streams. The reader should examine these on the large plate. The radiating character of the great dark rifts, which entirely cut out the light from some parts of the central region of the cluster, is also well shown in this small scale picture of the nebula.

It is interesting to compare it with the larger photograph of the nebula reproduced in our first plate, as well as with the large scale photographs of this nebular cluster reproduced in the March and April numbers of Knowledge for last year (1893). Sir John Herschel was the first to point out the lines of stars bordering the edges of the great dark rifts in this nebular cluster. There can be no doubt about the intimate connection between the dark structures and lines of stars in this cluster.

The trifid character of the great dark rift which blots out the central regions of the η Argûs nebula may be worth noting in connection with the somewhat similar though fainter trifid rift in the Hercules cluster, which was first observed by the Earl of Rosse, and described by him as "three dark lanes meeting in a point." They are well shown in several protographs of the Hercules cluster which have been taken by the Brothers Henry, Dr. Isaac Roberts, and others. It may be worth noting, also, that there are some dark patches and dark structures in the central parts of the cluster shown in Fig. 1. They are just visible in our plate, but are better seen in the silver print from Mr. Russell's negative.

Fig. 3 shows some curious closed curves of stars forming a meshwork, and a circle of stars surrounding a comparatively dark area. In the light of other phenomena, it seems not improbable that such closed curves of stars, which are found in many parts of the Milky Way, may be due to star clusters, the central parts of which are obliterated by dark structures enveloping and cutting out the light from the central parts of the cluster. Fig. 3 also shows several narrow dark channels in the general nebulosity. Similar dark channels may be traced running over nearly all the brighter regions shown in our second plate. There are also several broader branching dark structures, one of which (immediately to the left or following side of the cluster shown in Fig. 1) evidently extends in front of the cluster, for its branches interfere with some of the streams of stars from the cluster, a fact which renders it probable that this cluster lies at some depth within the star stream of the Milky Way.

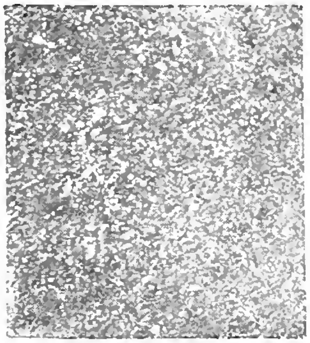


Fig. 3.—Meshwork of Stars to the South of cluster shown in Fig. 1.

LIQUID CHLORINE.

By A. G. Bloxam.

The critical temperature of chlorine gas,* or the temperature below which it must be cooled before it can be liquefied by pressure is about 33° C., so that this gas may be counted among those which are easily converted into liquids. Faraday first produced liquid chlorine, and described its colour as dark greenish-yellow; its specific gravity was afterwards determined to be 1·33, and its boiling-point 33·6 C.

It is very probable, however, that Faraday little dreamed of liquid chlorine as an article of commerce to be bought and sold by the hundredweight. He would, we imagine, have been rather hard put to it to suggest a material for the condensing pump and reservoir; though, in respect to his memory, be it said that a very few experiments could not have failed to furnish him with a solution to the problem.

The difficulties attending the production of chlorine, and the impossibility of transmitting it in the gaseous state, have combined to render chloride of lime in this country, and chloride of soda (*eau de javel*) in France, the only forms in which this indispensable bleaching agent can be put upon the market. When it is remembered that chloride of lime at its best does not contain more than 38 per cent. of "available chlorine," the advantage to be obtained in the matter of freight by transporting pure liquid chlorine instead of bleaching powder will be apparent.

The actual manufacture of liquid chlorine is now being undertaken by a firm of alkali-makers at Salindres, the process being conducted as follows, according to M. Fribourg:—

The condensing pump is provided with a piston of sulphuric acid, as being the packing best fitted to withstand the attack of the chlorine. To render such a piston effective, a pump of peculiar construction is of course essential. This takes the form of a U-shaped tube of cast-iron, lined with lead. The limb of this tube which is to receive the chlorine is partly filled with strong sulphuric acid, whilst the other limb contains petroleum oil, and is provided with an ordinary piston. The upstroke of the piston raises the petroleum, lowers the sulphuric acid, and allows the chlorine to flow into the vacuum thus formed, through a side tube provided with a leaden (?) valve; the downstroke compresses the chlorine through another pipe into the refrigerated receiver, re-entry into the generator being prevented by the leaden valve.

Such is the somewhat bald information connecting the compressing machinery, with which we have at present to remain satisfied. The receivers in which the liquid is transported are wrought-iron or steel cylinders, the necks of which are furnished with T-pieces carrying two bronze valves, the one connected with a tube reaching to the bottom of the receiver and destined to serve for withdrawing the liquid chlorine as such, the other serving for the withdrawal of gaseous chlorine. The cylinder weighs some 225 lbs., and is capable of containing 1 cwt. of liquid chlorine, or nearly 525 cubic feet of the gas. The pressure in the cylinder is 10 atmospheres at 35 C., but they are tested up to 100 atmospheres. The anhydrous chlorine has no action on the iron, bronze, and lead fittings.

It is proposed to sell small cylinders containing 10 lbs. of liquid chlorine for experimental use, so that the chemist may look forward to a day in the near future when his gas-generating flask shall be shelved once and for all, and his oxygen, hydrogen, nitrogen, carbonic acid, sulphurous acid, ammonia, chlorine, and sulphuretted hydrogen be at hand, each in its steel or glass cylinder.

* The article by M. Fribourg on Liquid Chlorine, from which the facts in this article are taken, appeared in a June number of *Bulletin Soc. Chim.*

Notices of Books.

Man the Primeval Savage: his haunts and relics from the hill-tops of Bedfordshire to Blackwall. By Worthington G. Smith. (Stanford, 1894.)—A most interesting and artistically illustrated book, in which the author describes, in "clear understandable words," several of his own researches, throwing light on the history and surroundings of palæolithic man in England. After the glacial epoch, when the boulder-clay was deposited, England seems to have been submerged to a great depth beneath an icy sea, where its surface received deposits of sea organisms; it then gradually rose till England was conjoined with that part of Europe now known as Northern France. The Thames, the Rhine and the Elbe were then tributaries of a great river which emptied itself into the North Sea; and the present English Channel was represented by a river which flowed towards the Atlantic, midway between Cornwall and the north coast of Brittany, and emptied itself into the Atlantic at a point to the west of where the Land's End now is. It is known that the Thames was then broad, and ran at a considerable height above its present level, depositing river gravel, sand and brick-earth, in terraces on the hillsides bordering its course. In these deposits the relics of primeval man first appear. In some localities such relics are comparatively abundant, not on the surface, but imbedded amongst the gravel, sand, or brick-earth, a hundred feet or more above the present river level. Palæolithic man seems to have wandered into what is now Great Britain from the mainland of Europe, and with him came the mammoth, or great hairy elephant, the rhinoceros, the lion, and the hyæna. But few relics of the bony fabric of the palæolithic savage remain, though the stone weapons and tools which he made use of are comparatively common; and Mr. Worthington Smith has found many other objects that he used, even wooden stakes, the points of which he sharpened with his rough stone implements. The book will be found easy reading and very instructive, both from a geological point of view and on account of the anthropological and archæological evidence which Mr. Worthington Smith brings before the reader in a most vivid manner.

Creatures of other Days. By the Rev. H. N. Hutchinson, B.A., F.G.S. (London, Chapman and Hall, 1894).—As Sir W. H. Flower remarks in his preface to this fascinating and interesting book, there must always be much that is mere guesswork in the restoration of the external appearance of extinct animals, known only by their bones and teeth, but Mr. Hutchinson and the accomplished artist, Mr. Smit, who has aided him, have both done their work very conscientiously, and have made use of much information that is not available to the general reader when he endeavours to reconstruct for himself the outward appearance of the ponderous uncouth mammals and enormous reptiles which held possession of the world for so many ages. We shall probably never know much more about the soft parts which have perished than can at the present time be gleaned from the skeletons, footprints, horns, and armour plates preserved in museums, though it is possible that in the future different interpretations may be placed upon obscure indications which are now imperfectly interpreted. The chapter on the horse and its ancestors is of special interest because of the wonderful series of fossil horses brought to light by geologists, and so clearly interpreted by Huxley, Marsh and other authorities. These remains constitute the most complete chain of evolution yet known to the palæontologist. When people inquire for the "missing links," he can point with satisfaction to the bones of ancient horses and show the gradual steps by which the little five-toed ancestor of the Eocene period gradually lost some of its toes, and took on other features till its descendants evolved into the noble animal of the present day. Most of the knowledge brought together by Mr. Hutchinson in this book is the outcome of the scientific work of the present century, and by far the greater part of it belongs to the second half of the century. It is difficult now to realize the ideas with regard to the past history of our globe which prevailed at the beginning of the century, when Cuvier, in 1804, from a study of the bones of the palæotherium, found in the celebrated gypsum quarries of Montmartre, near Paris, demonstrated for the first time to the satisfaction of the scientific world that vertebrated animals inhabited the earth in former times other than those now found upon its surface. The book is a sequel to Mr. Hutchinson's "Extinct Monsters," and will probably be still more popular.

The Economics of Commerce. By H. de B. Gibbins, M.A. (Methuen & Co., London, 1894.)—Mr. Gibbins' little book will be welcomed by those who want a concise and sound little manual on economic questions. At the end of each chapter, which deals with the subjects treated of in a simple as well as forcible manner, Mr. Gibbins gives valuable lists of the books and papers that should be consulted by those who wish to obtain a wider knowledge of the questions dealt with.

The Worlds of Space. By J. E. Gore (Innes & Co., London, 1894).—This is a collection of thirty-three very readable essays and articles on astronomical subjects, which have appeared at various times in *The Newbery House Magazine*, *Knowledge*, *The Gentleman's Magazine*, *The Sun*, and *Indian Engineering*. The publishers have reproduced very creditably many of the illustrations which have appeared in Knowledge.

The Art of Projection, and Complete Magic Lantern Manual. By an Expert (published by E. A. Beckett, London).—A well illustrated little book, giving several practical hints, and suggesting handy methods which will be found useful by lecturers.

The following books have also been received for review: *Our Country's Flowers and how to know them*, by W. J. Gordon, with an introduction by the Rev. George Henslow (Simpkin, Marshall, Hamilton, Kent & Co.); *Our Country's Birds and how to know them*, by W. J. Gordon (Simpkin, Marshall, Hamilton, Kent & Co.); *The Starry Skies: First Lessons on the Sun, Moon and Stars*, by Miss Agnes Giberne (Seeley & Co.); *The Amateur Telescopists' Handbook*, by Frank M. Gibson, Ph.D., LL.B. (Longmans, Green & Co.); *The Bluebook of Amateur Photographers for 1893* (Walter Sprange, London).

Science Notes.

Dr. Max Wolf is to be provided with a new observatory, which will be erected, at the cost of the city of Heidelberg, on the top of the "Gaisberg," about one thousand feet above the present university buildings. The Karlsruhe Observatory and its instruments is to be removed to the same spot, so that there will be a twin observatory on the summit of the "Gaisberg," the meridional department being superintended by Prof. Valentine, and the astrophysical department by Dr. Max Wolf, whose friends are providing him with a new and larger photographic instrument.

Mr. David Morris calls attention to the noteworthy discovery of the seeding of the sugar-cane, which has never before been observed, the cane having been entirely propagated by cuttings for many hundred years. By a curious coincidence a sugar-cane seeded both in Java and in the

East Indies in the same season. Some of the seeds were sent to Barbadoes and there planted, with extraordinary results, hardly any two of the plants produced being alike. Between some the differences were so great as to make them hardly recognizable as the same plant; one in particular was remarkable in having long roots springing from every joint in the stem. It is thought that many new and improved varieties might be produced if these plants could be induced to seed regularly.

Some beautiful photographs in colours of the solar spectrum have been taken by the improved method of M. Lumière. The essential principle of this colour photography is as follows: A sensitive film spread in the usual way over a glass plate is laid upon mercury, film downwards. Upon exposure the light rays fall through the glass upon the film, penetrate the film, and are reflected back through it from the surface of the mercury. The reflected vibrations interfere with the direct waves, so that at intervals the vibrations are neutralized, and at intermediate points they are intensified. At the former levels there will evidently be no photographic effect, while at the latter there will be a maximum. On developing, therefore, the part of the film acted upon by light of any colour, it is found to be, as it were, *stratified*, the strata being at a distance from each other equal to half the wave-length of the light in question; consequently when viewed by reflected light, the same colour is produced by interference.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

Sir,—Will you kindly inform me what part of our planet the Leonids are likely to strike on the 14th November, 1899? Will England be a good vantage ground for seeing them? and will there be a moon?

I am, yours faithfully,

Litcham, Norfolk. A. Collison.

[The rich part of the Leonid stream of meteors must be several hundred thousand miles in diameter, for in 1833 and 1866 the glorious display of meteors lasted for many hours. Since the earth in its orbital motion around the sun only takes about seven minutes to traverse a space equal to its own diameter, it follows that on the above occasions the earth must have been entirely immersed in the rich part of the Leonid stream, and that all parts of the earth's atmosphere on the hemisphere turned towards the Leonid radiant must have been peppered by meteoric particles; the central portions of the hemisphere, no doubt, receiving a greater share of bombardment, area for area, than the regions near to the limb. The Leonid radiant is situated at R.A. 150°, and N. Dec. 23°. The longitude of the part of the earth's northern hemisphere which will meet the greatest number of meteors will depend upon the exact time at which the earth passes through the thickest region of the swarm. The striking character of the display will, no doubt, be diminished by the light of the moon, which will be full on the 18th November, 1899. Those who wish to avoid the chances of November fog and cloud during the display would, no doubt, do well to go to Algeria or Egypt, where the radiant will pass near the zenith.—A. C. Ranyard.

VISIBILITY OF THE DARK LIMB OF VENUS.

To the Editor of Knowledge.

Sir,—In connection with the letter by M. Rudaux, in this month's Knowledge, I should like to be permitted to reiterate what I have on several occasions previously stated, both orally and in print, viz., that whenever Venus has been favourably situated, in or near her inferior conjunction, I have never failed to detect her unilluminated limb—in fact, that it has been so very visible as to have been at once perceived by totally inexperienced observers to whom I have been showing the planet.

But there has been no doubt whatever as to its appearing distinctly darker than the surrounding sky, and my own idea has always been that this had its origin (1) in the fact that it is the refraction of the sun's rays through the atmosphere of the planet, which, as it were, gives a very delicate bright fringe or seeming background to it; and (2) gives thus a complete disc, *very* slightly darker than the sky on which it is projected, as an effect of contrast to the brilliant hair-like illuminated crescent which partly surrounds it.

I do not believe in the unilluminated part of Venus being ever really seen as brighter than the sky, save as a purely optical illusion. I have myself, on several occasions, been able apparently to trace her entire outline thus, in the twilight; the dark portion presenting substantially the appearance of the lumière cendrée, or "old moon in the new moon's arms," with which everyone, astronomer or not, is so familiar. But on occulting the bright limb of the planet by suitable means, the pseudo-dark limb has absolutely vanished; showing conclusively, to my mind, that it had its origin somehow or somewhere in the eyepiece.

Yours faithfully,

Forest Lodge, Maresfield, Uckfield, William Noble.
May 9th, 1894.

COMET I. 1894 (DENNING).—PERIODICAL COMETS.

To the Editor of Knowledge.

Sir,—The very small inclination (6½°) computed for this comet a few days after its discovery induced the belief that it was revolving in an ellipse of short period, and this has now been realized, for M. Schulhof, in *Astronomische Nachrichten*, No. 3227, gives elliptic elements corresponding to a periodic time of 6·715 years. A more exact determination may possibly be made should additional observations be forthcoming, for it is highly probable the comet is still observable in a few of the largest telescopes.

If the computed period of six and three-quarter years is correct, it would appear that the comet is only perceptible to us once in four returns, *i.e.*, every twenty-seven years, for at other times its position is too far from the earth. In 1867, if the orbit were the same as at present, the comet might have been well seen, for the earth was nearly in the same longitude as the comet's perihelion at the time the comet was there, and so the distance separating the two bodies must have been near the minimum. This ought to occur again in February, 1921, as the comet and earth will be on the same side of the sun, and the former will be projected on much the same region of sky as during its recent apparition. It is remarkable that though the comet was favourably visible and at a considerable altitude in December, 1893, January and February, 1894, it was not discovered until the end of March. The fact is significant as proving the search for these bodies is not nearly so rigorous as it might be.

M. Schulhof expresses the belief that additional periodical comets await discovery, and that a promising field for the search will be in that region of the sky opposite to the sun. The experience of recent years fully bears out the opinion of the eminent authority named, for the number of short-period comets added to the list is quite surprising:—

Name.	Perihelion Passage.	Periodic Time. Years.	Perihelion Distance.
1889 V. Brooks	1889, Sep. 30	7·073	1·95023
1889 VI. Swift	1889, Nov. 29	8·534	1·35367
1890 VII. Spitaler	1890, Oct. 26	6·378	1·81791
1892 III Holmes	1892, June 13	6·909	2·13940
1892 V. Barnard	1892, Dec. 11	6·379	1·42911
1894 I. Denning	1894, Feb. 9	6·745	1·21

It will be noted that the perihelion distance of each of these bodies lies considerably outside the earth's orbit. It follows, therefore, that on reaching perihelion at a time when the earth is on the same side of the sun, they are very favourably visible during a considerable part, if not the whole, of the night. An encouraging line of observation is thus indicated to those interested in this branch, for careful sweeping amongst the zodiacal constellations may certainly be expected to reveal further periodical comets belonging to Jupiter's already numerous family.

Bristol, May 22nd, 1894. W. F. DENNING.

To the Editor of KNOWLEDGE.

DEAR SIR,—Prof. Barnard, in his article on "Magnifying Powers," refers to the fact that Saturn will bear the application of higher powers than Jupiter as a "singular peculiarity." I gave what appears to me to be the correct explanation of this matter in the *Journal of the Liverpool Astronomical Society* for February, 1886.

The focal image of any object of sensible diameter very much resembles the beautiful photographic reproductions which you give us in KNOWLEDGE. It is a stippled image, being made up of minute discs; but it differs from the photographs, in that in the focal image the bright points are so close in proportion to their diameter as to overlap. It is exactly as if the image were made up of closely set stars, which with sufficient power exhibit a spurious disc and rings. Any power that raises a disc upon a star will also raise a disc upon every point of a bright object, and this will soften the outlines and detail; but as a star disc is not a uniformly luminous patch, but is brightest in the centre, fading gradually to the first dark interference ring, it follows that with loss of brilliancy less of the spurious disc is intense enough to impress the retina, and a less brilliant star apparently gives a smaller disc. As the planets are less bright than stars, the spurious discs of which their outlines and details consist are smaller, and the less brilliant of two planets will be built up of the smaller discs, or finer stippling, and will stand a higher power before the softening effect which results is manifest. Saturn is less bright than Jupiter, therefore it should theoretically bear a higher power, as it is found to do in practice. Jupiter sends us much more light than a star, but that is because of his larger apparent diameter. His surface brightness is, however, much less than would be derived from an equal area of bright stars, but area for area he is much brighter than Saturn. This, I think, explains why Saturn bears more magnifying than Jupiter.

Yours faithfully,

EDWIN HOLMES.

[If Mr. Holmes is correct, the definition of the details visible upon Jupiter's surface should be improved by the judicious use of a dark wedge.—A. C. RANYARD.]

A BLACK AURORA.

To the Editor of KNOWLEDGE.

SIR,—In connection with your remarks on this phenomenon in the April issue of KNOWLEDGE, I ought perhaps to mention that the haze or cloud-haze in question seemed pretty high up, and appeared to form rapidly in the clear sky before the aurora was seen, as, indeed, often happens. You are probably right in supposing the black rays to be intervals between luminous streamers. I could see no luminous beams, but they might have been feeble or even above the layer of illuminated haze, which was apparently thin. Yours, J. MUNRO.

To the Editor of KNOWLEDGE.

Blackheath.

DEAR SIR,—It may interest your readers to know that a very large and brilliant meteor was observed here on Sunday evening, the 22nd April, at 7.35 P.M., travelling almost due south. The nucleus was extremely bright, and appeared to scintillate, throwing off small jets of flame, which would, I presume, indicate that it was in a state of semi-explosive combustion. No stars being visible at the time—it being still daylight—I cannot say exactly through what constellations it passed, but probably a line drawn from the Great Bear to Leo Major would indicate its path. It burst silently at about the latter point.

Yours faithfully,

F. MONTAGUE JAMES.

THE QUEEN BEE.

To the Editor of KNOWLEDGE.

SIR,—In reading the interesting paper on "Stinging Insects" in last month's KNOWLEDGE, I was much surprised to find the queen of the hive bees (*Apis mellifica*) referred to as being "the mother as well as the ruler of the hive." The latter part of this statement is, I think, quite erroneous; the mother bee can in no sense be called a ruler. She is, during the breeding season, an object of great regard and attention on the part of the workers, and this, together with her long, graceful form—quite unlike that of the little worker or the burly drone—may perhaps have given rise to this poetic fiction. She moves over the combs attended by a retinue of working bees, who offer her food from time to time as she is engaged in depositing her eggs in the cells prepared for their reception. The sole function of the queen is to lay eggs, which, as soon as deposited, are taken charge of by the workers, and are attended to by them through the various stages of development. If the queen, through an accident or old age, ceases to be prolific, she is cast out without mercy, and the workers raise another queen.

The whole of the affairs of the hive are regulated by the worker bees—some being attendant on the queen, some acting as nurse bees to the young brood, some gathering pollen, some building new comb, others gathering propolis for sealing all the chinks and crannies of the hive, some guarding the entrance to the hive against the predatory attacks of stocks in less flourishing circumstances, whilst others (and by far the greatest number) are gathering honey for the benefit of the whole community.

But though all this is done without confusion, and in the utmost order and harmony, there is, as far as I am aware, no evidence of one having more authority than another. A beehive is almost an ideal commune, where the daily and nightly labours are distributed and transacted with the most beautiful regularity and precision, each doing its own portion with a restless, untiring zeal which is marvellous.

But by what mysterious means of inter-communication, or by what strange instinct all this wonderful work is arranged and carried out—much of it in the darkness of the hive—so rapidly, with unerring precision, and with the most perfect harmony, who can tell?

Yours truly,

Lancaster, April 16th, 1894. J. T. DENHAM.

[No doubt the queen's chief function is the laying of eggs, and, in fact, this was the point intended to be emphasized in the passage in question. But as she is evidently the central figure in the hive, the prosperity of which depends upon her productiveness, and as her presence seems to be necessary for the orderly correlation of the various duties of the workers, it would appear to be somewhat speculative and hazardous to deny her any sort of regulative influence, such as is implied by the generally used term "queen." But a moment's consideration must satisfy anyone that comparisons between the beehive community and human communities, as they ordinarily exist, or as Mr. Denham supposes that they might exist, are probably equally far from the truth.—E. A. Butler.]

THE VENOM OF THE COBRA.

By C. A. Mitchell, B.A.Oxon.

Among the most potent causes of death in India must be reckoned the bite of the cobra-di-capello (*Naja tripudians*), the more so as the reputed native remedies, natural and artificial, all fail as antidotes to the venom when once introduced into the system.

Experiments made by various chemists have determined the chemical nature of the poison, though, owing to the difficulty and danger of procuring sufficient for the purpose, there are few quantitative results published.

To procure the poison the reptile, which is firmly held by a native snake-catcher or strapped down by the neck, is made to strike repeatedly at a large leaf, on which the venom from the fangs collects.

As first obtained it is a frothy liquid, varying in colour from pale amber to yellow, and according to Dr. Wall occasionally colourless. Its specific gravity as compared with water is 1·058. It may be kept in a stoppered bottle for some months without material change, but eventually decomposes, giving off carbonic acid gas, and losing its toxic properties. Bacteria are found in abundance in the fresh liquid venom, as well as particles of epithelial matter, the latter being more noticeable after the liquid has been kept for a short time. The bacteria are derived from the saliva of the snake, and have been proved to add no additional virulence to the poison. When allowed to dry in the air it leaves a yellowish film, which breaks up into yellow granules of crystalline appearance, resembling particles of gum-arabic. This residue preserves all the venomous properties of the fresh poison unchanged for years, as has been proved by experiments made on animals with venom that had been kept for over twenty years. Solution in glycerine is also found to be effective in preserving the toxic properties. The yellow granules are said to possess a sharp acrid smell, though this was not noticeable in some which the writer examined, which had been kept for several years. On heating this old sample in a platinum basin it swelled up into a coke-like mass, giving off ammoniacal vapours, and on ignition left a slight ash in which sodium chloride was detected. The ash amounted to 1·5 per cent., calculated on the weight of the dried poison.

It has often been asserted that snake-venom contains an animal alkaloid similar to the ptomaines found in putrefied animal matter, but this view is not supported by the majority of chemists. Though in some cases precipitates may be obtained with the ordinary test reagents, they are not distinctly crystalline as in the case of the alkaloids.

There is a class of complex substances containing a large percentage of nitrogen, and found chiefly in the animal world, to which the name of *proteids* or *albuminoid* bodies is given. Egg albumen, which constitutes nearly the whole of the solids in the white of the egg, may be taken as a type of the proteid bodies, the average percentage composition of which is—

Oxygen, 21 to 23·5.	Carbon, 51·5 to 54·5.
Hydrogen, 7.	Sulphur, 3 to 2.
Nitrogen, 15 to 17.	Ash, variable.

When exposed to the action of acids, either mineral or such as are contained in the gastric juice, any animal albumen is converted into a substance known as *peptone*, which, while of similar composition, differs in several respects in its behaviour towards reagents, and especially in its power of diffusing through a membrane such as parchment. There is also another albuminoid substance very similar to egg albumen in its chemical composition, but differing from it in being insoluble in pure water, which is known as *globulin*.

The complex nature of cobra venom has been noticed by many investigators, but Prof. Armstrong was the first to make a quantitative analysis of a small quantity of the liquid venom, sent to him by Sir J. Fayrer. He found that it left, on evaporation, a residue amounting to 28·28 per cent. of the weight taken, and that this residue, on analysis, gave the following percentage composition, after deducting the amount of ash :—

Carbon	52·87
Hydrogen	7·05
Nitrogen	18·29
Oxygen and Sulphur ...	21·33
	99·54

This closely corresponds to the general composition of albumens, but contains more nitrogen than egg albumen.

Prof. Weir Mitchell, in a long series of experiments, proved that there were two albuminoid bodies in the venom. By means of a parchment membrane floated on running water, on which the venom was placed, he succeeded in separating the two. The coagulable proteids were left on the membrane, while the dialyzable matter passed through. The substance deposited gave all the reactions of *globulin*. In the filtrate containing what had passed through the membrane was found a substance which could be precipitated but not coagulated by absolute alcohol, which property, among others, entitled it to be placed among the peptones. He thus identified two classes of proteids :—

1. A *globulin*—Coagulable and insoluble in pure water.
2. A *peptone*—Incoagulable by *brief* boiling and soluble in pure water.

There was one noticeable peculiarity about this venom peptone: although it did not coagulate at first on boiling, yet after some time it became coagulated, being apparently converted into a globulin. In this respect it differed from ordinary peptones. Careful experiments on animals proved that it was in the peptone that the toxic principle of the venom lay. Pedler succeeded in obtaining a yellow semi-crystalline precipitate with this poisonous principle by platinic chloride, which differed, however, from that obtained with alkaloids in being less crystalline; and a similar result has been obtained by the present writer.

Owing to the similarity between the albuminoid substances in the venom and those in the blood, there is not much chance of finding an antidote which will neutralize the former without also injuring the latter. It has been found that the strength of the poison is not impaired by being heated to 79° C., and that death occurs as rapidly as when the unheated poison is used, but Fayrer and Wall noted that prolonged boiling completely destroyed its power. Alcohol, often spoken of as an antidote, has been shown to have absolutely no effect on the venom, and is only of use as a general stimulant to the system after a bite from a serpent. Mineral acids and the caustic alkalies neutralize it, but alum, though it delays, does not prevent death. The most active neutralizing agents yet known are potassium permanganate, ferric chloride, and iodine, especially the first; but owing to the rapidity with which the venom circulates through the system they could only be of local use, and would be of little avail once the poison were absorbed.

Taken internally, the poison is as a general rule harmless, unless there be some abrasion by which it can get into the blood. The same applies also to its action on other mucous surfaces. Fayrer mentions a case where one of his assistants accidentally got some of the venom into his eye, with no worse result than temporary inflammation. Its primary action on the respiratory system is first to cause an increase in the number of respirations and then to diminish their number. Under its influence the blood corpuscles lose their shape and become fused together and the blood becomes incoagulable. Its action on the nervous system is, comparatively speaking, unimportant, and death occurs from paralysis of the respiratory centres or from inability of the blood corpuscles to do their work. The terrible local changes which occur after death from the bite of a rattlesnake are much less noticeable in the case of the cobra.

Among the most interesting properties of the venom is its action on other snakes. Sir Joseph Fayrer on more than one occasion caused a cobra to bite its own tail, which it would do very readily, but beyond the local wound it suffered no ill consequences. Cobras were found also to be immune against the bite of other cobras, but non-venomous snakes succumbed as rapidly as warm-blooded animals. The Indian viper, the *Daboia*, whose bite is as dreaded as that of the cobra, was found to be proof against the venom, and other species of poisonous snakes more or less so, apparently according to the strength of their own venom. It would thus seem that there is in the blood of the more poisonous snakes some principle which renders the venom innocuous, and in this direction may lie the possible discovery of an antidote.

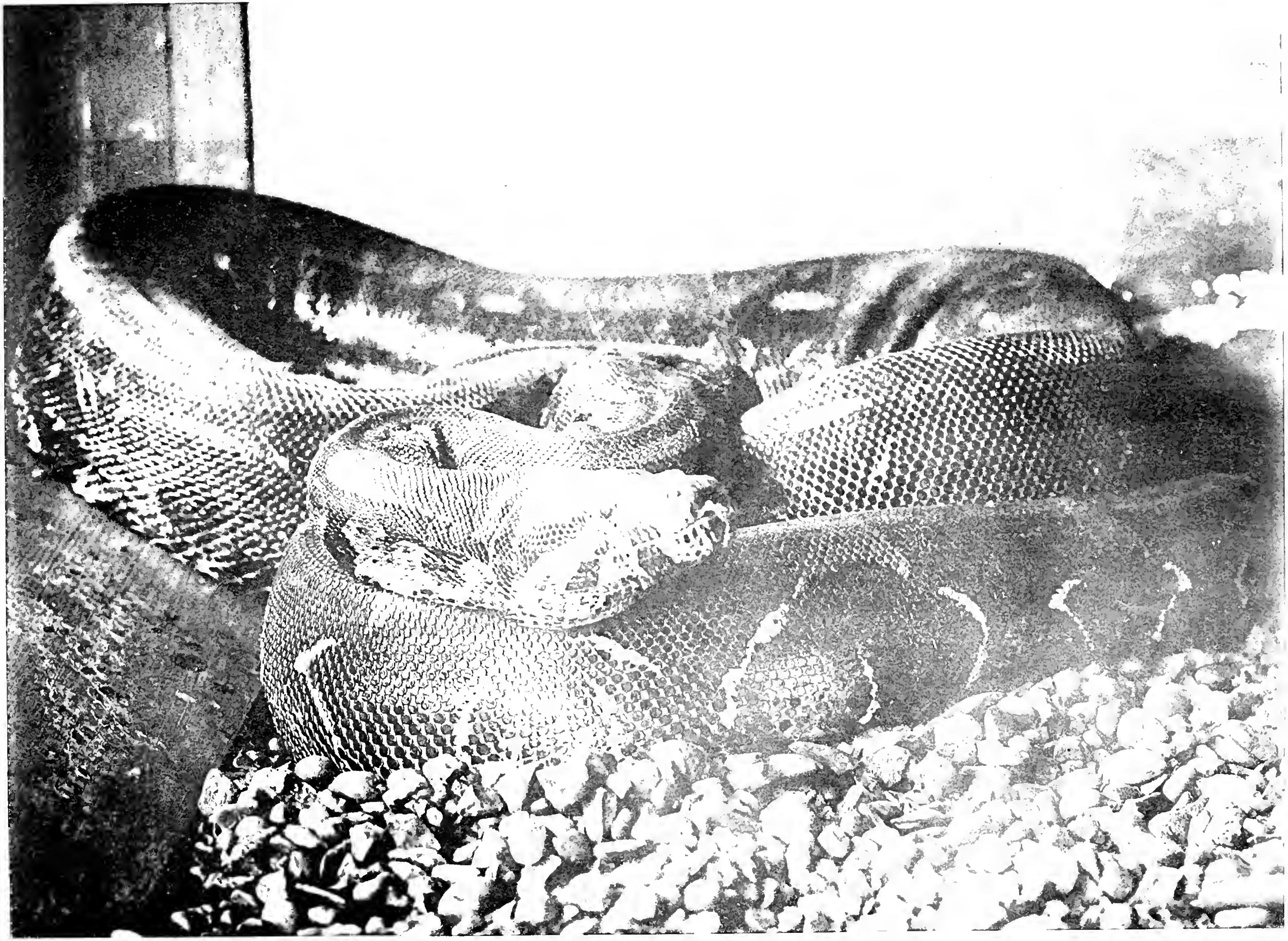
"RIB-WALKERS."

By R. Lydekker, B.A.Cantab.

To say nothing of invertebrates, among which the range of diversity is still more extensive, a great difference prevails among vertebrate animals in regard to the mode of progression, although movements of this nature are nearly always effected by means of the limbs. Ordinary mammals and reptiles, for instance, either walk or run by using both pairs of limbs; but in birds and kangaroos, as well as in some of the extinct dinosaurian reptiles, progression on land is effected by the hinder pair alone, aided in some cases by the tail. Jerboas and gerbils, as well as some other rodent mammals, have likewise taken to a saltatorial mode of progression; while frogs mainly progress by means of leaps effected by the elongated hind legs. Other mammals, again, are capable of making long flying leaps by the aid of parachute-like expansions of skin along the flanks and limbs; while the bats and most birds, together with the extinct pterodactyles, alone have the fore limbs so modified as to subserve the purpose of true flight. Then we may have both pairs of limbs converted into paddle-like flippers for swimming, as in the seals among mammals, and turtles in the reptilian class; while in other cases, as in the whales and porpoises, only the fore limbs are thus modified, while the hinder pair are aborted, the tail being also adapted to act both as a kind of screw-propeller and as a rudder. In fishes, on the other hand—in which, from its vertical position, the tail is a decidedly more rudder-like organ—both pairs of limbs are used in swimming, and are aided by various paired and unpaired fins, which have no connection with the latter. Aquatic birds which float solely on the surface of the water employ their hind limbs only in swimming, although when diving many of them use their wings to a greater or less degree; but in the penguins the wings have become modified into paddles pure and simple, and are only used in diving. Frogs seem to be almost, if not quite, peculiar in using only the hind pair of limbs when swimming.

In all these instances, it will be noticed, progression is effected either entirely or mainly by one or both pairs of limbs; but there are certain groups of vertebrates in which limbs have more or less completely disappeared, and where other means of progression have consequently to be employed. Among terrestrial types, the only completely, or even practically, limbless forms are the various groups of snakes, together with certain snake-like creatures, such as the familiar blind-worm and some of the skinks, which, although ordinarily denominated snakes, are in reality nothing more than specially modified lizards, which have assumed a snake-like form.

Although these snake-like lizards creep merely by a kind of wriggling motion along the ground, the majority of real snakes progress by means of a special modification of structure, which is, perhaps, the most unique and peculiar that could well have been hit upon by creatures hampered by having to adhere to the vertebrate type of structure. Snakes in general may be in fact not inappropriately termed "rib-walkers," since their ribs are the main instruments of progression; and in thus making use of the whole length of their body and tail for this purpose they may be compared to worms and certain other symmetrically segmented invertebrates, where every joint of the body takes its share in this function. As most of us are probably aware, in mammals true ribs are comparatively few in number, and are limited to a portion of the region of the trunk. If, however, we examine the skeleton of a snake, we shall observe, in the first place, that the number of joints, or vertebræ, in the backbone is exceedingly large, and that each of these joints, from the head to a considerable distance down the tail, is provided with a pair of curved and relatively long ribs, upon the extremities of which the skeleton rests. While comparatively short in the region of the neck, these ribs gradually increase in length towards the anterior part of the trunk, and thence diminish by almost imperceptible degrees as the tail is approached. As showing the extraordinary amount of elasticity of which the vertebrate type of organization is capable without the loss of its main distinctive features, we may contrast the skeleton of a snake with that of a frog, when we shall find that whereas the one attains the maximum development in the way of ribs, the other has these structures reduced to a minimum. In fact, for all practical purposes, a frog may be described as a ribless creature; the ribs being represented by small rudimentary bones attached to the extremities of long horizontal processes standing out from the sides of the vertebræ. And it may be incidentally mentioned that in consequence of this practical absence of ribs, a frog cannot

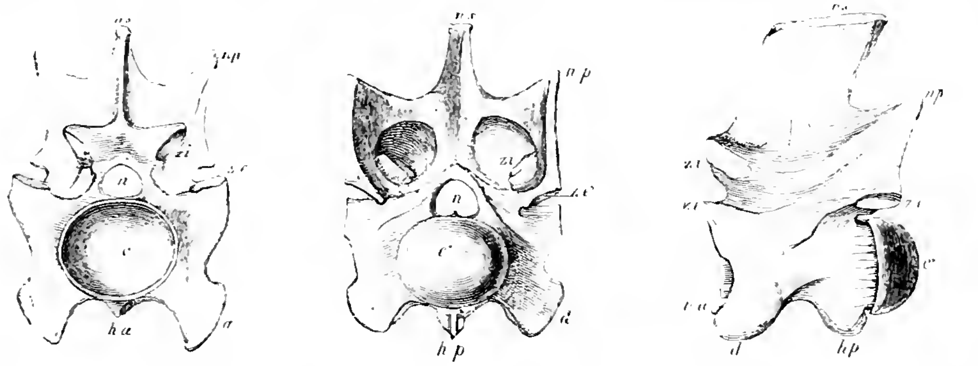


LARGE RETICULATED PYTHON FROM MALACCA (*Python reticulatus*).

Reproduced from a photograph taken inside its cage at the Zoological Gardens, Regent's Park. The forked tongue is withdrawn within the mouth, showing the notch in the upper lip through which the tongue protrudes. This Python is thirty years of age, is over twenty feet in length, and is twenty inches in circumference round its thickest part. It was presented to the Society in August, 1876, and is fed once a week with ducks and rabbits, which it kills by strangulation.

breathe in the ordinary way by expanding and contracting its chest, and therefore has to swallow air by taking in a gulp, closing the mouth, and then forcing it into the lungs.

Regarding, then, a serpent as essentially a "rib-walker," we have to see, in the first place, how this most peculiar and original mode of progression is effected; while in the latter portion of our article we must point out the chief family groups into which serpents are divided, and likewise indicate why naturalists will run contrary to popular opinion in telling us that a blind-worm is a lizard and not a snake.



Front, Back, and Left Side of the Vertebra of a Snake.

In a creature that has taken to a mode of progression so peculiar as is that of a snake, the first essential is a combination of strength with extreme flexibility in the backbone, and this is attained by the development of an extremely complicated system of articulation between its constituent vertebræ. In ordinary terrestrial vertebrates the vertebræ are connected with one another by two main articulations. In the first place, the centrum or body of every vertebra has a surface at each end for articulation with the adjacent members of the series, and when firmness and strength is the main object, as in the back of mammals, these two surfaces are nearly flat; when, however, greater mobility is required, as in the neck of the more specialized hoofed mammals, this is effected by means of a ball-and-socket joint; and in the snakes this ball-and-socket arrangement extends throughout the whole series, the cup (*c* of the foregoing figure) being in front, and the ball (*c'*) behind. In addition to this articulation, vertebræ are ordinarily connected by what are termed zygapophyses, or flattened facets attached to the arch or upper half of the structure—the anterior zygapophysis (*ze*) always looking upwards, while the hinder one (*ze'*) faces downwards. For all ordinary purposes these two systems of articulation are amply sufficient; but snakes required something more, and they have accordingly developed an additional pair. In the upper part of the middle figure of our illustration there will be seen a pair of deep pits (*zi*) on the hinder aspect of the arch of the vertebra, which have received the somewhat long name of zygantra, and show a flattened articular facet directed upwards and inwards on the lower half of their outer sides. Into each of these pits is received a somewhat wedge-shaped projection from the front of the arch of the adjacent vertebra (marked *zi* in the left-hand figure of our illustration), and termed the zygosphene, the flattened articular facet of which looks downwards and outwards. Such a triple system of articulation produces, of course, extreme flexibility of the backbone, without any danger of dislocation of the joints, as any of our readers may ascertain for themselves by handling the articulated skeleton of a snake. It might be thought that this remarkable system of articulation was peculiar to snakes, and if it were so we should be able to define that group of animals much more neatly and definitely than we are at present able to do. Unfortunately, however, for the systematist, the iguanas among living lizards, together with certain members of some extinct groups of reptiles, have precisely similar vertebral articulations, which are due to that tiresome parallelism in development alluded to so frequently in some of our earlier articles. We believe, however, we are right in saying that none of the snake-like lizards possess these additional articulations to the vertebræ.

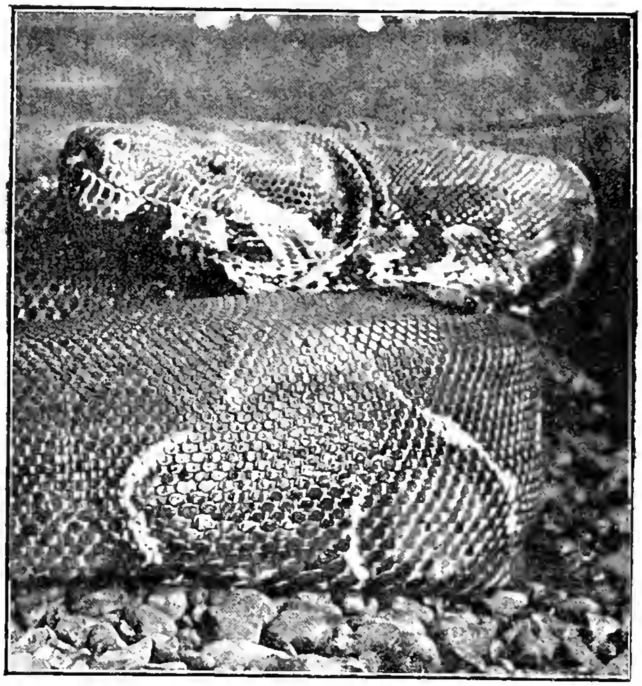
Before leaving the subject of the backbone, it must be added that the ribs, which are single-headed, are attached to a facet (*d*) on the lower part of the front end of each side of the body of the vertebra; such facets being usually situated on the body itself, although in the figured specimen, which belongs to an extinct genus, they have distinct pedicles. Although this mode of rib-connection is common to lizards and serpents, it is precisely that best adapted to afford the greatest amount of motion to "rib-walkers." It may be added that in all snakes the breast-bone and bones of the shoulder, like those of the fore limb, are completely wanting; while there are, at most, only vestiges of those of the pelvis and hind limbs.

Dismissing the interesting subject of the skeleton with these few remarks, we come to the consideration of how the reptiles under consideration walk. Now, if we examine any ordinary snake, we shall find that the under surface is covered with a series of oblong transverse shields, overlapping one another by their hinder edges, and in the body extending right across the lower surface, although in the tail they very frequently form a double series. Each of these shields corresponds to a pair of ribs, and all are of the utmost importance in terrestrial locomotion. On this point Dr. Günther writes that when any portion of the body of a snake "has found some projection on the ground which affords it a point of support, the ribs, alternately of one and the other side, are drawn more closely together, thereby producing alternate bends of the body on the corresponding side. The hinder portion of the body being drawn after, some part of it finds another support on the rough ground or a projection; and the anterior bends being stretched in a straight line, the front part of the body is propelled in consequence. During this peculiar kind of locomotion the numerous hard shields of the belly are of great advantage, as, by means of their free edges, they are enabled to catch the smallest projections on the ground, which may be used as points of support." It follows from this that on a perfectly smooth surface, like a sheet of glass, a snake is utterly unable to move. It may be added that these reptiles can only progress by undulating the body in a horizontal direction; and that the pictures sometimes seen of snakes with the body thrown into folds in a vertical plane are pure evolutions of the artistic imagination.

That the large inferior shields of snakes have been specially developed for the needs of this peculiar mode of progression, there can be no doubt; but, although they are absent in the snake-like lizards, they are by no means characteristic of the group as a whole. A further specialization seems, indeed, to have taken place in certain members of the group, which have adopted a mode of life in which these organs would be useless. An excellent instance of this is afforded by the venomous sea-snakes of the warmer oceans, the typical members of which are purely pelagic in their habits, and have the under surface of the body covered either with small scales, or retaining mere vestiges of the large shields. That this departure from the ordinary type is a specialized character is, fortunately, demonstrated by one genus of these serpents (*Platurus*), the members of which are partly terrestrial in their habits, and consequently retain the large inferior shields. All the burrowing blind snakes, so widely distributed over the warmer regions of the globe, together with members of several groups which have taken to a purely arboreal life, have likewise lost the large inferior shields, as being no longer useful.

In the pre-Darwinian days of natural history it was doubtless considered that snakes were created as such, and that they were always "rib-walkers." The modern naturalist, however, knows better than this, since some of the members of the group, fortunately, retain vestiges which enable him to say with confidence that serpents are the highly modified descendants of four-legged reptiles, more or less nearly akin to lizards. Among the better-known members of the group, pythons and boa-constrictors, collectively constituting the family *Boidæ*, are those alone retaining such vestiges, which externally take the form of a pair of claw-like spurs situated on the lower surface near the junction of the body with the tail. If, moreover, we dissect such a snake, it will be found that traces of the three bones of the pelvis are imbedded among the muscles, although now of no functional importance whatever. And if such rudiments are not to be regarded as indicative of the descent of snakes from reptiles furnished with limbs, we may as well give up trying to apply philosophical reasoning in zoology.

Putting aside the little-known group of blind snakes, the pythons and boas are indeed the most primitive of all serpents, and the more typical members of the group are distinguished by their habit of destroying their prey by "constriction." All pythons and boas, it is perhaps well to observe, are non-venomous, and the family includes by far the largest representatives of the entire ophidian group. The excellent photographs with which this article is illustrated were taken by Mr. Banyard inside the cage of the python, at the Zoological Gardens, Regent's Park. Formerly it was attempted to arrange all the other and more specialized snakes, in which traces of the hind limbs have completely vanished, into families, according as to whether they were innocuous or venomous; but modern research has shown that such divisions are purely artificial, and that the development of poison-bearing organs has originated independently in several distinct groups, thus affording another excellent example of parallelism. There is, however, one family of snakes (*Viperidæ*), including the ordinary vipers and rattle-snakes, all the members of which are venomous, and may be distinguished from the members of the other great family by the circumstance that when the jaws are opened the maxillary bones, in which are implanted the pair of long tubular poison-fangs, become erected at right angles to the hinder part, thus giving to the teeth the most powerful mode of action possible. The other great family of limbless snakes (*Colubridæ*) comprises both harmless and poisonous forms, and is distinguished from the viper family by the absence of the power of erecting the maxillary bones. These snakes, which include by far the greater majority of the entire group, are remarkable not only for the extraordinary adaptability to different modes of life they display—some of them being terrestrial, others arboreal, others fluviatile, and others marine—but still more for the circumstance that members belonging to totally different sections of the family have become independently modified to similar modes of life, and have thus acquired an external similarity which effectually masks their structural differences. Their true relationships appear to be best revealed by the structure and arrangement of the teeth; and on this evidence they are divided into three parallel sections, each of which shows a very similar series of adaptations to particular modes of life. In the first great section, or



Side view of the Head of the Python at the Zoological Gardens. The fold beneath the head and neck is more than six inches thick.

solid-toothed colubrines, the whole of the teeth are solid and frequently subequal in size; and it is, therefore, evident that all the members of the group (in which is included the common English ringed-snake), are perfectly harmless. In a second section, which may be termed the hind-fanged colubrines, one or more of the hinder upper teeth are enlarged and grooved; and it would appear that the majority of the group are more or less poisonous. Among these snakes are the well-known arboreal whip-snakes (*Dryophis*) and sand-snakes (*Psammophis*). The front-fanged colubrines, which are far more deadly, differ from the last in having the front teeth in the maxillary bones enlarged and either grooved or tubular for the purpose of carrying the venom from the poison-gland to the wound. This section includes the dreaded Indian crait, as well as the cobras of Asia and Africa, both of which are to the full as deadly as any of the vipers; while the sea-snakes also belong to it. That the front-fanged and hind-fanged colubrines have acquired their venomous properties entirely independent of one another is perfectly evident from the different position of the teeth modified for this purpose; and the wide structural difference between the vipers and colubrines shows that the former have no sort of connection with either of the sections of the latter. We have, accordingly, clear evidence of the development of poison-glands and fangs in three totally independent instances, which is perhaps the most striking example of parallelism that can be adduced. The extraordinary feature, to our mind, in the case is the eventual general similarity of structure which has been attained in the three instances—a similarity which appears difficult of explanation on the ordinary theories of evolution.

Coming to the last section of our subject, we have to indicate how snakes may be distinguished from lizards, and to add a few words as to the relations of the two groups. We have seen that neither the structure of the vertebræ nor the presence or absence of shields on the lower surface of the body will suffice to distinguish between the two groups; and it may be added that neither will the forked and retractile tongues of the snakes serve our purpose, since a similar structure is possessed by certain lizards. It has, however, been already mentioned that none of the snake-like limbless lizards have the additional articular surfaces characterizing the vertebræ of snakes; and to this it may be added that none of the former have the tongue capable of being retracted into a sheath at its base, in the manner distinctive of snakes. An infallible, though not very important, point of distinction between snakes and lizards is to be found in the circumstance that whereas in the latter the two branches of the lower jaw are always united by suture, in the former the bond of union is a ligamentous one; and there are also certain other points of distinction, into the consideration of which it will be unnecessary to enter.

The structural differences in regard to the vertebræ and tongue, coupled with the circumstance that there is more than a single group of lizards, render it pretty certain that snakes are not the final result of the modification of ordinary lizards into snake-like forms. The snake-like lizards may accordingly be regarded as a kind of bad attempt to evolve a snake, since these creatures are by no means numerous, and have not thriven and multiplied after the manner of the true snakes. Whether, indeed, snakes as such have taken origin from reptiles which would be included by zoologists among lizards is more than doubtful, although palæontological evidence is, unfortunately, very imperfect on this point. Both groups are, however, of considerable antiquity, true snakes of large size, and apparently as specialized as existing forms, dating from the London clay, while bones which have been referred to lizards occur in the Cambridge greensand. Possibly the nearest approach to the common ancestral form is a certain small lizard-like reptile from the English chalk known as *Dolichosaurus*, differing from existing lizards by the greater number of vertebræ in the neck and the more simple structure of the feet, and having snake-like vertebræ. Should this be the case, it would seem that ordinary lizards have lost the additional articulations characterizing the vertebræ of serpents.

THE WOOD-PIGEON.

By Harry F. Witherby.

THE wood-pigeon (*Columba palumbus*) is the largest representative of the genus *Columba* to be found in Europe.

It occurs plentifully throughout England and Scotland, and remains in the wooded and sheltered districts all the year round, but is only a summer visitor in the more northern parts of the kingdom. In winter wood-pigeons congregate, and go about the country in flocks, which are no doubt largely augmented by numbers of birds which come over from the Continent.

The wood-pigeon is sometimes called the ring dove, on account of the white feathers which form a partial ring round its neck. It is naturally a very shy and wary bird, and it requires careful stalking to get a shot at one in the daytime; but they may be easily shot in the evening, when coming home to roost in the trees. It is sought after on account of its destructiveness to crops, as well as on account of its flesh, which is very good eating as a rule; but at the time of the year when turnip-tops form its chief food, its flesh has a disagreeable flavour.

Although a very shy bird, the ring dove may often be seen in the London parks, especially in St. James's Park, where it even breeds. In the summer months I have seen as many as ten together, feeding on the piece of grass under Lord Beaconsfield's statue in Parliament Square, opposite Westminster Abbey. Here they seem quite at home, and take no notice of the people or traffic, and although there is always a large flock of dovecot pigeons close to them, the two species keep quite separate from each other. The ring dove becomes comparatively bold in gardens, and destroys a large amount of fruit in the summer months. It is especially fond of currants, pears being also a favourite dainty; but its ordinary food consists of buds and young green leaves, beech-mast, acorns, and grains of various kinds. Wood-pigeons swallow their food whole, and as many as ten perfect acorns have been found in the crop of a single specimen. When drinking, the ring dove does not take short sips like other birds, but satisfies its thirst in one long draught as a horse would.

Its mode of alighting is very elegant. It descends with a headlong swoop until within about two feet of the ground, when suddenly it checks its rapid motion by reversing the position of its head, and spreading out wings and tail, drops gently to the ground. It is when in this position that the tail is best seen, for it is then spread out like a fan, so that every feather is visible.

Its note is very plaintive and resembles the syllables "coo, coo, coo, coo," the first two and the last being long, whilst the third is very short. The number and length of these syllables are occasionally varied. This note may be heard at all times of the day in a neighbourhood frequented by wood-pigeons, and from its plaintiveness the bird is supposed to have received the name "Queest." In some parts of the country, however, it is called the cushat, a name the derivation of which is uncertain.

The ring dove's nest is of the frailest description; it is formed for the most part of sticks, while occasionally a few roots and feathers are placed on the top of these to do duty for lining. The nest is always very flat, and is sometimes so lightly put together that the eggs or young may be seen from below. It is generally built in small trees in woods and plantations, and is thus protected from the wind. Occasionally, however, the nest may be found in more open situations, and in this case it is built more compactly and is much stronger than when placed in a sheltered spot. The nest represented in the accompanying illustration is a good example of those found in isolated trees exposed to the full force of the wind. The nest is built at a height from the ground varying from six to forty feet. When the bird has been sitting some few days, the top of the nest assumes a whitish appearance arising from a white powder in the bird's plumage.

The eggs are pure white, and two in number. Two or three broods are reared in a season, the first eggs being laid in April, or even in March, and a wood-pigeon has been found sitting on two eggs as late as September.

The young are hatched in seventeen days; they are at first covered with yellowish down, and their eyes are covered by a film for the first nine days. They are fed from the beaks of the parent birds with a whitish secretion, often described as milk, which is supplied from the crops of the old birds. The habit of feeding the young in this manner applies to all the pigeon family.

The flight of the wood-pigeon is extremely rapid, and when in the air it may be distinguished from others of its genus at a considerable distance by a bar of white feathers, which traverses the wing. Its feathers are very loosely attached to the skin, so that they fall out with even a slight blow. When suddenly disturbed from a bush, a wood-pigeon will often lose several feathers by its contact with twigs in getting away.

The Wood-Pigeon and Nest.

The male measures seventeen inches from the tip of the beak to the end of the tail. The female is slightly smaller, and, except in this particular, scarcely differs from her mate in general appearance. The head and back are bluish-grey, and the upper part of the neck is of the same colour, but the feathers on the sides of the neck are tipped with white, and thus form the partial ring mentioned above. The breast and under side of the neck are purple-red, while the belly and under-tail coverts are ash-grey. The tail feathers are twelve in number, and are of three shades of grey. The beak, legs, and toes are dark pink.

Young birds of the year have no white on their necks, and their whole plumage is less glossy than that of adult wood-pigeons.

THE FACE OF THE SKY FOR JUNE.

By Herbert Sadler, F.R.A.S.

Whenever the solar disc is examined, it will be seen to be marked with spots and faculæ. A maximum of the beautiful red star R Leonis occurs on the 1st of June.

Mercury is an evening star during the whole of the month, and, but for the prevailing twilight, would be very favourably situated for the observer. He sets on the 1st at 9h. 27m. p.m., or 1h. 23m. after the Sun, with a northern declination of 25 16′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{83}{100}$ths of the disc being illuminated. On the 10th he sets at 10h. 4m. p.m., with a northern declination of 25° 2′, and an apparent diameter of $6\frac{1}{2}''$, $\frac{64}{100}$ths of the disc being illuminated. On the 16th he sets at 10h. 3m. p.m., or 1h. 47m. after the Sun, with a northern declination of 23° 34′, and an apparent diameter of $7\frac{1}{4}''$, just one half of the disc being illuminated. On the 21st he sets at 9h. 56m. p.m., or 1h. 39m. after the Sun, with a northern declination of 21° 54′, and an apparent diameter of $7\frac{3}{4}''$, $\frac{33}{100}$ths of the disc being illuminated. He is at his greatest eastern elongation ($25\frac{1}{4}°$) on the 23rd. On the 30th he sets at 9h. 27m. p.m., or 1h. 9m. after the Sun, with a northern declination of 18° 38′, and an apparent diameter of $9\frac{1}{2}''$, $\frac{26}{100}$ths of the disc being illuminated. During the month he passes from Taurus through Gemini into Cancer.

Venus is a morning star, but is now becoming rather an uninteresting object for the amateur. She rises on the 1st at 2h. 20m. a.m., or about an hour and a half before the Sun, with a northern declination of 9° 0′, and an apparent diameter of 17″, $\frac{65}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was on February 3rd. On the 10th she rises at 2h. 4m. a.m., with a northern declination of 12° 19′, and an apparent diameter of 16·0″, $\frac{69}{100}$ths of the disc being illuminated. On the 20th she rises at 1h. 50m. a.m., or nearly two hours before the Sun, with a northern declination of 15° 43′, and an apparent diameter of 15·0″, $\frac{73}{100}$ths of the disc being illuminated. On the 30th she rises at 1h. 41m. a.m., or 2h. 6m. before the Sun, with a northern declination of 18° 37′, and an apparent diameter of 14·0″, $\frac{76}{100}$ths of the disc being illuminated, and the brightness of the planet being about equal to what it was on February 5th. During June Venus passes through Aries into Taurus.

Mars, Jupiter, and Neptune are, for the purposes of the amateur observer, invisible.

Saturn is an evening star, and is well placed for observation. He rises on the 1st at 2h. 54m. p.m., with a southern declination of 4° 52′, and an apparent equatorial diameter of 18·0″ (the major axis of the ring system being 41″ in diameter, and the minor $8\frac{1}{4}''$). On the 15th he rises at 1h. 54m. p.m., with a southern declination of 4° 49′, and an apparent equatorial diameter of $17\frac{1}{2}''$ (the major axis of the ring system being $40\frac{1}{2}''$ in diameter, and the minor 8·0″). On the 30th he rises at 1h. p.m., with a southern declination of 4° 54′, and an apparent equatorial diameter of $17\frac{1}{4}''$ (the major axis of the ring system being $39\frac{1}{2}''$ in diameter, and the minor $7\frac{3}{4}''$). Titan is at his greatest eastern elongation on the 16th, and Iapetus is in superior conjunction on the 6th, and at his greatest eastern elongation on the evening of the 26th. During the month Saturn is almost stationary in Virgo.

Uranus is also an evening star, and but for his southern declination would be well placed for the observer. He rises on the 1st at 5h. 10m. P.M., with a southern declination of 15° 7′, and an apparent diameter of 3·8″. On the 30th he rises at 3h. 15m. P.M., with a southern declination of 14° 54′. During June Uranus pursues a short retrograde path to the N.W. of α^1 α^2 Libræ, being about 1′ north of a $10\frac{1}{2}$ magnitude star on the 22nd.

There are no well marked showers of shooting stars in June.

The Moon is new at 10h. 56m. P.M. on the 3rd; enters her first quarter at 1h. 14m. P.M. on the 10th; is full at 7h. 6m. A.M. on the 18th; and enters her last quarter at 10h. 3m. A.M. on the 26th. She is in perigee at 6h. A.M. on the 5th (distance from the earth 223,620 miles), and in apogee at noon on the 20th (distance from the earth 252,270 miles). At 9h. 0m. P.M. on the 12th the 6th magnitude star 58 Virginis will disappear at an angle of 187° from the north point, and reappear at 9h. 37m. P.M. at an angle of 246°. At 0h. 41m. A.M. on the 14th the 6th magnitude star B.A.C. 4700 will make a near approach to the northern limb at an angle of 23°, distance about 2′. At 11h. 20m. P.M. on the 14th the 6th magnitude star B.A.C. 4923 will disappear at an angle of 175°, and reappear at 11h. 57m. P.M. at an angle of 232°. At 9h. 2m. P.M. on the 15th the 6th magnitude star B.A.C. 5197 will disappear at an angle of 108°, and reappear at 10h. 23m. P.M. at an angle of 300°. At 10h. 46m. P.M. on the 19th the 6th magnitude star B.A.C. 6628 will disappear at an angle of 80°, and reappear at 0h. 8m. A.M. on the 20th at an angle of 267°.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of Problem No. 17.

Key-move—1. R to Q3.

If 1. . . . K×P, 2. Q to Kt3ch.
1. . . . P to B4, 2. Q to Kt3.
1. . . . K×R, etc. 2. Q to Q5ch.
Triple after 1. . . . P×P by 2. R to K3ch, or 2. Q×RPch, or Q to Kt3.
Dual after 1. . . . K to B4 by 2. Kt×Pch, or 2. P to Kt3.

Solution of Problem No. 18.

Key-move—1. B to R2.

If 1. . . . K×R, 2. Q to B4ch.
1. . . . Kt×R, 2. B to Q5ch.
1. . . . Kt (Q8) moves, 2. R to K3 (×Kt) ch.
1. . . . B moves, etc., 2. R to Q4ch.
Dual after 1. . . . Kt to R5 by 2. R to Q4ch or 2. B to Q5ch.

Solutions of Problem No. 19.

Two Solutions, viz.—1. R to R5 (Author's), and 1. P to K6.

Correct Solutions received from the following:—

Fifteen Points.—Guy.

Fourteen Points.—Semper, B. G. Laws.

Twelve Points.—A Norseman.

Eleven Points.—Chat, Kt. J.

Nine Points.—E. W. Brook, L. Bourne, A. C. Challenger.

Eight Points.—J. H. Christie.

No. 18 is correctly solved by H. S. Brandreth.

Mr. De Morgan's Conditional Problem is solved by Chat, W. Willby, E. W. Brook, B. G. Laws, A Norseman, and Guy. Strangely enough, it is pronounced unsolvable by Semper.

The solution is 1. Q to Q2, Q×B; 2. P to B4ch, R to Kt5; 3. Q×Q mate.

It should be noted that according to the supplementary rule, published in the December number of Knowledge, the triple continuation in No. 17 does not score more than an ordinary dual.

J. H. Christie.—In No. 17, after 1. . . . K×P, 2. Q to Q5, P to B4 is a good defence. One point was accordingly deducted from your score.

A Norseman.—Your three letters and postcard containing solutions were duly received. In No. 17 there is no dual after 1. . . . P to Q3 (*sic*), but as the claim was unintelligible, nothing has been deducted for it.

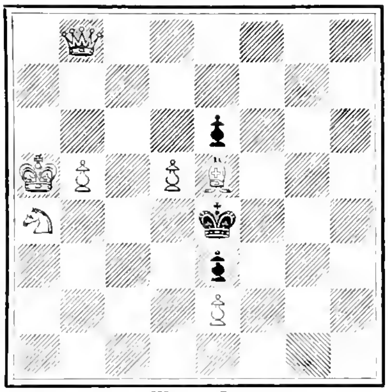
Guy.—You are quite right to inquire how we knew that the "Circle" was by a well-known composer. The sealed envelope has not been opened, but the problem was delivered to us by the hand of the composer in question, whose handwriting happens to be familiar to us. We assumed accordingly that it was his own composition.

A. C. Challenger.—Many thanks for the problems. Both are excellent and will appear next month.

PROBLEMS.

By Mrs. W. J. Baird.

Black (3).

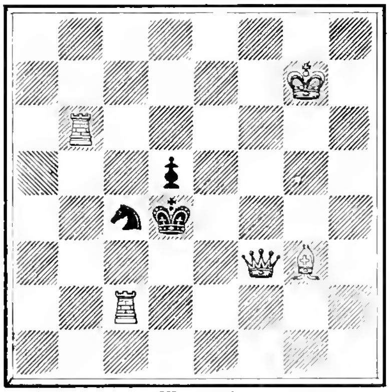


White (7).

White mates in three moves.

By C. D. Locock.

Black (3).



White (5).

White mates in two moves.

[After the hard work of the solution tourney, it is hoped that the foregoing comparatively simple positions will come as a relief.]

"Knowledge" Solution Tourney.

Final Score.

Guy ...	91	J. H. Christie	60
Semper	90	A Norseman	60
B. G. Laws ...	88	E. W. Brook	53
A. C. Challenger	79	H. Holmes	50
Kt. J.	69	L. Bourne	46
Chat ...	67		

The first prize is accordingly taken by "Guy" (F. H. Guest, Birmingham, and the second by "Semper" (T. Guest, Birmingham), who is only one point behind. Mr. Laws had the misfortune to miss one of the solutions of No. 15, or would have tied for first place. The remainder, some ot whom did not trouble themselves much about the search for duals and second solutions, have all proved themselves capable solvers in nearly every instance. It is noticeable that even the winner missed five duals in the fifteen sound problems. The highest possible score was 96. The award will, as usual, remain open for one month.

"Knowledge" Problem Tourney.

Of the nineteen positions published, four—viz., Nos. 6, 7, 15, and 19—having more than one key, are ineligible for prizes. The remainder have to be voted on by the solvers. Strictly speaking, the only solvers entitled to vote by the rules are seven in number, viz., Guy, Semper, B. G. Laws, A. C. Challenger, Kt. J., Chat, and J. H. Christie. We hope, however, that no objection will be raised to the admission of the following under the conditions named, viz.:—

A Norseman—Votes to be accompanied by full correct solution (including *all* the mates) of No. 11, the problem in which he failed.

E. W. Brook—Full solutions of Nos. 1 and 2, not received.

A. R. and *H. Holmes—Full* solutions of Nos. 17 and 18, not received.

These additions, including the Chess Editor, will bring the number of the jury up to twelve. The solvers named are requested, therefore, to send in, *on or before June 15th*, a list in order of merit of the *seven* problems which they consider best. Brackets may be used *sparingly* if desired. Any voting paper which names any one or more of the unsound problems referred to above, *or which does not name seven problems, neither more nor less*, will be disqualified. A problem placed first by any voter will receive nine marks, a problem placed second eight marks, and so on down to the seventh, which will receive three marks. A proble.. placed first will thus secure three times as many marks as a problem placed seventh. As soon as all he voting papers are received the marks will be added up, and he *six* problems which obtain most marks (or perhaps seven if the numbers are close) will receive the consideratio.. of the final judge, whose name will be announced shortly.

N.B.—In order to avoid mistakes, voters are requested to name the problems by the *motto* rather than by the number.

In order not to be influenced by the votes of others, the Chess Editor binds himself to complete his own voting paper before opening any others.

It is hoped that any solvers who may happen to be competitors in the problem tourney will not be deterred by any feeling of modesty from giving their own problems as many marks as they consider they deserve.

CHESS INTELLIGENCE.

The portion of the championship match played at New York resulted in favour of Mr. Lasker, who won four games to Mr. Steinitz's two. The Philadelphia games were even more disastrous to Mr. Steinitz, resulting as they did in three losses, the play of the loser being much below his usual standard. The concluding series took place at Montreal, and here, in a friendly city, Mr. Steinitz made an excellent start. The first game was drawn, and Mr. Steinitz won the next two in fine style. In the next two Mr. Lasker had his revenge, the score on May 20th being Lasker nine, Steinitz four, drawn four. Mr. Lasker accordingly only needs to win one game to win the match, and though his opponent is always at his best in an uphill contest, the result must now be regarded as a certainty.

A team of Manchester players has been visiting the Metropolis and playing matches with the leading London clubs. They lost by a narrow margin to the St. George's and Metropolitan Chess Clubs. Matches with the British Chess Club and the City of London will complete their programme. The composition of the team is by no means representative of the full strength of the northern club.

Late News.—Mr. Steinitz won the eighteenth game.

Contents of No. 103.

NOTICES.

TERMS OF SUBSCRIPTION.

Annual Subscription, 8s., Post Free.

"Knowledge" as a Monthly Magazine cannot be registered as a Newspaper for transmission abroad. The Terms of Subscription per annum are therefore as follows:—To any address in the United Kingdom, the Continent, Canada, United States, Egypt, India, and other places in the Postal Union, the Subscription is 8 shillings, including postage; or 2 dollars; or 8 marks; or 10 francs.

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KNOWLEDGE

AN ILLUSTRATED

MAGAZINE OF SCIENCE

SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: JULY 2, 1894.

CONTENTS.

ON THE MOUNTING OF LARGE TELESCOPES.

By Prof. GEO. E. HALE.

EVERYONE interested in the mounting of large telescopes will see in Sir Howard Grubb's paper, in your May number, a most valuable contribution to the literature of the subject. It seems likely that we are soon to be brought face to face with the problem of devising suitable mountings for instruments of great aperture, and the novel modification of Dr. Common's flotation method, described in the article referred to, contains features which commend it at once. At the same time it is not without disadvantages, but whether or not these are to be regarded as serious, experiment can best decide.

It is hardly to be doubted that Sir Howard is right in looking to the reflector as the most promising means of furnishing greatly increased light-grasping power. Such able opticians as Brashear and Clark have told me that they are ready to make objectives of as great aperture as the optical glass furnished them will allow, and during a recent visit to Jena I found Dr. Schott confident that he could soon make discs of hitherto impossible size. Nevertheless, an aperture of sixty inches is the largest I have ever heard of discussed for an objective, while Dr. Common has at least two mirrors of this size, not to mention Lord Rosse's great instrument. In default of glass, speculum metal could be used, and I feel certain that Brashear would undertake a mirror of ten feet aperture.

It is apparently only too true that for many classes of work the reflector is inferior to a refractor of the same or even much smaller aperture, but we may at present consider only such problems as require for their solution an instrument of great light-grasping power. I quite agree with Sir Howard that "the chief hope of progress in astronomical research lies undoubtedly in the application of photography," and the great telescope under consideration should most certainly be capable of being used for this purpose. But the possibility of photographing a field of stars or nebulæ at the focus of the instrument, while most eminently desirable, is not the only advantageous use to which a large instrument could be put. Indeed, I venture to believe that the employment of such a large telescope for the photography of stellar spectra would be of even greater value in the advancement of science than the results to be obtained by ordinary photographing in the principal focus; for so fruitful is the study of the spectra of the brighter stars with small telescopes, that a far more abundant harvest may be expected when greatly increased apertures bring the countless number of fainter stars within reach. In the case of the brighter stars, the manifold increase of dispersion made possible by the gain in light would render still more accurate than at present the measure of motions in the line of sight, and the spectroscopic method would become a hopeful means for the determination of the solar parallax. But the importance of stellar spectroscopy is too evident to require discussion, and I will merely point out one practical reason for designing the telescope with this end in view. If the definition of the instrument from any cause should turn out to be defective, unsuiting it for direct visual or photographic work, it might still be of great service in spectroscopy, especially with a spectroscope having a long collimator. Thus, if the telescope be of a design suitable for spectroscopic work, its construction need hardly be looked upon as an experiment, for the probability that it would not suffice for this purpose is very small.

If the desirability of constructing the telescope for spectroscopic work be admitted, the focal length must certainly be much longer than that chosen by Sir Howard Grubb. With a spectroscope of given aperture, the brightness of a star's spectrum is independent of the focal length of the large telescope. If we choose a collimator of about twenty-four inches focus, and give it an aperture of two inches (more than this would hardly be advisable, on account of the great size and weight of the prism-train), we have a ratio of one-twelfth. With an aperture of ten feet the great reflector would thus have a focal length of one hundred and twenty feet. In any case I hardly think a ratio greater than one-tenth would be advisable from a spectroscopic standpoint. Sir Howard has chosen a ratio of about one-fifth, giving a focal length of fifty feet for an aperture of ten feet. Doubling the length of the tube would certainly render the problem of mounting the instrument much more difficult, but this very increase emphasizes the necessity of employing some such method of supporting the tube as that devised by Sir Howard Grubb.

One of the greatest defects of all forms of telescope mounting at present employed is the method of supporting the tube at a single point, which is usually near the centre. In small instruments the difficulty is not felt, but as the focal length and weight of the objective increase, the question becomes serious. In the case of the forty-inch Yerkes telescope the objective will weigh about five hundred pounds, and the solar spectroscope nearly half a ton. These weights (with additional counterpoise at the objective end) will be carried at the opposite ends of a steel tube sixty-four feet long, supported at the centre by the great declination axis. Messrs. Warner and Swasey have done their work so well that we fear no serious flexure, but a certain small amount must be expected. If the aperture were trebled and the focal length doubled, a single support would hardly be sufficient.

With a reflector the conditions of the problem are quite different, as the mirror comes at the lower end of the tube. I have queried whether a slight modification of Dr. Common's mounting for his five-foot reflector would suffice for double the aperture and a much greater increase in focal length. As the mounting is constructed, the polar axis is a great cylindrical steel vessel so weighted as to float at the proper inclination in a tank of water. The declination axis is near the lower end of the short telescope tube, which is supported by it within a fork projecting from the upper end of the polar axis. As the tube is very short and light, the mounting is a very suitable one. If the fork were closed into such a form as that shown in the drawing of Sir Howard Grubb's model, and the upper end of the polar axis perhaps floated in a second tank, a long tube supported near its middle point might be carried fairly well, the range in declination being about the same as in the case of the instrument described in Knowledge. But as compared with the latter this telescope would have, in common with most other instruments, a number of serious disadvantages.

In the first place, the tube would be so supported as to show a marked effect of flexure due to its own weight. In Sir Howard Grubb's instrument the flexure of the lower portion of the tube would be very small, and that of the portion of the tube above the declination axis would also be small on account of its comparatively short length. There would, however, be a flexure produced by the resistance of the water to the motion of the tube when driven by the clock. It would be an important advantage if the driving power could be applied directly to the lower end of the tube, but on account of the motion in declination this is probably impracticable.

Again, the motion of the eye-end would be very great. In the case of a great refractor like the Yerkes telescope, the floor (seventy-five feet in diameter) of the observing room must be arranged to rise and fall through a distance of twenty-two feet. This seems unavoidable with a refractor, but Sir Howard's plan reduces the motion of the eye-end of an eight-foot reflector to so small a quantity as to make it always accessible by very simple and inexpensive means. For a ten-foot reflector of one hundred and twenty feet focal length the motion of the eye-end would necessarily be greater, but there would probably be no great difficulty in following it on a movable stage with stairway, or the observer might readily be carried on the telescope tube itself. But bearing in mind the purposes for which the instrument is designed—photography and stellar spectroscopy—this difficulty could easily be avoided. I would mount the spectroscope on the end of the tube, with the slit at the focus of the great mirror and the axis of the collimator coincident with the axis of the reflector.

The slit jaws should be polished, and inclined so as to make a small angle with the focal plane. A reflecting prism and telescope, supported near the centre of motion of the reflector, would enable the observer to keep a star on the slit. This device, which has been used by Dr. Huggins for years, is much superior to any other method of maintaining a star on the slit. For the second important use of the reflector the spectroscope slit could be pushed up out of the focal plane, to give place to a carrier for photographic plates. A small mirror, attached to the outer edge of the carrier, and adjustable in position, would make possible the observation of a star outside the field being photographed, with the small telescope used for a similar purpose with the spectroscope. Thus, in both cases the observer could stand near the centre of motion, and keep a star on the slit or cross-hairs for hours. It would be necessary to reach the upper part of the tube only for the purpose of inserting the plate-carrier, and for visual observations.

Another difficulty of ordinary mountings is the necessity of providing a very large and expensive dome to cover them. The dome fulfils a double purpose; it protects the instrument against the weather, and shields it from the wind during observation. The second point is perhaps of more importance than the first, for a large telescope might be so constructed as to suffer little from the weather, its more delicate parts being covered. As for the wind, a wall like that shown in Sir Howard Grubb's drawings would sufficiently protect an instrument three-fourths of which is under water. If a dome were desired, a comparatively small one would suffice. The great saving of expense on the dome and rising-floor is an important argument in favour of this form of mounting.

Of the possible disadvantages which Sir Howard Grubb has enumerated and discussed, it seems to me that the first is the only one to be regarded as at all serious. Considering its size and the immense number of interesting objects within its reach, the limited range of the reflector is no very great objection. The friction of the liquid would probably render the setting rather slow, but such a telescope is not designed to swing quickly about from one object to another. It could better be employed a whole night on one or two fields. As to the currents created in setting the instrument, they would certainly be of brief duration, and may therefore be disregarded. But the difficulty arising from the difference in temperature between the liquid and the air is a more troublesome matter. That the definition would be affected, and, worse still, the mirror dewed if the air were warmer than the liquid, must be expected. The remedies proposed might serve to remove these difficulties, but I am somewhat sceptical about the advisability of warming a mirror at the back. It might be well to employ a double system of pipes for heating and cooling, so controlled by a thermostat as to keep the liquid very nearly at the temperature of the outside air. I should still retain the proposed double tube, with the constant circulation of air; but even if every such precaution were taken, much trouble from dewing of the mirror might still be feared. Heating the mirror at the back, *if it could be managed so as not to interfere with the definition*, would probably be the most effectual remedy for dewing. It is hardly necessary to add that, in our northern latitudes, some liquid of lower freezing-point than water would have to be employed.

INSECT SECRETIONS.—III.

By E. A. Butler, B.A., B.Sc.

(*Continued from page* 123.)

Most people have probably noticed at some time or other certain small, dark bodies shaped something like mussel-shells, which are not unfrequently to be seen adhering to the skins of oranges or apples, or to the twigs and branches of apple and pear trees, but few would suspect them to be of insect origin. Yet such is the case, for in these "mussel-scales" we have examples of the family *Coccidæ*, or scale-insects, and it is in this family that we are to find our next examples of insect secretions. Amongst the *Coccidæ* there is the most extraordinary difference between the adult male and female insects. They are, to begin with, all small creatures, some very minute. The males are provided with a single pair of wings, which in itself is an exceptional circumstance, since they belong to an order—the Homoptera—the members of which are normally four-winged. Thus they remind us of the two-winged flies, or Diptera, and the suggestiveness of their appearance is strengthened by the fact that they possess a pair of short hooked appendages where we might expect hind wings, by which we are at once reminded of the "balancers" of flies. Nevertheless, their general aspect is so different from that of the majority of dipterous insects, that they are hardly likely to be mistaken for members of that order, especially as they usually carry a pair of long bristles as a sort of tail. (See accompanying plate.)

In the organization of these little males everything is sacrificed to the one purpose of their life, that of reproduction, and such other functions as may be more or less accessory to that, as, for example, sight and locomotion. Thus we find that the mouth organs are atrophied, the digestive apparatus shrivelled up, and that part of the body which usually lodges the stomach and intestines contracted to very small dimensions. They take no food, and necessarily, therefore, live but a very short time. On the other hand, they have an excellent supply of eyes, the usual masses at the sides of the head being supplemented by two large additional eyes on its upper surface, and this superabundance of the means of sight must be of considerable advantage in their search for mates. They are themselves not so well known as their partners, and in many species have not yet been discovered at all. As a consequence, it is evident that parthenogenesis must frequently take place.

The fully-grown females are about as different as could well be imagined. They have no power of flight—nor, indeed, of locomotion of any kind, for in their adult form everything is sacrificed to the nutritive and reproductive functions, since they are destined to be great feeders and mothers of large families. As they are not required to go in search of mates, but enjoy the honour of being themselves sought out, and have nothing to do but wait to be wooed and then settle down to their maternal functions, means of locomotion and organs of sense are alike superfluous. Accordingly we find that antennæ and legs all ultimately disappear, while the mouth organs become highly developed, the piercing beak being sometimes six times as long as the rest of the insect. When fully grown, they seem to be little more than minute, inert lumps of flesh, the animal nature of which is by no means obvious to the naked eye till they are crushed.

The different species have the power of secreting materials of various kinds, which, on exuding from their bodies, form in most cases variously shaped scales, under which the insect is to be found. The "mussel-shells" mentioned above are examples of these scales. There are many different species, and their scales are of varied forms and colours, the majority being more or less oval or linear. Those that will produce males are both differently shaped and differently coloured from those that will develop into females. They are often found on the leaves as well as the branches of plants, each species having its own distinct kind of food-plant. One very common species which proves itself a great pest in conservatories is found on the under side of the leaves of the oleander, especially along by the side of the midrib, where it forms oval, convex, orange or brownish scales. It is from these scale-like coverings that this particular section of the Homoptera have been called "scale-insects."

The glands by which the material of the scales is secreted lie, according to Mr. A. Morgan, on the upper surface of the hinder part of the abdomen, and are sometimes very numerous; they are tubular, and open by small pores in the skin. The exudation from them is of a very varied character. Sometimes, as we have seen, it forms a distinct scale, which shelters the insect beneath; sometimes it is in the form of cottony or silky threads, which may remain adherent to the body, or may be deposited as a covering for the eggs. Or, again, it is of a waxy nature, as is the case with the maker of the Chinese insect wax of commerce, a species of *Coccus* nourished on a kind of ash tree. The insects that form this secretion suck up the sap of the tree to such an extent that they ultimately become almost entirely converted into masses of wax, which encrust the branches. This wax, when separated from the branches, is melted over a slow fire and then poured into cold water, by which it is washed and at the same time solidified into flakes. These are again melted and cast into cakes, and the wax then appears as a hard, translucent, crystalline substance, something like spermaceti. It is used for a variety of purposes in the East, especially for making candles and in the practice of medicine. It must be carefully distinguished from Japanese wax, which is also used for candle-making, but is a purely vegetable product obtained direct from the fruits of certain trees, and not elaborated from plant juices through the medium of an insect's digestive and secretory apparatus, as is the case with the Chinese product.

Several other of these *Coccidæ* yield valuable products, of which they are either directly or indirectly the originators. For example, the splendid scarlet dye called cochineal is derived from a species which is cultivated on cactus plants in Mexico, Madeira and elsewhere. The wingless and legless bodies of the female insects are collected and dried, when they look something like seeds; and from these the dye is obtained. The substances called "lac" and "manna," again, are produced as exudations on certain trees by the punctures of other species of scale-insects, the former on a kind of fig tree and the latter on tamarisk. The lac, while still adhering to the branches, is called stick-lac, but after separation and various degrees of refinement it is known by the names of seed, lump, and shell lac, the latter being the form in which it is most familiar to the British public.

The life-history of insects belonging to this group is generally somewhat as follows. The young larvæ, when just hatched, are furnished with the usual insect appurtenances, and are more or less active; but they soon attach themselves to the leaf or bark, become modified in form, and begin to grow a scale. The female casts its skin twice, but the male only once. The cast skin is to be seen either in the centre or at one end of the scale, fastened there by the secretion of which the scale is composed. After a time, the insect changes into a chrysalis, which again is peculiar, for the rest of the Homoptera do not exhibit a complete metamorphosis, but are active throughout life. The female deposits her eggs, which are numerous, under the scale, just behind her own body, and having done this she dies, leaving her shrivelled body just where it was. The adult insect is often much smaller than the larva which yielded it, and this shrinkage of course leaves room for the eggs and young insects under the scale, until the latter leave the parental roof and settle down elsewhere by pushing their beak-bristles into the plant as a permanent anchor and suction apparatus. Sometimes there is not only the rounded scale on the insect's back, but in addition to this a flat one, very much thinner than the other, is formed underneath the body.

On removing the creature from the plant to which it is attached, the under scale often remains behind and appears as a thin film on the leaf. When the insect dies, its upper scale after a time falls off, but the under film still remains attached, to attest the former presence of the insect; and in this way relics of two or three generations, which have succeeded one another, may be found on the same area.

The life of a female *Coccus* is about as uneventful as one can well imagine; and in this respect it is a fitting accompaniment of a degree of degradation in structure which is almost without parallel amongst insects. If one felt inclined to moralize on the subject, one might well adopt the quaint words of an old naturalist writing a century ago about one of these scale-insects that is to be found on rose trees. He closes his paper with the words: "This is the biography of a creature whose world consists of two inches of a little branch of a rose bush, and it accomplishes what most men do: being born, multiplying itself, and—dying." The sluggish habits and semi-vegetative life of these degraded female *Cocci* render them peculiarly liable to the attacks of parasites of various kinds, and, amongst others, parasitic fungi have been discovered upon them. Some of these appear to attack them during life, but others locate themselves on their dead bodies, deriving their nourishment from the carcase. Of course all such fungi are exceedingly minute, but still some very beautiful forms are sometimes to be met with. In his "Vegetable Wasps and Plant Worms," Dr. M. C. Cooke figures one, of which we reproduce a sketch (Fig. 6), showing three pretty little clubs rising up from the surface of the convex scale.

Fig. 6. Scale-insect, with parasitic fungi. Much magnified. (After Cooke.)

Two other genera of this remarkable group of insects may be referred to as forming their waxy or silky secretions into different shapes from those mentioned above. The first of these is *Eriopeltis*. This forms little compact oval tufts, like pieces of cotton wool (Fig. 7) attached to the stems and blades of certain grasses, and there is certainly nothing whatever in their external appearance to suggest any connection with insects, unless, indeed, they might be cocoons of small ichneumon flies. But a close examination, revealing a number of separate threads standing out in all directions, would soon dispel this idea, and would leave their real nature as problematical as ever. Though apparently not uncommon, they have not long been generally known in this country, having previously, no doubt, been overlooked, partly because of the little attention that was until recently paid to the *Coccidæ*, and partly because of the completeness of their disguise. They seem to have been first noticed in this country in 1856, when there is a reference to them in "The Proceedings of the Entomological Society of London"; but that was soon forgotten, and they passed out of knowledge till 1885, when Mr. G. C. Bignell again called attention to them.

Fig. 7.—*Eriopeltis festucæ*, on blade of grass.

The other genus is called *Orthezia*, at least one species of which is a common and widely distributed insect (Fig. 8), though, as it is of retiring habits, it is not likely to be frequently seen except by those who specially look for it. The whole body is invested in the waxy secretion, and no parts of the real insect are visible except the legs and antennæ, which project from the waxen coat which envelopes the whole. There is also the further peculiarity that the exudation is not irregularly disposed in the form of loose threads, but is perfectly symmetrically arranged in the form of fluted columns and rosettes, so rigid and so exquisitely chiselled as to give the insect the appearance of being a little marble statuette. On the fore part the white secretion is arranged in a sort of rosette, and behind in parallel longitudinal lines, reminding one of stiffly arranged folds of drapery. Underneath, the surface is strongly convex and smooth, forming the outer boundary of a kind of pouch in which the eggs are carried. On seeing the insect from above, it appears simply to be an exquisitely neat cast in plaster of Paris, and there is nothing suggestive of a living being at all. On turning it over on its back, one is much astonished to find that the supposed mineral is provided with six little brownish legs, which by their movements show the thing to be alive; and there is then irresistibly suggested the idea of an imprisoned being enclosed in a perfectly rigid shell of plaster of Paris, with minute holes for the legs to come through, and one is apt to think that some misfortune must have happened to the creature to bring it into such a condition. The condition, however, is a perfectly natural one, and the insect may be found thus covered in all its stages amongst dead leaves and other rubbish. While it is young, little more than the rosette is developed, and the egg pouch is not added till the insect becomes fully grown. It is only the female insect that appears in this curious form; the male is a small winged creature, with a single pair of wings and a number of tufts from its tail, like spun glass.

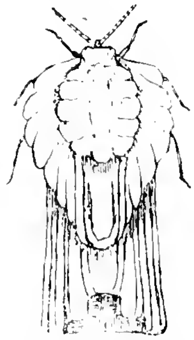
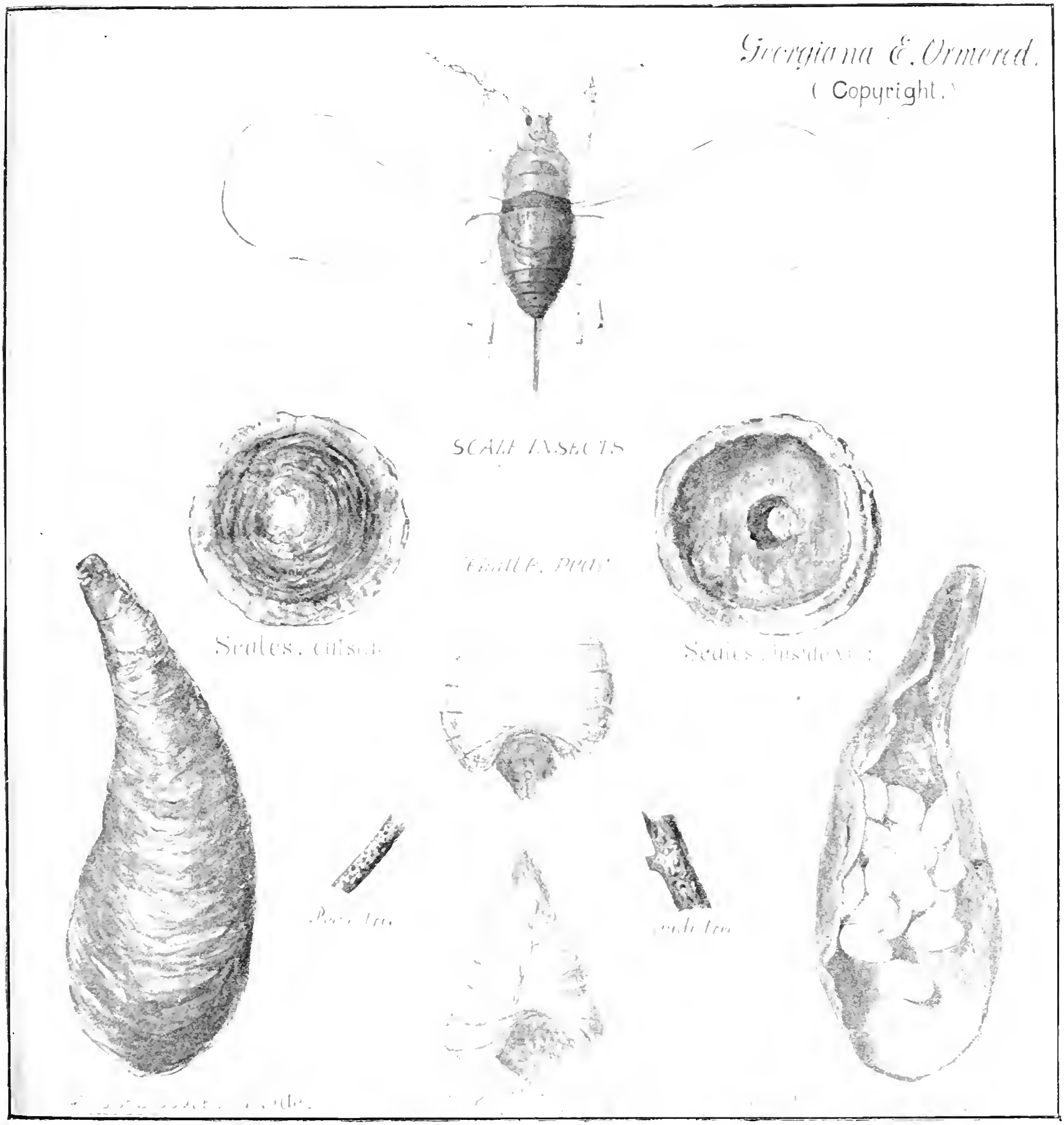


Fig. 8.—Adult female of *Orthezia urticæ*. Magnified eight diameters.

The aphides are closely allied to the *Coccidæ*, and amongst them too we find instances of the secretion of masses of protective matter, which are employed to shelter both old and young insects. Perhaps the best known example of this is to be found in the "American blight," or "woolly aphis," that sometimes infests apple trees. A badly infested tree will look as if its branches had had masses of cotton wool scattered about in all directions over them. The cottony substance will be found specially thick round crevices in the bark, or on places whence boughs have been removed in pruning or accidentally broken off, and occasionally it hangs down from the branches to the depth of several inches as loose masses, which wave about in the wind and are sometimes blown away on to the neighbouring trees. A cursory glance will probably fail to detect the insects, so completely are they concealed by the masses of down they secrete, and the white threads will very likely be set down as a sort of fungus. On turning it aside, however, the insects will be discovered in the midst of the mass as yellowish or reddish, wingless, fat-bodied, six-legged beings, of various sizes according to age. They differ from the majority of aphides in not possessing the two tubes which usually project from the hinder part of the body for the secretion of the honey-like liquid of which ants are so fond. Being deprived, however, of that secretion, they have all the more fully developed the power of exuding the protective cottony mass. In speaking of this secretion as "cottony," it will of course be understood that its appearance only, and not its constitution, is referred to. If its real nature were to be indicated by a name, the epithet "silky" would be



SCALE INSECTS.

A winged male is shown above. Its single pair of wings should be noted, and below them the hooked projections described in accompanying paper. In the centre, below, are two females, the upper, from pear tree, distended with eggs; the lower, from apple, after eggs have been laid. At the sides are outer and inner views of a circular scale and a "mussel-scale." The inner view of the latter indistinctly shows shrivelled body of female above, and plainly eggs below. Small portions of pear and apple twigs are shown between these and the female insects, with the scales of the natural size.

From a Photograph of Miss Ormerod's drawing, by Messrs. Newton, of Fleet Street.

a more correct term, as its properties are more like those of silk than of any other substance.

These cottony or silky masses must be extremely useful to the insects, both as a means of protecting them from birds and other predatory creatures, and of assisting their migrations, for when any of the loose masses are blown from one tree to another there are sure to be some insects in them, and these are thus rapidly introduced to new and more extensive pastures from which their own unaided and feeble powers of locomotion would have completely excluded them. Their attacks upon apple trees are much more serious in results than might have been anticipated from the size of the insect. It is not merely that they abstract a good deal of sap from the growing tree, thereby reducing its vitality, but their punctures give rise to a diseased condition of the wood beneath, which becomes soft, pulpy, and swollen, so that the bark splits and exposes fresh surfaces to attack. At the end of summer these moist tumours dry up and thus deepen the cracks, affording both safer anchorage and still more abundant pasturage for a new host of destroyers.

Many remedies have been suggested against these formidable pests. As the insects do not of their own accord wander much, anything that cuts off the supply of food in the spot in which they are located will be useful; or, again, anything that clogs up their breathing apertures, which are at the sides of the body as usual, will prove efficacious by suffocating them. Hence washes of some sort or other are the best kind of remedies, and any lotion in which soap forms a principal ingredient seems to be the most satisfactory in results. There is frequently a little difficulty in applying such remedies, in consequence of the tendency the insects exhibit to lurk in minute crevices, where it is difficult to get at them with any brush that is large enough to be used where great numbers are concerned. Fortunately, the insects soon give evidence of their presence by the snow-white appearance of the cottony down proceeding from them, and as prevention is better than cure, especially in such a case as this, every effort should be made, as soon as the tell-tale flecks appear, to rid the trees of their parasites, and massacre the whole tribe before they have time to follow the characteristic tendency of their race, and multiply indefinitely.

A similar secretion, though in much smaller quantity, is formed by those aphides that live beneath the soil and feed upon the juices of underground stems and roots. In this case the waxy material coats their bodies as a sort of mealy powder, and gives them the appearance of having been dusted over with flour. As the secretion is impervious to moisture, it serves the insects in lieu of a waterproof garment, and keeps them dry, notwithstanding the moistness of their surroundings.

The same order of insects, viz., the Homoptera, contains yet another group in which the power of secreting silky or waxy fibres is developed. These are a particular family of the frog-hoppers, which are so called from their wonderful jumping powers. The family in question is called *Cixiidæ*, and its British representatives are few in number, though two of those few are amongst our common insects. These are called *Cixius nervosus* and *C. pilosus*. They have brownish black bodies and four transparent glassy wings, and the nervures of the front pair are distinctly studded with black dots. The small head ends in a beak, which is bent under the body in repose, and the thorax is furnished with three longitudinal keels. The hind legs are considerably longer than the other two pairs, and it is with these that the insects perform their astonishing leaps. In repose the fore wings are placed along the sides of the body, and completely conceal the hind pair, so that the shape is something like that of a small moth at rest. Seeing one of these insects sitting thus on a leaf, you go to pick it up with your fingers, but just as you are about to lay hold of it, it vanishes from sight as suddenly and as utterly as if it had been gifted with the property of rendering itself invisible at will. The explanation is that it has suddenly leapt away with a vigorous stroke of the hind legs, aided by the wings, which are simultaneously outspread, and the movement is so sudden and unexpected that it is rarely possible to tell in what direction the creature has gone.

Cixius pilosus (Fig. 9), the smaller insect, which is not quite half an inch in expanse of wings, is, of the two, the more noted for the development of the cottony flocks at the end of the body. They very strongly suggest the idea of a parasitic fungus, and in fact a similar structure in an American species was once described as such. This was in 1769, when Fougeroux de Bonderoy submitted to the French Academy a paper descriptive of insects on which plants were to be found growing—an association of dissimilar organisms which was a great puzzle to the older naturalists, and led some of them to the conclusion that "the passage and mutation of animal species into the vegetable, and reciprocally from the vegetable to the animal," was not merely a possibility but even a frequent occurrence! After having cited a number of genuine instances of fungoid plants growing on the bodies of insects, the author proceeds to describe a growth on the body of one of the Cicadaria—that particular group of insects with which we are now specially concerned. The insect, he says, "is a native of Cayenne, and the plant is a species of fungus, but different from those we have described. It is formed of long and silky filaments, which cover the whole body of the insect, and project about seven to eight lines above and below the belly of the animal." But from the figure that accompanies the description, it is evident that what he had before him was nothing more than filamentous exudations similar to those of our own *C. pilosus*, though on a rather larger scale. Many other exotic species of this order, especially those belonging to the group of "lantern-flies," produce large masses of similar white tufts and threads, which cover more or less of their bodies, and give them a mouldy appearance. (*To be continued.*)

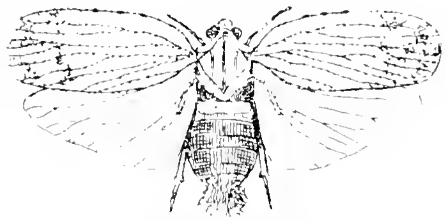


Fig. 9.—*Cixius pilosus*, with cottony filaments at tail. Magnified five diameters.

LIQUID AIR.

By J. J. Stewart, B.A.Cantab., B.Sc.Lond.

It is a familiar fact to all that some substances can be obtained in the varying forms of solid, liquid and gas; but many substances come under our notice only when occupying one of these states. When granite is mentioned we at once think of a hard, solid rock; few people have seen granite in a liquid state. Again, the name *mercury* calls to our mind the well-known liquid metal. So there are numerous gases and vapours which are known to us only under this somewhat impalpable and less tangible form. Amongst the substances familiarly known to us, however, there are a large number which, through the action of heat upon them, can be readily changed into a fluid and then into a vaporous state. Perhaps the best known of all is water, though even this in hot climates is rarely seen in the there uncommon solid form ; so that the African chief, who had accepted many statements from his European visitor, utterly refused to believe him when he was told that, owing to the intense cold in some countries, rivers got hard enough to be walked over.

Lately, in many text-books of science, gases were divided into two classes—those which could be liquefied by the application of cold, or pressure, or both, and those which were *permanent*, or were known to us only in the form of gases. It was suspected by scientific men, especially after the extensive experiments by Faraday, who succeeded in liquefying many of the "permanent" gases, that all gases without exception could be changed into the liquid form if they were exposed to a sufficiently great pressure and at the same time cooled down far enough. This surmise has been proved correct only within comparatively late years, and now all gases, including the air we breathe, must be considered as differing from vapours, such as steam, only because at the usual temperatures at which we generally deal with them they are in a condition similar to that which other substances attain when heated to a very high temperature.

I propose to give a short account of the work hitherto done in the liquefaction of gases, commencing with that so ably carried out by that unsurpassed experimenter Michael Faraday, and going on to refer to the researches commenced by Raoul Pictet and by Caillelet in France, who, about the same time (1877), succeeded in liquefying oxygen and even hydrogen. These researches were pursued by Wroblewski and Olzewski in Russia, and have been continued lately in our own country by Prof. Dewar, who, with such striking success, has liquefied air in large quantities, and has even handed it about in pint bottles for inspection by a large audience.

There are two means open to us of liquefying a vapour. Let us increase the pressure upon it, or lower its temperature, and if we proceed far enough in these operations the vapour will become liquid. A further condition is necessary with the "permanent" gases—we must cool them down below their *critical temperature*. This critical temperature is that above which no amount of pressure applied to the gas will be capable of changing its state into that of a liquid.

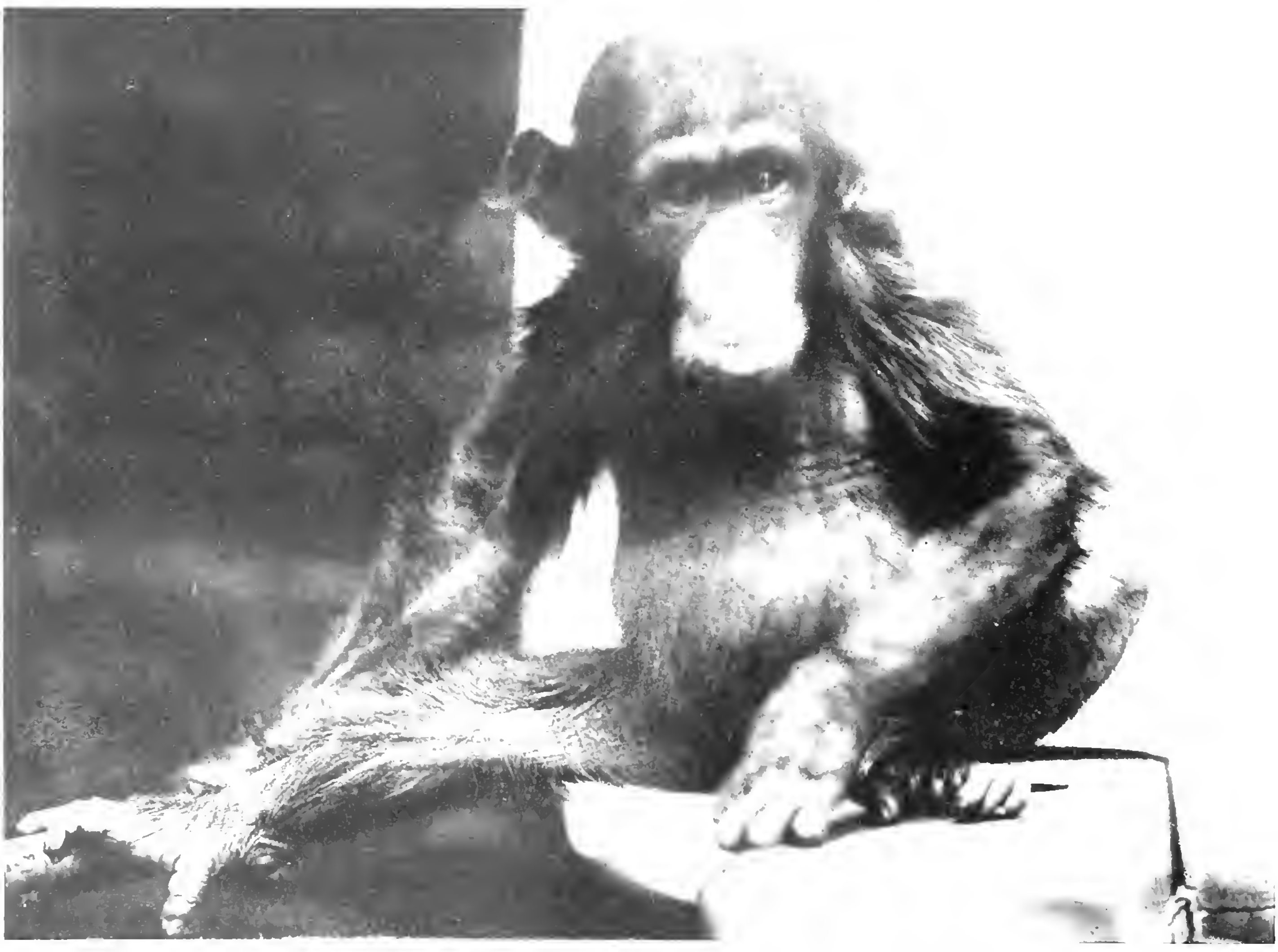
Faraday, in his series of experiments, applied the simple but effective means of generating the gas, in a strong glass tube, from those compounds which evolved the required gas on heating. In this way the gas, being produced in a limited space, produced a great pressure, under which pressure of its own vapour the gas became a liquid. On breaking the tube the gas, compelled by pressure to exist as a liquid, would revert to the form natural to it at the temperature of the experiment, and would do this with explosive violence. There was thus always a tendency for the gas to burst the tube, and this sometimes occurred during Faraday's experiments. Hence he was careful to wear a mask made from wire gauze or thick glass, but even thus he did not entirely escape injury. Faraday immersed one end of his tube in a freezing mixture while the other was exposed to heat. In this way he succeeded in liquefying a large number of gases, and examined their properties while in this unusual state. Amongst the gases so treated were the following :—carbonic acid, hydrochloric acid, sulphur dioxide, cyanogen, ammonia, and chlorine. He carried out his first set of experiments on this subject in the year 1823. Later, in the year 1845, after Thilorier had shown how carbonic acid gas could be obtained in the liquid form on a large scale, and also as a solid, Faraday used the solid carbonic acid mixed with ether, and by means of the cold produced by the evaporation of the mixture he reduced the temperature to about $-100°$ Cent., and obtained most of the above-mentioned gases, and also nitrous oxide, not only in a liquid but also in a solid state. Hydrochloric acid, hydrogen arsenide, ethylene, silicon fluoride, boron fluoride, and chlorine he at this time managed to get in the liquid form, but was unable to solidify these substances. The gases hydrogen, oxygen, nitrogen, nitric acid, carbon monoxide, and marsh gas resisted all Faraday's attempts to liquefy them, and it was not until more than thirty years later that these substances were condensed.

Andrews, by his classical researches on the critical point of gases and vapours, and especially by his thorough investigation of the behaviour of carbon dioxide when exposed to great pressure at varying temperatures, paved the way for future work on the liquefaction of gases, and showed that great pressure of itself was not sufficient to cause a gas to turn into a liquid, but that a certain limiting temperature must be passed in cooling down the gas before it can by any amount of pressure be liquefied. Thus above this limiting or critical temperature, which is different for each gas, it may be called truly permanent, while below this temperature the gas is liquefiable if only enough pressure is applied to it, and the gas may then be described as a vapour.

When substances evaporate or change from the liquid to the gaseous state, a large amount of heat disappears or becomes latent, and is used up in separating the molecules of the liquid farther apart and giving them increased energy of motion. On account of this disappearance of heat during evaporation great degrees of cold may be produced, and it was by this means that Pictet in 1877 obtained a temperature of $-140°$ Cent., and obtained oxygen in the liquid state. He cooled liquid carbon dioxide by surrounding it with liquid sulphurous acid, kept boiling in a vacuum, and got a still greater degree of cold by then allowing the liquid carbonic acid to evaporate rapidly in an exhausted space. The oxygen was generated in the usual way from potassium chlorate, a salt which splits up and gives off oxygen gas when it is heated ; but the gas was produced in a strong iron retort, so that by means of its own pressure alone the gas was compressed by a force several hundred times greater than that of the ordinary pressure of the atmosphere.

The method adopted by M. Pictet is the same in principle as that employed by Faraday. The gas is generated in a closed vessel capable of standing a great pressure, and it is condensed by being simultaneously exposed to great cold and to the pressure of the gas itself, forced to occupy a very small space. In Pictet's original experiment he obtained a temperature of $-130°$ Cent., at which temperature oxygen is liquefied, when the pressure is raised to two hundred and seventy-three atmospheres.

While Pictet was continuing his experiments and endeavouring to liquefy the hitherto permanent gases, the same subject was being investigated by Cailletet, and it was on the same day, the 24th December, 1877, that the French Academy was informed of the success of both these experimenters in liquefying oxygen. Cailletet attained his object by exposing the gas to enormous pressure, produced by means of a hydraulic press, while at the same time the temperature was lowered by suddenly allowing the gas to expand. In this way a sudden disappearance of heat takes place, the heat energy becoming transformed into mechanical motion of the particles of the expanding gas. In Cailletet's apparatus the pressure was produced



TWO PICTURES OF A FEMALE CHIMPANZEE [illegible] FROM WEST AFRICA.

[illegible]

by a steel piston working in a cylinder, the hydraulic cylinder being filled with water. The gas was contained in a capillary glass tube with small bore and thick walls which could support the strong pressure required. The glass tube containing the gas was connected to the hydraulic pump by means of a flexible metallic tube. Cailletet worked with small quantities of gas, while Pictet, by means of his machinery, was able to obtain relatively large quantities of the various liquefied gases.

The results got were only obtained after years of preparation and endeavour by both experimenters, working quite separately and independently. Cailletet made use of the skill and knowledge obtained by him in the prosecution of his business of an ironmaster at his works at Chatillon-sur-Seine; while Raoul Pictet carried on his experiments at Geneva, where he was engaged as a manufacturer of ice-making machinery.

Cailletet's apparatus is singularly simple and effective, and by it he also obtained liquid hydrogen, which appeared as a mist on the inside of his tube when the great pressure to which the gas was subjected was suddenly relieved, and heat thus suddenly absorbed. Hydrogen was thus liquefied into globules of mist on the glass when the pressure of three hundred atmospheres was suddenly removed, while air previously carefully dried changed into a liquid under a pressure two hundred times that of the atmosphere after it was cooled by means of liquid nitrous oxide. This is what happens in Cailletet's experiment: the gas, first of all cooled on account of its quick expansion, descends in temperature below its critical point, and then becomes liquid under the moderate pressure to which it is then exposed. But as expansion and relief of pressure continues, the liquid is soon under too little pressure to remain in this condition, and besides by conduction from surrounding objects heating occurs, so that the liquefied gas soon evaporates and the mist produced is fugitive; this is especially so in the case of hydrogen.

MM. Wroblewski and Olzewski have carried out many experiments, using an apparatus similar to Cailletet's. At $-136°$ Cent. a pressure of twenty atmospheres sufficed to liquefy oxygen, and the critical temperature of this gas is placed at $-112°$ Cent., that is, it must be cooled *at least* as far as this before liquefaction can take place. The critical temperature of nitrogen is found to be still lower than this, being $-147°$ Cent., or $-223°$ Fahr.

On Friday evening, June 26th, 1891, at the Royal Institution, the audience saw liquid oxygen in large quantities freely drawn off from the refrigerating apparatus, and having all the appearance of hot water, with a vaporous cloud above it. In reality the oxygen was boiling at a temperature of $-296°$ Fahr. — *i.e.*, 328° below freezing point, and the apparent vapour consisted of ice particles produced from the moisture of the surrounding air, cooled from the contact of the chilled gas. On filtering the liquid oxygen, to get rid of the minute particles of solid carbonic acid scattered through it, it was seen to consist of a blue limpid liquid not unlike water. It would naturally be expected that the liquefied gas, when placed in an open vessel in a room at the ordinary pressure and temperature, would with great rapidity, and even violence, hasten to take the gaseous form. But this was not the case; the liquid oxygen evaporated but slowly, and retained its liquid form for a considerable time, although it was only under the usual atmospheric pressure. When a few drops of the liquid were thrown into water, the effect was like that of plunging red-hot iron into a liquid; a fizzling noise was produced, and soon the globules of liquid oxygen were seen each floating about in a little cup of ice formed from the surrounding water. By means of the remarkably cold fluid, alcohol, which remains liquid in even the severest Arctic climate, was quickly frozen into solid lumps; the solidifying temperature for alcohol being $-130°$ Cent.

The effect of cold in rendering sluggish and inert substances which are usually chemically active is strikingly seen in the case of cooled oxygen. At ordinary temperatures oxygen gas has a great affinity for phosphorus, and combines readily with it, producing vigorous combustion with much heat, and light clouds of the solid phosphorus oxide being formed. But a piece of phosphorus when placed in liquid oxygen remains undisturbed; no combination takes place.

By means of liquid oxygen, nitrogen may be liquefied. Advantage is taken of the fact that liquid oxygen, when placed in vacuo, boils at a lower temperature than when under the ordinary pressure. A temperature of 328° Fahr. can thus be obtained, at which both nitrogen and atmospheric air can be liquefied. During the process of liquefaction of air, the two gases of which it is made up become liquid together, but when the temperature is allowed to rise they evaporate separately. The nitrogen, though more difficult to liquefy, comes off as a gas first, leaving almost pure oxygen behind.

Prof. Dewar has also solidified air as well as nitrogen by employing powerful pneumatic apparatus. Pure oxygen has itself never been obtained in the solid form. In order to obtain a succession of lower and lower temperatures, the various liquefied gases are caused to boil in a vacuum. Thus, the more easily liquefiable gases are made use of to abstract heat on their evaporation from those more difficult to liquefy. When these latter are made to boil in vacuo a still lower temperature is attained, and by successive steps a reading on the thermometer as low as $-211°$ Cent. (or $-346°$ Fahr.) has been reached. At these low temperatures experiments of an interesting character have been made on the electrical behaviour of metals, and their electrical resistance has been determined.

On boiling successively in vacuo carbonic acid, nitrous oxide, and ethylene, using the first to take away by their evaporation heat from the gases which are more difficult to liquefy, a temperature of $-229°$ Fahr. is reached, at which oxygen can be liquefied under a pressure of fifteen hundred pounds per square inch. The rapid evaporation of oxygen in vacuo so quickly removes heat from surrounding substances that air and nitrogen are soon liquefied, and these, when treated under powerful air pumps, abstract sufficient heat to allow of the production of solid nitrogen. This last experiment was successfully carried out for the first time in public on January 19th, 1894.

THE MAN-LIKE APES.

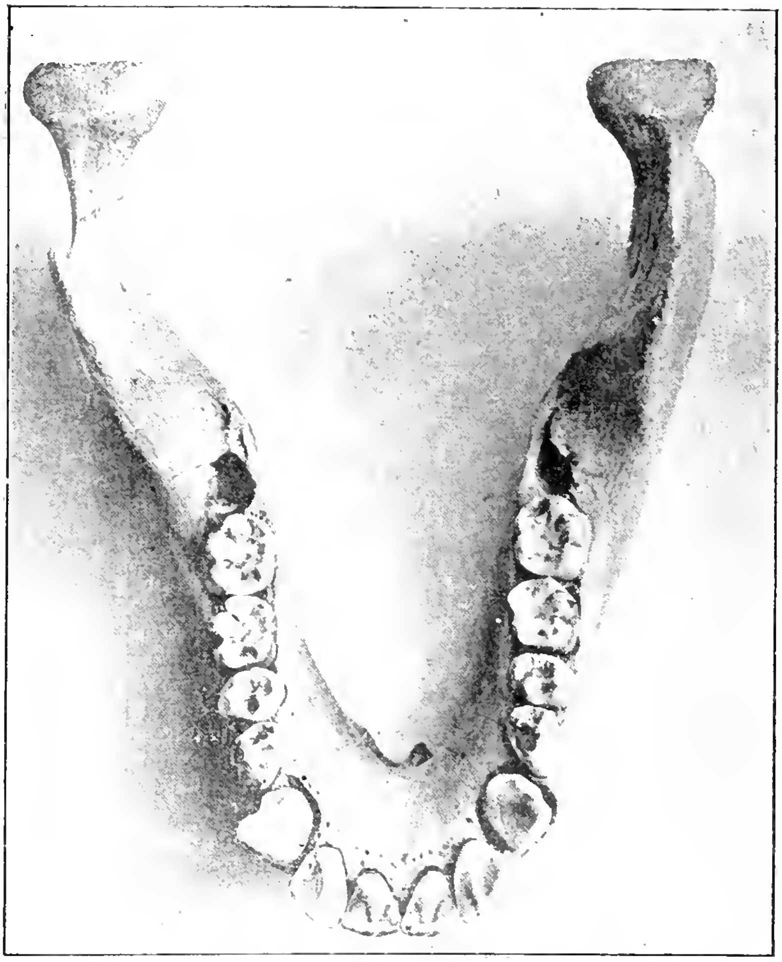
By R. Lydekker, B.A.Cantab., F.R.S.

Through the generosity of the Board of Governors of the Cheltenham Hospital, the Natural History Branch of the British Museum has been recently enriched by a specimen of great historical interest in the shape of the skeleton of a young chimpanzee from Angola, which was dissected and minutely described so far back as 1699, by Dr. Edward Tyson, in a rare work entitled "Orang-Outang, *sive* Homo Sylvestris," a copy of the volume being appropriately placed alongside of the skeleton in one of the bays on the left side of the great entrance hall. The work in question is the first account of a member of the group of man-like apes having any pretension to scientific accuracy; and the acquisition by the Museum of the skeleton and the volume in which it is described may well serve as the text for a short account of the man-like apes in general.

That these apes are our nearest cousins is probably well known to all our readers; but the degree and extent of this relationship, as well as the characters by which it is displayed, are probably far less familiar to many of them. In the first place it will be noticed that we speak of this relationship as one of cousinship, and not of ancestry; and it is well that the reader should at once free himself from any idea that there is any vestige of direct ancestral kinship between these, for the most part, hideous creatures and himself. Such relationship as does exist—and we cannot but believe that such there is—is of a comparatively distant kind; and the common ancestor must have lived ages before the mammoth roamed over the plains and valleys of England, since at that date man was as distinctly differentiated from the apes as he is in the present century. Whether this "missing link" will ever turn up, or in what country it is most likely to have lived, are questions impossible to answer; but from the extreme rarity with which fossil remains of man-like apes are found in countries where they are known to have existed for long ages, and from the probability that the distributional area of the aforesaid "link" was extremely limited, we cannot give much hope that the researches of palæontologists will ever be rewarded by such a "find."

From their large bodily size, coupled with that terrible caricature of the human face and form characterizing the more typical representatives of the man-like apes, no one would have any difficulty in picking out these creatures from among their lower relatives. There might, however, be some hesitation with regard to the long-armed gibbons, a specimen of which is represented in our third full page illustration; and we, therefore, proceed at once to point out how the members of the man-like group may be distinguished as a whole from other monkeys.

We presume, in the first place, that all our readers are aware that apes, monkeys, and lemurs constitute one great mammalian order—the Primates; and likewise that lemurs differ from apes and monkeys by their long fox-like faces and immobile expression, to say nothing of many anatomical peculiarities into the consideration of which it will be unnecessary to enter on this occasion. Possibly we shall be presuming too much as to the extent of their zoological knowledge if we also assume that they are acquainted with the difference between the apes and monkeys of the Old World and the monkeys of the New; and it is accordingly advisable to make this clear at starting. The whole of the Old World representatives of the division of the order to which we are confining our attention are characterized by having teeth agreeing both in number and arrangement with those of man. Thus in all cases in each jaw there are two pairs of incisors, a single pair of eye-teeth, tusks, or canines, and five pairs of cheek-teeth, of which the last, or "wisdom-tooth," is frequently very late in making its appearance, as shown in the accompanying figure of the lower jaw of an immature chimpanzee, in which it is still imbedded in a cavity in the bone, the top of which is open. It is further essential to observe that of these five cheek-teeth the first two on each side are simpler than the three hinder ones, and are preceded in the infant by milk-teeth, whereas the latter have no such predecessors. It is accordingly the custom to call the two simpler teeth premolars or bicuspids, and the three more complex ones molars. If now, we examine an ordinary American monkey, we shall find six cheek-teeth



Lower jaw of an immature Chimpanzee, with the "wisdom-tooth" still concealed in its socket.

on each side of both the upper and lower jaws, of which half are premolars and half molars, while in the marmosets, which constitute a second American family, although the total number of cheek-teeth is the same as in the Old World forms, yet the proportion is different, there being three premolars and two molars. It may, therefore, be concisely stated that all American monkeys differ from their Old World cousins in having three instead of two pairs of premolar teeth, whence it may be inferred that they belong to a lower and more generalized type, there being a universal tendency throughout the higher vertebrates to a diminution, or disappearance of the teeth with the advance of specialization. In the marmosets the loss of the last molar is unique in the higher division of the order, and is indeed a somewhat remarkable peculiarity to occur in a herbivorous mammal, among which the reduction is usually confined to the front and premolar teeth.

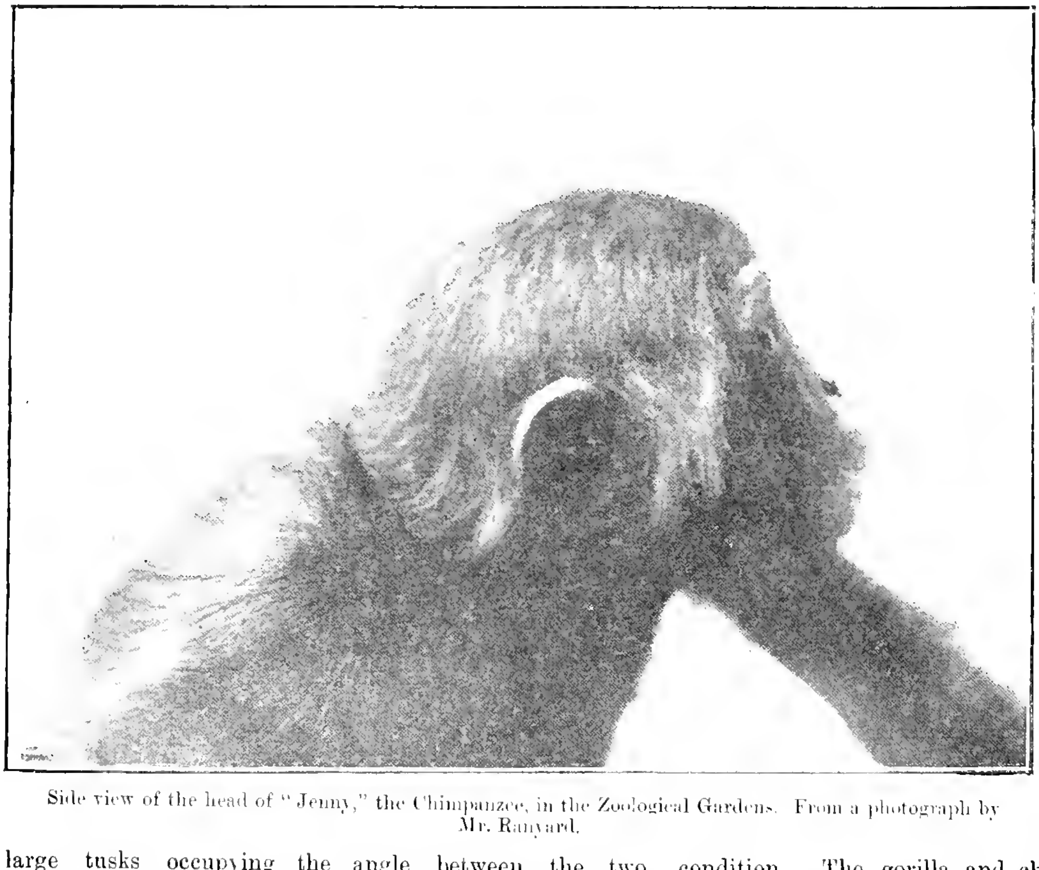
As the teeth serve most readily to differentiate the Old World monkeys from their American allies, so the man-like apes are sharply distinguished from their relatives by the conformation of these organs. As shown in the accompanying figure of the lower jaw of the chimpanzee, the molar teeth of the man-like apes closely resemble our

ONE OF THE GIBBONS, OR SMALLER MAN-LIKE APES.

From a Specimen in the Zoological Society's Gardens

The extreme length of the arms, characteristic of the genus, is well displayed, while this species also shows the white ring round the face distinctive of some Gibbons.

own, having the angles of their crowns rounded off, and carrying on their grinding-surfaces four very blunt tubercles, placed alternately to one another, as well as a somewhat smaller tubercle at the hinder end. On the other hand, in the monkeys the molar teeth are oblong in form, and carry four very prominent tubercles arranged in pairs at the two extremities of each, and each pair being connected so as to form a couple of more or less well-defined transverse ridges extending right across the crown. Then, again, whereas in the man-like apes the last molar, or "wisdom-tooth," in the lower jaw is similar in form to the two teeth in front of it, in the great majority of the Old World monkeys this tooth has a large projecting heel at its hinder end. These dental characters afford very important evidence of the close kinship of the man-like apes to man himself, and undoubtedly outweigh the difference in the form of the whole dental series now to be noticed, which is largely due to adaptation. In both the upper and lower jaws of man, the teeth, as we all know, are arranged in a regular horse-shoe series, with scarcely any interruption to the continuity by the tusks, which are but little taller than the other members of the series. In the adults (and especially the males of the larger species) of the man-like apes the cheek-teeth are arranged in a nearly straight line, and form a more or less angulated junction with the line of the incisors; the large tusks occupying the angle between the two series, and thus forming a marked break in continuity. In these respects the man-like apes resemble their inferior kindred. If, however, we take a young individual of the larger anthropoids, and especially the chimpanzee, it will be found (as shown in our illustration) that the teeth, owing partly to the imperfect protrusion of the tusks, form a much less interrupted and more regularly curved series. Indeed, with the exception that the whole jaw is longer and narrower, and the partially protruded tusks are proportionately larger, the characters of the figured specimen make a very marked approximation to the human type; and the jaw of a chimpanzee at this stage may be regarded as almost intermediate in structure between that of man and that of an adult male gorilla. Moreover, in this juvenile state the bony union of the two branches of the lower jaw partakes of the short and rounded form characterizing that of man; whereas in the adult it becomes longer and more deeply channelled, like that of the lower monkeys. In many respects the teeth and jaws of the gibbons, or smallest representatives of the group under consideration, conform to the intermediate type. Not only are the human characteristics most developed in the teeth and jaws of the young of the larger man-like apes and the gibbons at all ages, but the same is true with regard to the skull of the former. The skull of the young gorilla, for instance, lacks the beetling crests over the eyes and the prominent ridge down the middle of the crown which give such a forbidding and repulsive aspect to the cranium of the full-grown male. This loss of human resemblances is due to specialization taking two different lines in man on the one hand, and in the larger man-like apes on the other; the development in the one case tending to increased size of brain, coupled with no marked increase in the size of the tusks, while in the other the brain grows at a less rapid rate, and the skull and tusks (more especially in the male) assume characters approximating them to those of the inferior animals. Both in men and apes the young condition may accordingly be regarded as the most generalized.



Side view of the head of "Jenny," the Chimpanzee, in the Zoological Gardens. From a photograph by Mr. Ranyard.

Among the other features in which the man-like apes differ from monkeys and resemble man, are the absence of dilatable pouches in the cheeks for the storage of food, and the total loss of the tail, as well as the flattened, instead of laterally compressed, form of the breast-bone; the gibbons alone retaining the naked patches on the buttocks so characteristic of the monkeys, but only in a much reduced condition. The gorilla and chimpanzees further differ from the other members of the group, and thereby resemble man alone, in the loss of the so-called central bone of the wrist—a bone occupying a nearly central position between the upper and lower rows of small bones of which that joint is composed. What may be the object of the disappearance of this bone, it is not easy to say; but the fact that it is wanting in the two genera of apes just mentioned is very significant of their close structural affinity with man. In one respect the man-like apes stand apart both from the human and the monkey type, namely, in the great relative length of the arms as compared with the legs, the disproportion being most strongly marked in the gibbons, which are actually able to walk in the upright posture with their bent knuckles touching the ground.

So far, indeed, as their bodily structure is concerned, the man-like apes seem undoubtedly more nearly related to man than they are to the lower monkeys; and they constitute a family (*Simiidæ*) by themselves, which may be regarded as intermediate between the one (*Cercopithecidæ*), including the lower monkeys, and that represented by man himself. While at present, as we have said, the "missing link" between man and the apes is wanting, extinct forms tend to connect the latter very closely with the monkeys. For instance, a fossil ape (*Dryopithecus*) from the Miocene Tertiary strata of France has the bony union between the two branches of the lower jaw much longer than in any existing man-like ape, although it is approached in this respect by the gorilla; while from the corresponding beds of Italy another extinct form (*Oreopithecus*) appears to be in great part intermediate between the man-like apes and the lower monkeys. It may be mentioned here that in the same strata in which occur the remains of the dryopithecus are found flint flakes which have been regarded as exhibiting signs of artificial chipping, and the extinct ape in question has consequently been credited with the production of these supposed weapons. Although we have not seen these wonderful flints, we confess ourselves to be as sceptical in regard to their reputed manufacture as we are with respect to Prof. Garnier's ability to understand "ape-language."

The present distribution of the anthropoid apes clearly points to the existing species being the last survivors of a group which was once widely spread over the Old World, when warmer climatic conditions prevailed over what we now call the temperate regions. The gorilla, for instance, is confined to western equatorial Africa, where it is accompanied by the two species of chimpanzee, one of which ranges eastwards across the continent as far as Uganda.

The orangs, of which there are probably two species, on the other hand, are confined to the great islands of Sumatra and Borneo; while the numerous species of gibbons have a wide range in south-eastern Asia, attaining their maximum development in the Malayan Archipelago and the adjacent regions. This distribution is remarkably discontinuous, but the little that we at present know of the past history of the group tends somewhat to consolidate the scattered distributional areas of the group. One of the most noteworthy of such palæontological discoveries is the fact that a chimpanzee once inhabited northern India: while it is most probable that an orang also was a contemporaneous dweller in the same country. This suggests that India may have been the original home of the larger man-like apes; from whence the chimpanzees and gorillas migrated south-westwards to equatorial Africa, while the orangs travelled in an easterly direction to find a last home in the tropical islands to which they are now confined. This probability, that India was the home of the larger members of the group during the later Pliocene period, further suggests that it is on that country we should concentrate our hopes of discovering the "missing link": and it is not a little noteworthy that, so far as the very fragmentary specimen by which alone it is known admits of our forming a judgment, the Indian extinct chimpanzee appears to have approached nearer to the human type than do its living cousins. During the earlier Miocene epoch, as we have seen, an extinct genus of large man-like apes inhabited western Europe, which, during the commencement of the Pliocene period, was likewise the home of a species of gibbon.

Of the four existing genera of the man-like apes, the chimpanzees (*Anthropopithecus*) are clearly those which come nearest to man, this being especially shown by the shortness of the bony union between the two branches of the lower jaw, the form and mode of arrangement of the teeth (especially in the young), the relatively small development of the tusks of the male, the absence of the enormous bony crests on the skull so characteristic of the gorilla, and the slight difference in the size of the two sexes. The specimen shown in Mr. Ranyard's photographs is a female recently acquired by the Zoological Society, whose amiable disposition and general intelligence promise to make her almost as popular as the deceased "Sally."

The chimpanzees and the gorilla alone resemble man in having seventeen vertebræ between the neck and the sacrum, and likewise in the absence of the central bone in the wrist, although they differ in the comparatively unimportant feature of possessing an additional pair of ribs. In addition to the characters already mentioned, the gorilla (*Gorilla*) differs from the chimpanzee in the more oval contour of its brain, thereby approximating more nearly to the human type.

The reduction of the number of vertebræ between the neck and the sacrum to sixteen, together with the retention of the central bone in the wrist, the great length of the arms, which in the upright posture reach to the ankles, and the peculiar upward prolongation of the vertex of the skull, serve at once to show that the orangs (*Simia*) stand on a lower evolutionary platform than either of the preceding representatives of the family. Externally they are further distinguished by the rudimentary condition of the great toe, the peculiarly flattened form of the almost disc-like leaden-hued face of the adult, and the red tinge of the long and shaggy hair, the latter being in marked contrast to the black hue of the gorilla and chimpanzees. Although in possessing only a dozen pairs of ribs the orangs differ from both the latter and resemble man, yet this resemblance is greatly outweighed by the difference in the number of the vertebræ.

Agreeing with the orangs and the lower monkeys in the presence of a central bone in the wrist, the gibbons (*Hylobates*) make a further approximation to the latter in the retention of small naked callosities on the buttocks; while they are likewise distinguished by their small size, and the inordinate length of their arms, which, as already said, admit of the bent wrist being applied to the ground when the animals are walking in the upright posture. Another characteristic of the gibbons is the smooth contour and relatively large size of the brain-case of the skull, which gives them a more human-like physiognomy than the adults of their larger relatives: this does not, however, by any means imply that the brain-power of these creatures is greater, but is merely due to the circumstance that in any group of animals the relative size of the brain is necessarily larger in the smaller forms. In colour, gibbons are subject to considerable variation, the Hainan species being uniformly black, Müller's gibbon brownish-black and grey, with a whitish circle round the face; while the silver gibbon takes its name from the uniformly silver-grey hue of its pelage. Gibbons are the only apes which habitually walk in the upright position, and although they frequently aid themselves by applying the hands to the ground, they often while walking clasp them together at the back of the head. In addition to this peculiarity, these creatures are remarkable for the extreme agility of their movements, and their loud unearthly cries, which resound morning and evening through the forests frequented by these animals, and in imitation of which the hoolock of Assam and Burma takes its name. Although the confined limits of a cage in the Zoological Gardens are far from favourable for displaying the marvellous rapidity of the movements of these creatures—so rapid indeed that birds on the wing are not unfrequently captured—yet the specimen which has been photographed so excellently by Mr. Ranyard indulges in the most frolicsome antics among the ropes and branches placed in its cage, to the manifest delight of all spectators. Equally well marked is the delicacy of touch possessed by the gibbons: this being shown when they amuse themselves by playing with spiders, which they allow to descend by spinning a thread attached to a finger, and then suddenly jerking them back into their hands, when the unfortunate performers are devoured with much apparent gusto.

THE DEFINING POWER OF INSECTS' EYES.

By A. C. Ranyard.

The exquisite minute details which the microscope so frequently reveals to us, on examining insects and the minute objects by which they are habitually surrounded, might lead one to suppose that insects can see and appreciate much smaller things than are visible to the eye of man; but though we know very little as to what range of sounds insects can hear, or as to their sense of smell, and the other senses they possess, we are able to assert pretty confidently that the defining power of the composite eye of an insect is very inferior to the defining power of the human eye.

A man with keen eyesight can just distinguish as separate objects adjacent lines or dots which are separated by an interspace that subtends about a minute of arc. The reader may easily try the experiment for himself. The lines in the shaded area in Fig. 1 are separated by intervals of about a millimetre from the centre of one line to the centre of the next. Seen from the distance of a foot or fifteen inches, at which he is reading this page, the lines are easily perceived as separate rulings, but from the other side of the room the shading in Fig. 1 appears of a uniform grey tint. At a distance of three thousand four hundred and thirty-eight millimetres, or about eleven feet, a millimetre subtends an angle of one minute. With a suitable light a keen-sighted person will just distinguish the separate lines at a distance of about eleven feet. I can only distinguish them as separate lines at a distance of about six feet. Hence for a keen-sighted person, in order that two objects may be seen as two, they must subtend at least an angle of about one minute at the eye. For objects which are not suitably illuminated, or for faint stars, a still greater angular distance is necessary in order that we may see them as distinct and separate objects. Thus in ϵ Lyræ, the quadruple star near Wega, the two pairs are separated by a distance of about three minutes twenty-seven seconds, but I only see them as an elongated pair; and I gather from experiments I have tried with children and elder friends that very few people see the two pairs as separate stars, though most long-sighted people see them as an elongated disc, and are able to point out with certainty the direction in which the disc is most elongated.

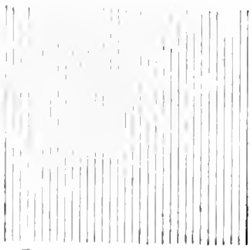


Fig. 1.—Lines about a millimetre apart.

There is more than one reason why the limit of distinct vision for the human eye corresponds to about one minute of arc. The retina is a sort of tessellated pavement made up of small organs known as rods and cones, and the spot in the retina which we use when we fix our attention on the examination of an object is termed the *fovea lutea*. In the *fovea* there are only cones packed closely together and separated by intervals of about four millionths of a metre, or about half the diameter of the red corpuscles. The optical centre of the eye lies at a distance of about a centimetre and a half in front of this part of the retina, and at this distance four millionths of a metre, or the distance between the centres of adjacent cones, subtends an angle which is just a little less than one minute; hence, in order that the images of two points of light may fall on the corresponding parts of adjacent cones, their distance apart must subtend an angle of about one minute as seen from the optical centre of the eye.

There are other reasons, however, why the human eye cannot perceive objects as separate objects when they are separated by intervals of less than one minute. As has been pointed out by Mr. Johnstone Stoney in a very interesting paper published by him in the *Scientific Proceedings of the Royal Dublin Society* of 20th December, 1893,* the interference due to the small diameter of the pupil of the eye causes the image of a point to be represented by a patch or spurious diffraction disc which fixes the *minimum visibile* corresponding to the diameter of the pupil.

Thus the angular diameter of the first dark ring seen about the image of a star in a telescope, estimated from the middle of the object-lens, is $\theta = (1{\cdot}22)\ \frac{\lambda}{A}$, where λ is the wave-length of the light, and A the aperture or diameter of the object-lens. If in this formula we put $\theta = 1' = {\cdot}00029$ in circular measure, and $\lambda = {\cdot}6$ of a millionth of a metre (which is the wave-length for yellow light), we have

$${\cdot}00029 = (1{\cdot}22)\ \frac{{\cdot}6}{A},$$

which gives A = 2524 millionths of a metre, or very nearly one-tenth of an inch, as the diameter of the pupil of the eye, which would give rise to a spurious disc of one minute in angular diameter; and when we scrutinize well-illuminated objects, one-tenth of an inch is about the

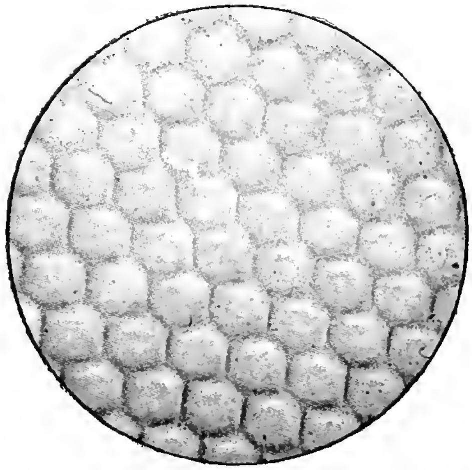


Fig. 2.—Micro-photograph of the lenses of the compound eye of a Water Beetle.

* "On the Limits of Vision: with special Reference to the Vision of Insects," by G. Johnstone Stoney, M.A., D.Sc., F.R.S., Vice-President Royal Dublin Society (republished in the *Philosophical Magazine* for March, 1894.)

diameter to which the pupil of the eye shrinks. Again, the human eye, viewed as an optical instrument, is far from perfect. It is not corrected for chromatic defect or spherical aberration, and such optical imperfections affect the sharpness of the image thrown upon the retina, and if the texture of the retina were finer, and the diameter of the pupil larger, they would alone fix the limit of the *minimum visibile* for human vision at not far from one minute.

In the composite eyes of insects the retina is convex, with a number of separate small lenses in front of it,

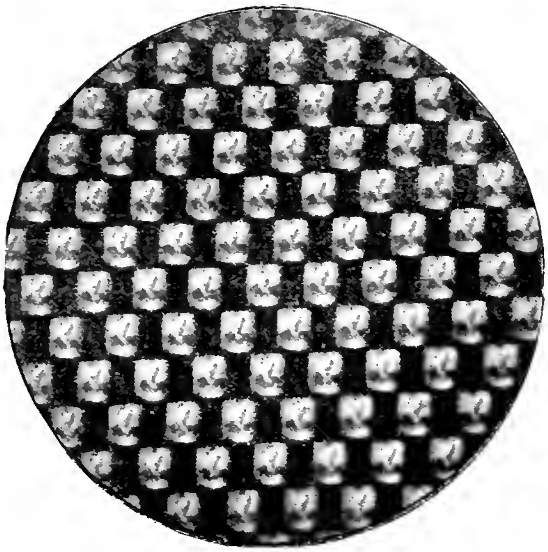


Fig. 3.—Reproduced from a photograph of a carte-de-visite, taken through the lenses of the multiple eye of a Water Beetle.

while in the eyes of vertebrates the retina is concave, with one lens which serves for the whole retina. At last year's meeting of the British Association at Nottingham, the president mentioned in his opening address that the image formed by the compound eye of an insect had been photographed.

By the kindness of Dr. Spitta I am able to exhibit such a photograph to the readers of Knowledge. Fig. 2 is the micro-photograph of a part of the compound eye of a water beetle (*Dysticus marginales*), showing the lenses slightly pressed between a microscope slide and a thin cover, so that each of the little lenses is slightly flattened or depressed at its centre, and Fig. 3 shows the multiple image of a photograph as seen through the above mosaic of hexagonal lenses.

By the kindness of Mr. Gerard Smith, M.R.C.S., I am also enabled to reproduce, for the benefit of our readers, a micro-photograph of the section of the eye of a large fly (*Erystalis tenax*), Fig. 4, which Mr. Smith has very beautifully mounted and photographed. In describing the photograph, Mr. Smith says the little lenses of the cornea can be made out on the surface with a few protective hairs; each facet forms the base of a tiny cone—the points or apices of all these cones are towards the interior of the eye; each cone is lined with pigment in such a way that only a microscopic passage is left clear in the centre, through which a ray of light can penetrate and affect the single nerve which enters the apex of each case. Fig. 5 is a more enlarged photograph, also made by Mr. Gerard Smith, of a portion of the same section, and in it the arrangement of nucleated nerve cells can be seen forming a stratum around the lower ends of the cones. Around each nerve which passes into the apex of a cone there is a group of three large nerve cells, the central one being apparently on the main nerve, and the two outer ones apparently attached by short fibres to the nervous filament along which the optical impression is carried to the brain of the insect.

Fig. 4 shows in a very diagrammatic form the section of a compound eye, with the lenses, which throw minute images of the objects opposite to them on to the blackened sides of the conical tubes behind them; a nerve filament leads into the apex of the cone, and carries the optical impression perceived to the insect's brain.

Fig. 4

The simplest form of composite eye would be a spherical shell perforated with a number of small radial holes. If a sensitive paper were placed in contact with the inner surface of the shell, it would be impressed with a confused picture of surrounding objects, for the light which reaches the bottom of any hole would be derived from objects situated immediately in front of the hole, and the smaller and deeper the holes the less confused would be the mosaic picture imprinted upon the sensitive paper. Mr. A. Mallock, in an interesting paper recently communicated to the Royal Society, and printed in the February number of the Royal Society's "Proceedings,"* has shown that a spherical composite eye without lenses would need to have a diameter of some sixty-nine feet in order to have a defining power equivalent to that of the human eye, for he shows that the diameter of the holes in the shell should not be less than two thousand wave-lengths of light—say one twenty-fifth of an inch—or diffraction would materially interfere with the result; and in order to give a defining power of one minute the thickness of the shell would need to be seven thousand times one twenty-fifth of an inch, or twenty-three feet. The radius of the sensitive sphere within the shell is determined by the condition that, if the picture is to be continuous, the adjacent

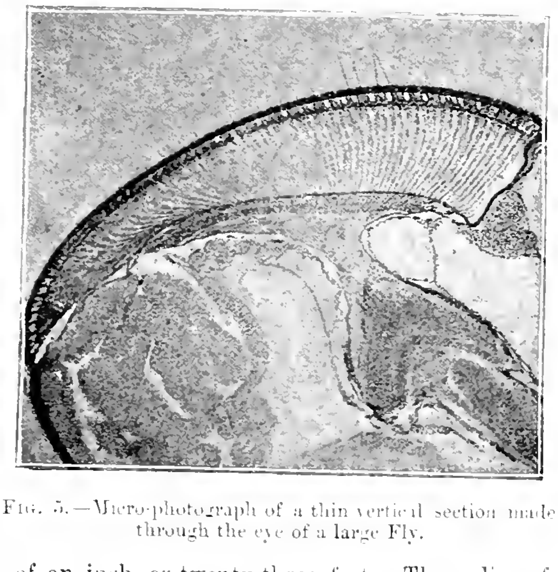


Fig. 5.—Micro-photograph of a thin vertical section made through the eye of a large Fly.

* "Insect Sight and the Defining Power of Composite Eyes," by A. Mallock. Communicated by Lord Rayleigh, Secretary of the Royal Society.

holes must just be in contact at the internal surface of the shell; that is to say, the diameter of the hole must subtend one minute at the centre of the spherical shell, or the sensitive surface must have a radius of eleven feet six inches.

If, still keeping one minute as the limit of definition, we substitute the arrangement actually found in composite eyes, and in place of the long tunnels in a thick shell we use short tunnels or cones with a lens at the outer end of each, and a diaphragm at the inner end, pierced with a small central hole, the proportions of the eye will be determined in the first place by the diameter of the lens which will just define one minute, and secondly, by making that diameter subtend one minute at the centre of the sphere.

The size of the image of a point formed by a lens (as seen from the optic centre of the lens) is inversely as the diameter of the lens, and it takes a lens four inches in diameter to define one second of arc, *i.e.*, to separate points

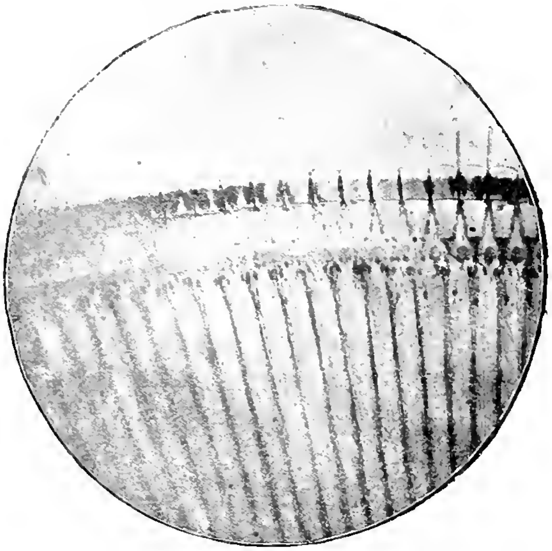


Fig. 6.—Micro-photograph made with a high power of vertical section through the eye of a Fly.

one second apart; hence the lens which will just define one minute is $\frac{4}{60}$, or 0·066 of an inch in diameter, and the radius at which 0·066 of an inch subtends one minute is about nineteen feet. Mr. Mallock therefore concludes that no composite eye of practicable dimensions, acting as supposed above, could be made to give definition even approaching that of the human eye.

The great advantage of the composite eye to insects lies in the fact that the closer they are to an object the better will be their sight of it, for the greater will be the number of lenses employed to produce the impression; whereas in the simple eye, the greater focal length of the lens inconveniently limits the distance at which a distinct view can be obtained. Insects evidently see all distant objects in a very diffused and badly defined manner. The impression perceived must be something like a picture executed in very coarse wool-work—or very rough mosaic—near and distant objects being equally in focus; and it is only when an object is brought close to the eye, so that it covers an area corresponding to several facets of the eye, that its outline would be defined. Mr. Mallock has measured the diameters of the facets and of the composite eyes of many insects, and gives the following interesting table indicating the probable defining power of their vision. It will be seen that the blow-fly and the dragon-fly are keen-sighted as compared with the bees and butterflies.

Species	Length of body.	Greatest dimension of eye.	Diameter of aperture of ommatidium.	Angle between axes of adjacent ommatidia in minutes.	Defining power of lens of diameter *d* in minutes.
	Inches.	Inches.	d.	θ	δ
Diptera					
1. Fly like a bee, *Eristalis*	0·60	0·108	0·0012	56	55
2. Fly like a wasp, *Sericomyia*	0·70	0·12	0·0016	48	71
3. Blow-fly, *Lucilia*	0·34	0·07	0·0018	84	35
4. Very small flies, species not identified	0·20	0·026	0·00076	126	87
5. Ditto	0·13	0·021	0·0005	105	113
Hymenoptera—					
6. Hornet ...	1·0	0·152	0·0014	53	48
7. Wasp	0·7	0·088	0·0011	84	60
8. Bee	0·6	0·100	0·00072	50	90
9. *Chrys's*, scarlet and blue	0·4	0·045	0·00094	105	70
Lepidoptera					
10. Small cabbage, white ...	0·8	0·059	0·00072	86	90
11. Red admiral	1·0	0·072	0·00095	76	69
12. Small copper	0·5	0·050	0·00071	100	93
13. Yellow underwing	0·75	0·064	0·00092	70	72
14. *Noctua*	0·7	0·060	0·00090	70	74
Dragon flies—					
15. Large dragon fly, (*Eschna cyanea*	3·5	0·282	large lenses 0·0023; small lenses 0·0016	48	41
16. *Libellula Strio lata*	2·5	0·191	large lenses 0·0027; small lenses 0·0015	50	45
17. Green grasshopper	1·1	0·057	0·0011	80	60
18. *Tipula*	1·0	0·027	0·00095	200	70

Notices of Books.

The Fauna of the Deep Sea. By Sydney J. Hickson, M.A. Cantab. et Oxon., D.Sc. London. (Kegan Paul, Trench, Trübner & Co., 1894.) Dr. Hickson remarks that the bottom of the deep sea was, until recently, quite an unknown region. It was regarded by most persons, when it entered into their minds to consider it at all, as one of those regions about which we do not know anything, never shall know anything, and do not want to know anything; but during the last quarter of a century the English, French, German, Italian, Norwegian and American Governments have vied with one another in despatching expeditions, well equipped for exploring the dark regions beneath the sea, and a vast store of information is to be found in the scientific reports of these expeditions which have been issued. Dr. Hickson's book brings together, in a small compass and in a very interesting form, many of the more important conclusions which have been arrived at, as well as the facts on which these conclusions are based, and the whole is presented in a form which will be readily understood by those who do not possess a specialist's knowledge of genera and species.

The deep sea seems to be absolutely dark, so far as sunlight is concerned. The temperature is only a few degrees above the freezing point, and the pressure is enormous. There is little or no movement of the water. The bottom is composed of a uniform soft mud, and there is no plant life.

Dr. Hickson thinks that the darkness of the deep sea is probably relieved by the brilliant phosphorescence of many of the deep sea fish. If, he says, we may be allowed to compare the light of abysmal animals with that of surface forms, it is possible that some regions of the deep sea may be as brightly illuminated as a European street is at night—an illumination with many bright centres and many dark shadows, but quite sufficient for a vertebrate eye to distinguish readily, and at a considerable distance, form and colour.

To give an example of the extent to which the illumination due to phosphorescent organisms may reach, he quotes Sir Wyville Thomson as stating "that on leaving the Cape Verde Islands the sea was a perfect blaze of phosphorescence. There was no moon, and although the night was perfectly clear and the stars shone brightly, the lustre of the heavens was fairly eclipsed by that of the sea. It was easy to read the smallest print, sitting in the after port in my cabin, the bows shed on either side rapidly widening wedges of radiance, so vivid as to throw the sails and rigging into distinct lights and shadows." All the abysmal creatures have eyes, and the deep sea crustacea are uniformly coloured red, though the sun's light does not give any perceptible illumination at a depth of even two hundred fathoms. MM. Fol and Sarasin, experimenting with very sensitive bromo-gelatine plates, found that there was no reaction after ten minutes' exposure at a depth of four hundred metres on a sunny day in March.

At a depth of two thousand five hundred fathoms the pressure is, roughly speaking, two and a half tons per square inch—that is to say, several times greater than the pressure exerted by the steam upon the pistons of our most powerful engines. Every animal at the bottom of the Atlantic Ocean lives under a pressure about twenty-five times greater than will drive a railway train. What this enormous pressure is may be realized by the fact that thick glass tubes, filled with air and sealed up at either end, are crushed to powder by the water pressure before they reach a depth of two thousand fathoms.

Though Dr. Hickson's book contains an immense amount of accurate information, it is comparatively light reading, and may be confidently recommended.

Practical Photo-Micrography. By Andrew Pringle, F.R.M.S., &c. (Iliffe and Son. London, 1894.)—Mr. Pringle's book gives valuable practical instruction in methods of research which are every day becoming more and more important to biological students, as well as to doctors and men of science generally. It does not profess to give any history of micro-photography, or to treat theoretically of the optical and photographic matters dealt with, but the practical hints and suggestions to be found on nearly every page will be welcomed by those who wish to retain photographic records of the researches they are engaged upon.

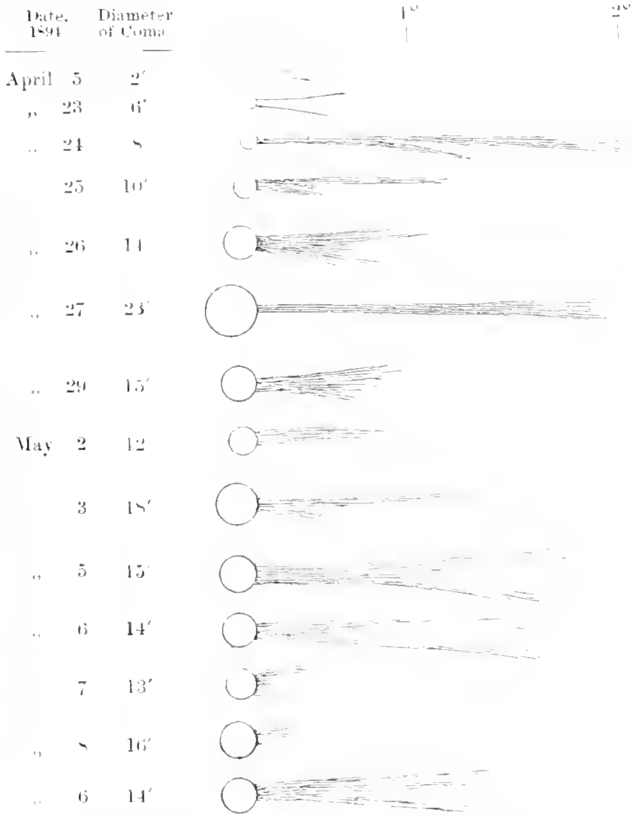
ON THE CHANGES OF FORM IN COMETS' TAILS.

By A. C. Ranyard.

Evidence is very rapidly accumulating which tends to show that the matter of a comet's tail is (at all events in the case of small comets) driven away from the nucleus in a very irregular and spasmodic manner, indicating that the action going on in the nucleus as the comet approaches the sun is by no means quiescent and regular, but rather corresponds in spasmodic irregularity with the outbursts which accompany the rapid boiling of a liquid. There seems to be a capricious irregularity about the explosive phenomena we are familiar with in the action of terrestrial volcanoes and also in the solar chromosphere; possibly such irregularities are always observable when a rapid change of physical condition is going on.

Mr. H. C. Russell, the Director of the Sydney Observatory, has kindly sent me some photographs he has taken of the Comet "Gale," with the accompanying series of drawings showing the remarkable manner in which the tail of the comet appeared to him to vary in length and brightness from day to day. The presence or absence of moonlight or hazy weather might have given rise to slight differences in the apparent length of the tail, though none actually existed, but it will not be contended that the great changes shown in this series of drawings can be accounted for in any such simple manner.

Rough Sketches of the Tail of Comet "Gale." April—May, 1894.



Mr. Russell carefully estimated the diameter of the head of this comet on each occasion, and found the great and irregular variations indicated in his diagrams. If we could be sure that the nebulous and apparently spherical envelope about the nucleus was gaseous, and that it was held in equilibrium by the attraction of the nucleus, we should have at our disposal a very satisfactory means of estimating the mass of the comet, or rather of making a minimum estimate of its mass; for the envelope, if apparently spherical, could not have approached the neutral point between the sun and the comet, where the attraction of the sun and the cometary nucleus counterbalance one another. A gaseous envelope about the nucleus held in equilibrium by attraction, and extending to a height equal to half the distance between the nucleus and the neutral point would, if viewed from the direction in which we were viewing Gale's comet, have appeared distinctly elliptical;

but if the nebulous envelope was composed of a fog of solid particles, each acted upon by repulsive forces from the nucleus as well as by a repulsion from the sun, this test for comparing the mass of the comet with the mass of the sun fails us. Although we know from observation that incandescent gaseous matter generally exists round the head of a comet, we have no evidence that the gaseous matter forms an atmospheric envelope in equilibrium under gravity: indeed, it seems probable, from polariscopic observations, that a great part of the nebulous light is due to solar light dispersed by small particles.

Through the kindness of Mr. J. N. Cobb, of Philadelphia, I have obtained from Mr. Alfred Rordame, of Salt Lake City, Utah, a beautiful photograph of Rordame's comet, taken on the 13th July. Its very rapid motion amongst the stars is evidenced by the long trails they have left on the plate while the camera was kept following the comet in its motion amongst the stars. It will be seen that, as in the photograph of Brooks' comet, reproduced in the May number, the photograph of Rordame's comet affords ample evidence that the matter of the tail was driven away in clouds of varying density, and that these clouds have a structure which suggests an analogy with solar prominence forms, and seems to indicate that the outrushing material has suffered resistance in passing through a resisting medium.

That these rapid changes of form and cloud-like masses in comets' tails have only recently been noted seems to point to the conclusion that the intermittent character of the outflow of matter along the tail is more marked in small comets than in the larger comets with which we were previously familiar. It may be that the feeble gravity that holds together the group of meteoric stones which probably forms the nucleus of a comet, permits the form of the group to be more easily disturbed by the ebullition of vapour in the case of a small group than in the case of a large group.

Thus, in the case of a small comet, fresh meteors would continually be brought to the outer part of the swarm, where they can be more freely acted upon by the sun's radiation, and with a given evolution of vapour these changes would take place more rapidly in a small than in a large group of stones, where the gravitating forces between the various stones of the swarm are larger compared with the gaseous repulsion due to the vapour evolved; and in the case of a small comet, the changes of form within the nucleus would probably be greater, and the evolution of vapour more irregular, with a given rise of temperature than in the case of a large comet.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of Knowledge.

Sir,—In a letter in your May number (p. 116) Mr. Skene states that he observed the zodiacal light "in daylight, *i.e.*, immediately after sunset, of a pretty rose colour," but I would venture to suggest that it is quite impossible that what he saw really was the zodiacal light at all. Even in the tropics the zodiacal light is never visible till at least half an hour after sunset, and even then it can be seen only with difficulty. The mention of the "rose-colour" suggests the probability that what was really seen was a crepuscular ray, which would answer very well to the description given. During nearly twenty years of careful observation of the zodiacal light I have never been able to distinguish any trace of colour in it. My observations, indeed, have been almost entirely made within the tropics, where the light makes a large angle with the horizon, but this is the most favourable condition for seeing it in its true form and colour.

I would like to add that, whether or not there is any connection between the intensity of the zodiacal light and the sunspot cycle, there can be no doubt that during the past three years the light has been more brilliant than during several preceding years. At present the light is very strong, and one and a half hours after sunset it can easily be traced through an arc of from 60° to 70° from the horizon.

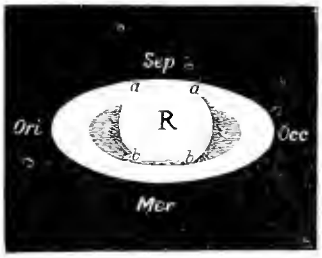
Yours truly,
C. Michie Smith.

The Observatory, Madras,
30th May, 1891.

SATURN'S DARK RING.

To the Editor of Knowledge.

Sir,—When, at the end of 1850, the now familiar "crape ring" of Saturn was practically simultaneously discovered in America by Prof. Bond, of Cambridge, U.S., and in this country by Dawes, the question at once arose as to whether this was, so to speak, a recent addition to or development of the Saturnian ring system, or whether it had merely escaped the attention of earlier observers. When this question was first mooted, it was speedily remembered that in the year 1838 Galle, in examining Saturn, at Berlin, had noticed a perceptible shading off on the inner edge of the interior bright ring, and that Encke had, in fact, published a description of this observation, to which at the time but scant attention would seem to have been paid, possibly owing to the somewhat vague language in which it was couched. Nay, ten years previously, the dusky ring would seem to have been perceived by the observers in Rome, who, however, apparently did not consider the phenomenon worthy of record, or, at all events, of publication.



Beyond this, in the outset, no one attempted to go, and the advocates of the recent evolution of this strange appendage of the planet entrenched themselves behind the authority of Sir William Herschel, who, in his innumerable observations of Saturn, *must*, they contended, have seen it at one time or another had it been then existent, or, at all events, as visible as it subsequently became. Further research, however, once more showed how utterly fallacious merely negative evidence may prove, for Chambers, in his *Descriptive Astronomy*, speaks of a passage in the *Philosophical Transactions* for 1723 which "almost leads one to infer that he (Hadley) had seen the dusky ring, though without being able to make up his mind what it was." Moreover, we find Hind thus expressing himself on page 32 of Vol. XV. of the Royal Astronomical Society's *Monthly Notices*, in connection with this question: "I have found among Picard's observations on the ring, in the same work, a notice of that second dark belt, traversing the globe at the interior edge of the rings, which, with every appearance of probability, has been identified with the obscure ring of modern observers. M. Otto Struve alludes to observations of this nature made early in the eighteenth century; but probably Picard's had escaped his notice. . . . We have, therefore, reason to suspect the existence of the obscure ring, at least as far back as 1673, notwithstanding the negative evidence which the subsequent observations of Sir W. Herschel and others may be considered to afford."

COMET b 1893 (RORDAME).

From a Photograph taken July 13th—9h. 10m. to 10h. 20m.

Direct Photo Engraving Co., 9, Barnsbury Park, N.

But a recent attempt has been made by Mr. H. T. Vivian, F.R.A.S., to carry this discovery still further back, and to attribute it to Dr. Robert Hooke, the famous first Curator of the Royal Society, an observation of whose he quotes in the columns of one of your contemporaries, illustrating it with what purports to be an accurate copy of the original engraving in the *Philosophical Transactions* for 1666. Now this is a point of such curious historical interest that I have taken the pains to inspect the original engraving, which, I am bound to say, I do not find to bear out Mr. Vivian's contention. Through the kindness of my friend Mr. C. Leeson Prince, F.R.A.S., who has taken a photograph from the plate in the *Philosophical Transactions*, I am enabled to give an accurate reproduction of it here. Should it be rendered in these columns with the exactness which usually distinguishes your beautiful protographic illustrations, I think that the following facts will become evident to the careful observer :—In the first place, the lines representing shading between ring B and the body of the planet will be seen to be carried uniformly across that interval, and the apparent darkness in actual contiguity with the globe of Saturn to have had its origin in the printing. But, furthermore, if we are to accept this seeming difference of tint within the ansæ as an attempted delineation of the actual dark ring, what interpretation are we to put upon the perfectly apparent, carefully engraved, and cross-hatched dark lune *outside of the following ansa?* Did—or did not—Hooke see an exterior dark ring in this portion (and nothing whatever outside of the western ansa) or what? Surely no unprejudiced observer, approaching the consideration of this question without prepossession, will deny that this strange feature is much more definitely shown than is that which Mr. Vivian imagines to represent ring C.

William Noble.

To the Editor of Knowledge.

Sir,—In your note to my letter published in the May number, you ask how I can distinguish between the effects of the different concurrent circumstances which accompany "changes of air." This is only to be done by making use for observation of chance occasions when the usual "concurrent circumstances" are absent, and of those occasions when the effects of similar circumstances without changes of air may be observed. The following is an unusually plain example of what I refer to. Two children of my own went into the country for three weeks in very bright weather; three others stayed in London, but were made to spend the greater part of the day in a neighbouring open space. The result was that they all got much strengthened and bronzed, and equally so.

When one is "below par"—that is, when one's full vigour is lessened, the lowering influence may almost always be discovered by careful inquiry. It may be over-exertion and too little sleep, or anxiety, or constant family cares, or spending too much time indoors, or living in an overheated room or street, or cold or many other things; but it will be found that in those cases where the change of air is not accompanied by relief from the injurious influence, no good is effected. On the other hand, the benefit that is usually obtained by "a change" may almost always be traced by inquiry to causes much more evident than any difference in the composition of the air. For instance, a woman living in a stuffy house in an ill-ventilated street is rendered languid and oppressed by hot weather. She goes on to a breezy common, and although the temperature of the air there may be nearly the same, its motion about her is much more rapid and constant, and therefore its cooling effect much greater, and she gets correspondingly braced. With "change of air," moreover, people are ready to make changes of habits which they cannot, or have not the force of will to make at home. Thus the circumstances concurrent with "change of air" which act beneficially are usually of a negative character, and consist in the leaving behind some lowering influence. This opinion is not in any way opposed to the fact that the air in different places varies much in its condition (without change in composition), and so is more or less beneficial or detrimental in various diseases and states of constitution.

I am, Sir, yours obediently,

Tunbridge Wells, Edw. G. Gilbert, M.D.

May 29th, 1894.

[The isolated instances referred to by Dr. Gilbert can hardly be taken as sufficient to upset the generally received theory as to change of air. But if those who have charge of schools or institutions would make notes of the effects produced by change of habit on the weight and strength of groups of individuals as compared with other groups taking change of air, we should have something more definite to go upon and the facts accumulated might possibly be of great value to the community. A. C. Ranyard.]

THE VENOM OF THE VIPERS.

By C. A. Mitchell, B.A.Oxon.

Poisonous serpents are classified in two main groups—the *Colubrina*, with poisonous fangs permanently erected, and the *Viperina*, nearly all of which have fangs which they can erect or depress at will. The cobra may be taken as the type of the former, while to the latter belong the *Crotalidæ* or rattlesnakes, and the various species of vipers. The *Viperidæ* are distinguishable from the *Crotalidæ* in having no pit between the eyes and the nostrils, but in many other respects they closely resemble each other. The chemical and physiological effect of their venom is also very similar, and presents marked differences to that of the cobra, of which a description was given in a previous paper.

The venom from the common viper (*Pelias Berus*) when freshly obtained is a yellow, viscid liquid which dries into a gummy inodorous mass. As early as the beginning of last century it had attracted the notice of scientific men, for in 1702 we find that a book was published by Dr. Richard Mead called "The Mechanical Action of Poisons," in which he gave an account of his experiments on the viper poison. Misled by the magnified appearance of a drop of the venom when drying, he came to the conclusion that the poisonous principle was due to the presence of caustic saline salts. "These saline particles," he writes, "were now shot out as it were into crystals of an incredible tenuity and sharpness, with something like knots here and there from which they seemed to proceed; so that the whole texture did in a manner represent a spider's web, though infinitely finer and more minute."

This book ran through several editions and Mead's theories were accepted until, in 1767, the Abbé Fontana, naturalist to the Grand Duke of Tuscany, published his classical treatise on viper poison. He proved that no salts were present, as Mead affirmed, and brought forward instead the suggestion that the venom was a natural gum. He also showed that it might be swallowed with impunity by getting his servant to make the experiment on several occasions, the only unpleasant result being a tingling sensation on the tongue, which lasted five or six hours.

In 1843, Prince Lucien Bonaparte obtained an active principle from the venom which he called *viperin* or *echidnin*. He also found a yellow colouring matter, a substance soluble in alcohol, albumen, fatty matter, chlorides, and phosphates. This *viperin* was a glittering, transparent mass, containing nitrogen, which detached itself in scales from the glass on drying, and which on injection produced all the symptoms of viper poisoning.

Later research has shown that, as in the case of cobra and rattlesnake poison, the venom of the viper contains more than one albuminoid substance—a *peptone* soluble and incoagulable in water, and a *globulin* coagulable and insoluble. Dr. Winter Blyth and Dr. Guiseppe Badaloni have independently expressed their opinion that the active principle in the poisons of the rattlesnake and the viper tribe is identical. Though this has not been thoroughly settled, the similarity of the symptoms produced by the poisons makes a close resemblance highly probable.

Five years ago Dr. Weir Mitchell published an account of his later work on crotalus venom, from which it appears that he has been able to separate four albuminoid bodies —three *globulins*, all with different chemical reactions, and one *peptone*. In the case of the cobra he was only able to separate one *globulin* and one *peptone*. The amount of the venom of the Indian viper (*Daboia*) at his disposal was too small for him to prove whether it contained more than one *globulin*. In the venom of the moccasin (*Ancistrodon piscivorus*), however, he found three. Whether the venom of our own viper also contains three, as is very probable, has yet to be determined.

The quantity of the *globulins* present is believed to be of importance. as throwing some light on the different physiological effects of the venoms of different serpents. The crotalus poison was found to contain 24·6 per cent., while in cobra venom only 1·75 per cent. was present. Comparative study of the physiological effects showed that the *globulins* tended to prevent the blood coagulating, while the *peptones* had little power to prevent this, and were the active agents in breaking down the tissues. The *peptone* of the cobra venom also seems to have a more decided power of producing convulsions than the rattlesnake *peptone*.

These observations received corroboration from the experiments of Brunton and Fayrer, who showed that in the case of bites from colubrine or viperine serpents the blood remained fluid—

1. When a large quantity of cobra poison was injected;
2. In the case of viper bites (*e.g.*, the *Daboia Russellii*);
3. Nearly always in the case of man bitten by either;

and that the blood coagulated—

1. When only a small quantity of the cobra venom was injected;
2. In the case of small animals bitten by the cobra.

It thus appears that whereas in the case of viperine venom the blood invariably remains fluid, cobra poison often only partially prevents coagulation, and in some cases not at all. Another important difference is that after the bite of a viper subsequent blood poisoning often follows, while, should there be recovery from the first results of the cobra venom, no such after effect is likely.

If the venoms of the rattlesnake and the common viper be of similar composition, the difference in the virulence of the symptoms produced by them may be accounted for (1) by the difference of climate, and (2) by the much larger quantity of venom which the rattlesnake can inject. Fontana noticed the effect of climate and atmospheric temperature on the power of the viper, pigeons recovering readily on certain occasions. These observations were confirmed by Badaloni in 1883. On December 13th a mouse bitten by a viper died in three-quarters of an hour. On the 17th, when the temperature had fallen to zero, a mouse was placed in a cage with four vipers, which at once attacked it, and in all it received eight bites. It seemed prostrated for some time, but in half an hour was as well as before. In summer a mouse bitten by a viper succumbs in less than ten minutes. Dr. Mitchell has found that cold weather has no effect in diminishing the power of the poison, so that the reptile must lose its power of secretion. The rattlesnake, too, seldom attempts to bite in the spring, and when it does so its venom is milder. Valentin found that confinement had a similar effect. A large viper, after being kept for four months, could not by any means be persuaded to bite. After its death some of the fluid squeezed from the poison duct was found to be almost without effect on frogs. The same happened in the case of other vipers.

There can be no doubt that the quantity of poison injected, and the comparative size and strength of the animal bitten, have much to do with the severity of the symptoms. Fontana found that one four-thousandth of a grain was sufficient to kill a sparrow, while six times as much was required to kill a pigeon. Moreover, animals bitten several times by a viper, or by more than one viper, succumbed much more rapidly than those receiving only one bite. Small dogs were easily killed by a single bite, while larger ones offered much more resistance to the poison, and in many cases recovered. Five bites from three vipers were not enough to kill a dog weighing sixty pounds. From these results he calculated the amount that would be necessary to kill a man. Assuming that the average viper secreted about two grains of the venom, he computed that it would require the entire venom of six vipers to kill an ox and of two to kill a man.

It has been stated that viper venom destroys the life of plants, but the experiments of Gilman are too inconclusive to establish his assertion; and on the other hand, Dr. Mitchell states that there is no reason for such a belief, as does also the French surgeon Viaud-Grand-Marais. It is interesting to notice in this connection that Darwin found that the cobra venom acted as a powerful stimulant to the protoplasm of the cells of the *Drosera*.

All warm-blooded animals are susceptible to the poison, though in different degrees. The cat offers a marked resistance, and has been known to survive bites. Vipers being made to bite each other, which they are very unwilling to do, readily recover, and it has been found that many invertebrate animals suffer no ill consequences. A horse-leech bitten several times by a strong viper was on the following day perfectly well. Snails and slugs also recovered in every instance, the majority covering the bitten part with their viscous secretion.

As in cases of cobra poisoning, the reputed remedies for the bite of the viper are worth very little. Alcohol does not diminish the virulence of the venom, and an alcoholic solution acts as powerfully as the fresh poison. In 1737 the Royal Academy of Sciences of Paris caused experiments to be made to test the efficacy of olive oil as an antidote, and came to the conclusion that it was of no use. Potassium permanganate may be of use occasionally in destroying poison not yet absorbed. In estimating the value of an antidote it should be borne in mind that in the case of the more common European vipers, owing to the small quantity received from a bite, the mortality is very slight, and that therefore recoveries after the use of some special treatment would probably have taken place as well without it. In England it is only those of weak constitution who have much to fear from the bite of a viper, even in the

See KNOWLEDGE, June, 1894.

hottest months. Unfortunately, the same cannot be said of the bite of the Indian and African vipers, and of the various species of American rattlesnakes.

TYPES OF FLORAL STRUCTURE.

By the Rev. Alex. S. Wilson, M.A., B.Sc.

A FLOWER commonly consists of organs of four different kinds, arranged in concentric circles or whorls. The order in which these organs occur is always the same relatively to the centre of the flower. The carpels forming the gynæcium are most central; next come the stamens composing the andrœcium; outside of these is the corolla, made up of petals, invested externally by the sepals, which collectively constitute the calyx. There is no apparent reason why the carpels and stamens should not occasionally change places, and an explanation of this invariable order is still a *desideratum*.

A second very obvious character of flowers, which admits of better explanation, is the prevalence of certain numbers among the members composing the different whorls. There is a constant recurrence of the same number of parts in the different whorls of the same flower, and in corresponding whorls of different flowers. The number five is exceedingly common. Thus in the violet, with its five sepals, five petals, and five stamens, we have an example of a pentamerous flower. Three is another favourite number, and of this ternary symmetry the iris, with its three sepals, three petals, three stamens, and three carpels, is a good instance.

By founding his classification of plants so largely upon the number of the floral organs, Linnæus gave prominence to this numerical character, and, highly artificial though it be, the Linnæan system has the merit of recognizing the fundamental importance of this feature as an index of natural affinity.

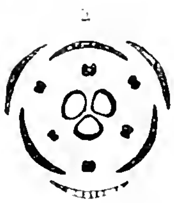
When we study phyllotaxis, or the modes in which leaves are arranged on stems and branches, the reason for the prevalence of certain numbers in flowers becomes apparent. Leaves on a plant's stem are not arranged at random, but according to a definite law. A very frequent arrangement is the alternate, where they are separated by equal spaces or internodes, and so placed that a line drawn through the bases of successive leaves describes an ascending spiral. This line, winding round the stem, is known as the *generating spiral*; the fraction of the stem's circumference which it traverses in passing from one leaf to the next is the *angular divergence*, and the *leaf-cycle* is the portion of the generating spiral included between one leaf and the next above it in the same vertical line. Angular divergence is expressed by such fractions as $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{8}{21}$, &c., where the denominator indicates the number of leaves encountered, and the numerator the number of revolutions round the stem made, by the generating spiral in completing the cycle—that is, in passing from one leaf to the next above it in the same perpendicular line.

Frequently, though not always, the angular divergence is the same for the stem and branches of the same plant; it is generally constant for the same species, and may even be characteristic of genera and natural orders. A common case is where the leaves are separated from each other by one third of the circumference of the stem; the angular divergence in this case is $\frac{1}{3}$ and the cycle includes three leaves. A still more frequent arrangement gives an angular divergence of $\frac{2}{5}$ with five leaves and two turns of the generating spiral to the cycle. Many plants, again, produce their leaves in pairs, one on each side of the stem; since the vertical planes of the successive pairs commonly cut each other at right angles, this arrangement, well exemplified in the mint and other Labiatæ, is described as opposite and decussate. Three, four or more leaves springing from the same node constitute a whorl or verticil; such a verticillate arrangement is seen in the leaves of the wood-ruff and other Rubiaceæ. The whorling of leaves may be regarded as resulting from the suppression of internodes at regular intervals. A shoot having three leaves placed according to the $\frac{1}{3}$ arrangement would, if we suppose its internodes to remain undeveloped, give rise to a whorl of three leaves; similarly a shoot with an angular divergence of $\frac{2}{5}$ would furnish whorls composed of five leaves if its internodes were suppressed. Hence it is held that each flower whorl represents a compressed leaf-cycle, the number of its constituent parts depending on the leaf arrangement to which it corresponds. The frequency of the numbers 3 and 5 among the organs of the flower becomes intelligible in view of the prevalence among foliage leaves of the $\frac{1}{3}$ and $\frac{2}{5}$ arrangements.

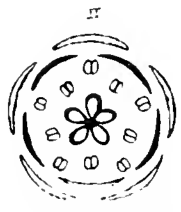
Between phyllotaxis or leaf arrangement and floral symmetry there is thus a very close connection, and we might therefore be led to expect that they would always be in agreement; we might not unnaturally suppose, for example, that every plant with pentamerous flowers should have its leaves arranged on the $\frac{2}{5}$ plan and *vice versa*. Although this rule holds good for many plants, it is very far from universal, and the numerous exceptions point to the conclusion that floral organs have more frequently retained the ancestral phyllotaxis than foliage leaves, which in many cases seem to have departed widely from the primitive arrangement. In other words, the hereditary tendency asserts itself much more strongly in the arrangement of the floral organs than in that of foliage; hence the importance assigned to the flower in every system of classification.

From cases of reversion like the flowering cherry, where the carpels are replaced by ordinary green leaves, we learn that a flower is simply an arrested branch or leafy shoot having its internodes undeveloped and its leaves modified to subserve the function of reproduction. The passage from vascular cryptogams to phanerogams involved, as was shown in a previous article (Vol. XVII., p. 125), the arrest of certain structures belonging to the seed and pollen grain; it now appears that in the formation of the flower we have a further illustration of arrested development.

Excluding the Coniferæ and their allies, which are gymnospermous, all flowering plants have their seeds protected by closed carpels, and are on this account designated angiosperms. Plants embraced under this designation are either monocotyledons or dicotyledons, as the two great classes are called into which angiosperms are divided. To which of these classes a plant belongs can easily be ascertained from its flowers. Each whorl in the flower of a monocotyledon consists of three parts, or of a number which is a multiple of three. The flower of a dicotyledon, on the other hand, is made up of whorls each commonly composed of five parts, or a multiple of five; less frequently, as in the fuchsia and wall-flower, of four, or a multiple of four. Besides this distinction, there is a difference in their floral envelopes; a monocotyledon has the sepals and petals alike—thus in the tulip both whorls of the perianth are coloured or petaloid. Dicotyledons, again, have the sepals mostly green, the petals alone being gaily coloured. The two classes are further distinguished by the characters of their vegetative organs; monocotyledons have parallel-veined leaves, endogenous stems and endorhizal roots; the leaves of dicotyledons are net-veined, their stems exogenous, and their roots usually develop in exorhizal fashion. The first leaves of the dicotyledonous embryo arise in a whorl—they are the two opposite cotyledons; the subsequently-formed leaves may arise either in pairs or verticils, but far more frequently they follow the $\frac{2}{5}$ arrangement. There is but one cotyledonary leaf on the embryo of a monocotyledon; in succeeding leaves the $\frac{1}{3}$ phyllotaxis prevails, though $\frac{1}{2}$ is not uncommon.



I. Monocotyledonous Type.



II. Dicotyledonous Type.

The persistence of these characters points to an early separation of the primitive angiosperms into two well-defined groups having their leaves differently arranged. Although monocotyledons appear first in the geological series, it is by no means certain that they represent the earlier type. Pentamerous and trimerous flowers may have arisen independently after the separation of the two families, but the leaf systems they respectively represent should at least admit of reference to a common origin. The opposite and decussate arrangement some botanists, with good reason, regard as primary for dicotyledons; from it the $\frac{2}{5}$ and all other divergences occurring in this class can easily be deduced. The two opposite cotyledons favour this view, and the passage from the opposite to the $\frac{2}{5}$ arrangement may be actually observed in the artichoke, willow-herb and other rapidly-growing plants. The $\frac{1}{3}$ type does not admit of direct derivation from opposite leaves, and this Henslow gives as the reason why it is never found among the foliage of dicotyledons; the 3-merous symmetry of such exceptional flowers as *Berberis* he regards as due to the breaking up of a high continuous spiral into groups of threes. The $\frac{1}{3}$ arrangement so characteristic of monocotyledons may have come from the opposite type in this indirect way, through an $\frac{8}{21}$ or more complex cycle; but it is much more probable that it arose by symmetrical decrease. A hint of what was, perhaps, the condition in the common ancestral form is furnished by the herb paris, belonging to a family which has the closest relations with the Liliaceæ. The flowers of *Paris quadrifolia* are 4-merous; its leaves are reticulated and arranged in a whorl of four. We have in this undoubted monocotyledon a combination of monocotyledonous and dicotyledonous characters with a phyllotaxis closely approximating to what in all probability was the primitive type in dicotyledons. It should not be forgotten, however, that in the phyllotaxis of fossil cryptogams and gymnosperms much diversity is found.

In diagrams I. and II. the whorls are shown alternating; this is their normal position. Now since foliage leaves develop in acropetal succession—that is, from below upwards—the floral organs ought theoretically to do the same; but if they followed the strictly spiral succession, the whorls would not be alternate, but superposed. To account for the alternation we must therefore assume that each whorl as a whole has shifted its position, the displacement being equivalent to the rotation of a floral axis through half the angular divergence. The angular divergence itself is observed to change in some flowers: in aconite, for example, from $\frac{2}{5}$ in the calyx to $\frac{3}{8}$ and $\frac{8}{21}$ in the corolla and andrœcium. One or two of the Ranunculaceæ, such as *Garidella* and *Helleborus*, have the petals superposed to the sepals in strict accordance with spiral phyllotaxis, but this is rare in the floral envelopes. Where the andrœcium consists of numerous stamens, these are frequently arranged in a spiral manner, giving rise to superposed whorls. The sepals and petals of the buttercup arise in alternate whorls, but the stamens and carpels develop in spiral fashion like ordinary leaves. To this condition the name hemicyclic has been given. In the water-lily order, Nymphaceæ, all parts of the flower follow the spiral order; this condition also occurs in the camellia, in the Magnoliaceæ and Calycanthaceæ, and is approached by several of the Ranunculaceæ. A significant fact in connection with the simplicity of the flower of the water-lily is the circumstance that, notwithstanding its truly dicotyledonous embryo, the root-stock shows the endogenous structure of the monocotyledonous stem.

Considerations like the foregoing make it clear that acyclic flowers, or those whose parts form a continuous spiral, represent a primitive type, upon which the hemicyclic condition of the buttercup is a slight advance. The passage from these to the regular alternating whorls of the eucyclic class involves a modification of the phyllotaxis for each succeeding whorl. Under the term cyclic are included all flowers whose parts occur in whorls, but some confusion has arisen from a lax use of the latter term. Some writers call any set of leaf organs a whorl which arise on the same horizontal zone of the axis—*i.e.*, which are produced at the same height, or what amounts to the same thing, at equal distances from the growing point; others restrict the term to circles in which the parts appear simultaneously. Sepals, as a rule, arise in succession; petals, for the most part, simultaneously. The calyx of the rose illustrates this successive character; its outermost and oldest sepal has fringes on both its edges which are free; so has the second sepal, which is placed at an angle of 144° to the first—*i.e.*, with a divergence of $\frac{2}{5}$. At an equal distance from the second stands No. 3, fringed on its outer edge only; No. 4 is similar, while No. 5, which completes the cycle, has no fringes, both its edges being overlapped by the other sepals. A corresponding order can often be traced even in the corolla—in the butterfly blossoms of Leguminosæ, for example, the large standard petal begins the leaf cycle, one of the keel petals completing it; and generally the æstivation of the flower—that is, the manner in which its parts are disposed in the bud before expansion—admits of explanation on the principles of phyllotaxis. The two examples just given illustrate respectively the quincuntial and vexillary modes of æstivation. As early stages in the evolution of the blossom, then, we have to note: I. The spiral arrangement of the floral organs. II. Whorls due to the arrest of the internodes of the floral axis. III. Alternation, or a change in the orientation of each whorl disturbing the spiral order; and IV. Simultaneous whorls with synchronous development of parts, which still further obscures the original phyllotaxis.

NATURE'S PROTEST AGAINST CHANGE.

By Vaughan Cornish, M.Sc., F.C.S.

THE two great laws of conservation—the law of conservation of mass and the law of conservation of energy—have familiarized the educated world with the doctrine that in Nature nothing is lost. The form of matter changes, but the quantity remains unaltered; the form of energy changes, but its "mechanical equivalent" is constant—that is to say, the amount of mechanical effect it would produce if the energy were all converted into the motion of a mass of matter. In Nature nothing is lost! Surely no dictum of science was ever more contrary to the voice of common sense—that is to say, the sense of what is reasonable derived from the ordinary experience of life.

Let us take first the law of conservation of mass. It has been the common experience of mankind for ages that solid fuel burns away, producing a certain amount of smoke and leaving a little ash behind, no other substance being formed in the burning. There is nothing else produced which is either visible, tangible, or, as far as common experience goes, ponderable. Common experience failed to afford an insight into the changes in the forms of matter which happen during burning. Lavoisier's *Expériences* (*vide* Knowledge, February, 1892) corrected common sense in this, and we now say that in chemical changes no matter is destroyed. Common experience tells us, however, that things have a tendency to wear out and get used up—iron rusts, for instance, and soil loses its fertility. Later chemical research has confirmed this common experience, and shows that the general tendency of chemical changes is to the production of material less capable of reacting chemically, and therefore less available for the work of the world. The carbon chemically combined in plants is still capable of burning, and as a constituent of vegetable food is converted by animals into carbonic acid. Certainly no carbon has been annihilated, but when it has got to the final form of carbonic acid there is little more that carbon can *do*. If it is not lost, it is at all events pretty securely locked up. Were it not for the extraneous energy the earth receives from the sun's rays, the carbon in carbonic acid would be, in this sense, irretrievably lost. In the processes of industrial chemistry we may often see the manufacturer's art applied to the production of some material in a form in which it is chemically active; we may cite, for instance, iron-smelting and alkali-making. Dwellers in the neighbourhood of Middlesborough, or of Widnes, realize better than most people that for every ton of iron a far greater quantity of an effete slag is formed—slag which has accumulated in masses greater than the pyramids of Egypt—and that for every ton of soda there are produced nearly two tons of alkali waste.

The balance of chemical change is on the side of diminished chemical activity. Nature grows weary, and protests afterwards against changes which she does not prevent, and often scarcely hindered at the time.

It is, however, in the domain of physics rather than in chemistry, in transformations of energy more than in transformations of matter, that Nature's protest against change is most strikingly shown. We do not refer merely to the property of inertia, in virtue of which all bodies *resist* a change in their state of rest or motion. In this case, if the resistance be overcome and the motion of the body be increased, energy is stored up in the increased momentum of the body; but when such exchanges of energy are examined in detail there always appears a residual phenomenon which mars the simplicity and completeness of the result. Take the case of any of the well-known mechanical appliances. A small force is made to raise a large weight, and if we multiply the force by the distance through which its point of application is moved the product would be equal to that of the weight multiplied by the distance which the weight is raised, were it not for the inevitable friction which fritters away a part of the mechanical energy in the less available form of heat. It is true that the heat so produced has its mechanical equivalent. Heat can be converted into mechanical work, and one unit of heat converted into mechanical energy produces one thousand three hundred and ninety foot pounds, the same amount of mechanical work which was required to produce the unit quantity of heat; but if we are dealing with the unit quantity of heat, it is found in practice to be impossible to transform the whole of it into mechanical work. Part still remains in the form of heat. Perhaps one half of the unit quantity of heat may be converted into six hundred and ninety-five foot pounds, leaving the other half still in the form of heat energy. This is an example of the conservation of heat energy, but it is a somewhat unsatisfactory form of conservatism, for the half unit of heat which is left is heat at a lower temperature or heat-level than that with which we started, and is less available for further transformation. Only a reduced proportion of this heat can be converted into the higher or more available forms of energy. Hirn's experiments with the steam engine illustrate this point. The loss of heat between the boiler and condenser is accounted for by the mechanical work done, and the mechanical equivalent of heat determined in this way is identical with the heat equivalent of work determined by Joule's method of warming a liquid by the friction of paddle-wheels driven by a falling weight. But the steam engine cannot be worked without a transference of heat between the boiler and the condenser, over and above the heat that is used to overcome resistance. This surplus heat is degraded from the high temperature of the boiler to the low temperature of the condenser. It is still the same in quantity, but it is less available for transformation, less ready to undergo further change. In this case of the running down or degradation of energy an external mechanical effect is produced, and the result is in accordance with our every day experience, and therefore is consistent with the expectations of common sense. We cannot work without growing tired, and it does not seem unreasonable that something analogous to fatigue should be shown by inorganic nature. But the inorganic world shows loss of vigour, not only after effort, but after any change, even though not accompanied by external effect. It is in such phenomena of diminished vigour, resulting from all those natural changes which proceed without effort and without the accomplishment of work, that we best see Nature's protest against all change. One of the best illustrations, which is not only a striking one, but has been carefully and quantitatively examined, is afforded by the expansion of compressed air into a vacuum. In Joule's well-known experiments, a vessel containing compressed air and provided with a stop-cock was attached to a similar vessel which had been exhausted of air. The two were placed in the same vessel of water, and the temperature carefully noted. The stop-cock was then opened, and the compressed air was allowed to rush into the empty vessel. The empty vessel is thereby heated, and the full vessel cooled; but on stirring the water of the outer or containing vessel so as to equalize the temperatures throughout, it is found that the temperature of the system of bodies has, as a whole, undergone no alteration. The only change is that the energy of the air is less available than it was before. There is the same amount of energy *in* it, but in order to get energy *out* of it we should have to expend work upon it, *e.g.*, by compressing it again into a smaller space. A similar and even more important case is that of the equalization of temperatures which is constantly taking place by the flow of heat from hotter to colder bodies, or from hotter to colder parts of the same body. The amount of heat received by the cold body is equal to that lost by the hot body, but whereas work, mechanical, electrical, chemical and so forth, could always be got out of the two bodies as long as there was a difference of temperature between them, now that the temperatures are the same no work or effect can be obtained from the interaction of the two.

The tendency of all forms of energy to transform themselves into heat, and the tendency of heat energy to become uniformly distributed and therefore ineffective, is one of the most important modern generalizations from the study of physical forces. A levelling process appears to go on everywhere in the inorganic world, and if the tendencies which are so distinctly seen to operate now are a part of a continuing order of all things, then we cannot avoid the logical conclusion that the world tends towards a state of death in life in which all the mass and all the energy of the present cosmos are undiminished but impotent. Then there shall be no more change.

Such is the dreary prospect afforded by the attempt to push beyond the limits of our experience the conclusions to which observation of inorganic nature undoubtedly leads. What a different prospect is unfolded by the doctrines which have grown out of the scientific study of the animated world! Natural selection, the survival of the fittest, evolution, familiar terms expressing the generalizations of biological science, point to differentiation, development and progress. It is easy to observe the effect of the doctrines of evolution and development in the optimistic tone as to progress and the future of human society adopted by many writers of the present day.

How is it, one may well ask, that the tendency of things appears so different when looked at from the point of view of the physical and of the biological sciences? Perhaps it is that the progress of species, in which the exercise of volition plays an important part, resembles the processes of the industrial arts, in which the finer and more serviceable forms of matter are produced by aid of thought and contrivance rather than the ordinary operations of inorganic nature. We have pointed out how the manufacture of metallic iron involves the simultaneous production of greater quantities of the effete iron slag. Something analogous seems to be indicated in the frightful waste of animal life, and in the extinction of species. Death, however, removes these from the sphere of action —a difference between the organic and the inorganic world, the importance of which will be realized more particularly by those who have studied the processes of chemical change.

Neither should it be forgotten that, after all, the student of physical science deals statistically with the phenomena he investigates, whereas the work of the student of biological science, as the student of mankind also, is to a large extent concerned with individuals. Physical science deals with the properties of energy as exhibited by matter. The units or individuals of matter are atoms and molecules, and we cannot examine individual molecules. Could we do so we might, and probably should, find that the history of any one of the small number of molecules which we might individually study would differ from the history of the body of which they form a part, as much as the fortunes of the individual man may differ from the general lot of the human race. Referring back to the example of the compressed air expanding into a vacuous vessel, it might occur that certain molecules would receive impacts so directed and so timed that their velocity of motion and their individual energy would be greatly increased. If chance directed our attention to such cases, we might be led to suppose that the change which accompanied the expansion of air had been "progressive" in its character, since it acted for the "benefit" of the "fortunate" molecules. But the statistical study of the phenomenon as a whole would show that, in spite of the "development" of individuals, there had been a general lowering of vigour all round.

But, however these things may be, it is undoubtedly the fact that the powers of the animated world are ultimately derived from the inorganic source of physical energy, and sooner or later the powers of organic development must cease if the phenomena of degradation of energy as exhibited by the inorganic world are really, as they appear, universal in their application.

THE FACE OF THE SKY FOR JULY.

By Herbert Sadler, F.R.A.S.

Sunspots show little, if any, signs of decrease. Conveniently observable minima of Algol occur at 11h. 32m. p.m. on the 1st, and at 10h. 3m. p.m. on the 24th.

Mercury is an evening star during the first few days of the month, and a morning star at the end, but is not very well situated for observation in July. On the 1st he sets at 9h. 23m. p.m., or 1h. 5m. after the Sun, with a northern declination of 18° 18′, and an apparent diameter of 9½″, one quarter of the disc being illuminated. On the 6th he sets at 8h. 58m. p.m., or 43m. after the Sun, with a northern declination of 16° 47′, and an apparent diameter of 10½″, $\frac{17}{100}$ths of the disc being illuminated. After this he approaches the Sun too closely to be visible, coming into inferior conjunction with him on the 20th. On the last day of the month he rises at 3h. 24m. a.m., or 1h. before the Sun, with a northern declination of 18° 2′, and an apparent diameter of 9½″, just one quarter of his disc being illuminated. While visible in the early part of the month he is almost stationary in Cancer, to the S.W. of Præsepe, and on the 31st he is again almost stationary in the extreme eastern portion of Gemini.

Venus is a morning star, but, as we observed last month, is becoming rather an uninteresting object for the amateur. On the 1st she rises at 1h. 40m. a.m., or 2h. 9m. before the Sun, with a northern declination of 18° 52′, and an apparent diameter of 14″, three-quarters of her disc being illuminated, and her apparent brightness being about equal to what it was on February 5th. On the 19th she rises at 1h. 35m. a.m., or 2h. 20m. before the Sun, with a northern declination of 20° 38′, and an apparent diameter of 13¼″, $\frac{79}{100}$ths of the disc being illuminated. On the 19th she rises at 1h. 35m. a.m., or two hours and a half before the Sun, with a northern declination of 22° 4′, and an apparent diameter of 12½″, $\frac{82}{100}$ths of the disc being illuminated. On the 31st she rises at 1h. 47m. a.m., or 2h. 37m. before the Sun, with a northern declination of 22° 29′, and an apparent diameter of 12″, $\frac{85}{100}$ths of the disc being illuminated, and her apparent brightness being about equal to what it was on February 7th. She is in conjunction with Jupiter at 8h. a.m. on the 20th, 0° 51′ to the south. During July she describes a direct path through part of Taurus into Gemini, being very near η Geminorum on the 26th, and μ Geminorum on the 28th, being only 0° 3′ south of μ Geminorum at noon on the 28th.

Mars is an evening star in the sense of rising before midnight during July. On the 1st he rises at 11h. 43m. p.m., with a southern declination of 0° 30′, and an apparent diameter of 10·8″, the phase on the preceding limb amounting to 1·7″. On the 10th he rises at 11h. 17m. p.m., with a northern declination of 1° 29′, and an apparent diameter of 11·5″, the phase amounting to 1·8″. On the

20th he rises at 10h. 49m. P.M., or 2h. 45m. after sunset, with a northern declination of 3° 30′, and an apparent diameter of 12·3″, the phase amounting to 1·9″. On the 31st he rises at 10h. 18m. P.M., or 2h. 30m. after sunset, with a northern declination of 5° 28′, and an apparent diameter of 13·4″, the phase on the preceding limb amounting to nearly 2″. During the month Mars describes a direct path in Pisces, being closely *s f* the 5th magnitude star μ Piscium on the evening of the 30th. At about 1h. A.M. on the 17th an 8·0 magnitude star will be $\frac{3}{4}'$ north of the planet, and three or four minutes after midnight on the 29th a 9th magnitude star will be $\frac{1}{4}'$ north of Mars.

Both Jupiter and Neptune are, for the purposes of the amateur observer, invisible.

Saturn is still an evening star, but should be looked for as soon after sunset as possible. On the 1st he sets at 0h. 15m. A.M., with a southern declination of 4° 54′, and an apparent equatorial diameter of $17\frac{1}{4}''$ (the major axis of the ring system being $39\frac{1}{2}''$ in diameter, and the minor $7\frac{3}{4}''$). On the 16th he sets at 11h. 13m. P.M., with a southern declination of 5° 8′, and an apparent equatorial diameter of $16\frac{1}{2}''$ (the major axis of the ring system being $38\frac{1}{2}''$ in diameter, and the minor $7\frac{3}{4}''$). On the 31st he sets at 10h. 14m. P.M., with a southern declination of 5° 29′, and an apparent equatorial diameter of $16\frac{1}{2}''$ (the major axis of the ring system being $37\frac{1}{2}''$ in diameter, and the minor 8″). Iapetus is at inferior conjunction just before midnight on the 14th. During the month Saturn pursues a short direct path in Virgo through a region destitute of naked-eye stars.

Uranus is also an evening star, but should be looked for as soon after sunset as possible. On the 1st he rises at 3h. 11m. P.M., with a southern declination of 14° 54′, and an apparent diameter of 3·7″. On the 31st he sets at 10h. 50m. P.M., with a southern declination of 14° 53′. He is almost stationary in Libra during the month. A map of the stars near his path will be found in the *English Mechanic* for March 23rd.

Shooting stars are fairly numerous in July, though twilight interferes with observation. A well-marked shower radiates from near δ Aquarii, the maximum being on the 28th. The radiant point is in 22h. 40m.—13°.

The Moon is new at 5h. 45m. A.M. on the 3rd; enters her first quarter at 10h. 15m. P.M. on the 9th; is full at 10h. 3m. P.M. on the 17th; and enters her last quarter at 9h. 7m. P.M. on the 25th. She is in perigee at 2h. P.M. on the 3rd (distance from the earth 225,215 miles), is in apogee at 3h. P.M. on the 17th (distance from the earth 252,460 miles), and is in perigee at 11h. P.M. on the 31st (distance from the earth 222,280 miles). At 8h. 42m. P.M. on the 17th the 5th magnitude star A Sagittarii will disappear at an angle of 55° from the north point, and reappear at an angle of 286° at 9h. 52m. P.M. At 8h. 55m. P.M. on the 18th the 6th magnitude star B.A.C. 7197 will make a near approach at an angle of 346°. At 10h. 33m. P.M. on the 20th the 6th magnitude star 50 Aquarii will disappear at an angle of 354°, and reappear at 10h. 57m. P.M. at an angle of 315°. At 2h. 1m. A.M. on the 21st the $6\frac{1}{2}$ magnitude star B.A.C. 7835 will disappear at an angle of 47°, and reappear at 3h. 20m. A.M. at an angle of 241°. At 11h. 30m. P.M. on the 25th the 6th magnitude star 19 Arietis will disappear at an angle of 60°, and reappear at 0h. 25m. A.M. on the 26th at an angle of 243°. At 3h. 40m. A.M. on the 27th the $4\frac{1}{2}$ magnitude star ζ Arietis will disappear at an angle of 117°, and reappear at 4h. 18m. A.M. at an angle of 186°. At 11h. 51m. P.M. on the 27th the 6th magnitude star 36 Tauri will disappear at an angle of 126°, and reappear at 0h. 20m. A.M. on the 28th at an angle of 197°

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

COMMUNICATIONS for this column should be addressed to C. D. LOCOCK, Burwash, Sussex, and posted on or before the 12th of each month.

Solutions of June Problems.

No. 1 (By Mrs. Baird).

Key-move—1. Q to KR8.

If 1. . . . K × P,	2. Q to B6.
1. . . . K to B4	2. Q to R5ch.
1. . . . P × P,	2. Kt to B5ch.

CORRECT SOLUTIONS received from H. S. Brandreth, Alpha, J. Perkins, A Norseman, W. Willby, B. G. Laws, E. W. Brook, J. St. L. Kirwan, Chat.

No. 2 (By C. D. Locock).

1. Q to B5, and mates next move.

CORRECT SOLUTIONS received from H. S. Brandreth, Alpha, J. Perkins, J. E. Gore, W. Willby, B. G. Laws, E. W. Brook, J. St. L. Kirwan, G. G. Beazley, Chat.

ADDITIONAL SOLUTION of Mr. De Morgan's problem received from J. St. L. Kirwan.

J. Perkins.—There is no Solution *Tourney* in KNOWLEDGE at present, but solutions will always be acknowledged.

Yum-Yum.—This page was in the printers' hands when your letter arrived last month.

E. W. Brook.—Much regret that you decided not to take part in the adjudication. Your previous experience of most of the positions published in this and other columns was surely a sufficient qualification. Solutions of Nos. 1 and 2 are quite correct.

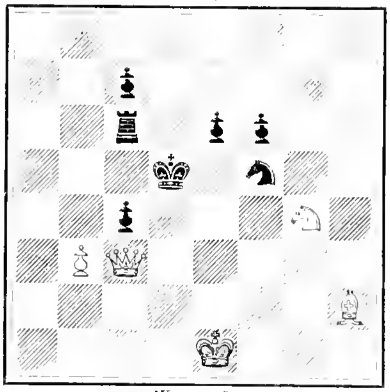
Many correspondents have congratulated us on the success of the Solution Tourney, and on the high standard of the problems in it. We have to thank them also for many discriminating criticisms of the problems, and regret that we have not space for their publication. Some of their ideas, however, will be found embodied in our brief criticism of the less fortunate problems. The more fortunate, of course, cannot be criticized in print till the judge has decided on their respective merits.

PROBLEMS.

By A. C. CHALLENGER.

No. 1.

BLACK (7).

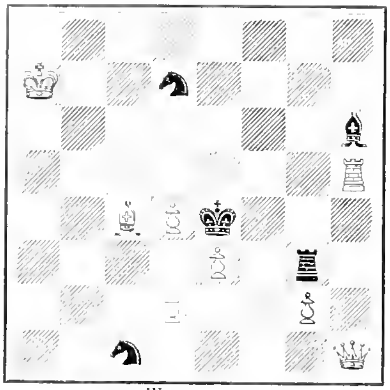


WHITE (5).

White mates in two moves.

No. 2.

BLACK (5).



WHITE (8).

White mates in two moves.

KNOWLEDGE PROBLEM TOURNEY.

Only seven took part in the preliminary adjudication, viz., J. H. Christie, A. C. Challenger, Semper, A Norseman, Chat, Guy, and the Chess-Editor. Marks, awarded on the plan given last month, were divided among the various problems as follows:—44½, 37½, 34½, 33½, 28, 27½, 26½, 25½—13½, 10, 8, 5, 0, 0, 0. Total 294 = 7 × 42. As the voting was very close, and the gap obviously comes after the first eight, the Chess-Editor decided that these eight problems ought to go before the judge. The eight successful problems, named in the order of publication, are —No. 2 ("*I can't help your troubles*"), No. 3 ("*Sweetness and Purity, &c.*"), No. 4 ("*Stella*"), No. 5 ("*Bonne Bouche*"), No. 10 ("*Nulli Secundus*"), No. 11 ("*Pearl of the Garden*"), No. 14 ("*Enrichetta*"), and No. 18 ("*Fortes fortuna juvat.*")

Chat and the Chess-Editor alone placed seven of these on their lists, A. C. Challenger, Semper and Guy placing six. The problem which obtained 37½ marks was the only problem on every list. One solver placed it first, while no less than three placed it seventh.

Mr. E. N. FRANKENSTEIN has kindly accepted the post of judge. We expect to publish his award next month.

CRITICISMS.

No. 1 ("*Pro virtute*").—Spoilt by the weak key and dual. The construction is a little clumsy, but there are some creditable variations.

No. 8 ("*Morceau*").—Neat and unpretentious. The dual short mate is a drawback.

No. 9 ("*Lieblich sind, etc.*").—In spite of the weak key and crowded forces, the author's idea of meeting 1. . . P to B5 by 2. Q to Kt7, resulting in three absolutely pure mates, is perhaps the finest in the whole tourney. Unfortunately, there is a dual in this the main variation.

No. 12 ("*Slender*").—Pretty and elegant, with a fairly good key, and one quiet second move. But like No. 8 it is rather a light weight.

No. 13 ("*Invicta*").—Some nice variations; but the symmetrical construction makes the key obvious, and not only halves the variety but doubles the dual.

No. 16 ("*A Norseman*").—A fair key, but the duals leave only two sound variations.

No. 17 ("*Posuit ultimum lapidem*").—Rather a crowded position. The triple and dual completely spoil an otherwise fairly good position.

Of the unsound problems, "*La Retraite*" was perhaps the best: "*East Harling*" had a fine strategical key: "*The Circle*," if sound, would probably have been the most difficult problem in the tourney.

CHESS INTELLIGENCE.

The result of the Championship Match was received too late to report last month. Mr. Lasker won the last game in fifty-two moves, and the match by ten games to five and four draws, almost the identical score by which Steinitz himself defeated Zukertort in their last match. It is stated that the loser has issued a challenge for a return match to be played under similar conditions next December. In the meantime Mr. Lasker, who is expected in Europe shortly, must be considered champion of the world. Till quite recently it was the fashion to minimize in every possible way the merit of Mr. Lasker's successes, though exactly two years ago an opinion was expressed in KNOWLEDGE that he had no equal in Europe except Dr. Tarrasch. Now his reputation rests on a securer basis. To what extent Mr. Steinitz's defeat is due to increasing years and ill-health cannot be accurately determined; but, as is well known, his victories during the last few years have not been marked by those crushing majorities to which we were accustomed fifteen years ago. He defeated Gunsberg and Tschigorin by a very small margin of games, and subsequently lost both games in his match by correspondence with the latter player. It is extremely improbable, therefore, that he was quite at his best this year. The internal evidence of the games shows inequality of play and a certain lack of patience, though at times there was much of the old brilliancy.

The Championship of the Southern Counties' Chess Union has fallen to Surrey. After their victory in the south-eastern division the result was practically decided, though they still had to play matches with Northamptonshire and Gloucestershire, both of which counties they defeated without much difficulty.

Mr. Teichmann has considerably added to his reputation by two consecutive victories in tournaments at Simpson's Divan. Messrs. Bird, Müller and Rolland were among the competitors.

On May 26th the City of London Club defeated a strong team of the St. George's Chess Club by the decisive majority of eleven and a half to three and a half. Mr. Wayte was the only prominent absentee on the defeated side.

CONTENTS OF No. 104.

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CONTENTS.

THE ANCIENT MAMMALS OF BRITAIN.

II.—THE FOREST-BED AND CRAG PERIODS.

By R. LYDEKKER, B.A.Cantab., F.R.S.

THE freshwater deposit on the eastern coast of England known as the forest-bed, of which the age is preglacial, occupies a somewhat intermediate position in regard to its mammalian fauna between the cavern and crag periods; some of the species characterizing the former epoch extending downwards to the forest-bed, while others are replaced by those of the crag. Still, however, the percentage of existing species is high, and as but few of the genera appear to be extinct, we prefer to assign the formation in question to the Pleistocene rather than to the Pliocene epoch.

Commencing with the carnivores, we have evidence that the forest-bed possesses a sabre-toothed tiger apparently specifically distinct from the cavern species, and not improbably identical with one (*Machærodus cultridens*) from the upper Pliocene beds of the Val d'Arno in Tuscany; while the hyæna is identical with the cavern form, that is to say, the existing South African species. The wolf, and probably the fox, as well as the marten and the glutton, are likewise existing species ranging as far down as the forest-bed; and the occurrence of the last-named is somewhat notable, as showing that even at this early epoch northern types were capable of existing in England before we have any evidence of the incoming of strongly-marked glacial conditions. The other land carnivores of the forest-bed are the otter and the cave-bear; while the teeth of a smaller bear have been tentatively assigned to the American grizzly, although we should think it more probable that they pertained to the brown species. Of marine forms, a walrus which has been regarded as specifically distinct from the living representative of the genus, and the bearded seal (*Phoca barbata*), now inhabiting the North Atlantic, have been recorded from the formation under consideration.

In the hoofed order we find the bison and the musk-ox, as well as a large sheep (*Ovis savini*) apparently allied to the Himalayan argali, inhabiting East Anglia during the deposition of the forest-bed; while the roebuck, an extinct kind of elk (*Alces latifrons*), and the red deer likewise lived at the same time. There appear also to have been several species of extinct deer, among which Savin's deer (*Cervus savini*) is remarkable for the flattened form of the brow-tine, while in the magnificent species (*C. sedgwicki*) named after the well-known professor of geology at Cambridge the spreading antlers attained a complexity of structure unknown in any other member of the genus. Of other ungulates, the hippopotamus, the wild boar, and the horse date from the forest-bed; and the occurrence in this formation of the former species in association with the musk-ox, glutton, and walrus, presents us with another of the puzzles which almost break the heart of the palæontologist. In addition to the common horse, there was an extinct species known as Steno's horse (*Equus stenonis*) and distinguished by the small size of the so-called front inner pillar of the upper molar teeth, or the portion occupying the middle of the lower border of the annexed figure. In this respect the species in question was less specialized than the modern horse, and makes a step in the direction of the under-mentioned hipparion. On the Continent Steno's horse occurs in beds of upper Pliocene age, where it was accompanied by the Etruscan rhinoceros (*Rhinoceros etruscus*), as was also the case in the forest-bed. This Etruscan rhinoceros differs from the leptorhine and megarhine cavern species by the much lower crowns of its molar teeth, and is likewise, therefore, a more generalized type. So far as can be determined, the mammoth does not appear to have come into existence at the period of the forest-bed; but the so-called straight-tusked elephant (*Elephas antiquus*) was abundant, as well as a third species (*E. meridionalis*), unknown in the higher deposits. This southern elephant, which takes its name from its occurrence in the upper Pliocene strata of the Val d'Arno, attained enormous dimensions, and is characterized by the smallness of the height of the crowns of the molar teeth in comparison with their width, as well as by the large size and lozenge-like form of the discs of ivory enclosed by the enamel-plates on their grinding surface, and the width of the intervening spaces of cement. The enamel-plates themselves are very thick and smooth, being almost completely devoid of the puckerings characterizing those of the mammoth. Although anyone can see the difference between a typical molar of the southern elephant and one of the mammoth, some teeth of the former are very like certain of those of the straight-toothed elephant, while some of the latter come very close to those of the mammoth. It is, therefore, advisable in determining the teeth of fossil elephants to seek the aid of a specialist. It may

FIG. 1.—Right upper molar tooth of Steno's Horse.

be added that remains of the southern elephant have been met with in a remarkable deposit at Dewlish, in Dorsetshire, which must consequently be correlated either with the forest-bed or the upper crags.

Among the smaller mammals we find the rodents well represented in the forest-bed, some of the species still existing in Britain, while others are now confined to the Continent, and a few are extinct. In the former class we have the squirrel, the wood-mouse (*Mus sylvaticus*), and the bank-vole (*Microtus glareolus*); and in the second the beaver, the continental field-vole (*M. arvalis*), and the Siberian vole (*M. gregalis*); while of the extinct forms the giant beaver (*Trogontherium cuvieri*) indicates a genus characteristic of this formation and the upper Pliocene, and a vole (*M. intermedius*) intermediate in size between the water-vole and field-vole differs from both in having distinct roots to the molar teeth. In the insectivorous order we have the mole, and the common and pigmy shrews, as representatives of the existing British fauna; while the Russian desman (*Myogale moschata*) is now found only in the districts between the rivers Don and Volga, where it leads an aquatic life, not unlike that of our water-vole, save that its habits are insectivorous instead of herbivorous.

The few cetacean remains from the forest-bed appear all referable to existing forms, and indicate the same mixture of southern and northern forms as characterizes the land fauna. Among these are the southern right whale (*Balæna australis*), a large fin-whale (*Balænoptera*), the sperm-whale—which still occasionally straggles as far north as Britain—the killer, or grampus (*Orca gladiator*), the false killer (*Pseudorca crassidens*)—originally described from a skull from the fens near Stamford, but subsequently found living in the North Sea,—the Arctic narwhal (*Monodon monoceros*), and white whale (*Delphinapterus leucas*), the common dolphin, the bottle-nosed dolphin, and the porpoise.

We now come to the shelly deposits of the east coast, locally known by the term of "crags," a name which has been adopted into geological nomenclature. These beds admit of a three-fold division, namely the Norwich, fluvio-marine, or mammaliferous crag, the red crag, and the coralline, or white crag. The former, which is partly of freshwater and partly of marine origin, shows a molluscan fauna of a decidedly northern type, and has at its base a bone-bed in which mammalian remains occur in considerable quantities. The red crag takes its name from the colour of its sandy beds, and likewise contains a bone-bed in which the fossils are mainly converted into phosphate of lime, and are thus valuable as a source of artificial manure. Although its molluscs are generally of a northern type, this feature is less marked than in the Norwich crag. The lowest, or coralline crag, which is generally of a light colour, takes its name from the number of species of polyzoa found in these beds; its molluscan fauna indicating warmer conditions than those prevailing during the deposition of the upper members of the series.

One of the features of the mammalian fauna of the crags is the occurrence of remains of mastodons, which are quite unknown in the higher beds, and the comparative rarity of true elephants; while still more noticeable is the abundance of the remains of cetaceans, referable to many species and genera. Although some of the crag mammals belong to existing species, the great majority are extinct, and a small proportion belong to genera no longer existing. It is probable that the greater number of the mammals found in these beds belong to species which were living during the time of their deposition, although a few may have been derived from antecedent Miocene beds. Certain specimens are, however, met with which have clearly been washed out from the London clay or other older Tertiary formations; and these, which may generally be recognized by their water-worn condition, will be omitted from our survey. Although the mammals obtained from the different crags are by no means always the same, it will be convenient to treat of the whole series collectively.

Among the most difficult fossils to determine specifically are detached teeth of the cats, and certain such specimens from the red crag, which have been regarded as indicating an extinct species, are so like the corresponding teeth of the leopard that it would be hazardous to say they do not belong to that animal, although, on the other hand, it would be equally rash to say positively that such was the case. Whether a sabre-tooth occurs in these deposits is uncertain; but there is no doubt as to the existence in that epoch of the striped hyæna (*Hyæna striata*), of northern Africa and India, as several well-preserved teeth have been obtained from the red crag. The occurrence of this species in the crag, and its replacement in the forest-bed and cavern-period by the spotted hyæna, is one of those remarkable facts in distribution which we have at present no means of explaining. Both the wolf and the fox appear to date from the period of the red crag, while the polecat apparently occurs in the still earlier coralline crag. The common otter seems, however, to be of more modern origin, since a member of the same genus from the Norwich crag, and a second from the red crag seem to be both extinct. By far the most remarkable of the red crag carnivores is the giant panda (*Ælurus anglicus*), at present known only by an upper molar and a fragment of the lower jaw with the last tooth, since the genus to which it belongs is represented elsewhere solely by the panda or cat-bear (*Æ. fulgens*) of the south-eastern Himalaya. The existing panda, which is an animal of about the size of a fox, with a bright red coat and long bushy tail, is of especial interest as being the sole Old World representative of the raccoons, and is characterized by the peculiarly complex structure of the upper molar teeth and the remarkably curved form of the lower jaw. Since the crag fossils present precisely the same character, there can be no doubt of their having belonged to an animal of the same genus, which was, however, double the size of its existing representative. That a creature so isolated and peculiar as the Himalayan panda should be represented by a closely allied but gigantic species which lived in Britain in company with the wolf and the fox, is one of the most unexpected facts revealed by palæontological investigation.

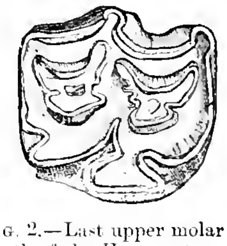


FIG. 2.—Last upper molar tooth of the Hyænarctus.

So far as can be determined there is no evidence of the existence of true bears in the crag, and it is probable that both the cave-bear and the brown bear do not antedate the forest-bed, although an extinct species occurs in the upper Pliocene of the Continent. In the red crag the place of these animals is taken by a huge carnivore known as the hyænarctus, which was in many respects intermediate between bears and dogs, the upper molar teeth, as shown in the accompanying cut, being shorter and squarer than those of the former, while the carnassial or flesh-teeth were of a cutting type more like those of the latter. Species of the same genus occur in the Pliocene and Miocene formations of the Continent, as well as in the

Indian Pliocene. A walrus (*Trichechus huxleyi*), apparently identical with the forest-bed form, as well as two species of seals, one of which is assigned to an extinct genus (*Phocanella*), complete the list of the carnivores of the red crag; and it may be added that the occurrence of the former is not out of harmony with the climatic condition indicated by the molluscs.

Neither oxen, musk-ox, sheep, or goats are known from the crag; but a gazelle, apparently extinct, from the Norwich crag is of considerable interest as indicating the probable existence in England at that period of open, more or less desert plains like those frequented by the majority of the existing members of that group. In contrast to this paucity of hollow-horned ruminants is the abundance of stags, which are especially common in the Norwich crag, and for the most part belong to types unlike any now existing, although Falconer's deer (*C. falconeri*) was near akin to the fallow deer. Among the most peculiar is a species named *C. verticornis*, characterized by its short and thick antlers, in which the cylindrical brow-tine curves downwards over the forehead, while above it are two oval tines, and superiorly the beam becomes flattened and expanded into a crown of two points. The pigs were represented by two extinct species, one of which was nearly allied to, if not identical with, the gigantic *Sus erymanthius* from the Pliocene deposits of Attica; while the smaller one has been identified with another continental species known as *S. palæochærus*.

Among the odd-toed ungulates, true horses seem very rare, although Steno's horse, alluded to above as characteristic of the forest-bed, has been recorded from the Norwich crag. Three-toed horses of the genus *Hipparion* were, however, common in the red crag; their upper molar teeth, as shown in the accompanying figure, being always distinguishable at a glance by the isolation of the antero-internal from the enamel-folds of the centre of the crown. The red crag rhinoceroses are quite distinct from those of the overlying beds, one being identical with the hornless *Rhinoceros incisivus* of the continental Pliocene, while it is possible that a second may be the same as a two-horned form (*R. schleiermacheri*), which is apparently nearly allied to the living Sumatran species, having, like the hornless forms, large tusks in the lower jaw. The occurrence of a tapir in the red crag assists in explaining the present anomalous distribution of these animals; one species of which is Malayan, while all the rest are South American. Although the straight-tusked elephant occurs in the Norwich crag, while the southern elephant dates from the subjacent red crag, the commonest proboscideans of the period under consideration were mastodons, which, it is scarcely necessary to mention, differ from elephants in the much lower crowns of their molar teeth, which are surmounted by low tubercles, frequently arranged in a small number of transverse ridges, separated from one another by more or less completely open valleys, this type of tooth being much more generalized than that of the elephants. In one of the crag mastodons (*M. arvernensis*) the tubercles of the molars were arranged alternately and the lower jaw was short and devoid of tusks; in a second (*M. longirostris*) the same tubercles were arranged in transverse ridges, with their worn summits showing a trefoil pattern like those of the hippopotamus, the lower jaw being at the same time greatly produced and armed with a large pair of tusks; while in the third (*M. borsoni*) the ridges in most of the teeth were three, instead of four in number, and retained much less distinct evidence of their constituent tubercles.

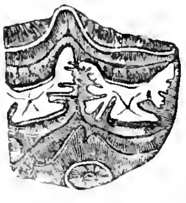


Fig. 3.—Left upper molar tooth of Three-toed Horse (*Hipparion*).

The rodents need not detain us long, but the giant beaver of the forest-bed was sparingly represented in the Norwich crag, while a smaller member of the same genus (*Trogontherium minus*) is found in the subjacent beds; the only other named rodent being the extinct vole referred to above, which ranges downwards from the forest-bed to the Norwich crag.

The whales and dolphins of the crag are so interesting that they would afford ample material for an article by themselves, and can, therefore, receive but scant notice in the limits of space available. Among the whalebone group there appear to have been no less than four species of right whales, one of which (*B. affinis*) resembled the Greenland whale, while a second (*B. primigenia*) was more nearly allied to the southern right whale, and a third (*B. balænopsis*) was characterized by its small dimensions. Humpbacks (*Megaptera*) were likewise well represented, as were also the finners (*Balænoptera*); while an extinct genus (*Cetotherium*) allied to the last contains several species from the crag. It may be mentioned here that all these whales are represented by the shell-like tympanic bones of the inner ear, which differ remarkably in form in the various genera, and thus form unerring guides both for generic and specific determination. Another type of these bones, remarkable for its egg-like form, serves to differentiate yet another extinct genus (*Herpetocetus*) of whalebone whales. Turning to the toothed whales, a remarkable feature in the red crag is the number of teeth indicating the occurrence of large forms more or less closely allied to the sperm-whale, but mostly distinguished by the presence of small caps of enamel. There were likewise smaller forms, one of which has long been known under the name of *Physodon*, although it was only recently that the writer was able to determine from the evidence of a Patagonian specimen that it differed from the sperm-whale in having teeth in the upper as well as in the lower jaw, and thus indicates a distinct and more primitive family connecting the sperm-whale with the dolphins. That a bottle-nosed whale nearly allied to the existing *Hyperoodon rostratus* inhabited British water during the red crag period is proved by an ear-bone in the Ipswich Museum; and the number of beaked whales living at the same time must have been extraordinarily great, from the profusion in which their dense bony beaks occur in these deposits. Most of them belong to the same genus (*Mesoplodon*) as that rare visitor to the English shores, Sowerby's whale; although a few pertain to an extinct genus (*Choneziphius*) characterized by the presence of an unossified tubular perforation running through the centre of the beak. A species of the extinct shark-toothed dolphins (*Squalodon*), together with a killer (*Orca*), black-fish (*Globicephalus*), dolphin (*Delphinus*), and bottle-nosed dolphin (*Tursiops*), completes the list of crag cetaceans. It may be added that the sirenians, that is to say the order to which belong the living manati and dugong, are represented by a skull of the extinct genus *Halitherium* from the red crag, but it is quite possible that this specimen may have been washed out of Miocene beds.

Although the fauna of the crag would have appeared strange and foreign even to an inhabitant of Britain during the early historic period, when the wolf, bear, aurochs, and beaver still lingered in our islands, could a cave-man have seen Britain as it existed during the period of the crags, he would not have found the fauna very different to the one with which he was acquainted, mastodons taking the place of elephants, and the hornless rhinoceros representing the two-horned woolly species which he had probably been accustomed to hunt.

INSECT SECRETIONS.—V.

By E. A. Butler, B.A., B.Sc.

(*Continued from page* 178.)

AMONGST butterflies and moths, the exciting moment when the most wonderful change in their whole history takes place—the moment when they throw aside the deathlike torpor of the limbless chrysalis and take on, to all appearances suddenly, a complete locomotive equipment consisting of six legs and four wings—is an occasion which, in consequence of its exceptional requirements, is fruitful in the production of characteristic liquids. When a chrysalis is enclosed in a cocoon, it is obvious that some substance must be produced by the newly emerging insect, which it may use as a means of escaping from its enveloping shroud of silk. It has no biting jaws, as it had just before it entered on the pupa stage, so that gnawing its way through is altogether out of the question, and it must make its escape by using some solvent which will chemically affect the silk, and either loosen its component threads at the spot where the exit is to be made, or absolutely dissolve them. In our articles on "Curious Cocoons," we have already pointed out that it has recently been discovered that, in one instance at least, this solvent has the remarkable characteristic of being a strong caustic alkali—none other, in fact, than potash itself. We refer to the instance of the puss moth, whose exceptionally hard cocoon necessitates an equally powerful solvent. That an alkaline fluid was produced by this insect on its emergence was indeed noticed nearly fifty years ago, but its exact nature was not determined until quite recently. Analogy would lead us to conclude that a liquid of somewhat similar nature, or at any rate of similarly corrosive action, must be produced by other moths which enjoy the shelter of closed cocoons during their period of lethargy.

Those who have kept caterpillars, and watched the changes through which they pass, are familiar with the fact that a newly emerged butterfly or moth discharges a quantity of a reddish fluid from its digestive tube, so that the ground in the immediate neighbourhood of such an emergence, and the various objects around, including often the old chrysalis shell, become bespattered with drops of coloured liquid, which soon dry up and leave behind a reddish or orange powdery deposit. This liquid is of an acid character, since it reddens blue litmus paper when placed upon it. It is often shot out in considerable quantity and with great force, especially when the insect is disturbed before it has become properly prepared for its new style of life.

Not only does this discharge take place when a chrysalis becomes a perfect insect, but a similar incident often occurs when the caterpillar becomes a pupa. The contents of the alimentary canal are then voided in a semi-fluid condition, though under ordinary circumstances the excrement is compact, and comparatively dry and hard. In the case of the emperor moth (*Saturnia carpini*), Mr. Bateson has made a careful examination of this discharge, specially with a view of determining its relation to the colour of the cocoon. While still contained within the alimentary canal the liquid is green, but shortly after being ejected it becomes reddish-brown. Microscopically examined, it is seen to consist of a coloured liquid containing partially digested food. If it be filtered through blotting paper, a clear green liquid is obtained, which turns reddish-brown in the course of a few minutes. This is no doubt a chemical change due to oxidation, resulting from exposure to the air, as the following experiments tend to prove. If a little be placed on a glass plate, the outer layer may be seen to have changed colour, while the lower part, being out of contact with the air, still remains green. If again the liquid be placed in a tube, and then shaken up with air, the darkening process is accelerated. Yellow nitric acid, a body which easily yields up oxygen, destroys the green colour at once, and turns the liquid reddish-brown. The question whether this substance is a true secretion, or merely a product of the digestion of the food, is not so easy to determine, but that the latter is its true source seems probable from the fact that no such colouring matter can be discovered in the walls of the intestine, though one would expect to find it there if it were a true secretion from glands on the walls.

But though these coloured liquids ejected by caterpillars just before pupation may not really be connected with any special secretory organs, there is an instance of a remarkable product which has been traced back to a special part of the alimentary canal, and is thus shown to be of the nature of a secretion. The product referred to is a powder formed by the caterpillar of the lackey moth (*Clisiocampa neustria*), a well-known flabby creature, striped with reddish, orange and blue, and often found abundantly on whitethorn hedges. This caterpillar fashions for itself a delicate white silken cocoon, of loose and semi-transparent texture. The part immediately surrounding the insect is more compact than the rest, but even that remains sufficiently thin for the outline of the chrysalis to be faintly traced through it. When the caterpillar has completed its task, it discharges from the end of the alimentary canal a quantity of a pale yellow powder, which looks a good deal like flowers of sulphur. This powder, lodging in the meshes of the silk, of course renders the cocoon a good deal more opaque, and thus may perhaps be a source of protection to the insect.

Mr. Poulton recently examined this powder chemically and microscopically, and found that it consisted of minute crystals of carbonate of lime. Dissections of the caterpillars showed that the ultimate source of the powder was the malpighian tubules, the long thin tubes that open into the intestine just behind its junction with the stomach. It is, of course, initially obtained from the food, and apparently accumulates in the tubules till the end of the feeding life, when it is got rid of and made to subserve a possibly useful function in giving greater opacity to the cocoon. This would be of little avail if the creature remained in the chrysalis condition throughout the winter, for the winds and storms of that season would very soon shake all the powder out. But as the insect remains a chrysalis only for a very short time, the obscuration caused by the powder may perhaps be of some slight advantage to it.

Like the skunk amongst mammals, many insects are distinguished for the strong odour that attends them, and that usually proceeds from fluids which they secrete. In a few instances the odour is agreeable to the human olfactory sense, but generally it is quite the reverse. These odours may in some cases be a means of sexual attraction, and in others the liquids which produce them may cause the insects to become nauseous and unpalatable, and so protect them from their enemies. But it would be unsafe to conclude that scents which are agreeable to human beings are also necessarily a source of attraction to the lower animals, and in fact often the very reverse is the case, for many insects are strongly attracted by decaying matter, which to us smells most foully, and if this be so with what we call evil scents, the same may be true of other kinds. It is not, therefore, a legitimate inference that sweet scents are always possessed by insects as a means of attraction, but that evil odours are a means of protection. But, nevertheless, it may well be the case that the substance which yields the odour may be of such an irritating nature as to make both fragrant and malodorous insects unpalatable.

Two orders of insects are particularly noteworthy for the odours that attend them—the Hemiptera in one division of which, viz., the Heteroptera, or dissimilar-winged bugs, the majority are supplied with a more or less penetrating and disagreeable smell, and the Coleoptera, or beetles, a good many members of which exhale odours, agreeable or otherwise. Outside of these two orders we only meet with occasional instances of odoriferous insects, such as the cockroaches amongst the Orthoptera, the lacewing flies amongst the Neuroptera, and the caterpillar of the goat moth amongst the Lepidoptera. Mr. Robson thinks that the female swifts, which are nearly related to the goat moth, also have the power of exhaling a faint odour which is attractive to their mates, and that the fluttering of their wings which takes place while they are waiting for a partner helps to disseminate the odour.

Amongst the Hemiptera-Heteroptera, or bugs, there is a wonderful uniformity about the nature of the scent, as well as of the organs by which it is secreted. In almost every instance amongst the scores of odoriferous species we possess in this country, the odour resembles that of the bed-bug, so that even in this respect there is a family likeness which enables the entomologist at once to refer them to their proper order. As a rule, the larger the insect the more powerful the scent, but that is not universally the case, and amongst the more delicately constructed species, irrespective of size, the smell is often so feeble as to be practically imperceptible to human sensibilities, though of course it does not follow that it is imperceptible to the more acute senses of the insects themselves. The glands by which the fluid is secreted lie on the under side in the central line of the body, and open between the third pair of legs. The form of the orifice and its surroundings varies in the different species, so that it can sometimes be used for classificatory purposes.

The larger, hard-bodied bugs, whose curious shape has gained for them the popular name of "bishops' mitres," often smell very strongly, and so penetrating and persistent is the odour that if the substance stains the fingers, the odour is difficult to eradicate, and clings to them even after washing. If after touching them the finger be applied to the tongue, a burning and very irritating sensation is felt. Most of these larger species are not very common with us; they are met with on trees and bushes of different kinds, and are to some extent indifferent as to diet, feeding on the sap of trees or the blood of insects. As they do not occur in large numbers together, their very strong scent is hardly noticed until one comes within two or three feet of them, but then it is found to be very powerful, and if the entomologist happens to have included one of them in his net as the result of sweeping amongst long herbage, he is sure to be made acquainted with the fact by his nose, even if his eyes are not acute enough to single out the offender at once from amongst the rest of his captures. The smell of the bed-bug is also peculiarly nauseous, though no doubt our dislike of the scent is in this case accentuated by the knowledge of the uncleanly conditions which are indicated by the presence of the insect. But the worst offender in the whole order is a field species which is often to be met with in profusion amongst grasses and other long herbage. It is called *Leptopterna dolobrata*; the male (Fig. 14) is a very handsome insect, and differs a good deal from the female. It is long and narrow, very variable in depth of colour, but with the fore parts yellow marked with longitudinal black bands, and the upper wings orange variegated with dark streaks. The female is much paler, being greenish-yellow, and rarely has her wings fully developed. The scent of this insect is most sickening, especially that of the female, and I have passed by places where the air has been strongly impregnated with the smell, though the insects were not nearer than ten or twelve feet off, and many of them much further than that. It is hardly likely that an insect so nauseous can have many enemies.

Fig. 14.—*Leptopterna dolobrata* (magnified two diameters).

The evil repute of this order of insects is to some extent redeemed by one species, a sand- and heath-loving creature, and no very distant relation of the bed-bug itself. This insect (*Coranus subapterus*) is very elegantly marked with a cool grey, and smells strongly with a fragrance which reminds one of pears. It is exceedingly well protected by its great similarity in colour to its surroundings, so that possibly the smell in this case may be a guide to its mates as to its whereabouts.

Amongst the Coleoptera, or beetles, there are species equally renowned for their scent. The beautiful green tiger beetles, which are such attractive adornments of sunny banks in early summer, exhale, when captured, a powerful and very agreeable odour, something like that of sweetbrier. Considering that the insects are fiercely carnivorous, this is perhaps hardly what was to be expected. That scents such as this are indeed independent of the nature of the food is shown again in the musk beetle, a very large dark-green insect with extremely long antennæ. The smell of this creature is not unlike that of the tiger beetle, and equally agreeable, but its food is totally different, for the larva is an inhabitant of tree trunks, the solid wood of which forms its daily diet. Thus we have a predaceous beetle and a wood-feeder producing similar agreeable scents, while other members of the family to which the musk beetle belongs, though of quite similar habits, are devoid of smell altogether.

In all the cases already noted the fluid secreted is so extremely volatile that it is never seen to issue from the insect, and its presence is only detected by the smell, but in the cases now to be noticed the liquid is not so volatile, and its emission is itself one of the most objectionable features of the insect, even when the scent is not decidedly disagreeable. The various species of ladybirds are well known to emit from their mouth and other parts of the body a yellow, oily, acrid liquid, which has a very strong and disagreeable smell. This habit is paralleled, and in some cases exceeded, by members of the *Chrysomelidæ*, or golden apple beetles. The most noteworthy offender in this group is a shining metallic blue beetle with red wing covers, called *Lina populi*. Its larva, which feeds on poplar leaves, has two conical warts on the fore part of its body, and two rows of smaller tubercles on the back and down the sides, and from all these warts, as well as from the mouth and the joints of the legs, a horribly fœtid, whitish fluid exudes when the creature is alarmed. Notwithstanding the disgusting nature of these secretions, or rather, perhaps, we should say *because* of this quality, they were formerly considered to have valuable medicinal properties, and are said to have been used as a specific against toothache.

Closely allied to the golden apple beetles, and indeed belonging to the same family, is the well-known "bloody-nose beetle" (*Timarcha tenebricosa*) (Fig. 15), which is a very common insect on wayside banks in limestone districts. It is a large and heavy, slow moving, very convex, black creature, faintly tinged with blue, with broad feet, which are of great service to it as it slowly crawls over the herbage. Its popular name arises from its disagreeable habit of exuding from its mouth and from the joints of its limbs a clear red liquid, which reminds one somewhat of the colour of the blood of a vertebrate. Here, again, one can only imagine a protective function in this liquid. The appearance is the most objectionable feature of this secretion, there being no very strong smell attached to it. But such is not the case with the predaceous ground beetles, or *Carabidæ*, all of which pour out a fœtid black or brown liquid from the mouth when handled. A similar habit is exhibited by many carrion feeders, and in this case, as might be expected from the nature of the food, the liquid is still more foul.

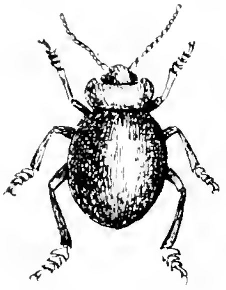


Fig. 15.—Bloody-nose Beetle (*Timarcha tenebricosa.*)

The evil odour of scavenger beetles, however, does not always proceed from the mouth. Among the rove beetles there are many species that have a most repulsive odour, and in their cases the glands are often situated at the tail. The largest species of the group, *Ocypus olens*, the "Devil's coach-horse," may be taken as an example. It is a long, dull black creature, shaped something like a gigantic earwig, attaining a length of upwards of an inch. It is extremely active and remarkably courageous and aggressive. It may often be seen running about at the foot of brick walls, or by the side of pathways, where it is provided with subterranean cavities for retreat if necessary. But it is always prepared to show fight to any object, however large, and if interfered with, at once faces the intruder, and cocking up its tail, and raising its head, glares open-jawed defiance at its opponent with an aspect of the utmost ferocity. At the same time two milk-white vesicles make their appearance at the tail, standing out in bold relief on the dead black background of the body. A very disagreeable odour proceeding from these vesicles is soon perceptible, and makes one still less inclined than before to press one's attentions on so formidable a being.

The larger water beetles, again, emit an extremely fœtid fluid when handled, but of the whole tribe, none perhaps is so repulsive as the little shining whirligig beetles (*Gyrinidæ*), whose mazy gyrations on the surface of still water must be familiar to everyone. These little, highly polished creatures have the power of exuding an oily milk-white liquid from various parts of their bodies, which, spreading over their shiny black surface, gives them the appearance of having been dipped in milk. So acrid is this liquid that the beetles must be an extremely undesirable article of diet, and, as they spend their life at the junction of two transparent media, air and water, each of which is inhabited by predaceous and insectivorous beings, their villainous secretion no doubt serves them in good stead against both sub-aquatic and aërial foes, as well as possibly improving their means of flotation.

One of the most remarkable of the numerous secretions formed by beetles is that of the bombardier (*Brachinus crepitans*) (Fig. 16). This is a small beetle with red head, thorax, and legs, and bluish-grey wing covers. Itself predaceous, it is nevertheless hunted by larger species which desire to prey upon it, and as speed and agility are unavailable against its larger and more active pursuers, it has developed a sort of battery of stern-chase guns, by the aid of which it can effect a Parthian retreat, and bring about the discomfiture of its foes. When attacked it elevates its tail, and discharges therefrom towards its assailant a small quantity of a liquid which instantly vaporizes with a slight explosion, and forms a bluish-white cloud. The expulsion of the liquid appears to require a certain amount of force, and so volatile is it, that if the insect be killed by plunging it into boiling water, the heat volatilizes the liquid while it is still within the abdomen, and causes the latter to swell out to a considerable size. This insect is to be found not unfrequently in the south of England, under stones, by the banks of streams, &c. Its secretion is a strong acid, which acts as an irritant when applied to the skin.

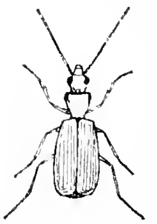


Fig. 16. — Bombardier Beetle (*Brachinus crepitans*), magnified two diameters.

(*To be continued.*)

THE WANDERINGS OF A SUNSPOT.

By E. Walter Maunder, *Hon. Sec. R.A.S., Physical Superintendent Royal Observatory, Greenwich.*

Dr. A. Brester, in his interesting "Theory of the Sun," first published in 1888, and to which he has again recently invited attention, speaks of the singular manner in which spots are apt to move forward during the stage of growth. Quoting from Prof. Young, he writes: "Every time a spot undergoes sudden changes it ordinarily advances on the solar surface by making a sort of leap." I do not propose to discuss Dr. Brester's theory—at any rate on the present occasion—but it seems to me that the proper motion of a sunspot deserves a little more particular description than the above sentence supplies, and, if I interpret the phenomenon rightly, it fails to afford Dr. Brester that confirmation of his theory which he supposes.

Forward motion in a spot is certainly the kind of movement which most readily attracts attention. It is a very ordinary phenomenon of a particularly interesting type of group, viz., the "trains" and "streams," to use Miss Brown's nomenclature. A "train" or "stream" is "a group of spots following each other in succession, having nearly the same latitude, but varying in area and form." When these spots are of considerable size and are not closely connected, the group is called a "train." When the constituents of the group are smaller and less widely separated, the group is termed a "stream."

A train or stream frequently shows itself first as a pair of small spots. The preceding spot of the pair will then move forward at a much quicker pace than its companion, and new spots will break out around those first seen, and especially along the line connecting them. The first and last spots grow rapidly, but usually present different characteristics; the leader being circular and sharply defined, with dark central nucleus, whilst the spot in the rear is much more irregular in outline, not so dark in tone, and with a smaller and more broken nucleus. As the leader spot is the more definite and regular, and as it pushes its way quickly forward whilst the rear-guard either halts entirely, or even moves slowly backwards, its motion naturally attracts great attention. This period of forward motion is also very commonly one of rapid growth, and as both phenomena are very frequently observed, it has no doubt given rise to the idea expressed in the quotation which Dr. Brester makes from Prof. Young.

But though this is typical of the behaviour of a large number of groups, we must not associate the growth and forward motion of the leader spot too closely together, and it certainly is not motion of the nature of a "leap." It will often happen that in a growing "train" the last spot will increase even more rapidly than the leader, whilst the leader will often continue its motion forward at a rapid but equable pace some considerable time after it has reached its greatest extension. Nor is the very opposite phenomenon unknown, viz., that of a recession in longitude during the development of a group.

An actual example will, however, convey much more information than mere general description, and for this we will turn to the last volume of Greenwich *Observations*. Here we find that a simple form of train took its rise on October 16th, 1891 (No. 2325), and, developing rapidly, was observed till it reached the west limb on October 25th. On the first day of observation only two small well-defined spots were seen, their total area only nineteen of the Greenwich units (millionths of the sun's visible hemisphere). By the next day a number of spots were seen, and the total area was one hundred and one units, the increase being principally in the case of the preceding of the two spots of the day before, which had increased from eight to seventy-three units. The third day showed the group at its maximum area of three hundred and twenty units. It now consisted of two great spots. A few spots were seen between the two, linking them as it were together, on the succeeding days, but the first and last spots, the giants of the group, were slowly diminishing the while. By October 23rd the last spot had broken up, and it dwindled with great rapidity, and by October 25th the leader spot alone remained, a solitary spot.

But though the increase in size took place entirely between October 16th and 18th, the drift apart of the two principal spots continued right on to the time of the break-up of the following spot on October 23rd. As the following little table will show, the movement lay almost entirely with the leader, the following spot remaining almost stationary, for the apparent change in longitude near the beginning and end of its career may at least be partly attributable to its growth and decline taking place not quite symmetrically :—

Date. 1891.	Heliographic Longitude. Spot *a*.	Spot *b*.	*a*—*b*.
October 16	330·1°	327·3°	2·8°
,, 17	331·1	328·0	3·1
,, 18	333·2	328·1	5·1
,, 19	334·2	327·5	6·7
,, 20	335·6	327·5	8·1
,, 21	336·5	327·6	8·9
,, 22	337·2	327·4	9·8
,, 23	337·3	327·1	10·2
,, 24	337·8	327·7	10·1

In groups which have been longer under observation than the above, it has sometimes been the case that the disappearance of the following portion of the group has been followed by a backward drift of the leader spot. In the present case the group died out whilst in the unseen hemisphere, but another group, which appeared in 1891, shows this retrogression in a slight degree. The group (No. 2255) was a fine train at its first appearance on July 8th. The forward impulse was still active in the leader, a well-defined circular spot, as the following longitudes, taken on July 9th and the succeeding days, sufficiently show :—177·0°, 178·8°, 179·7°, 180·3°, 181·6°, 181·8°, 182·5°. Here, however, its progress stopped. The retinue of small spots that had attended it hitherto had all but disappeared by the following day, and though the leader itself continued still to grow until it reached the west limb on July 20th, the longitudes recorded for it show no stable progress, but are accordant almost within the limits of error of observation for so large a spot, the mean place being 182·4°. A fortnight later the group was again seen at the east limb as No. 2277 ; the retinue had entirely disappeared, and the leader of the former apparition appeared alone. The longitude had scarcely altered from that it had on July 20th, being 183·1° as against 182·6° ; the advance during an entire fortnight amounting only to half a degree. It was now slowly diminishing in size, its areas on succeeding days reading as 221, 221, 198, 190, 195, 185, 185, 177, 162, 140, 172, 107, and 104. In strict correspondence with this diminution in area was a decline in longitude, the readings for the same period being 183·1, 182·7°, 182·7, 182·5°, 182·4°, 182·2°, 181·9°, 181·7°, 181·5°, 181·2°, 181·3°, 181·5°, and 181·0°, the ephemeral recovery in area on August 14th being accompanied by a feeble but longer-lived return in longitude.

A more complicated movement was witnessed in the group numbered at its successive returns as 2256, 2278, 2294, and 2311. Nothing is more striking in the case of a considerable disturbance than to see it repeat itself as it were in another latitude, and an active train will often be accompanied by a feebler copy of itself a few degrees north or south. An outbreak of the first magnitude, indeed, will reproduce itself in several directions, and will be both preceded and followed by small groups on the same line of latitude, whilst other groups will form between it and the equator, but on the same meridian.

In the present instance, groups 2255 and 2256 both lay on the same meridian and were of very equal dimensions ; the more northern group, as of longer duration than its companion, having perhaps the better right to be considered the principal. As in the October group (No. 2325), the train consisted principally of two great spots, and the second of these remained almost stationary, its longitudes reading as 168·5°, 168·2°, 168·2°, 168·0°, 168·1°, 168·3°, 168·4°, and 168·4° on July 11th and the succeeding days. The leader during the same period had shown a slight tendency to advance, its position varying as follows :—174·4°, 174·8°, 174·9°, 175·6°, 176·3°, 175·7°, 175·7°, 176·3°. The leader attained its maximum on July 12th, the rear-guard on July 13th, but the latter had broken up by July 15th,* and it dwindled rapidly. Its decay was accompanied by a check to the advance of the leader, and by a sudden increase in size, but after the disappearance of the rear spot the leader again moved forward, its longitudes for July 18th, 19th, and 20th being 176·3°, 176·9°, and 177·8°, but its area again steadily diminishing. Here, then, two periods of contraction were associated with a steady advance, but a sudden expansion with a halt and slight retrogression.

At its return, as group 2278, the leader was found in longitude 179·7°. It had considerably increased in size—from one hundred and eight to three hundred and five units—and was alone but for the presence of a faint area apparently recently separated from its penumbra. During this apparition the spot steadily moved backward in longitude, and, with some slight irregularities, on the whole decreased in area. The longitudes ran 179·7°, 179·0°, 178·3°, 178·1°, 177·4°, 177·2°, 177·0, 176·8°, 176·8° 176·5°, 176·1°, 175·9° and 175·3°.

The group was seen during the two next rotations ; from August 31st to September 13th as No. 2294, and from

* The letter *b* for the rear spot is retained after its division in the Greenwich Results for its preceding portion.

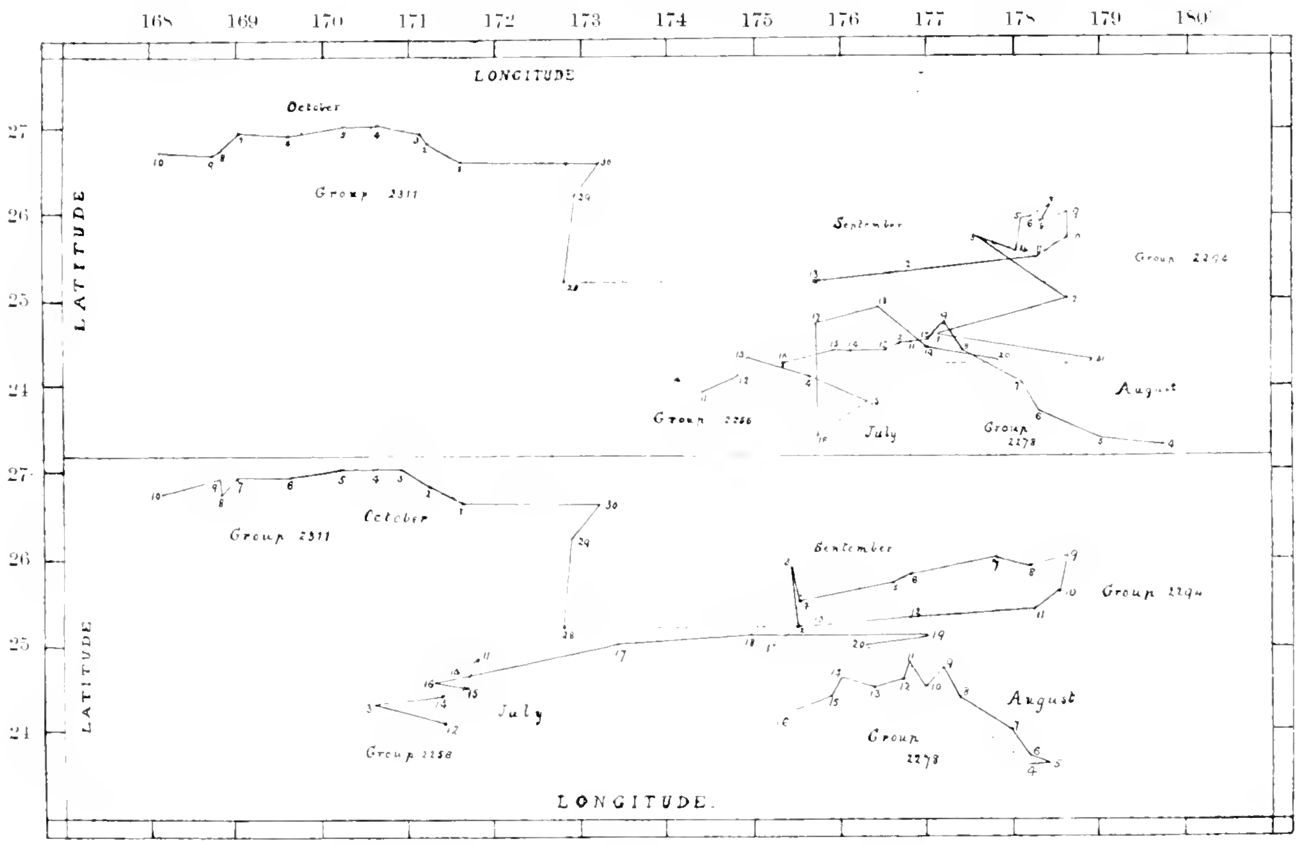
September 28th to October 10th as No. 2311. As No. 2294 it pursued an erratic course, moving irregularly backwards and forwards over a small area, and was last seen at the west limb of the sun on nearly the same meridian as that on which it had been first seen on the east limb. But during the next fortnight, whilst in the unseen hemisphere, it had drifted backwards at a very rapid pace, a drift which still continued during its final apparition as No. 2311, and the group first seen on July 9th in longitude 175·1° was last seen on October 10th in longitude 168·1°.

The accompanying diagram exhibits separately the motion of the circular leader spot taken by itself, and of the centre of gravity of the entire group. The minuter irregularities are possibly due to errors of observation, a discrepancy of one or two tenths of a degree being readily admissible in the estimation of the centre of a spot some backwards along a course as even and straight as it had previously been erratic.

It would be tedious rather than instructive to multiply examples of this forward and backward movement of spot groups, which is extremely typical of the greater and more long-lived disturbances. The instance selected is an ordinary one, and might be matched by the dozen. But to my mind this extension of a group in longitude, till from being one or two degrees in length it becomes ten or twelve degrees, the sympathy often manifested between the extreme spots of a much extended group, and the tendency of a group to return to its original meridian as it approaches dissolution, are plain indications that the cause of the outbreak is something very deeply seated in the sun, whether the actual spots be deep or not.

In other words, in spite of the obstacles which the solar

Curve showing Drift of the Leader Spot.



Curve showing Drift of the Centre of Gravity of Entire Group.

three degrees in diameter, and still more so in the computation of the centre of gravity of an irregular group which sometimes straggled over more than ten degrees. But it would rather appear that they are real, for it will be noted that, except during the first development of the group, the curve for the entire group is actually smoother than for the leader alone. In other words, the waxing and waning of the spots in the after part of the group, and their oscillations of position, were so instantly responded to by a partially compensating motion of the leader, that the group, considered as a whole, kept a more even course than the single spot. This was especially the case during the third rotation, when the leader followed a particularly zigzag path so long as it had a train of attendants. When these had all disappeared it moved gravity and the rapid increase of temperature with depth place upon vertical disturbance in the sun, vertical disturbance and disturbance from a great depth is just the very thing which the greater sunspots evidence.

The groups we have taken as examples were only of the third or fourth order of magnitude, yet they furnish us with instances of spots with areas of two hundred or three hundred millions of square miles, moving at a speed of from two hundred to four hundred miles an hour. There can be no question of a calm atmosphere where movements of this order are in frequent progress. Our wildest tornadoes would appear but as zephyrs in comparison. The argument, therefore, that the solar atmosphere must be quiescent, because the external causes of storms and cyclones at work upon the earth are absent there, is not valid. Whatever the cause, disturbances of greater energy, and on a vastly greater scale than anything we witness here, are manifestly in continual operation.

One other point should be noted. The forward motion of the group was considerably greater than the longitudes given above would indicate, for they were computed with an assumed rotation period of 25·38 days; but this period corresponds, according to Carrington's law, to a latitude of 15°. For spots in north latitude 25°, the daily angular rotation should be 831′ instead of 851′, and the group on October 10th should have been some 27° behind its place on July 10th, instead of not quite one-tenth of that distance. The movements of the group in a forward direction were therefore one hundred miles an hour swifter, as compared with the photosphere in that latitude, than the foregoing figures would indicate.

It may also be pointed out, as showing how difficult it is to obtain a satisfactory determination of the solar rotation from the sunspots, that the group in question would give a different value for the rotation period from each of its four apparitions and from each of the three periods during which it is in the further hemisphere. And that, further, we should get different periods from the group as a whole, and from the stable and well-defined leader spot, which always constituted its principal member. Two of these values, as given by the leader spot, would correspond closely to the theoretical rotation for the latitude; the others would all be much shorter, as this table shows:—

Limiting Dates.	Rotation Period. Entire Group.	Leader Spot.
July 11–July 20	24·52 d.	24·71 d.
July 20–August 4	25·15	25·15
August 4–August 16	25·81	26·06
August 16–September 1	25·38	25·18
September 1–September 13	25·29	25·59
September 13–September 28	25·72	25·72
September 28–October 10	26·12	26·12

This question of the rotation period for different latitudes renders it a difficult matter to trace with certainty an interrupted disturbance. Yet it is not uncommon, when the site of some great outbreak is traced back for two or three rotations, to find that it has for a long time past been the seat of short-lived displays. Thus, the chief group of 1891, No. 2293, had its centre in longitude 221·5° and north latitude 21·8° during its greatest development, August 29th to September 10th. The following table will show how, for several months before, outbreaks of varying importance and duration had been common in the same locality:—

No. of Group.	Limiting Dates.	Long.	Lat.
2293	August 29–September 10	221·5°	+21·8°
2272	August 1–10	222·7°	+18·2°
2254	July 6–17	219·1°	+20·4°
2240	June 17–20	213·9°	+22·1°
2235	June 10–20	199·7°	+26·1°
2222	May 22–25	196·8°	+25·6°
2218	May 16	200·4°	+25·7°
2203	April 19–25	225·5°	+25·5°

Similarly, after the dissolution of the group a number of short-lived groups were scattered over the entire region which it had occupied.

No. of Group.	Limiting Dates.	Long.	Lat.
2306	September 24–October 5	227·4°	+23·2°
2328	October 22–November 2	218·1°	+18·0°
2329	October 23–30	228·2°	+25·9°
2330	October 24–27	225·7°	+19·0°
2335	October 28–November 2	223·0°	+29·4°

Here, again, the final position for the centre of disturbance is nearly the same as the original position, in spite of the high latitude. The real fountain of the formation of the spot, therefore, would appear to have rotated with a speed which was independent of latitude, and which did not greatly differ from the mean period of the spots.

ON THE ORIGIN OF THE GOLD IN QUARTZ VEINS.

By Henry Louis, *Assoc. R.S.M., F.I.C., F.G.S., Mem. Amer. Inst. Min. Eng., etc. etc.*

Whenever we find rival sets of theories held by acknowledged authorities in any branch of science, one of the best services that can be rendered to that science is the collation and criticism of these theories as applied to some one closely defined subject. In no other way can the weakness and strength of the respective positions be as clearly seen, and the probabilities in favour of each as successfully studied.

The general question whence the various substances have come that constitute the filling of mineral veins is still to-day, in spite of the immense amount of work that has been bestowed upon it, one of the most debatable within the whole range of geology. Whilst no one nowadays doubts that the filling up of the fissures, which constitute veins, has been brought about by aqueous or hydro-thermal agencies, and that the various minerals have been introduced in solution, opinions vary greatly as to the direction whence these mineral solutions have come: they may have entered the open fissure from above or from below, or may have been forced in by pressure or by capillary attraction through the pores of the rocks that form the walls of the fissure. There are accordingly three main schools of theorists—the descensionists, the ascensionists, and the lateral secretionists. Prof. Lobley has ably sketched the theory of the origin of gold in quartz veins from the descensionists' point of view, and it should prove a profitable and an interesting task to now attack the same problem from the opposite standpoint, and to briefly summarize what may be considered the case for the opposition.

It is hardly worth while to insist upon the primary point that gold, like other minerals, has been deposited from solution. Prof. Lobley has accumulated a considerable body of negative evidence on this head, his proofs resting upon the fact that gold does not exist within regions of known volcanic action. This evidence is hardly, however, as satisfactory as it might be; first of all because it is negative, and secondly because there are at any rate two well-known and oft-quoted localities—Sulphur Bank, California, and Steamboat Springs, Nevada—where gold may actually be traced in process of deposition, both of which offer unmistakable evidence of volcanic phenomena in the shape of hot mineral waters and gases. According to some authorities, too, the famous Mount Morgan Mine in Queensland is simply a geyser deposit, though it is but right to say that this theory has by no means passed unchallenged. I recently attempted to obtain some more direct proof of the aqueous origin of vein gold, and for this purpose compiled as complete a list as possible of all minerals known to accompany gold in auriferous veins. ("The Mode of Occurrence of Gold," *Mineralogical Magazine*, Vol. X., No. 47, p. 241.) This list comprised no less than seventy-seven mineral species; fully two-thirds of these, however, are beyond doubt decomposition products of others, which had as clearly been the minerals primarily accompanying the deposition of the gold. Of the entire list, however, there was not a single one that is not well known to be producible by deposition from solution, whilst the true volcanic series are conspicuously absent. After all, however, the soundest argument on this point is from analogy, and if there were no other evidence forthcoming, it would yet be safe to conclude that gold, like the other constituents of mineral veins, has found its way into them in solution. When we find crystalline particles of gold in the midst of a vein filled with crystalline quartz, which we know to have been deposited from solution and not injected in a state of fusion, the inevitable conclusion is that the gold, too, was precipitated from solution, and probably even from the same solution as that which held the quartz dissolved. It is therefore satisfactory to be able to confirm Prof. Lobley's views as to the non-igneous origin of gold by means of a totally different line of argument.

With respect, however, to Prof. Lobley's next step, in which the ocean is looked upon as the source of this gold, the proposition becomes far more open to debate; whichever view we now take, there are difficulties on every side, and the problem assumes such a degree of complexity that its complete solution in the present state of our knowledge is out of the question. It is just possible to suppose that sea water could find its way directly into fissures of the earth's crust; nevertheless, direct deposition of the gold from its solution in sea water is pretty well out of the question. In the first place, it is rather difficult to conceive of any system of circulation by which sea water should directly find its way into fissures that were being at the same time filled with a deposit of silica from other sources. Quite apart from the scientific interest of the question, the practical conclusions that would follow from the acceptance of this theory are so far-reaching that they cannot be assented to without the strongest possible proofs. It is fairly clear that if the gold of mineral veins were derived directly from the sea—that is to say, if the descensionists' theory in this form is the correct one—the upper parts of gold veins would be the richest. It is quite true that there is frequently a superficial enrichment of auriferous veins near the surface, due to combined physical and chemical causes, to the concentration, in this portion of the reefs, of the gold derived from the degradation in time past of still higher-lying portions now denuded away, such degradation having, of course, occurred subsequently to the consolidation and upheaval of the vein, together with the surrounding strata. It is also true that the upper portions of reefs are mostly richer in free gold than the lower-seated portions, but this again is only due to the oxidation by atmospheric agencies of the previously existing pyrites with which the gold was intimately combined. The total tenour of gold in the vein is not necessarily affected by this latter change, and upon the whole there is no evidence whatever that gold veins become progressively poorer as we go down deeper upon them. Practical gold miners are fond of saying that gold reefs improve in depth, but practical gold miners are a sanguine race, and it seems but too probable that in the majority of cases it is the "wish that is father to the thought." Instances can, no doubt, be quoted where gold mines, like other mines, have improved in depth, but this must by no means be interpreted into a general law. The richness of gold reefs varies in their vertical as it does in their horizontal extension, but not regularly; in the present state of our knowledge it would be unsafe to predicate more.

According to Prof. Lobley's view, however, sea water is not the direct but the indirect source of the gold of quartz veins. If we admit as proven that sea water contains gold in solution—and the balance of evidence appears, perhaps, to be in favour of this view, although it is by no means easy to speak with certainty when such minute quantities are in question*—the gold most probably exists therein as a haloid salt, possibly as a double chloride of gold and sodium or potassium. This, although one of the most stable salts of gold, is nevertheless so readily decomposable by every reducing agent, including light and a comparatively low degree of heat, that it would be quite inconceivable that metallic gold should not be deposited from this sea water, together with the sedimentary rocks forming on the sea bottom, if it is allowable to take the ordinary laboratory reactions of gold salts as our guide. Modern chemical research has, however, shown that the effect of mass action is too important to be disregarded, and that solutions of extreme tenuity are subject to laws differing widely from those governing the ordinary solutions with which the chemist is in the habit of dealing. Moreover, we are confronted by the difficulty that if this gold were precipitable in the usual way, there would be none left in the ocean, unless it were being redissolved as fast as it was precipitated. The fact, if it be a fact, that the ocean everywhere contains a minute but approximately uniform quantity of gold, is in reality a fairly good proof that this gold is *not* being precipitated. Having regard to the circumstance that very many rock masses have been proved to contain minute quantities of gold, it is, moreover, quite unnecessary to go back to the ocean for a known source of this metal. The evidence that gold does occur in various rocks seems to be tolerably complete, and its presence has been detected not only in sedimentary but also in eruptive rocks. Whatever may be said about sedimentary strata, eruptive rocks cannot well be supposed to have obtained the gold they contain from sea water. In fine, reviewing the facts before us a whole, it seems far more probable that whatever gold is contained in the ocean has been leached out of rocks, than that the rocks have derived their gold from the ocean.

We have so far cleared up two distinct points in our investigation, and are justified in assuming—firstly, that the gold of veins was introduced in solution, and secondly, that its source may probably be traced to various rocks of the earth's crust, and very possibly deep-seated ones, such as eruptive rocks must have been originally. Two other points yet remain: How was the gold dissolved out of the rocks in which it existed? and how was it deposited from such solution? To these latter two queries I fear that our answer will have to be less definite than to the former ones, much of our knowledge, if knowledge it is, being only inferential. If we consider a fissure in the earth's crust, lying below the region of the superficial currents of underground water—the "vadose circulation" of Pošepný—we must in the first place look upon it as necessarily filled with water, and in the second place we must suppose this water to be in motion. The pressure in the fissure will probably be less than in the deeper-lying and adjacent rock-masses, and the greater temperature of the lower parts of the fissure will give rise to convection

* Whilst these pages were passing through the press, I received a copy of the presidential address of Mr. Stanford to the Society of Chemical Industry, delivered in July, in which that gentleman says: "No analysis can give us any idea of what the ocean really contains. . . . The presence of gold has not been satisfactorily proved; it was expected it might accumulate in the copper sheathing of ships, and Messrs. Muntz obliged me with specimens of old sheathing, both copper and Muntz metal. Mr. Inglis, who kindly examined these for me, found both gold and silver, but not in larger proportion than usual."—(*Journ. Soc. Chem. Ind.*, Vol. XIII., No. 7, p. 697). H. L.

currents carrying the lower water to the upper portions of the fissures; other water must descend to take the place of that so driven upwards, and thus a deep circulation will be maintained, aided, no doubt, by inequalities of pressure and capillary action. These water currents would evidently suffice for the conveyance of dissolved gold into the fissures, if we can account chemically for its solution. It must not be forgotten that we have no actual knowledge of the behaviour of substances under such conditions of intense temperature and pressure as prevail in the deeper regions of the earth, and that we are compelled to reason from our laboratory experiments, which may, however, be leading us directly away from the truth. With this proviso, it is not difficult to imagine conditions under which gold may pass into solution. The most permanent soluble salts of gold are the haloid salts, and it has usually been assumed that it is in this form that gold occurs dissolved in Nature. In the paper already referred to, I suggested that it is far more probable that the gold is dissolved in the form of an alkaline aurate. It is well known that fused alkalies, in the presence of air or of an oxidizing agent like nitre, attack gold, forming an aurate soluble in water, and also that many natural waters are strongly alkaline. Perhaps the strongest argument in favour of this view is the invariable association of gold with quartz, an association too invariable to be accidental; so that it seems natural to suppose that the solvent that carried the quartz into the fissure carried the gold also. I personally prefer this explanation, which rests upon reactions and compounds that we know, to imagining a hypothetical soluble silicate of gold that may or may not exist. It presents, moreover, distinct analogies to another mode of solution of gold, of which we have positive evidence—its solution as a sulph-aurate in the two localities already quoted, Steamboat Springs and Sulphur Bank. Both these localities have been repeatedly described by writers on the genesis of mineral deposits; nevertheless, a few lines about them, with reference more particularly to the question we are now considering, may prove of interest. The best account of both is to be found in Becker's monograph on the geology of the quicksilver deposits of the Pacific slope in the *United States Geological Survey*, Vol. XIII. (1888); J. Le Conte has also written on the subject in the *American Journal of Science*, Vols. XXIV. and XXV. Steamboat Springs is the name given to a small district in Washoe County, Nevada, well known as a thermal health resort, some six miles from the Comstock lode. The underlying rock of the district is granite, which is overlaid in many places by metamorphosed rocks of the Jurassic system and by lavas. The springs issue from a series of vents in a narrow valley between two volcanic ridges, the waters being very hot, alkaline, and charged with carbonic acid and sulphuretted hydrogen. Analysis has shown that these waters contain traces of many metals, amongst them gold. The vents out of which the water comes are the remains of a series of extensive fissures, which are now nearly choked up by having been filled with silica deposited by the springs themselves. These deposits are "in many places stained and clouded with metals. . . . In places where there is water still issuing slowly, silica is found in a gelatinous condition. . . . Here then, undoubtedly, mineral veins are now forming under our eyes, but their metallic contents are in very small proportion" (Le Conte, *loc. cit.*). It is noteworthy that cinnabar has been mined in the immediate neighbourhood, and that the deposits of this mineral are evidently closely connected with the springs themselves. The phenomena at Sulphur Bank, California, closely resemble the foregoing. The country rock consists of Neocomian sandstones and a series of metamorphic rocks, intersected by eruptive basalts. There are numerous hot mineral springs carrying alkalies and alkaline sulphides in solution, associated with a series of deposits of cinnabar and silica, crystallized and amorphous. These latter have been mined, and streams of heated water and gases were met with in the course of the operations. The deposits occur both in the sandstones and the basalts. Other sulphides are present besides cinnabar, and these have been shown to contain gold. Most geologists who have studied these deposits are of the opinion that their formation has not yet ceased. Becker thus summarizes his views on both these deposits: "I regard many of the gold veins of California as having an origin entirely similar to that of the quicksilver deposits. . . . The evidence is overwhelming that the cinnabar, pyrite and gold of the quicksilver mines of the Pacific slope reached their present positions in hot solutions of double sulphides, which were leached out from masses underlying the granite or from the granite itself" (*op. cit.*, pp. 449, 450). In both these locailties, therefore, gold has been pretty conclusively proved to be in the course of deposition from hot alkaline sulphuretted solutions, in which there is little doubt that the gold is dissolved as a double sulphide of gold and an alkali, or, in other words, as an alkaline sulph-aurate. Apart, therefore, from the doubt thrown at the outset upon any theories based upon our laboratory experience, there seems to be little difficulty in accounting for the solubility of gold at depths far beneath the earth's surface.

The last stage of the process is also the most difficult of explanation. Given that the gold is in solution, we have to account for its deposition in the fissure under circumstances that do not admit of its re-solution in the same water current. Perhaps the wisest course is simply to confess our ignorance whilst suggesting tentatively a few plausible hypotheses. Of course the solution, when it enters the fissure, contains a number of other substances, notably silica, in solution besides the gold, and whatever cause determined the deposition of these substances most probably precipitated the gold also. For all we know, this cause may have been some electrolytic action. Or again, if temperature and pressure are requisite for the retention in solution of the various substances, these latter would naturally be deposited when the solution found its way into the upper parts of the fissure, where the pressure would be lower and the temperature would be gradually decreasing as the solution rose upwards. It is easy to imagine the mixture in the fissure of the original solution with another which might contain dissolved in it various reducing agents. Or, if the fissure already contained particles of various metallic sulphides, these would precipitate gold readily from such a solution as the one described above. I have proved experimentally that natural sulphides, such as galena and iron pyrites, precipitate gold readily from a solution of an alkaline aurate. The simultaneous deposition of such a metallic sulphide and of gold from a sulph-aurate would probably account for the intimate state of combination of gold with various "sulphurets," which, to his sorrow, the primitive gold miner knew but too well, and to extract the precious metal from which, all the resources of modern scientific metallurgy are needed.

Any of the above hypotheses are admissible as possibly correct explanations, though it is hardly safe to say anything more than this in their favour. It is more than probable that no one simple reaction can account for all the various occurrences of gold in veins, and that whilst the above may all be valid hypotheses, there are probably many other causes of precipitation besides those enumerated.

There is no branch of geology less advanced at the present day than geological chemistry, to which subject this sketch of the genesis of gold reefs properly belongs. At nearly every step we are groping in the dark, with but faint gleams of light from experimental science—the only safe guide we can have—to show us the way that we should attempt to follow. And whilst none can be more sensible than myself of the numerous defects and shortcomings in the theory here presented, I venture to hope that even the mere attempt to put together the different hypotheses on the subject may have its value, were it only in accentuating the extent of our ignorance.

WHAT IS A STAR CLUSTER?

By A. C. Ranyard.

According to the generally received nebular hypothesis, our sun and the luminous stars have been formed by the condensation of nebulous masses. Kant, Sir William Herschel, La Place, and the other earlier exponents of the nebular hypothesis who lived before the great principle of the conservation of energy had been propounded, assumed that the nebular masses must, when originally distributed in space, have been intensely heated to a far higher temperature than the luminous stars which were evolved from them.

The great difficulty of conceiving of a hot nucleus remaining after ages of radiation into space from the vast surface of a nebular mass does not seem to have occurred to these earlier theorists, or, if it occurred to them, the difficulty was swept on one side by assuming a still higher temperature for the parent nebulous mass. But when the mechanical equivalence of heat with other forms of energy was demonstrated, it became evident that the heat of the condensed nucleus might be derived from the motion of the nebulous particles colliding with one another during condensation. Thus a method of accounting for the great heat and light of the stars was offered, and the popularity of the nebular hypothesis was greatly enhanced.

It seemed reasonable to suppose that we should find large and small nebulous masses in all stages of condensation. The large and irregular nebulæ were pointed to as nebulous masses which were in the earliest stages of condensation. Nebulous stars were supposed to be in an intermediate stage, and ordinary stars were in a still later stage, approaching a condition in which they would cease to shine as incandescent bodies. But if the ordinary assumptions of the nebular hypothesis were true, the earlier stages of condensation would occupy a much longer period than the final stages, and we might expect to find a much greater number of oblate nebulous spheroids (such as the hypothesis of La Place assumes) than of stars in the later stages of condensation before their incandescent condition had passed away. It could hardly be urged that the stars and nebulous condensing masses were all so far removed from us that they all equally appeared as stellar points of light; for incandescent spherical masses, comparable in diameter with the orbit of Neptune, or even with the orbits of Saturn or Jupiter, would in our larger telescopes present very recognizable discs if they were situated at distances from us ten or fifteen times as great as the space which separates us from our nearest stellar neighbours.

While there are millions on millions of stellar points of light to be observed in the heavens, the number of spherical nebulous masses revealed by the telescope is comparatively few, a fact which may be reconciled with the nebular hypothesis by assuming that the condensing masses only commence to be incandescent when they have shrunk to diameters of a few million miles, and that in the earlier stages of incandescence the nebulous matter is cold and dark, or only glows at a faint red heat, which is not sufficiently bright to render the nebulous mass visible at a distance.

There are also a few nebulous rings and spirals which shine with a faint nebulosity in the heavens, and a great many nebulæ of very irregular form generally surrounding stars or associated with groups of stars, in a manner which would seem to indicate that the nebulous matter had issued from the stars rather than that it is condensing about them, for frequently there are arms of nebulosity or nebulous structures which appear to spring from the place occupied by a star or group of stars within the nebula. Such nebulæ would seem to present a closer analogy with the solar corona than with the fiery condensing mists conceived of by La Place.

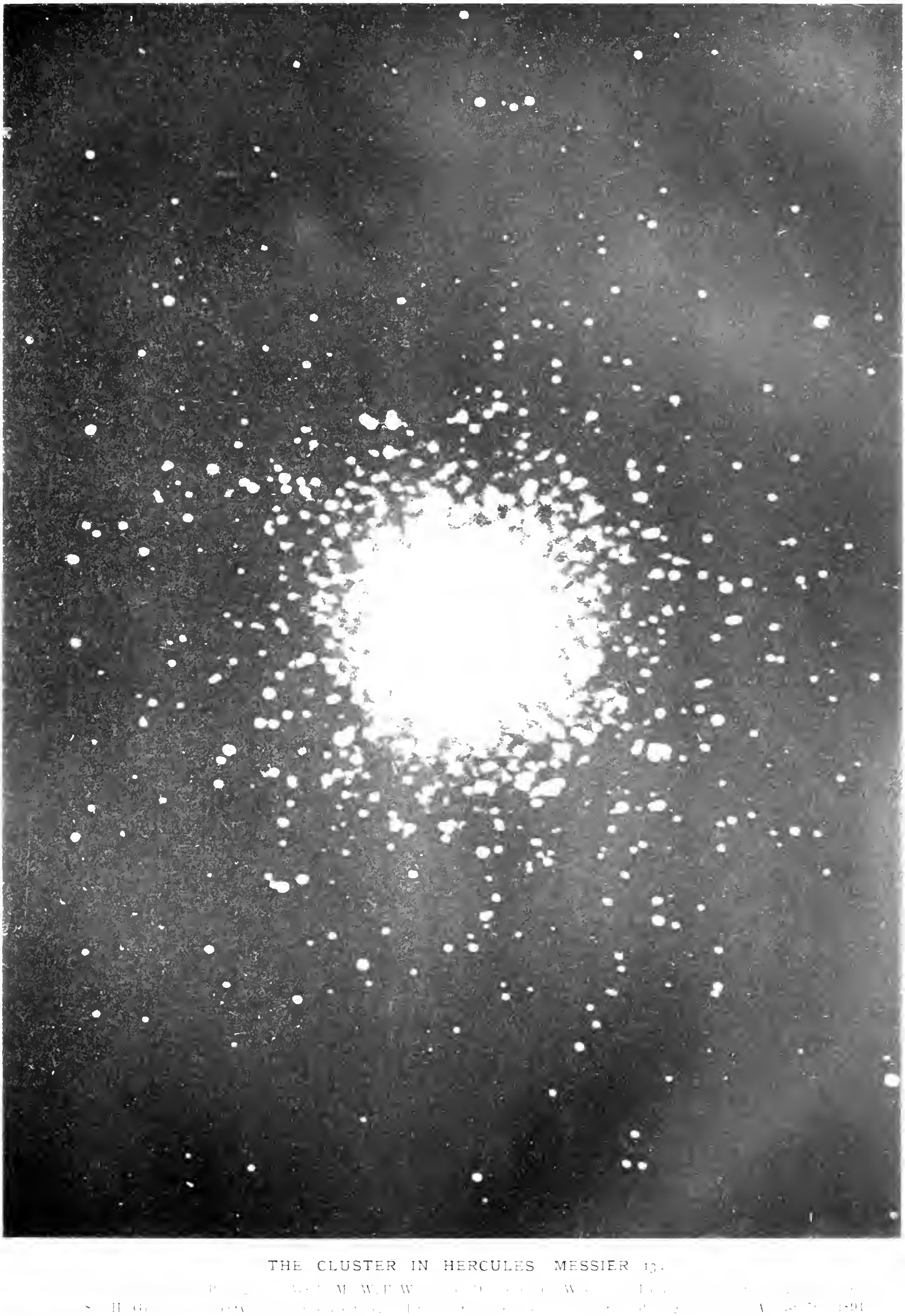
The form of the coronal structures about our sun indicates that the coronal matter has issued from the sun, and though we may, no doubt, assume that the matter which is shot forth from the sun, as a general rule, returns to it again, the brighter structures of the corona seem to indicate by their form that they are composed of matter on its outward course, that is, in its hot condition, as it is shot upward from the sun. There are no coronal structures the form of which indicates a downward flow of matter, and it seems, therefore, reasonable to assume either that the coronal matter returns to the sun as a uniform mist or that it returns in a comparatively non-luminous form.

There seems to be a very close analogy between the irregular nebulæ and star clusters. Recent photographs indicate that most star clusters are nebulous, or contain whisps of faint nebulosity, and the irregular nebulæ are all associated with groups or clusters of stars. Irregular nebulæ, as well as star clusters, are distributed along the region of the Milky Way, and seem in some way to be associated with it, while the smaller and regular nebulæ have a tendency to cluster in the poles of the Milky Way.

If the nebulous matter of the large and irregular nebulæ has been shot forth from stars, it seems to follow that the nebulous matter of star clusters has had its origin in the stars of the cluster rather than that the stars of the cluster have condensed from the nebulous matter.

Prof. George Darwin pointed out some four or five years ago that if two solid bodies were to collide with planetary velocities, such a rapid evolution of gas would take place, by reason of the heat developed at the region of contact, that the bodies would rebound from one another almost as if they were perfectly elastic bodies. If the moving bodies were liquid or gaseous, no doubt a similar evolution of heat at the region of contact would take place, causing an elastic rebound, and it seems not improbable that within a short period after such a collision the gaseous matter evolved at the region of contact would be distributed in space between the rebounding bodies, forming as it were a nebulous ligature between them; but it seems difficult to account on this theory for a line of stars joined by nebulosity such as we find in the Pleiades, or for a series of stars in a curving line ligatured together by a band of nebulosity. Such curving prominence-like forms as are shown in Fig. 1, or the branching form shown in Fig. 5, seem rather to indicate that the matter which is now luminous has been shot out as a gaseous stream, and that the luminous matter has subsequently aggregated into luminous masses.

The very beautiful pictures of the Hercules cluster which



THE CLUSTER IN HERCULES MESSIER 13.

[illegible] M. W. F. W. [illegible]

[illegible] 1891

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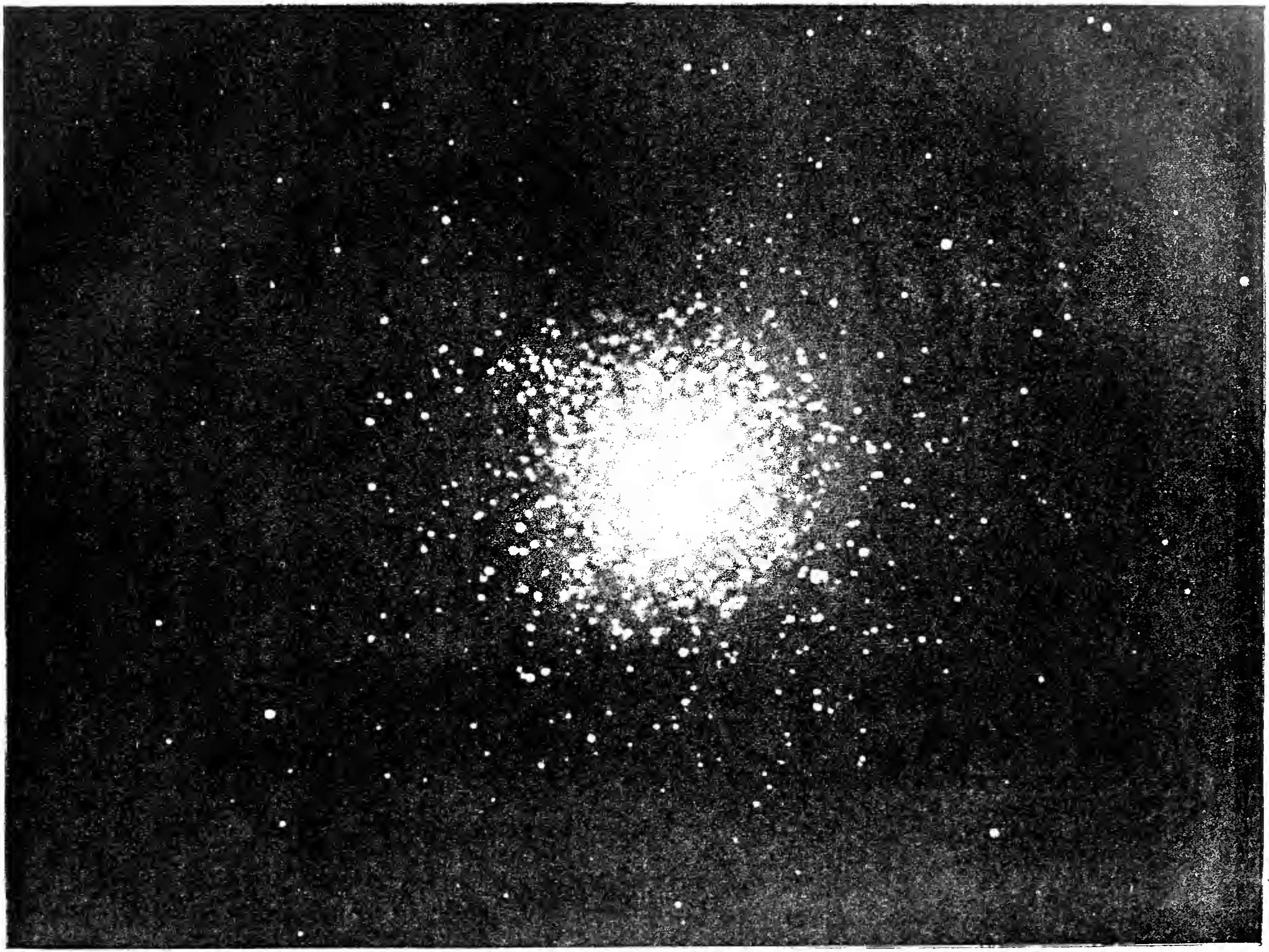


THE CLUSTER IN HERCULES (MESSIER 13).

From a Photograph taken by Mr. W. E. Wilson of Daramona, Co. Westmeath, Ireland, with a reflector of two feet aperture, and focal length of ten feet six inches. Exposure, one hour.

illustrate this paper have been reproduced from photographs given me by Mr. W. E. Wilson, of Daromona.

The light-grasping power of Mr. Wilson's instrument is so great that, with only an hour's exposure, smaller stars and a considerably larger area of nebulosity have left their imprint upon the photographic plate than are to be traced upon the photographs made at the Lick and Paris observatories with exposures three times as long. Therefore, in comparing these photographs of the Hercules cluster with the photographs published in the June number of Knowledge for 1893, the reader must bear in mind that the structures and star-streams which appear to project from the edge of the spherical cluster in the Lick and Paris photographs are in Mr. Wilson's photographs to be found imbedded in nebulosity at some distance below the boundary where individual stars become separately visible.

Fig. 1.—Prominence-like Structure, from photograph by the Brothers Henry.

This will be more clearly recognized if we take an example; thus, the prominence-like structure shown in Fig. 1, which in the Henry photograph projects from the upper part of the nebulous mass, will be found in the Wilson photographs imbedded in nebulosity. The scale on which the Wilson photograph is here reproduced is smaller than that of Fig. 1, so that the prominence-like structure about corresponds with the scale of Fig. 4. This structure, as seen in Mr. Wilson's photographs, is somewhat interfered with by a dark bar or lane extending horizontally across the page. It is one of the three dark lanes, diverging from a point, which were first noted by the Earl of Rosse, and have been described by Webb and several observers since his day. These diverging dark lanes are pretty obvious when the cluster is observed in a large telescope. It will be noticed that the outer lane (which is nearly radial with the centre of the cluster) is much the most marked of the three, as shown in Mr. Wilson's photographs, and that there are some small, branching, dark structures which diverge from it on either hand. Mr. Wilson's photographs also show several other small dark areas within the cluster, which should be compared with the dark areas within the ω Centauri cluster, a photograph of which is reproduced in Knowledge for May, 1893. But one of the most interesting features in Mr. Wilson's photographs is that many of the stars in the outer parts of the cluster are distinctly seen upon the photographs to be united by ligatures of nebulosity. It has been very difficult to reproduce these nebulous ligatures in the etched blocks or in the collotype plate. They are, perhaps, most marked and easily recognizable in the upper right hand quadrant (see Fig. 3). But there is no doubt about their existence, and in the silver prints and platinotype prints made from Mr. Wilson's original enlargements they are very clearly shown. Mr. Wilson himself has no doubt as to their actual existence; that is, he believes that they are not due to any optical or photographic defect.

Fig. 2.—Untouched etched block made from a photograph of the Cluster in Hercules taken by the Brothers Henry on the 23rd June, 1886.

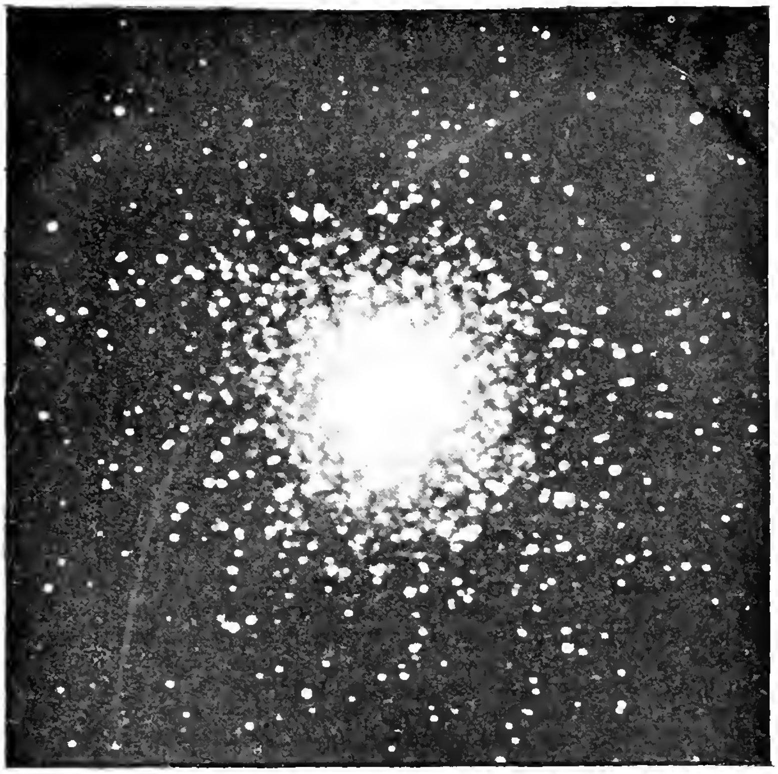


Fig. 3.—Untouched etched block made from a photograph of the Hercules Cluster taken by Mr. W. E. Wilson on the 5th August, 1894.

Fig. 4.—Prominence-like Structure. Reproduced from the Henry photograph.

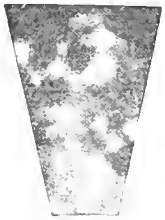


Fig. 5. Branching Structure, from photograph by the Brothers Henry.

It will be remembered that in the enlargements from the Henry photographs similar nebulous ligatures between stars were observable, joining them up into branching streams radiating outwards from the central regions of the cluster. We therefore appear to have corroborative evidence in these photographs by Mr. Wilson, proving that in both the inner and outer parts of the cluster the stars are physically connected with one another in streams which seem to be radially arranged with respect to the centre of the cluster, and that these streams of stars linked together by nebulosity are intimately associated with streams or patches of the light-absorbing material which gives rise to the dark lanes or patches.

PHOTOGRAPHS OF RORDAME'S COMET.

The photograph of Rordame's comet, published in the July number of Knowledge, is referred to as having been sent to me by Mr. J. N. Cobb, of Philadelphia, who obtained it from Mr. Alfred Rordame, of Salt Lake City, Utah. I have since learned, by letters received from Mr. Rordame as well as from Mr. Cobb, that the photograph was taken by Prof. W. J. Hussey, when on a visit to Mount Hamilton, with the Crocker telescope of the Lick Observatory. Prof. Hussey has also kindly sent me glass transparencies of five other photographs of Rordame's comet, making in all six photographs, obtained by Prof. Hussey on the 12th, 13th, 14th, 15th, 16th and 18th of July, 1893. I have reproduced three of the glass transparencies on the accompanying plate. The photograph taken on the 13th was reproduced in the July number, and those taken on the 15th and 16th have arrived in a scratched condition, which makes them unsuitable for reproduction, but they form a most interesting series, illustrating the great rapidity with which the tails of small comets vary in form from day to day. For the purposes of reproduction silver prints or platinotypes from the original negatives are generally preferable to copies on glass, which are very apt to get injured. The streamers of the tail appear to issue from the centre of the nucleus, and not from either side of the envelopes about the comet's head, as the drawings of some of the larger comets would lead one to suppose, but this may possibly be due to photographic irradiation, which causes the bright nucleus and surrounding envelopes of the comet's head to appear on the photographs larger than they really are.

Notices of Books.

Celestial Objects for Common Telescopes. Vol. II. Fifth Edition; revised and greatly enlarged by the Rev. T. E. Espin, M.A., F.R.A.S. (Longmans, Green & Co., 1894.) The re-editing and bringing up to date of this valuable book must have been a very difficult task, but Mr. Espin has accomplished it with great tact and discretion, leaving sufficient of the original matter unaltered to preserve the charm of Prebendary Webb's style, and yet adding sufficiently to the text and in foot-notes to bring the work abreast with the time. The earlier editions of "Celestial Objects" appeared when comparatively little had been done in stellar spectroscopy, and Mr. Webb had modestly decided not to attempt to enter upon the subject, as being too difficult for himself and his readers; but this subject has now become such an important department of modern astronomy, and so many more amateurs now make use of spectroscopes, that spectroscopy could no longer be ignored. Few better men than Mr. Espin could have been found to bring up to date the stellar chapters of Mr. Webb's classical handbook, and he has evidently worked at it as a labour of love. The second volume, which now appears, contains only the chapters referring to stars, clusters and nebulæ. The division of the book into two volumes is necessitated by its increased bulk due to the growth of observational astronomy, and the division is convenient, for this portion of the book is the part which will be most required for use in the observatory, while the first volume may be kept for indoor use. The descriptions of celestial objects are now arranged in order of their right ascension in each constellation, thereby saving the fifty pages of Appendix II. in the fourth edition.

A Treatise on Astronomical Spectroscopy, being a translation of "Die Spectralanalyse der Gestirne." By Prof. Dr. J. Scheiner. Translated, revised, and enlarged by Edwin Brant Frost, M.A., Assistant Professor of Astronomy in Dartmouth College. (Ginn & Co., Boston and London, 1894.) The thanks of astronomers are due to Prof. Frost for the labour he has bestowed upon this English edition of Prof. Scheiner's book. In many parts of the work he very closely follows Prof. Scheiner, but in others he has needed to expand the text considerably in bringing the work up to date. An interesting fact, indicating the relative compactness of the English and German languages, may be noted, where Prof. Frost has most closely followed Scheiner's original; the English saves one page in about every ten of the German. The book will be welcomed by all English-reading spectroscopic observers.

The following books have been received for notice:—

Practical Work in General Physics. By W. G. Woollcombe, M.A., B.Sc. (Clarendon Press.)

Fifth Annual Report of the Missouri Botanical Garden. (St. Louis, Mo.)

The Stereoscope and Stereoscopic Photography. From the French of F. Drouin. (Percy Lund & Co.)

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

A PROLONGED SUNSPOT MINIMUM.

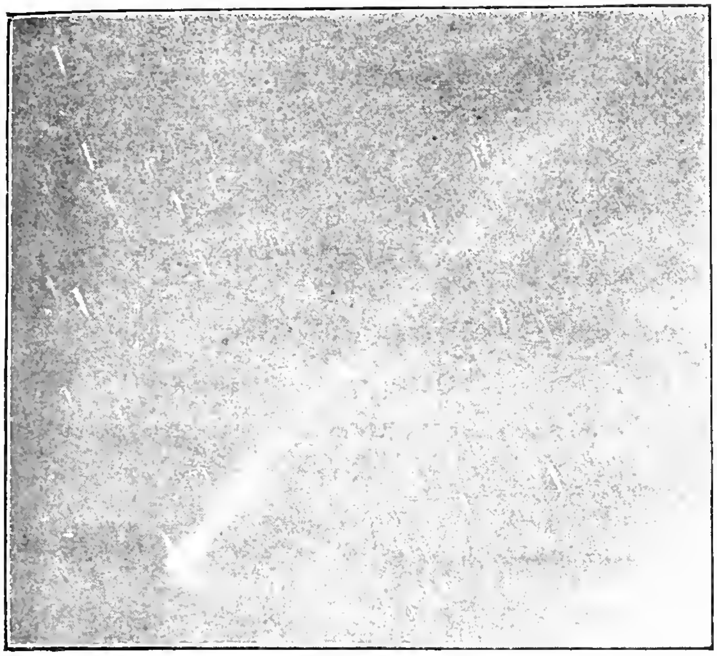
To the Editor of Knowledge.

Dear Sir,—The partial suspension of solar activity, established by Mr. Maunder in his article entitled as above (Knowledge, August, 1894), represents a curious phase of solar history. There is, besides, strong, although indirect evidence that the "prolonged sunspot minimum" was attended by a profound magnetic calm. This evidence is to be found in the auroral records of the time. For the connection between the occurrence of auroræ and the magnetic condition of the earth is so close, that the absence of one kind of disturbance may safely be held to betoken the absence of the other.

Now in England, during the whole of the seventeenth century, not an auroral glimmer was chronicled. Stowe recounts that on the 14th and 15th of November, 1574, "the heavens from all parts did seem to burn marvellous ragingly";* and the next similar occurrence took place on March 17th, 1716. Upon his observations of this fine display, Halley founded his magnetic theory of auroræ.† The event created an extraordinary sensation throughout the country, some slight and partial sky-illuminations in 1706 and 1709 having escaped general notice.

* *Annales of England*, p. 678.

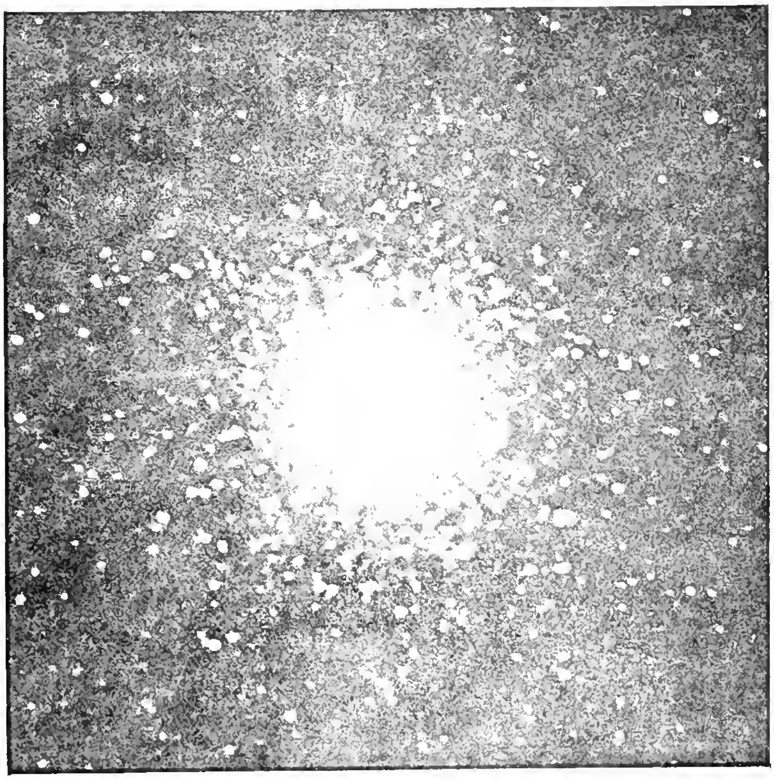
† *Philosophical Transactions*, Vol. XXIX., p. 407. See also E. J. Lowe's "Chronology of the Seasons," quoted by Dr. Garnett in *Nature*, Vol. III., p. 46. For a fuller account of auroral history during this period we may refer to the *Edinburgh Review*, No. 336 (October, 1886), pp. 418-421.



1893, July 12th, 9h. 0m. to 10h. 12m. Pacific Standard Time.

1893, July 18th, 9h. 1m. to 10h. 21m., Pacific Standard Time

1893, July 14th, 9h. 8m. to 10h. 28m., Pacific Standard Time.



(13 Messier). From a Photograph by Mr. W. E. Wilson.

COMET b 1893 (RORDAME).

From Photographs taken by Prof. W. J. Hussey with the Crocker Telescope at the Lick Observatory

Direct Photo Engraving Co., 9, Barnsbury Park, N.

On the Continent, the auroral blank was much less complete than in this country. Gassendi's aurora of September 12th, 1621, was seen as far south as Aleppo; Cromerus registered the passage of "whole armies" across the sky in 1629; in 1640, south polar lights were visible in Chili every night of February and March, and some corresponding appearances were noted in northern latitudes. By the middle of the century, however, polar lights had virtually died out everywhere, except perhaps in northern Scotland, where the "merry dancers" were seen without surprise in 1691. But even in Iceland and Norway they became so rare as to be considered portentous, and their reappearance at Copenhagen in 1709 was greeted with consternation and amazement. De Mairan, in his "Traité de l'Aurore Boréale," makes the curious remark that a great extension of the zodiacal light attended the auroral outburst of 1716.

As regards the solar corona during the "prolonged minimum," it appears probable that (as Mr. Maunder suggests) its radiated structure was in abeyance, but there is positive proof that the inner corona maintained at least its average brightness in 1666. The partial solar eclipse of June 22nd in that year, being viewed through Boyle's sixty-foot telescope by Hooke, Pope (Professor of Astronomy in Gresham College), and others, "there was perceived a little of the limb of the moon without the disc of the sun, which seemed to some of the observers to come from some shining atmosphere about the body either of the sun or moon."*

Yours faithfully,
Agnes M. Clerke.

* *Philosophical Transactions*, Vol. I., p. 295.

THE PROGRESS OF ASTRONOMICAL PHOTOGRAPHY, by H. C. Russell, F.R.S., Government Astronomer, Sydney.

To the Editor of Knowledge.

Dear Sir,—Mr. Russell chose wisely the subject of his recent presidential address before the Mathematical Section of the Australasian Association for the Advancement of Science. With what authority he is entitled to speak upon it, your readers can judge for themselves from the specimens of his photographs reproduced in Knowledge. The delineations obtained by him of the Magellanic clouds and of the Coal-sack region of the Milky Way have, indeed, a significance which is as yet very far from being exhausted. The story that he now recounts is a marvellous one. "The results," he truly says, "obtained by means of photography come upon us so fast that one hardly realizes their importance." The method has developed in so many different directions, and lent itself so readily to specialization, that their history, short though it be in time, has already assumed an exceedingly complex character. Mr. Russell has adopted a strictly chronological mode of treating it, and has brought together in small compass a large amount of valuable information; but with some startling omissions. Thus, Prof. Barnard's name is not so much as mentioned. Yet the fame of his achievements in this department is world-wide. We need only recall his initiation of galactic photography in 1889, and his subsequent successful prosecution of it; his registration, from night to night, of changes in comets' tails, his discovery on a sensitive plate, in 1892, of an additional member of Jupiter's cometary family, besides his exquisite picture of the solar corona of January 1st, 1889. Dr. Max Wolf and M. von Gothard, each of whom has done important and distinctive work in celestial photography, incur similar oblivion; but they may take heart when they find Dr. Gill no better treated. It seems incredible that a man who is the very head and front of photographic star-charting should be passed over in such a record as Mr. Russell's; but such is the fact. Not only was the star-crowded background of his portrait of the "great September comet" of 1882 the object lesson from which astronomers learned its possibility, but he was foremost in starting and developing in detail the international scheme now in course of execution at a score of observatories. Above all, he set the example of *doing*, by completing Argelander's *Durchmusterung* to the southern pole. The resulting catalogue—the first photographic work of its kind—gives the places, accurate to within about one second of arc, of some 350,000 stars. It is at present rapidly passing through the press. Nor should it be forgotten that Prof. Kapteyn generously devoted five years to the labour of its preparation from the Cape plates.

We look in vain, too, in this address, for any allusion to Nova Aurigæ, the first "blaze-star" investigated photographically, or Nova Normæ, the first similar object discovered photographically. Indeed, none of Mrs. Fleming's valuable detections are chronicled. Nor do we find the slightest reference to the self-registration of new asteroids or of meteors, although researches of the latter kind seem about to enter upon a fresh stadium of progress through the possibility, just demonstrated by Dr. Elkin, of determining the radiants of meteoric showers from the imprinted trails of their constituents.† Mr. Russell, however, eagerly anticipates novelties, and is full of well-grounded confidence in the future. He himself promises a photographic transit recorder, and indicates several lines of imminent advance. Obstacles there are, but only to be overcome. "The army of science," he continues, "is in one respect like the army of war—it is stirred to conquering effort by the difficulties that stand in the way. Given a citadel to be won, and there is always a forlorn hope to win it." These words breathe the true spirit of a scientific pioneer.

Yours faithfully,
A. M. Clerke.

† Dr. Elkin's success is too recent to have been known to Mr. Russell when his address was delivered.

To the Editor of Knowledge.

Dear Sir,—The Rev. A. S. Wilson, in an article on "Types of Floral Structure" which appears in the July issue of Knowledge, says "there is no apparent reason why the carpels and stamens should not occasionally change places, and an explanation of this invariable order is still a *desideratum*."

A sufficiently obvious reason, it seems to me, is found in the fact that the stamens of the flower are not persistent. As soon as their pollen is shed, their work is done, they become useless and decay, or fall off. If they occupied the centre of the flower they would be prevented from so doing by the carpels, which persist long after the stamens have decayed, and in the case of syncarpous pistils there would be a central cavity in the fruit enclosing the dead stamens.

Besides this, if the stamens were central it would be easy for their pollen to become dusted on to the adjacent stigmas, an arrangement which Nature has, in the great majority of cases, endeavoured to avoid.

Yours faithfully,
Kingswood School, Bath, Geo. H. Pethybridge, B.Sc.
August 14th, 1894.

THE PERIODICITY OF THE SOLAR SPOTS, AND ITS CAUSE.

To the Editor of Knowledge.

Sir,—In his exceedingly interesting article, "A Prolonged Sunspot Minimum," in the August number of Knowledge, Mr. Maunder mentions that the cause of the periodicity of the solar spots has been ascribed to the periodical returns of the planet Jupiter to the perihelion of its orbit, but significantly adds that if this were the true cause, "since that return is regular, punctual, and unfailing, so ought its effect to be, and it should be as impossible for the sun to intermit two or three of its cycles as for Jupiter to wander from his orbit." To me the theory in question never had much to recommend it; not only is the eccentricity of Jupiter's orbit very small—less than that of Saturn, and considerably less than that of Mars—but his period (11·9 years) is much longer than that of the average period of the solar spots. The facts about the latter which are adduced by Mr. Maunder are surely sufficient to negative any connection between the periodicity of the spots and the regularity which characterizes planetary motions, disturbed only by perturbations which cannot affect such a question as this.

Some little time ago, I suggested in *The Observatory* that the recurring maxima and minima of solar spots might be due to a swarm of meteoric bodies which move in an eccentric orbit, and pass, when in perihelion, near the outer envelope of the sun. Although the period suggested by Schwabe for the solar spots was 10·4 years, it is now well understood that the true average period amounts to 11·1 years. Now a body or bodies revolving round the sun with this period would have a mean distance from him of 4·98 in terms of the earth's mean distance; and if the perihelion distance were small, the aphelion would not differ much from that of Saturn. *L'Astronomie* did me the honour to refer to my suggestion, but pointed out that the details of explanation and of the action of the meteors were wanting. Now time may supply what is certainly beyond my power at present; but it seems to me that if the theory be true, one remarkable detail in connection with it is suggested by this article of Mr. Maunder. "The sequence," he justly remarks, "of maximum and minimum has been unfailing during the present century." He then goes on to dwell on his main point, that not only this cannot be affirmed of the phenomena during preceding centuries, but the observations recorded, though not made of course with Greenwich regularity and perseverance, are abundantly sufficient to prove that the matter was then far otherwise; and particularly that during the fifty years which elapsed from 1655, or thereabouts, to 1705, very few solar spots were seen, or, as he puts it, "an extraordinarily and immensely prolonged minimum" subsisted. But what if regular maxima and minima had not then begun to be, and the spots seen previously were of a more sporadic kind? Le Verrier thought that the Leonid meteors were introduced into our system by the attraction of Uranus about the second century after Christ. Perhaps the swarm of meteors to which I suggested we owe the present regular recurrence of the spots may have been introduced by the attraction of Saturn in the early part of the eighteenth century.

Yours faithfully,

Blackheath, August 10th, 1894. W. T. Lynn.

[I would refer Mr. Lynn to Prof. Rudolf Wolf's paper on "Sunspot Maxima," published in the *Memoirs of the Royal Astronomical Society*, Vol. XLIII. Unless he is prepared to reject Prof. Wolf's laboriously collected evidence, he must admit that there have been wide variations in the form of successive waves of the sunspot curve, even during this century; thus Wolf gives a sunspot maximum in 1804, another in 1816, followed by another which was deferred till 1830, while the next maximum period followed in 1836-7, giving intervals of twelve, fourteen and six and a half years. Such tidal action as Mr. Lynn suggests would, if caused by a single flight of disturbing bodies, necessarily be regular.—A. C. Ranyard.]

ANTARCTIC BIRDS.

By William S. Bruce, *Naturalist to the Antarctic Expedition*, 1892-93.

THE term "Antarctic regions" is vague, and it is necessary to define to our readers the limits of this region about which we have such scanty records. The Antarctic Ocean proper is that portion of the great oceanic area of our globe which lies within the Antarctic circle, or south of the latitude of 66½° S. In dealing with the Antarctic, however, few, if any, writers confine themselves to this area. Many include regions as far north as Patagonia, Falkland Islands, south of South Africa, south of Australia, and the south of New Zealand, while others vary their limitations of the Antarctic by various localities lying between these northern and southern limits. In this article it is proposed to call those birds Antarctic birds which are to be found in higher southern latitudes than the extreme limit of floating ice according to the most recent research. The northern boundary of these regions is somewhat irregular, but roughly may be said to extend as far north as 40° S., *i.e.*, a latitude corresponding to that of Madrid and New York in the Northern Hemisphere. This excludes Tristan d'Achuna, South Africa, and Australia—which lie north of 40° S.—Tasmania, New Zealand and Auckland Islands, South America and the Falkland Islands, and Kerguelen Island; for although these last-named are in latitudes south of 40° S., yet the ice line rises southward in their respective longitudes. Three exceptions are made to this boundary, viz., the Tristan d'Achuna group, Kerguelen, and the Auckland Islands, which have always been associated so intimately with Antarctic exploration. In this way we exclude the great continental masses, save Antarctica itself, but include almost all those islands which most writers term Antarctic islands.

With few exceptions, the birds of the Antarctic are all oceanic species, the penguins and the petrels being by far the most important groups. Besides these, there are also gulls, terns, and the remarkable sheathbills or paddies. Let us first consider the penguins, which are perhaps the most typical of all Antarctic birds, although they may also be found as far north as the Galapagos group of islands, which lie almost upon the equator, off the west coast of South America.

A very interesting and graphic description of these remarkable birds has been given by the late Prof. Moseley.* Whilst the "Challenger" was in the vicinity of the Tristan d'Achuna group, he says, "as we approached the shore I was astonished at seeing a shoal of what looked like extremely active, very small porpoises or dolphins. I could not imagine what the things could be unless they were indeed some most marvellously small cetaceans; they showed black above and white beneath, and came along in a shoal of fifty or more from seawards towards shore at a rapid pace, by a series of successive

* "Notes by a Naturalist on H.M.S. Challenger," by Moseley: J. Murray, London.

leaps out of the water and splashes into it again, describing short curves in the air, taking headers out of the water and headers into the water again; splash, splash, went this marvellous shoal of animals, till they went splash through the surf on to the black stony beach, and there struggled and jumped up amongst the boulders and revealed themselves as wet and dripping penguins, for such they were. Much as I have read about penguins, I never could have believed that the creatures I saw thus progressing through the water were birds, unless I had seen them to my astonishment thus make the shore."

The first I saw of these birds was off the shores of the Falkland Islands, over two hundred miles from the nearest land. The vessel was making little headway through the water, the wind having fallen, and coming on deck for midday observations my attention was called to "some small seals," which were playing about the stern of the vessel. They were swimming calmly about in the water, now immersing themselves entirely, now lifting their heads only above water much in the same way as one sees seals doing in the evening, or on a bleak day, when they prefer to remain in the water rather than to come out and lie on the ice, as they do when the sun shines brightly. What the sailors took for seals were really macaroni penguins (*E. chrysolophus*), with their silky, hair-like feathers looking like wet fur. The sailors refuse to recognize feathers in this close-fitting fleece, black on the back, and white on the breast. These are the two ways in which penguins make headway through the water. The reader has only to go at feeding time to the diving birds' house at the Zoological Society's Gardens, in Regent's Park, in order to see the penguins disport themselves. On the land, or on snow and ice, they also have two or three modes of progression; one is when they are standing in an upright position—in this way they may be seen wobbling over the ground with their very short legs and padded feet. When they are in danger, however, they throw themselves upon their white breasts, and use their fore limbs as legs as well as their hind limbs. "When crawling," Darwin says, "it may be said on four legs, through the tussocks or on the side of a grassy cliff, it moves so very quickly that it might easily be mistaken for a quadruped." On the ice they move even more swiftly, as they take advantage of any slope, and glide swiftly down it, toboggan fashion, upon their breasts. In this way, if they choose, they can easily, and sometimes do, escape their captors upon the ice floes; for a man may sink knee-deep into the snow while they glide onward upon its surface. But they are inquisitive, and, fearing no danger, approach their pursuers, only too often to be felled with a club or stick; this is especially the case with the smaller birds. It is to be hoped that penguins will not share the fate of their near relative, the great auk, which at one time was plentiful in the northern seas, but is now a thing of the past.

Rock hopper penguins, which abound in the Tristan d'Achuna group, and which swim in the manner of porpoises or dolphins, "hop from rock to rock with both feet placed together, scarcely ever missing their footing." This method of getting over the ground is also adopted by the king penguin whilst hatching its egg; for it carries its egg from place to place in a pouch, holding it in with its broad webbed feet.

Penguins are gregarious, literally herding together in millions. Sometimes their breeding places, or rookeries, as they are generally called, cover many acres of ground. Some have their rookeries among tussock grass, where there are many streets and side streets occupied by myriads of birds; their dung is a rich manure for the grass, which grows luxuriantly from four to six feet high in clumps, with hard woody masses at their base formed of the old roots and stems, and arches over the streets. Anyone entering these streets is unmercifully pecked at by the birds; their cries are terrific, and the odour arising from their dung is stifling; eventually one flees headlong, tramping on birds and eggs at every footstep. Some breed on the open and bare rock, others, such as the gentoo, build in holes they have burrowed in the ground; and others again, such as the small penguin of New Zealand (*E. minor*) nest in caves. At the entrance to rookeries the rocks are often smooth and polished, which is probably due to the diatoms in the food and dung of the birds, which clings to their feet. The king penguin builds no nest at all. The jackass penguin of South Africa builds its nest of stones, shells, wood, nails, bits of rope, &c., evidently for drainage purposes, although, as Moseley suggested, this may be due to "a sort of magpie delight in curiosities." The magellanic, or jackass penguin of the Falkland Islands, similarly collects variously coloured pebbles at the mouth of its burrows. Most penguin's eggs are greenish-white; that of the king penguin is more than ordinarily pointed at the thin end. As yet we know nothing of the breeding habits, nest, or eggs of the emperor penguin.

It is unnecessary to enumerate and describe all the different species of penguins here; but it may be mentioned that the following four genera are usually recognized, viz., Aptenodytes, Eudyptes, Sphenisci, and Pygosceles. About fifty specimens of about sixteen different species of these four genera are exhibited in the British Museum, South Kensington, and it is well worth while for the reader to pay a visit to the museum to see these most remarkable birds. As in most museums, however, these birds are not as well stuffed as they might be, and it may here be mentioned that one scarcely ever sees a trustworthy picture of a penguin. A penguin in good condition is very plump, and does not go about with an elongated neck, although it is capable of extending its neck considerably. One can never tire of watching these most extraordinary and interesting creatures, they look so human! Often one cannot help laughing outright at the attitudes they assume.

The largest and rarest of penguins is the emperor penguin, which, along with the king penguin, belongs to the Aptenodytes. We must stop specially to consider this bird. The emperor penguin (*A. forsteri*) was first discovered by Captain Cook, and was met with again by Sir James Ross during his ever famous voyage to the South Seas in 1839–43. It was next seen and captured by the Antarctic Expedition, 1892-93. Some fine specimens of the bird may be seen in the British Museum. The largest Ross obtained weighed seventy-eight pounds. "Its principal food," says Ross, "consists of various species of cancri, and other crustaceous animals; and in its stomach we frequently found from two to ten pounds' weight of pebbles. . . . It was a very difficult matter to kill them, and a most cruel operation until we resorted to hydrocyanic (prussic) acid, of which a tablespoonful effectually accomplished the purpose in less than a minute." The largest specimen we obtained weighed seventy-four pounds. The measurements of the dead bird were as follows:—

Length (from tip of beak to vent)	3 ft. 8 in.
Breast girth	29 inches.
Abdominal girth	34 inches.
Muscles of breast (equal to more than one-third total weight of bird, viz.)	25 lbs.

I had hoped to bring this splendid bird home alive, but accommodation on board the vessel did not allow me to attempt it. It is now to be seen stuffed at the Museum of Science and Art, Edinburgh. I shall presently describe the great strength of this bird.

Among other characteristics, penguins are distinguished by having the bones of the fore-arm flattened, and by a very broad shoulder-blade. The wing feathers are very short and are not differentiated into quills. The young are hatched in a helpless condition. In many respects they resemble, and they are probably related to, the puffins and the auks of the Arctic Ocean.

Although penguins are quite unable to fly, one must not look upon their fore limbs as feeble and useless members. They are indeed highly specialized for swimming and crawling, and occasionally also they are used as powerful weapons of defence, as anyone who has seen the effects of a blow which an emperor penguin can give will easily recognize. During the recent expedition, as already stated, we succeeded in capturing and bringing on board alive a very fine emperor penguin; he stood on deck, clothed in silken robes of white and black, decked with gold and purple, a very monarch among his many admirers. An almost full-grown retriever pup that belonged to one of the seamen disapproved of his presence and pounced upon him from behind; the bird seemed to deem his assailant of little importance, as he only turned his head round and drove the dog off with his beak. A second time the dog approached the penguin at his side, and with such force did the bird strike the dog on its head with his flipper, that he sent it away howling with its tail between its legs. It was with the utmost difficulty that five of us secured this penguin, on account of its great strength; it required a man to each leg, a man to each flipper, and a man to his head and neck in order to hold him down. He even broke loose after being strongly bound. The muscles of its breast weighed more than one-third the total weight of the bird, and all this mass of muscle is used to force the wing downwards and forwards. If the reader will look at the keel of the breast-bone of the emperor penguin in the British Museum, he will find that it does not compare meanly with that of the golden eagle and the swan, both powerful birds of flight, while its coracoids are very much more strongly developed. Now this keel serves for the attachment of the muscles of the breast, and is, therefore, an indicator of the relative strength of the fore limbs of different kinds of birds. Although all penguins are not as large as the emperor penguin, they are all equally powerful in proportion to their size. I have seen the smaller kinds jump out of the water on to a cake of pack ice, the surface of which was fully three feet above the surface of the water. Curiously enough, they do not take the advantage of distance, but approach quite close and rise almost vertically out of the water, neatly settling on their hind limbs in an erect position. This is accomplished by the propelling power of their fore limbs.

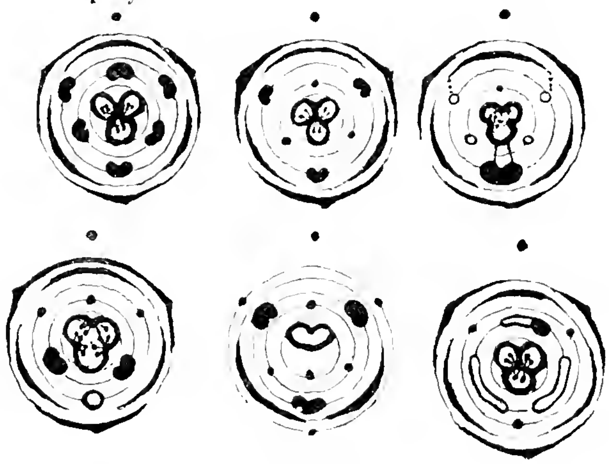
TYPES OF FLORAL STRUCTURE.—II.

By the Rev. Alex. S. Wilson, M.A., B.Sc.

(*Continued from page* 164.)

The natural order to which a flower belongs can sometimes be approximately ascertained from the number and position of its parts alone; thus, if we find a specimen with five petals and five stamens placed opposite them we need have almost no hesitation in concluding that it belongs to Primulaceæ. The sea-pink is almost the only native flower outside the primrose order, at all common, which possesses a pentamerous corolla and antipetalous stamens. The order Cruciferæ is easily known; its flowers have a four-petaled, cruciform corolla and six stamens, two of the latter being shorter than the others. Compositæ, Labiatæ, Umbelliferæ, and a few other orders may likewise be recognized by head-mark. To determine the systematic position of a flower, a number of characters must, however, as a rule, be taken into account. We require to know what whorls are present, of how many parts each is composed, and whether the whorls are alternate or superposed. The *cohesion* or degree of union existing among the members of the same whorl must be observed; also whether or not all the parts in any whorl resemble each other, the flower being regular or actinomorphic where they are alike, and irregular or zygomorphic if the parts are dissimilar. The placentation, or mode in which the ovules are disposed within the ovary, is another character of primary importance in identifying plants. The different whorls of a flower may be quite separate and independent of each other, or they may adhere; the degree of *adhesion* is of the greatest use in classification. This last-mentioned character is ascertained from a vertical section of the flower, and is not therefore shown in the floral diagram, since this is merely a representation of what one sees on looking down into the blossom—a ground plan in fact, into which one or two particulars from the cross section are introduced. For the present we shall confine our attention to those characters which admit of representation by means of a floral diagram, leaving aside meantime, for the sake of simplicity, adhesion and other characters which are only visible in a vertical section.

Lily. Iris. Orchis.



Cypripedium. Grass. Canna.

Floral diagrams, as will be readily understood, greatly assist the memory in retaining the general characters of the various natural orders, and are therefore most helpful to the beginner in botany; but besides this, they often bring out in a most instructive way the affinities of different groups. As an illustration of this we may take the Orchidaceæ, an order in which the flowers assume the most irregular, diversified, and fantastic shapes; they have little or no resemblance to the simple, regular, and symmetrical blossoms of the lily order, to which, however, they are very closely related. The Liliaceæ, which probably represent a very early monocotyledonous type, have six stamens, while *Orchis* has but one; genera allied to the latter, however, exhibit every gradation, from the hexandrous to the monandrous conditions. The single perfect stamen of orchis is homologous, with the anterior or lower member of the outer staminal whorl of the lily: four of the others are frequently represented by protuberances or staminodes, while one is, as a rule, completely aborted. The lady's-slipper orchid, Cypripedium, has a large staminode representing the fertile stamen of orchis; its two perfect stamens correspond to the two anterior ones in the inner whorl of the lily. All three stamens of the outer whorl are present at first in the bud of *Calanthe*, but only the anterior one is ultimately developed. *Uropedium* lacks the outer whorl, but has the inner one complete, all the three stamens being perfectly developed, while five often, and occasionally the whole six members of the andrœcium are present in *Isochilus*.

The andrœcium of Iridaceæ consists of three stamens homologous with the outer whorl of the lily; the inner whorl is entirely suppressed. Although the irises are in some respects intermediate between Orchidaceæ and Liliaceæ, the fact that among the orchids sometimes the inner and sometimes the outer staminal whorl is represented shows that they cannot be directly derived from the iris type. There is apparently only one possible interpretation of such facts; they point distinctly to the six-stamened lily as the type from which both orchids and irises have diverged. This interpretation is strongly supported by anatomical considerations, the number of vascular bundles or leaf-traces present in the flower-stalk being such as we should expect in accordance with this view. These homologies, which are exhibited in the foregoing diagrams, afford as strong evidence as perhaps can be given of the origin of different species, genera and orders of plants by descent and modification from a common ancestral form.

Notwithstanding their odd and irregular shapes then, all orchids may be referred to the simple lily type. The single fertile stamen of orchis bears the same relation to the six stamens of the lily that the single enlarged toe of the horse does to the five toes of the archetype from which the horse is supposed to be descended. Cypripedium, Calanthe and to some extent the irises stand very much in the position of the eohippus and miohippus, since they represent intermediate phases in the development. In the floral series the theoretical line of descent is indicated by abortive stamens or staminodes, in the equine series by rudimentary and functionless digits.

Like the perianth of the lily, that of the orchid is composed of a sepaline and petaline whorl, each containing three leaves or segments, but while the parts of each whorl are alike in the lily, in the orchid they are dissimilar. This irregularity of the perianth arises mainly from the enlargement of the lip or labellum, which is usually prolonged into a hollow pouch or spur; it is composed of the anterior petal combined with two of the sterilized stamens. Other peculiarities of the orchid which may be mentioned in passing are the gynandrous condition caused by the adhesion of the fertile stamen to the style, the modification of one of the three typical stigmas to furnish sticky discs for the pollen masses, and the twisting of the ovary by which the labellum, which is uppermost in the bud, is brought down to the lower or anterior side of the flower.

The degraded and aberrant blossoms of grasses are connected with the lily type by a corresponding series of transitional forms. *Bambusa*, which has six stamens, differs from the type only in the absence of the outer perianth-whorl, but in most grasses the posterior leaf of the inner perianth-whorl has also disappeared, together with the whole inner whorl of stamens and the anterior carpel; the latter is the only member of the carpellary whorl present in the mat-grass, *Nardus*. The flowers of sedges are also fashioned on the lily pattern, the three inner stamens being suppressed as in iris. Zingibereæ agree with orchis in having only one fertile stamen, but its position in the ginger order is posterior, not anterior as in the orchid; the rest of the six-merous andrœcium is represented by petaloid pieces. The allied Canna or Indian shot has likewise all the members of the andrœcium developed as petals, with the exception of one which bears pollen, and is half petal, half stamen, as indicated in the diagram.

Facts of this description, and many others which might be mentioned, go to show that such regular six-merous flowers as we find in Liliaceæ, Amaryllidaceæ, Juncaceæ, and Palmaceæ, represent the primitive type from which most, if not all, existing monocotyledons have been derived. Although other divergences of character have occurred independently, which make it impossible to trace the actual descent or phylogeny of a particular species, still there is little difficulty in following the steps by which any single character has been acquired.

Equally striking are the relationships rendered apparent by the floral diagrams of dicotyledons. In the vegetable, as in the animal kingdom, the excessive repetition of similar parts is held to indicate a low grade of organization. The simplest flowers in the dicotyledonous class consist of many parts; the Nymphaceæ and Cactaceæ have numerous sepals, petals, and stamens, arranged in a spiral or acyclic manner. A corolla, consisting of twelve petals, occurs in the house-leek *Sempervivum*. The numerous stamens of the rose, buttercup, and poppy constitute a feature which these flowers have doubtless inherited from very remote and simply organized ancestors. The first two also possess numerous distinct carpels, another mark of primitive simplicity.

The great majority of dicotyledonous orders, however, admit of being referred to a floral type, consisting of six alternating whorls containing five parts each, viz., a sepaline, a petaline, two staminal, and two carpellary whorls. A close approximation to this type occurs in some of the crassulas or stonecrops. The geraniums have the formula S5, P5, St10, C5, which differs from the type only in the absence of the inner whorl of carpels. This whorl is rarely developed, possibly for want of room on the apex of the floral axis. If the number of parts in the different whorls correspond the flower is symmetrical, but the carpellary whorl is so often incomplete that it is not taken into account in reckoning symmetry. The number of carpels varies greatly even within the limits of the same order; thus among the Caryophyllaceæ it fluctuates from two to five. The presence of two carpels, on the other hand, is a constant character of the order Scrophulariaceæ, while the Leguminosæ never have more than one. The evident tendency to reduction observed in the carpellary whorls shows that there is a struggle for space among the floral organs leading to the elimination of superfluous members. Not improbably the difficulty of accommodating many members on the floral axis may originally have led to the establishment of the six whorled type as an improvement upon an earlier model made up of an indefinite number of perianth-segments, stamens and carpels. A good example of the struggle for existence among the organs of the same flower is seen in the calyx of the rock rose, *Helianthemum*: three of its sepals are much enlarged, but this has apparently taken place at the expense of the other two, which are quite rudimentary. A symmetrical decrease affecting all the whorls in the same manner is met with in the yellow tormentil; the potentillas generally have five-merous flowers, but in *P. tormentilla* the calyx and corolla have only four parts each. The same thing occurs in Rubiaceæ, Rubia having five-merous, Galium four-merous flowers. A decrease which renders the flower unsymmetrical is of much more frequent occurrence, and, in this case, the decrease seems to be in consequence of the irregular development of the perianth tending in some way to limit the space and nutriment available for the more internal parts. The geranium, for example, has a regular five-merous calyx and corolla and ten stamens; its ally, pelargonium, which is slightly irregular and more highly specialized in relation to insects, has three of the outer stamens imperfect; Erodium, again, has regular flowers and only five stamens. The loss of symmetry in the staminal whorl is therefore closely connected with the irregularity of the floral envelopes. This connection is well exemplified in the foxglove order, which includes the mullein Verbascum, with regular five-merous flowers; also Calceolaria and Veronica, with irregular corollas and the stamens reduced to two. Most of the Scrophulariaceæ, however, are unsymmetrical and irregular, having a five-merous calyx and corolla with four stamens, but the fifth stamen is often present in a rudimentary form; thus in the figwort the nectary is a staminode, while in the garden pentstemon the fifth stamen remains as a barren stalk or filament on which no anther ever develops. As in the case of monocotyledons the most probable explanation of these various conditions is that they represent so many stages in the evolution of genera and species from a common ancestral stock. Where flowers are irregular the departure from the typical form is almost invariably in the direction of better adaptation to insects as fertilizing agents, or of specialization for the visits of particular kinds of insects; the irregularity may in part be due to the action of the insects themselves, but in any case the loss of symmetry arises from the same cause as the irregularity. There is reason to think that the cohesion of sepals or petals is also a provision in favour of insect fertilization, and it is noteworthy that this has also been generally accompanied by a reduction of stamens. In flowers like the rose with separate petals numerous stamens occur, but where the petals are united and the corolla gamopetalous seldom more than five are to be found. Irregularity is uncommon with separate petals, and where it occurs is not accompanied by loss of symmetry, as we see in the irregular but symmetrical flowers of the violet and sweet pea; it is otherwise among the gamopetalæ, where an irregular shape is much more common, and is usually accompanied by loss of symmetry. Cohesion occurs much less frequently among stamens than in the petaline whorl; it is seen, however, in the united filaments of the mallow, and in the anthers of Compositæ and Cucurbitaceæ. Cohesion is most frequent in the gynœcium, the syncarpous pistil being formed of the carpels combined into one body, very possibly as the result of compression.

Hitherto we have been occupied only with complete flowers in which four different classes of organs are present. There is a marked tendency in some families for one or more of the whorls to disappear; this is especially the case with the sepals when, as in the rhododendron, the Compositæ, and the Umbelliferæ, the flowers are produced in crowded clusters, and the protection afforded by the bracts renders sepals unnecessary. It is the corolla, however, that is much more frequently the missing whorl; the petals of many of the Ranunculaceæ are either very small or wanting, but in the anemone, globe-flower, marsh-marigold, peony, &c., this loss is compensated for by the bright colours of the sepals. The substitution of a petaloid calyx for the corolla in these instances appears to show that there is a competition between the two whorls for nourishment; it would further seem that in them the sepals have overpowered the petals, and while successful in appropriating the share of nutriment have also assumed the attractive functions pertaining to the corolla.

The dicotyledonous sub-class Incompletæ is so named on account of the absence from its flowers of one or both sets of floral envelopes. This sub-class embraces the goose-foot order, the sun-spurges, the docks, sorrels and nettles, the hop, the elm and the catkin-bearing trees, such as birch, alder, willow, poplar, oak and hazel. The bulk of these incomplete flowers are adapted for wind-fertilization. As the earlier gymnosperms had their pollen carried by the wind, it is natural to suppose that this would also be the case with the first angiosperms, but there is some doubt whether any of the original anemophilous families have survived to the present time. From the fact that the stamens in these incomplete flowers are mostly superposed to the sepals, it has been inferred that a whorl of petals must have been lost; and since petals may be supposed to have been acquired for the attraction of insects, the conclusion has been arrived at by some that all existing wind-fertilized angiosperms have degenerated from the entomophilous condition. Reversion to wind-fertilization has occurred again and again in many different entomophilous families; the common road-weed Plantago, our native Clematis and Thalictrum are without doubt examples of such reversion, but the view that all existing anemophilous angiosperms have degenerated from entomophilous ancestors, though supported by very many facts, should hardly be accepted as yet without some reservation. The mere opposition of the stamens to the sepals does not afford conclusive proof that a flower or its ancestors ever possessed petals, for, as was shown in a previous article, the superposition of whorls is a more primitive arrangement than even the alternate. The geological antiquity of several families of Incompletæ points rather to an early divergence in the direction of adaptation to wind-fertilization from a primitive unspecialized stock, which had not so far become greatly differentiated in relation to the visits of insects. It is at least a striking anomaly that those families to which the oldest monocotyledons and dicotyledons belong should be regarded as having undergone the greatest possible amount of degeneration. The aroids, which include the familiar Nile lily and cuckoo-pint, are, perhaps, the most ancient of known angiosperms, and yet they are the most degraded of all monocotyledons, so much so that the entire inflorescence is only functionally equivalent to a single flower. They are fertilized by minute flies which are temporarily imprisoned in the enlarged spathe, but it is quite a reasonable supposition that the aroids have acquired this entomophilous character without passing through any intermediate stages of high specialization either in relation to the wiud or to insect agency.

THE WATER-HEN.

By HARRY F. WITHERBY.

THE water-hen or moor-hen (*Gallinula chloropus*) is very generally distributed throughout the British Isles. It may be numbered amongst our most familiar birds, but owing to its shy nature its habits are difficult to observe.

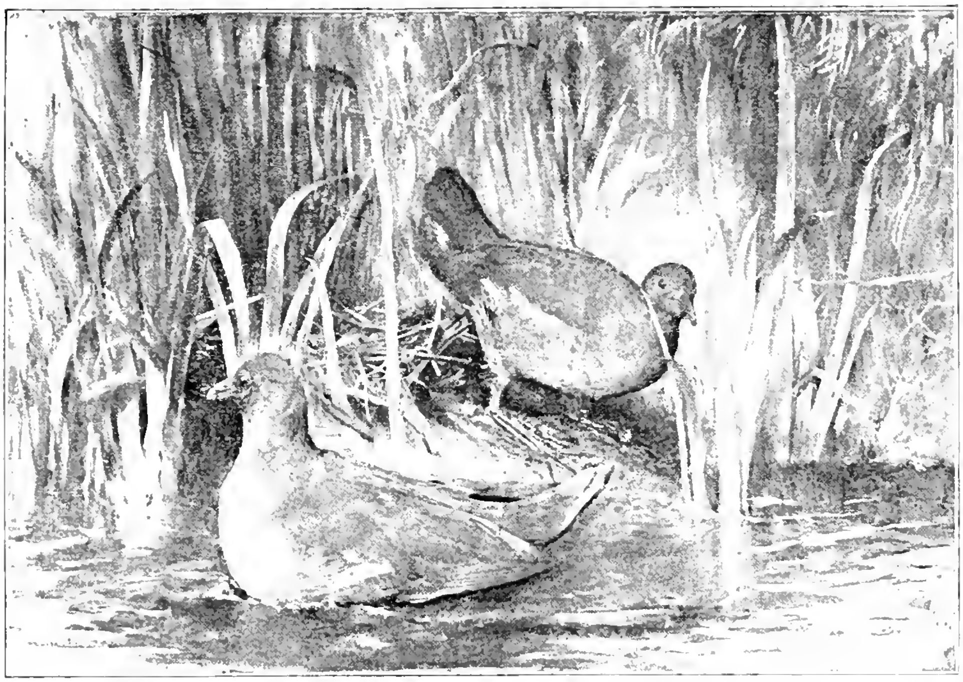
The word "moor" seems to have once signified a marsh, and the moor-hen being an inhabitant of marshy places thus received its name, but since by "moor" we now understand heathy and more or less dry land, the name water-hen seems to be more appropriate.

On almost every lake, pond, or stream on the sides of which reeds and rushes grow, there will be found one or more pairs of water-hen, and when frost drives them from the lakes and ponds they resort to running streams and tidal rivers; but except on these occasions they remain, summer and winter, in the same locality.

The water-hen belongs to the rail family (*Rallidæ*), the members of which have not webbed feet, though several of them have either partially webbed feet, or are provided with an analogous growth to aid them in swimming. The water-hen has on both sides of each of its toes a narrow membrane, which expands as the foot strikes the water, thus greatly enlarging the width of the toes, and affording the foot a greater resistance against the water.

The feet are exceedingly large, and the toes very long for the size of the bird, making it look almost awkward. The usefulness of these overgrown toes, however, is soon apparent when we watch the bird gliding over reeds and rushes, and threading its way in and out through a labyrinth of flags. The bird walks with perfect ease over huge networks of reeds, which have laced themselves together after the growth of years, its large feet preventing it from slipping through the meshes.

The water-hen resorts to all sorts of methods to elude its pursuers. Sometimes it will lie motionless, hiding itself amongst rushes and refusing to fly. I have known them to lie so close that a young retriever brought one in his mouth out of some reeds. At other times the water-hen swims along half under water, like a water-logged vessel, with just the top of its back and its head and neck showing above the surface, thus often escaping notice. In swimming and diving the water-hen is also an expert; it dives down, swims some distance under the water, using both wings and legs, and suddenly comes up again at the most unexpected spots. Sometimes it will only put its head and beak above the surface, and after taking a breath of air disappears again, to rise in the midst of some rushes, amongst which it is soon lost to view.



Water-Hens and Nest; the female bird is leaving the eggs.

The bird swims with a very jerky motion, going from side to side in a restless way, and moving its head backwards and forwards as it proceeds, every now and then dipping its head into the water in pursuit of some small fish or insect.

A bird so clever in the water is usually clumsy on land, but not so with the water-hen. It walks about neatly, and runs very quickly, nodding its head and bobbing its tail, each time displaying its white under-feathers. Its adroitness on land enables it to obtain more varied food than if it were confined to the water only—grass, slugs, worms, insects, and grains being in this way added to its diet.

Although very shy, the water-hen soon becomes tame, and indeed semi-domesticated, on a piece of water near the haunts of men. If ducks are kept on the same pond the water-hens will come and feed with them when corn is thrown down, and they may often be found on ponds adjoining a railway, taking no notice of the passing trains.

Its flight is low and straight. When passing over the water it keeps so low that its legs, which hang down during flight, very often trail along the surface, leaving a track of bubbles.

The call note is a loud "crek-rek-rek," seldom uttered in the day, but during the evening the note may be repeatedly heard.

It builds its nest in very varied situations. Usually it is placed amongst reeds or rushes, but often in the branches of a tree overhanging the water and nearly touching it, and sometimes even in a branch ten or twelve feet up a tree. At other times it may be found on the top of a mass of *débris* on the bank of a stream. The water-hen is a careless builder and seldom attempts to conceal the nest, although it will often cover the eggs on leaving them. The nest is built of flags or rushes, and varies greatly in size. Though generally flat and long, I once found one round and deep, which, strange to say, was composed of leaves and grass. The eggs are six to eight in number, and they are dull white speckled with reddish-brown. Two or even three broods are reared in a season, so that although the water-hen may be a careless nest-builder she cannot be said to be an idle mother.

The first eggs are generally laid early in April, and in three weeks the young are hatched. When first hatched they appear as fluffy black balls of down, and immediately take to the water, swimming about and diving with perfect ease. In the evening the old bird may often be seen brooding the young in the nest, with perhaps one or more of her chicks on her back. When they are big enough to fly, however, they accompany their parents to roost in the bushes and trees near the water.

The eggs of this bird can be hatched under a hen, and when the young are so reared they become very tame, and may be kept in an aviary, or on ornamental water.

The female is slightly larger and a little brighter in colour than the male, but otherwise she resembles her mate. The upper parts of the bird are of a glossy olive-brown, so dark that at a distance the bird appears to be almost black. The under parts are dark slate-grey shading down to a clouded white, while there are streaks of the same colour on the flanks. The under feathers of the tail are white, contrasting with the almost black upper feathers. The iris and bill are red, and the bill is rendered still more striking by a bright yellow tip. The legs, which are of a pale green, have a bright red band just above the so-called knee. It may here be said that what is generally known as the knee of a bird is in reality the tarsal or ankle joint, and not the knee at all; the knee joint being higher up and concealed by skin and feathers.

The young birds of the year are lighter in colour than the mature birds, and they have green beaks.

THE FACE OF THE SKY FOR SEPTEMBER.

By Herbert Sadler, F.R.A.S.

There is but little diminution at present in the number of spots on the solar surface. There will be a total eclipse of the Sun on the 29th, which, however, will be invisible in Europe or America. Conveniently observable minima of Algol occur at 10h. 16m. p.m. on the 5th; at 7h. 5m. p.m. on the 8th; at 11h. 58m. p.m. on the 25th; and at 8h. 47m. p.m. on the 28th.

Mercury is too near the Sun to be observed this month; he is in superior conjunction on the 3rd.

Venus is a morning star, rising on the 1st at 3h. 1m. a.m., or 2h. 12m. before the Sun, with a northern declination of 16° 25′, and an apparent diameter of $10\frac{3}{4}''$, $\frac{92}{100}$ths of the disc being illuminated, and the apparent brightness of the planet being about what it was on February 8th. On the 10th she rises at 3h. 27m. a.m., or 2h. before the Sun, with a northern declination of 13° 5′, and an apparent diameter of $10\frac{1}{2}''$, $\frac{93}{100}$ths of the disc being illuminated. On the 20th she rises at 3h. 57m. a.m., or 1h. 47m. before the Sun, with a northern declination of 8° 48′, and an apparent diameter of 10·4″, $\frac{95}{100}$ths of the disc being illuminated. On the 30th she rises at 4h. 29m. a.m., or 1h. 30m. before the Sun, with a northern declination of 4° 6′, and an apparent diameter of $10\frac{1}{4}''$, $\frac{96}{100}$ths of the disc being illuminated. During the month she pursues a direct path through the whole of Leo into Virgo, being just over $\frac{1}{2}$° north of Regulus on the morning of the 11th.

Mars is an evening star, and is becoming very well situated for observation. He rises on the 1st at 8h. 34m. p.m., or 1h. 48m. after sunset, with a northern declination of 9° 15′, and an apparent diameter of 17·4″, the phase on the *s p* limb amounting to 1·7″. On the 8th he rises at 8h. 8m. p.m., or 1h. 39m. after the Sun, with a northern declination of 9° 37′, and an apparent diameter of 18·4″, the phase amounting to 1·5″. On the 18th he rises at 7h. 29m. p.m., or 1h. 22m. after the Sun, with a northern declination of 9° 50′, and an apparent diameter of 19·8″, the phase amounting to 1·1″ On the 30th he rises at 6h. 36m. p.m., or 55m. after the Sun, with a northern declination of 9° 37′, and an apparent diameter of 21·1″, the phase now only amounting to 0·5″. During the month he describes a short curved path to the N.E. of the $4\frac{1}{2}$ magnitude star ξ^1 Ceti, on the confines of Cetus and Aries, the planet being situated between ξ^1 Ceti and ξ Arietis ($5\frac{1}{2}$ magnitude), and being stationary in the heavens on the 15th. On the evening of the 2nd an $8\frac{1}{2}$ magnitude star will be closely *n p* the planet.

Jupiter is an evening star in the sense of rising before midnight. On the 1st he rises at 11h. 11m. p.m., with a northern declination of 23° 4′, and an apparent equatorial diameter of 36·0″, the phase on the *p* limb amounting to 0·3″. On the 7th he rises at 10h. 51m. p.m., with a northern declination of 23° 3′, and an apparent equatorial diameter of $36\frac{1}{2}''$. On the 18th he rises at 10h. 14m. p.m., with a northern declination of 23° 1′, and an apparent equatorial diameter of $37\frac{3}{4}''$. On the 30th he rises at 9h. 26m. p.m., with a northern declination of 22° 59′, and an apparent equatorial diameter of $39\frac{1}{4}''$, the phase amounting to 0·4″. The following phenomena of the satellites occur while the Sun is 8° below and Jupiter 8° above the horizon:—On the 1st an occultation reappearance of the third satellite at 0h. 53m. a.m. On the 2nd an eclipse disappearance of the first satellite at 3h. 13m. 27s. a.m. On the 3rd a transit ingress of the shadow of the first satellite at 0h. 28m. a.m., a transit ingress of the satellite itself at 1h. 43m. a.m., a transit egress of its shadow at 2h. 43m. a.m., and a transit egress of the satellite at 3h. 59m. a.m. On the 4th a transit ingress of the shadow of the second satellite at 0h. 43m. a.m., an occultation reappearance of the first satellite at 1h. 10m. a.m., a transit egress of the shadow of the second satellite at 3h. 14m. a.m., and a transit ingress of the satellite itself at the same time. On the 6th an occultation reappearance of the second satellite at 0h. 42m. a.m. On the night of the 6th Jupiter will appear with apparently seven satellites in a small telescope. At midnight an 8·6 magnitude star will be nearly midway between the first and third satellites, rather nearer the third, the star *p* the planet about $3\frac{1}{2}'$, 0·1′ south of the centre. Closely *f* the planet at the same hour (between the second satellite and Jupiter), about $1\frac{1}{2}'$ *f* and $\frac{1}{2}'$ south, will appear an 8·1 magnitude star, which will be just south of the planet's centre at a distance of rather over $\frac{1}{4}'$ from the southern limb at 4h. a.m. on the 7th. And at the same hour (midnight) on the 6th an 8·5 magnitude star will be about $\frac{1}{2}'$ *f* the fourth satellite, and about $2\frac{3}{4}'$ south of it; at 4h. a.m. on the 7th this star will be $2\frac{1}{2}'$ *f* Jupiter, and $2\frac{1}{2}'$ south. Besides these, there will be six more stars between $8\frac{1}{2}$ and $10\frac{1}{2}$ magnitudes within a radius of 15′ from the planet, making, with the four satellites, thirteen objects visible in a field of 30′ diameter, with a planet in the centre, on a $2\frac{1}{2}$ or 3 inch achromatic. On the 8th an occultation disappearance of the third satellite at 2h. 22m. a.m. On the 10th a transit ingress of the shadow of the first satellite at 2h. 22m. a.m., of the satellite itself at 3h. 39m. a.m.; a transit egress of the shadow at 4h. 37m. a.m. On the 11th an occultation reappearance of the first satellite at 3h. 6m. a.m., and a transit ingress of the shadow of the second satellite at 3h. 17m. a.m. On the 12th a transit egress of the first satellite at 0h. 24m. a.m. On the 13th an eclipse reappearance of the second satellite at 0h. 40m. 39s. a.m., an occultation disappearance of the second satellite at 0h. 49m. a.m., and its occultation reappearance at 3h. 23m. a.m. On the 15th an eclipse disappearance of the third satellite at 1h. 20m. 17s. a.m., and an eclipse reappearance of the satellite at 3h. 43m. 30s. a.m. On the 17th a transit ingress of the shadow of the first satellite at 4h. 16m. a.m. On the 18th an eclipse disappearance of the first satellite at 1h. 28m. 31s. a.m., and a transit egress of the third satellite at 11h. 25m. p.m. On the 19th a transit ingress of the first satellite at 0h. 4m. a.m., a transit egress of its shadow at 1h. 0m. a.m., a transit egress of the satellite at 2h. 17m. a.m., and its occultation reappearance at 11h. 29m. a.m. On the 20th an eclipse disappearance of the second satellite at 0h. 49m. 54s. a.m., of its reappearance at 3h. 17m. 17s. a.m., and its occultation disappearance at 3h. 28m. a.m. On the 22nd a transit egress of the second satellite at 0h. 23m. a.m. On the 25th an eclipse disappearance of the first satellite at 3h. 21m. 52s. a.m. On the 26th a transit ingress of the shadow of the first satellite at 0h. 38m. a.m., a transit ingress of the third satellite at 0h. 44m. A.M., a transit ingress of the first satellite at 1h. 58m. A.M., a transit egress of its shadow at 2h. 53m. A.M., a transit egress of the third satellite at 3h. 29m. A.M., a transit egress of the first satellite at 4h. 14m. A.M. On the 27th an occultation reappearance of the first satellite at 1h. 23m. A.M., an eclipse disappearance of the second satellite at 3h. 26m. 1s. A.M. On the 29th a transit egress of the shadow of the second satellite at 0h. 14m. A.M., a transit ingress of the satellite at 0h. 22m. A.M., and its transit egress at 2h. 58m. A.M. The following are the times of superior and inferior conjunctions of the fourth satellite with the centre of the planet:—Superior, September 6th 0h. 57m. A.M.; September 22nd, 7h. 42m. P.M. Inferior,, September 14th, 10h. 57m. A.M. Jupiter is in quadrature with the Sun on the 28th, and during the month he describes a direct path in Gemini, being about $\frac{1}{2}$° north of η Geminorum on the 1st, and about the same distance north of μ Geminorum on the 16th.

Saturn is invisible, and we defer an ephemeris of Neptune till October.

Uranus can still be seen, but must be looked for directly after sunset. He sets on the 1st at 9h. 14m. P.M., with a southern declination of 15° 7′, and an apparent diameter of 3·6″. On the 30th he sets at 6h. 50m. P.M., with a southern declination of 15° 32′. During the month he describes a direct path in Libra, being a little to the S.E. of α^1 α^2 Libræ at the end of the month.

There are no well marked showers of shooting stars in September.

The Moon enters her first quarter at 1h. 3m. A.M. on the 7th; is full (harvest Moon) at 4h. 21m. A.M. on the 15th; enters her last quarter at 0h. 32m. P.M. on the 22nd; and is new at 5h. 44m. A.M. on the 29th. She is in apogee at 8h. A.M. on the 10th (distance from the earth 251,600 miles), and is in perigee at 6h. A.M. on the 26th (distance from the earth 227,230 miles). At 8h. 21m. P.M. on the 7th the 6th magnitude star B.A.C. 4923 will make a near approach to the lunar limb at an angle of 17°. At 9h. 3m. P.M. on the 6th the $6\frac{1}{2}$ magnitude star B.A.C. 5603 will make a near approach at an angle of 184°. At 6h. 5m. P.M. on the 9th the 6th magnitude star B.A.C. 6628 will disappear at an angle of 37°, and reappear at 7h. 4m. P.M. at an angle of 307°. At 8h. 45m. P.M. on the 11th the $5\frac{1}{2}$ magnitude star χ Capricorni will make a near approach to the lunar limb ($2\frac{1}{2}$′ distance) at an angle of 335°. At 0h. 43m. A.M. on the 12th the $5\frac{1}{2}$ magnitude star ϕ Capricorni will disappear at an angle of 72°, and reappear at 1h. 50m. A.M. (the star setting at the time) at an angle of 227°. At 1h. 17m. A.M. on the 14th the 6th magnitude star 70 Aquarii will disappear at an angle of 88°, and reappear at 2h. 16m. A.M. at an angle of 200°. At 2h. 6m. A.M. on the 17th the 4th magnitude star ϵ Piscium will disappear at an angle of 353°, and reappear at 2h. 43m. A.M. at an angle of 293°. At 8h. 16m. P.M. on the 18th the 6th magnitude star 27 Arietis will make a near approach at an angle of 334°. At 9h. 59m. P.M. on the 19th the $6\frac{1}{2}$ magnitude star 66 Arietis will make a near approach at an angle of 336°. At 1h. 28m. A.M. on the 20th the 6th magnitude star 9 Tauri will disappear at an angle of 84°, and reappear at 2h. 37m. A.M. at an angle of 225°. At 8h. 4m. P.M. on the same day the $5\frac{1}{2}$ magnitude star χ Tauri will disappear at an angle of 52°, and reappear at 8h. 49m. P.M. at an angle of 276°. At 0h. 48m. A.M. on the 22nd the $6\frac{1}{2}$ magnitude star B.A.C. 1746 will make a near approach at an angle of 168°, and at 11h. 10m. P.M. the $5\frac{1}{2}$ magnitude star 49 Aurigæ will make a near approach at an angle of 356°. At 0h. 41m. A.M. on the 24th the 6th magnitude star c Geminorum will disappear at an angle of 81°, and reappear at 1h. 34m. A.M. at an angle of 287°. There will be a partial eclipse of the Moon on the morning of the 15th, which will be partly visible at Greenwich. The first contact with the penumbra takes place at 2h. 0.m. A.M., with the shadow at 3h. 36 m. A.M. (exactly at the northern-most portion of the limb for direct image), the middle of the eclipse at 4h. 32m. A.M.—magnitude (Moon's diameter = 1) 0·225; last contact with shadow 5h. 27m. A.M. (angle 58° from north point towards the west). The Moon sets at Greenwich eleven minutes later, the Sun rising at about the same time.

Erratum.—"Face of the Sky for August," page 191, column 1, line 9, *for* "11h. 52m.," *read* "Ih. 52m."

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

J. E. Gore.—It seems to us that economy of force has not been sufficiently studied in the two-movers enclosed. Some of the pieces, too, appear to be unnecessary.

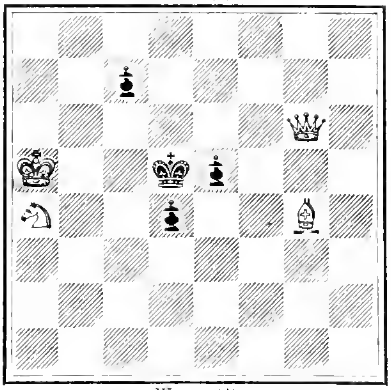
Mrs. Baird and *Messrs. B. G. Laws* and *W. De Morgan* are thanked for problems, which are marked for insertion at an early date.

W. Pennett.—Thanks for the game, which is inserted below.

PROBLEMS.

By F. H. Guest (Smethwick).

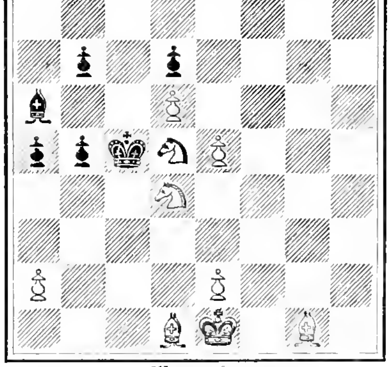
Black (4).



White (4).

White mates in two moves.

Black (6).



White (9).

White mates in three moves.

The following is one of nineteen simultaneous games recently played by Mr. C. Moriau at the Chess Bohemians Club:—

"EVANS GAMBIT."

WHITE (C. Moriau).	BLACK (W. Pennett).
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	3. B to B4
4. P to QKt4	4. B×P
5. P to QB3	5. B to B4
6. Castles	6. P to Q3
7. P to Q4	7. P×P
8. P×P	8. B to Kt3
9. P to Q5	9. Kt to R4
10. B to Kt2	10. Kt to K2
11. B×KtP (*a*)	11. KR to Ktsq
12. B to KB6 (*b*)	12. Kt×B
13. Q to R4ch	13. Q to Q2
14. Q×Kt	14. R×KtPch
15. K to Rsq (*c*)	15. Q to R6
16. QKt to Q2 (*d*)	16. B to Kt5
17. Q to K2 (*e*)	17. Kt to Kt3 (*f*)
18. QR to QKtsq (*g*)	18. Kt to B5
19. R to Ktsq (*h*)	19. R×Rch
20. R×R	20. Kt×Q
21. Kt to Kt5	21. Kt×R
22. Kt×Q	22. Kt×Kt and wins.

NOTES.

(*a*) 11. B to Q3 is the accepted continuation here. It is less probable that Mr. Moriau was ignorant of the dangers attending this capture than that he fancied or hoped that his opponent might be in that blissful state.

(*b*) The books give 12. B to Q4, with a similar continuation, the Black Knight ultimately going to KR5.

(*c*) Clearly 15. K×R, Q to Kt5ch leads to a speedy mate.

(*d*) Or 16. B×Kt, B to Kt5; better than 16. . . Q×Kt, 17. Q to B3.

(*e*) A grave mistake. 17. Q to R4ch was much better.

(*f*) For now Black might have won the Queen at once by 17. . . R×RPch.

(*g*) As the previous note still applies, the only chance now was 18. Q to Kt5ch, K to Bsq; 19. Q to Kt3.

(*h*) Now there is nothing left; for if 19. Q to Kt5ch, P to B3, followed by R×Pch. White's defence throughout was too difficult for the simultaneous player, to whom an attacking game is always more suitable.

We have received for review a copy of the Games of the Steinitz-Lasker Championship Match, edited by Mr. J. G. Cunningham. The book, which may be obtained from 19, Bagby Street, Leeds, for 1s. 6d., is a paper pamphlet of 80 pages, resembling, externally, a double number of the British Chess Magazine. The contents consist of the biographies and performances of the two players, short accounts of their predecessors, a description of the match, and the nineteen games played in it, with copious notes quoted from various authoritative sources. The same move is frequently annotated by two or more able analysts, the result being at times strangely contradictory. The misprints of daily journalism, such as "constellation" for "continuation," are inserted without correction. But these do not in any way detract from the value of the book as a permanent record of the most important match played in this generation.

CHESS INTELLIGENCE.

Messrs. Blackburne, Mason, and Teichmann are spoken of as probable competitors in the International Tournament at Leipsic. Messrs. Loman, Trenchard, and E. O. Jones are likely to take part in the minor tournament.

A match will shortly take place at the Manhattan Chess Club between Herr Albin, formerly of Vienna, and N. Jasnagrodsky, well known in England a few years ago. Both players seem to have made the United States their permanent abode.

The correspondence games between Mr. Steinitz and the Liverpool Chess Club have been resumed. A correspondence match is also in progress between Paris and St. Petersburg. M. Rosenthal is a notable absentee from the Parisian Committee.

A match has just been concluded at Nuremburg between Dr. Tarrasch, of that city, and Herr C. A. Walbrodt, of Berlin. The result was a most decisive victory for Dr. Tarrasch by seven games to none, with only one game drawn. This is certainly a most disappointing performance on the part of the man who did not lose a single game in the Dresden International Tourney, and was thought to have improved since then. Certainly his supporters must have been surprised at his inability to draw more than a single game against his opponent, though the latter played in fine style throughout. A notable feature of the match was the absence of any time limit.

CONTENTS OF No. 106.

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CONTENTS.

EXPERIMENTS ON THE RADIATION OF CERTAIN HEATED GASES AND VAPOURS.

By J. Evershed, F.R.A.S.

THE recently published researches of Dr. Pringsheim (*Weidmann's Annalen*, 1892, No. 3) and Prof. Smithells (*Philosophical Magazine*, March, 1894) on the radiation of gases, raises an important question in connection with solar physics, namely, do the various gases forming the chromosphere and prominences, and the metallic vapours in which the photosphere is bathed, emit their special light radiations merely by reason of the high temperature to which they are exposed, or is there some chemical process involved; the luminosity being caused by what, from sheer ignorance as to the actual relations existing between matter and the ether, has been called "chemical luminescence," or the direct transformation of chemical energy into light? The latter view appears to have been adopted by A. Brester, and in his theory of solar phenomena he supposes a continual recombination of dissociated matter in the outer cooling layers, where other matter, condensed by the loss of heat into mist, no longer forms an obstacle to the free play of the chemical forces involved.

Or again, is the gaseous luminosity the result of electrical excitation, as other physicists have supposed, notably M. Deslandres, of the Paris Observatory? On this view the solar atmosphere is believed to be the seat of violent electrical disturbances, somewhat analogous to our terrestrial thunderstorms and auroræ but on a colossal scale, the prominences and those curious patches of bright calcium vapour which have been found to be so intimately associated with the faculæ on the solar disc, being regarded as local manifestations of electrical energy.

I propose in this article to bring forward evidence to show that whilst both chemical and electrical phenomena may, and very probably do, at times produce luminous effects on the sun, yet there is no necessity whatever to invoke the aid of either of these forces to account for the general illumination of the chromospheric gases and the ordinary prominences or the metallic vapours forming the "reversing layer" at the base of the chromosphere, and that there is strong reason for believing that these gases shine simply because they are excessively hot.

This, of course, was Kirchoff's original idea, but it seems to have been called in question of late years on account of the difficulty or impossibility experienced by experimentalists in inducing any gas or vapour to emit its own characteristic light radiation, or indeed any radiation, except when under the influence of the electrical discharge as in Geissler tubes, or of chemical forces as in ordinary flames; and it has always hitherto been through one or other of these agencies that the emission spectra of bodies has been studied in the laboratory. Quite recently, however, Prof. Smithells has carefully studied the glow produced when iodine vapour is heated, and has come to the conclusion that the light is simply the result of the high temperature. The vapour is in fact "red hot" just like any heated solid body, and it is this observation that has led me to make a series of experiments both with iodine and several other elementary gases and vapours, with the view of determining, first, whether the glowing iodine obeys Kirchoff's law, according to which the radiations of the heated vapour should have the same wave-lengths as are absorbed when white light passes through it, and secondly, whether this property of glowing is peculiar to iodine or is shared by other elementary bodies in a greater or less degree. After this I proposed to attack the problem of heated metallic vapours, and find an answer to the question whether they can be made to emit their characteristic light radiations by heat alone, the results of the researches of Dr. Pringsheim in this direction (above quoted) not appearing to me to give a decided verdict one way or the other.

The first experiments which I shall describe answer the first two questions quite satisfactorily, and as these are comparatively simple in their nature, and easily verified, it will be unnecessary for me to give an exact and detailed description of the apparatus actually employed; the only essential parts being a spectroscope, a Bunsen burner, and a piece of hard glass tube. I will, however, ask the indulgence of the readers of Knowledge when we come to consider the more critical experiments with glowing sodium, when it will be necessary to describe at some length the disposition of the various parts of the apparatus used, and the precautions taken to insure a valid result.

To determine, then, the first point—that is, the nature of the light emitted by iodine—a piece of hard glass tube, closed at one end, was strongly heated about the middle, and an image of the hot part was thrown across the slit of a spectroscope by means of a lens. A faint streaky spectrum, due to glowing opaque particles in the glass, was all that could be seen. A little iodine was then pushed into the tube, and immediately a bright glow filled the central bore. The spectrum showed no lines or bands, but appeared perfectly continuous, and similar to that produced by a red-hot iron wire, with which it was directly compared; no sign of resolution into lines could be seen, even with a highly dispersive train of five prisms.

Next, a ray of white light from the flame of a paraffin lamp was made to pass through the glowing tube and enter the spectroscope, after having suffered absorption by the heated vapour. The dark bands characteristic of cooler iodine were seen to be unchanged, and there was no sign of any continuous absorption. Thus, at the temperature of the experiment, iodine emits a continuous spectrum, and does *not* emit only those rays which it absorbs.

The second question, as to whether this curious phenomenon of a gas glowing with continuous light like a solid was a property special to iodine, was soon answered in the negative. Thus bromine was tried with exactly the same results, the glow being quite as conspicuous as that of iodine. Then chlorine was attacked, and after several unsuccessful attempts, this also was found to give a perfectly distinct glow of the same character as the others. The experiment was arranged as follows: chlorine from a generating flask was thoroughly dried by passing slowly through a long tube of calcium chloride; the dry gas was then passed along a straight piece of combustion tube heated strongly in the middle, this tube being connected with a larger glass tube, in which was placed a small reflecting prism, which allowed one to look along the central bore of the hot tube. With the room in which the experiment was performed made as dark as possible, and the eye screened from the light of the Bunsen, a faint but perfectly distinct glow was seen to gradually fill up the tube, beginning on the lower or hottest portion. With a spectroscope of very small dispersion and wide slit, the light appeared to be continuous, but it could only be traced between the positions of D and E of the solar spectrum, probably because of the greater sensitiveness of the eye for this region. There seems to be no more reason to suppose any chemical "luminescence" in the case of dried chlorine than in that of iodine or bromine.

After these experiments it was thought probable that all *coloured* vapours would be found to glow in the same way. Accordingly the vapours of sulphur, selenium, and arsenic were tried in an atmosphere of nitrogen, and all were found to glow faintly. Phosphorus, however, which gives a colourless vapour, appeared to give no light when free from every trace of oxygen.

The conclusion, therefore, is that all the elements which have been named, except phosphorus, can be made to emit light by the mere application of heat, but that probably in every case Kirchoff's law is entirely disregarded, the emission not corresponding in any way with the absorption spectra, and for this reason one cannot compare these luminous vapours with the chromosphere radiations, or with discontinuous radiation generally. It might still be contended that *line* spectra can only be generated by chemical or electrical luminescence.

My next endeavours were, therefore, directed to the production of metallic line spectra by heat, rigidly excluding chemical action. Sodium was the element chosen for the initial experiments; the powerful absorption produced by the vapour of this metal on yellow "D" light seemed, on Kirchoff's hypothesis, to give the best chance of success at the very moderate temperatures at my command.*

The apparatus used in this research, although apparently rather complicated, is really simple enough and can easily be rigged up by anyone at all familiar with chemical manipulations. It was designed with the object of excluding absolutely from the tube which was to be heated any gas that might be expected to act chemically on the vapour of the metal. In the diagram Fig. 1, A and B are two similar gas holders, improvised by inverting a couple of two gallon tins mouth down into larger iron vessels containing strong brine; guides are provided, so that the tins will float up perpendicularly when full of gas, a stopcock is soldered into the bottom plate of each tin (at the top in the position used), and a rubber tube leads from A to a couple of wash bottles (S′ S″) containing strong sulphuric acid; from S″ a long tube of hard glass (P) containing a little phosphorus leads into the drying tube (C), which is packed with calcium oxide and calcium chloride, the former to remove carbonic acid and the latter the last traces of water which may remain in the gas used after passing the sulphuric acid bottles. The drying tube connects on to the porcelain heating tube (H) through a metal T-piece, one end of the T having a glass plate carefully cemented in so that one may look along the inside of the heating tube, to which the T is connected by rubber tube tightened with wire, both connections being also buried in sealing wax. At the other end of H, which is covered in the centre by a fire-clay arch, is a second T of glass, one limb connecting with a glass gland or stuffing-box (G) with pierced rubber ends and filled with mercury. A long steel rod passes through the gland, the end being flattened to a spoon shape; this can be pushed along to the centre of H or drawn out past the entrance of the side tube of the T. This side tube is closed by a perforated rubber stopper, through which a small glass tube passes bearing a small reflecting prism cemented to the end, which is thus closed up; but in order to allow of the escape of the gases, so that a current may be set up in the apparatus, a hole is blown in the side of this tube near the prism. The outer end of the tube is connected by rubber tubing to another wash bottle (S‴) containing sulphuric acid, and from this again a tube leads to the gasholder B. Thus the entire apparatus forms a closed circuit and has no inlet or outlet. The gasholders have each a Y tube attached, one branch of the Y leading to the apparatus and the other connecting A with B by means of a rubber tube carrying a clip. The S at the foot of the diagram is a direct vision spectroscope, and L is a lens focussing the central parts of the tube H on to the slit of the instrument; both are attached to a strip of hard wood movable horizontally about an axis placed between the lens and the slit. This enables one to instantly push aside the spectroscope into the position shown by dotted lines, and observe the glowing tube directly.

The *modus operandi* of an experiment is as follows: First, one fills the gasholder A with some neutral gas containing no oxygen, or only a trace of that element, such as nitrogen or hydrogen, or ordinary coal gas. When full it is disconnected with the gas generator or gas main, as the case may be, and connection is made with the apparatus. Next, weights are put on the inverted tin until sufficient pressure is obtained to drive a current of gas through the wash bottles, drying tube, &c., into B, which will rise as A sinks. Then the Bunsen is lighted under the porcelain tube, which it presently heats up to a white heat for about two inches of its length. After sufficient dry gas has passed through, and all trace of moisture has gone, the current is stopped by closing the stopcock on A, and a small pellet of sodium is dropped into the steel spoon through the side tube of the glass T, the stopper with the inner tube and prism being removed for this purpose and quickly replaced; the current is then restarted in order to drive away any oxygen that will have diffused in by the operation, and at the same time the tube

* My heating outfit consists of a single Bunsen burner with an oblong aperture, supplied from a half-inch gas main, and giving a flat flame about six inches high and two inches wide.

P is gently heated by a spirit lamp flame until a small faintly luminous flame is seen, indicating combination of the last traces of oxygen with the phosphorus. After this has gone on a sufficient length of time, and the apparatus may be considered to be absolutely free from oxygen, water, or carbonic acid, the stopcock on A is again closed

Experiment II.—A pellet of clean sodium was placed in the steel spoon and the gas (coal gas) allowed to circulate, the phosphorus being heated. The line seen in Experiment I. was watched, and some time after it had quite disappeared the current was stopped, and the sodium pushed into the hot part of the tube. Instantly the central

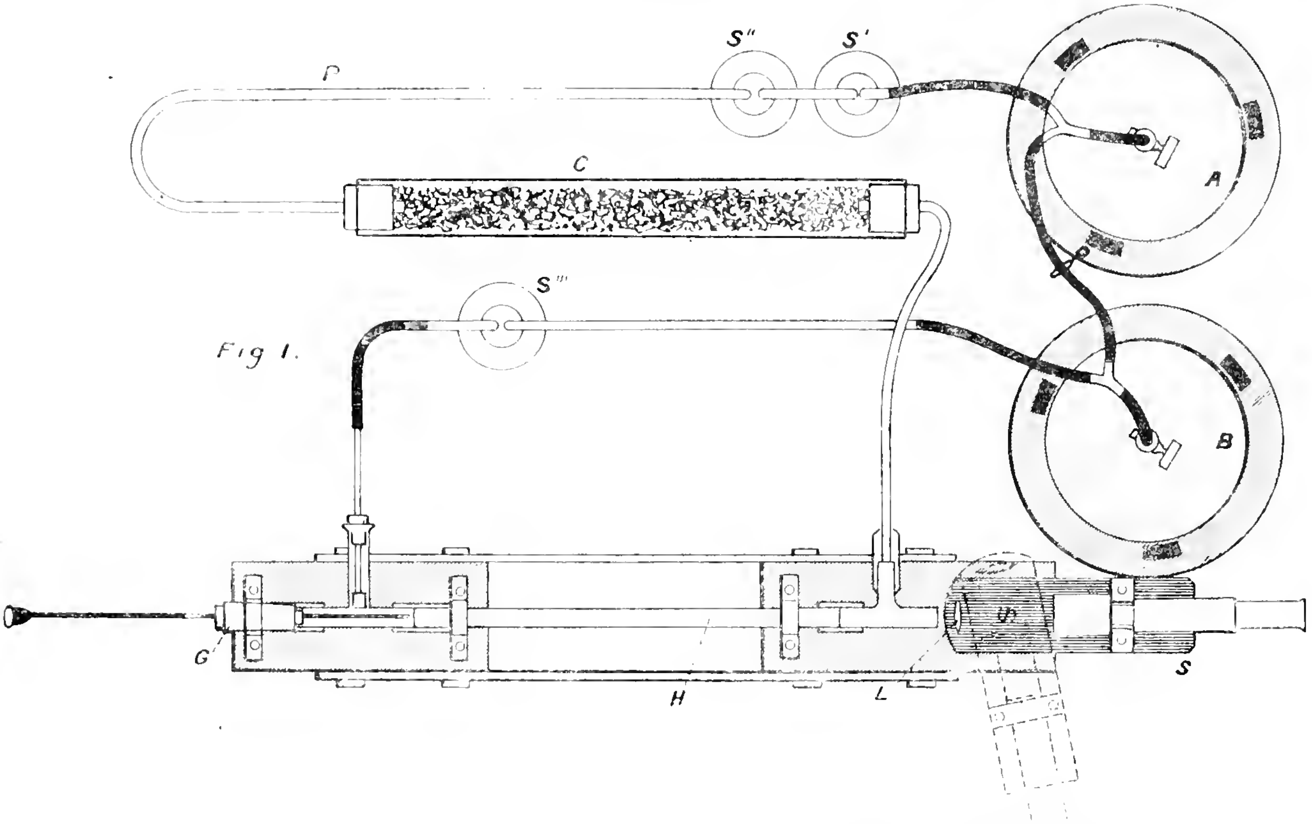


Fig. 1.

and the steel spoon carrying the sodium is pushed into the hot part of the tube H, turned over, the sodium shaken out and again withdrawn past the entrance of the side tube. Now the tube carrying the prism is pushed down into line with the tube H, and the white flame of a paraffin lamp is placed close alongside the glass T, so that a ray of white light can be made to traverse the glowing vapour in H. One may now observe at will the absorption or emission spectrum of the glowing sodium by the simple operation of turning the lamp flame up or down.

I will now proceed to describe some of the experiments actually performed.

Experiment I.—With the porcelain tube strongly heated a slow current of coal gas, not specially freed from oxygen, was allowed to circulate in the apparatus, no sodium being admitted. A distinct and fine sodium line was visible in the spectroscope, which increased in brightness when a little air was mixed with the gas, but which gradually faded to invisibility when the phosphorus tube was heated so as to eliminate oxygen.

The explanation of this result is quite simple; the hydrogen combines with the trace of oxygen when it reaches the hot tube, and the "flame" so formed (which, however, is not visible as such except when a large quantity of oxygen is present) becomes tinted with sodium derived from the tube itself just as the Bunsen flame outside is tinted. This line, then, may be classed as the result of chemical "luminescence," whatever physical meaning may be ascribed to that expression.

bore of the porcelain was filled with light, which in the spectroscope was found to be perfectly continuous, but crossed by a very wide black line at D. Gradually the continuous spectrum faded, and as it became fainter the dark D line was seen to be bordered with a fringe of light on each side; and as the vapour became less and less dense, owing to the distillation of the sodium into cooler parts of the tube, the D line went through the changes represented in Fig. 2, in the order *a*, *b*, *c*, *d*, finally persisting as a rather wide* bright line in which a very fine dark line could usually be made out. But at any stage of the experiment, the dark central line could easily be extinguished by allowing a gentle current of gas to push back the cooler absorbing layer into the hotter regions. Now the question to decide was, whether this bright, broad, hazy D line was or was not the result of chemical activities.

Experiment III.—The sodium spectrum was examined as in Experiment II., but without heating the phosphorus, a considerable trace of oxygen, therefore, remaining in the gas. With the current stopped, the phenomena observed were the same as in Experiment II., but as soon as a slow current was allowed to impinge on the sodium by partly opening the stopcock on A, the *centre* of the broad bright line became much brighter, and could be seen projected on the adjacent continuous spectrum from the glowing sides of the tube.

* The dispersion of the spectroscope being insufficient to separate the components of the D line, it is evident that when a "wide" line was seen the two components of the pair were fused into one.

I consider that Experiments II. and III. prove that oxygen derived from the coal gas* used plays no noticeable part in the production of the bright line, for it is evident from the very great width of the line that the light is coming from a considerable thickness of very dense vapour, and it is impossible to believe that oxygen can be continually diffusing into the central dense regions without being arrested at the outer layers; and in proof of this, Experiment III. shows the actual effect of allowing oxygen to impinge upon the outer layer, the only result being to obliterate the absorption line and produce a central narrow line brighter than the broad line.

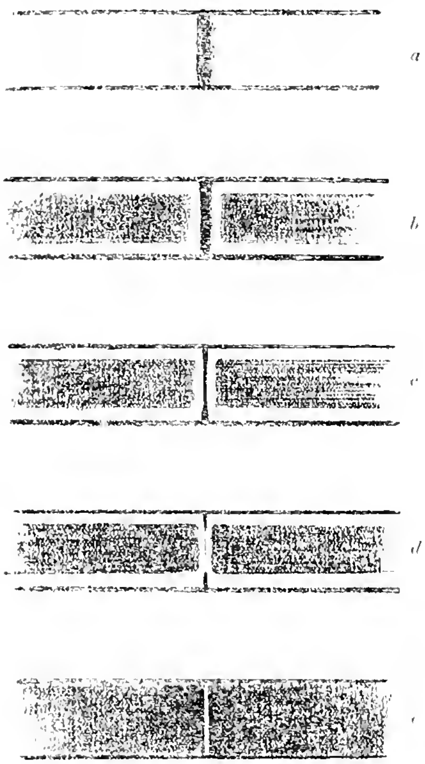


Fig. 2.—*a*. Continuous spectrum of dense sodium vapour with D absorption. *b, c, d*. Successive appearances after the continuous light has faded; the glowing sides of the tube give the bright edges to the spectrum. *e*. Ordinary flame spectrum of sodium with low dispersion.

There is, however, another possible source of chemical energy, namely, the porcelain tube itself, whence oxygen may be derived from the silicates of which it is composed; and some support is given to this supposition by the fact that after the experiments the tube is found to be considerably corroded, black silicon being deposited on the inside.

To test this I arranged another experiment as follows:

Experiment IV.—A short piece of iron tube, two and a half inches long and about three-eighths of an inch bore, was bevelled at the ends and fitted between two pieces of hard glass tube, the joints being ground to fit. This made a practically air-tight joint when the glass became soft by contact with the heated iron and was pressed close up, and it permitted a high temperature to be attained in the iron without the loss of heat by conduction which would ensue if the tube were made wholly of iron. Moreover, the temperature gradient being very sharp at the joints on account of the bad conducting power of the glass, there will only be a thin layer of the cooler absorbing vapour formed, through which one must always observe the bright-line phenomena.

With the tubes thus arranged the Bunsen was made to play only upon the iron, and when this had reached its maximum temperature the sodium was tipped out from the steel spoon as before. Now, if in the previous trials the luminosity was due to chemical action taking place between the sodium and the oxygen compounds of the porcelain, one ought in this experiment to find a striking difference in the intensity of the radiation. No such difference was, however, to be observed, the sequence of phenomena being exactly similar to that represented in Fig. 2. Some more experiments are contemplated with the iron tube, but I think enough has already been done to dispose of the theory that the light is caused by chemical processes.

In the foregoing experiments there still remains to be explained the continuous spectrum seen for a short time when the sodium is first volatilized. To investigate this the lamp and reflecting prism are brought into operation, and directly the sodium is pushed in, filling the tube with a reddish glow, the lamp is turned up and the prism adjusted. Then a most beautiful phenomenon is revealed; the glowing vapour is apparently opaque to white light, but projected upon it is seen a splendid violet light gradually changing to a fine blue as the vapour becomes more transparent, then greenish, and fading until finally no tint is seen—the heated vapour being at this final stage, to all appearance, perfectly transparent. Viewed with the spectroscope one sees, first, a bright band in the violet, the rest of the spectrum being dark except for the feeble continuous *emission* glow visible in the red and green, then a bright green band is transmitted, and later still a red band appears. These three beautiful bands of transmitted light gradually widen, the black absorption spaces between them becoming less and less in width and intensity; finally, the dark space in the blue fades away altogether, leaving only the band blotting out the yellow, which soon narrows down and becomes the ordinary D absorption line.

Now, by comparing the emission with the absorption at every stage, it was found that the continuous glow was brightest at first, when the absorption was greatest, and as the dark bands diminished the emission also faded, persisting, however, as long as the least trace of a dark band could be seen in the blue, vanishing when this disappeared.

The explanation of this result, I have no hesitation in saying, is as follows:—When the sodium vapour is above a certain density it gives the remarkable absorption spectrum described, but like iodine and other *coloured* vapours it emits, when in this condition, continuous light. I must here remark, however, that in performing this last experiment great care must be taken to have the apparatus dry and free from oxygen, and the metal must be pure and bright, otherwise the result is complicated by the production of a spurious glow due to solid particles of oxide forming a smoke-like cloud.

Here, then, we have found a connecting link between the radiation of the coloured vapours of the metalloids† and the line spectra of the metals. May we not, therefore, assume that all gaseous bodies are subject to the same general laws governing their light radiations, and that a sufficiently high temperature (coupled with not too great a density) is the only condition required to make each element strike its own characteristic light chord upon the ether. The bearing of these experiments on the solar radiation is obvious. Leaving alone the puzzling question as to how the vibrating molecules are enabled to impart their energy to the ether, we find it quite unnecessary to introduce further mysteries, implied by the term "luminescence," into the subject. The glowing calcium and hydrogen of the chromosphere are in all probability merely converting its enormous heat energy directly into

* These experiments have been repeated with nitrogen in place of coal gas, and with identical results.

† Iodine vapour at higher temperatures is said to emit a discontinuous spectrum, corresponding to the absorption bands (*Salet, Spectroscopie*, p. 174); thus the relation is still closer.

light. In the absence of any knowledge regarding the radiation of gases under the enormous pressures and temperatures which must obtain in the deeper layers of the photosphere, it would be hazardous to assert that the continuous spectrum of these regions is in any way analogous to the continuous spectra of the comparatively dense vapours that I have subjected to experiment.

THE ANCIENT MAMMALS OF BRITAIN.

III.—The Lower Tertiary Period.

By R. Lydekker, B.A.Cantab., F.R.S.

BETWEEN the coralline crag and the Hempsted beds of the Isle of Wight, which belong to the middle portion of the Oligocene period, and are the next Tertiary deposits met with in Britain, is a long gap, owing to the complete absence of all representatives of the Miocene and upper Oligocene strata of the Continent. In consequence of this imperfection of the record, instead of finding a gradual transition from the mammals of the crag period as we pass downwards through the Miocene beds till we reach the Oligocene, we notice that the mammalian fauna of the lower Tertiaries of Britain is utterly unlike that of the upper beds, and shows not the faintest trace of connection with it. In place of deer, rhinoceroses, horses, and pigs we have, even in the highest beds of the lower Tertiaries, ungulate mammals of strange and unknown types, all of which belong to genera long since extinct, and differing widely in the structure of their low-crowned cheek-teeth from all modern mammals, although some appear to have approximated in external form to the tapirs and others to the pigs. Elephants and mastodons were entirely unknown, and the place of monkeys was filled by primitive lemur-like creatures. All the indications afforded by the flora and the molluscan life of the Oligocene and Eocene beds point to the conclusion that during those epochs Britain enjoyed a tropical or sub-tropical climate; and, in some respects, its fauna may be compared to that of Madagascar at the present day, although, of course, the genera of the mammals, and in many cases even the families were different. Indeed, of the land mammals inhabiting Oligocene and Eocene England, only two groups can be referred to genera that still exist, one of these being now relegated to the New World.

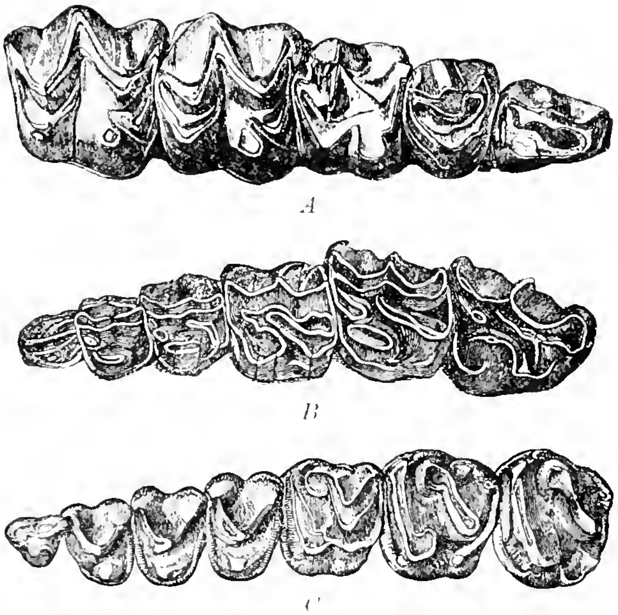
Lest the reader should begin to think that the whole of the strata whose fauna we have to consider in this part of our subject belong to nearly the same geological period, we hasten to point out the various groups into which they are divided, preparatory to the consideration of their fauna. The highest of the Oligocene beds in Britain are those forming the steep clay cliffs on the western side of the Isle of Wight, in the neighbourhood of Yarmouth, and termed the Hempsted beds, from a village of that name which is situated upon them. These belong to the middle portion of the Oligocene period, and have a fauna similar to that of certain beds at Ronzon, near Puy-en-Velay, in the Haute Loire. Next in descending order are the Bembridge beds of the Hampshire basin, whose fauna corresponds with that of the gypsum beds on which Paris stands, and which are consequently assigned to the lower part of the Oligocene; the beds of Hordwell, in Hampshire, and Headon, in the Isle of Wight, likewise belonging to the same great division. The clays of Barton, in Hampshire, which, like those next mentioned, unfortunately yield scarcely any mammalian remains, bring us to the upper portion of the Eocene period; while the older clays of Bracklesham, in Sussex, are assigned to the middle division of the same epoch. Better known than these is the London clay, forming the upper portion of the lower Eocene, and yielding several types of mammals; beneath which are the unfossiliferous Woolwich and Reading beds, resting on the chalk. Before proceeding to the consideration of the fauna of these various beds, it may be observed that mammalian remains are for the most part rare and fragmentary, and that for a full knowledge of the extent of the fauna of the period, and the structure of its component items, we have to depend largely upon the discoveries made on the Continent or in the United States, both of which are more favoured than Britain in regard to the preservation of early Tertiary mammals. In our survey of the fauna of all these beds, it will be more convenient to treat of the animals according to their zoological position, indicating the different horizons in which they severally occur.

At the present day, as explained in a former article, lemurs are chiefly characteristic of Madagascar, although likewise occurring in Africa, and also represented in south-eastern Asia, but in the Oligocene period they were abundant in Europe. One of these early lemurs was described from the Hordwell beds as far back as the year 1844 under the name of *Microchœrus*, but it is only recently that its true affinities have been recognized. Not much larger than a squirrel, this creature approximated in the structure of its skull to the African lemurs known as galagos, but differed from all the existing members of the group in that the lower tusk was formed by the canine tooth and not by the first tooth of the premolar series. Still more different from any living lemur was the Oligocene *Adapis*, first described from France, and regarded as an ungulate, but subsequently recognized from the Hordwell beds. It differs from all modern lemurs in the presence of four pairs of premolar teeth in each jaw, and one of the species attained a comparatively large size, its skull measuring upwards of four inches in length.

In Madagascar lemurs are now accompanied by many kinds of insectivores, and it is, therefore, not surprising to find a member of that order in the Hordwell beds. This animal (*Necrogymnura*), instead of being allied to the Malagasy insectivores, appears, however, to have been related to the gymnura of Borneo, which may be described as a long-tailed hedgehog without spines, and therefore somewhat rat-like in general appearance. Civets likewise form an important element in the modern Malagasy fauna, and the Hordwell lemurs were accompanied by a member of that group assigned to the existing African and Oriental genus *Viverra*, which includes the true civets. With the exception of the opossums, this civet is the only terrestrial mammal from the earlier British Tertiaries which can be referred to a still living genus. The other early British carnivores belong to an extinct group known as the creodonts, which disappeared with the close of the Oligocene period, and differed from modern carnivores in that all their molar teeth were furnished with sharp cutting blades, instead of a single pair of cheek-teeth in each jaw being specially modified for cutting with a scissor-like action. In their dentition these primitive carnivores approximate, indeed, both to the insectivores and the marsupials, and they are undoubtedly far more generalized types than the existing members of the order to which they belong. While some were not larger than a fox, others fully equalled the dimensions of the largest bears. In Britain they are represented by one genus (*Hyænodon*) from the Hordwell beds, by a second (*Pterodon*) from the Bembridge limestone, and a third (*Argillotherium*) from the London clay. The last is, however, only known by an imperfect skull without the teeth, and may prove to be identical with one of the foreign genera.

Passing on to the hoofed order, one of the most interesting of the even-toed section is the *Dichodon* of the Hordwell and Headon beds, as being the only early British ungulate having the upper molar teeth with the four crescentic columns characterizing the true ruminants, to the ancestors of which group it was probably more or less closely allied. Connecting these early ruminant-like forms with the ancestors of the pigs is the *Hyopotamus* of the Hempsted beds, in which the upper molars were of the same general type as those of the anoplothere (represented in figure *A* of our illustration), although the whole form of the creature was more pig-like, the skull being long and narrow, with large tusks, separated by an interval both from the incisor teeth in front and the premolars behind. The *Hyopotamus* was doubtless a four-toed animal like the hippopotamus, but an apparently allied form from the Headon beds takes its name of *Diplopus* from the reduction of the toes to two in each limb. In the allied *Anthracotherium*, of both the Hempsted and Headon beds, the molars lose to a great extent the crescentic structure of those of the *Hyopotamus*; and in the gigantic *Elotherium* from Hempsted, and the smaller *Chæropotamus* of the Bembridge series, we come to ungulates having tubercular molars of the same general type as those of the pigs, although in the upper jaw they retain the five-columned arrangement characterizing the *Hyopotamus*, and have much squarer crowns than those of the pigs. There can, however, be little doubt that in this group we are very close to the ancestral stock from which the modern pigs and ruminants have alike originated.

On the other hand, the anoplotheres (*Anoplotherium*), which occur in the lower Oligocene of the Isle of Wight, and the upper molars of which are shown in figure *A* of the



Upper cheek-teeth of (*A*) Anoplothere, (*B*) Palæothere, and (*C*) *Coryphodon*. *A* is from the right, while *B* and *C* are from the left side.

accompanying illustration, belong to what is called an inadaptive type—that is, one which has died out without leaving descendants. These long-tailed animals, some of which reached the dimensions of an average-sized mule, were remarkable for the circumstance that the teeth formed a continuous series round the jaws, without any interruption by large tusks; and they were further peculiar among the group to which they belong in that in some cases there were three toes to each foot, although in others they conformed to the more normal type in having but two. In these animals the premolar teeth (two of which are shown on the right side of the figure) were only slightly compressed, but the nearly allied small and delicately built xiphodons take their name from the extreme compression and secant form of the teeth in question, in which respect they recall the modern chevrotains, or mouse-deer. Whether the xiphodons are really British is not quite clear, although a skull from the red crag, evidently derived from an older structure, has been assigned to them. The large size of the "tear-pit," or lachrymal fossa in front of the eye, has suggested for another member of this group, having teeth of the anoplothere type, the name of *Dacrytherium*, the English representative of the genus having been originally described from the Hordwell and Headon beds under the name of *Dichobune*.

This completes our list of the even-toed ungulates, and we proceed to notice the few early Tertiary British representatives of the odd-toed group, or those in which the toe corresponding to the human middle finger is symmetrical in itself and larger than either of the others. To this group belong the well-known palæotheres (*Palæotherium*), so abundant in the gypsum of the Paris basin and more sparingly represented in the Headon and Bembridge beds of Hampshire and the Isle of Wight. The structure of the cheek-teeth of a medium-sized representative of this genus is exhibited in figure *B* of the illustration; and in general form these animals somewhat resembled tapirs, although the neck was relatively longer, and there were but three toes to each foot. It was long considered that the palæotheres were on the ancestral line of the horse, but this view is now discarded, and they are considered, like the anoplotheres, to represent an inadaptive type. A much smaller animal described as *Anchilophus*, of which teeth have been found in the Bembridge limestone, is, however, either very close to, or actually on the ancestral line in question. Its upper molar teeth are not very unlike those of the palæotheres, but have the oblique cross-crests, narrower, less inclined, and separated by a more open valley. Although very common in the middle and lower Eocene beds of the Continent, the large genus of odd-toed ungulates known as *Lophiodon* are represented in Britain only by a single species from the Bracklesham beds. While their teeth are of the same general type as those of the palæotheres and *Anchilophus*, the upper molars differ in having the outer wall formed by sub-conical columns instead of flattened lobes, thereby resembling the corresponding teeth of the modern tapirs. Although most, if not all of these lophiodons died out without giving origin to any posterity, the case is very different with the nearly allied little *Hyracotherium*, originally described upon the evidence of an imperfect skull from the London clay at Herne Bay, since this genus is one of the earliest to which the ancestry of the horse can be traced. Thanks to the perfect preservation of specimens discovered in the United States, where they were long known under a totally different name, we now know that the hyracothere was a small four-toed animal, intimately connected with a still earlier five-toed type, while superiorly it leads on to the *Anchilophus* and certain allied Miocene continental forms, and thus to the modern horse. The hyracothere received its name from an idea that it was related to the existing hyrax; and it is a curious comment on the early history of palæontology to notice that the lower teeth of a second species obtained from the lower Eocene sand of Kyson, in Suffolk, were at first supposed to pertain to a monkey.

If the palæontological riches of the United States have helped in the elucidation of the true affinities of the hyracothere, still more markedly is this the case with regard to the much larger ungulate originally described on the evidence of detached teeth from the London clay under the name of *Coryphodon*, in allusion to the strongly marked oblique crests surmounting their crowns. From nearly complete skeletons discovered in America, we know that the coryphodons, which were animals with somewhat the proportions of a bear, although furnished with a well-developed tail, differed from both the odd-toed and even-toed ungulates in having five toes to each of the very short and wide feet, and likewise in the structure of the feet themselves. The molar teeth, too, as shown in figure *C* of the illustration, are likewise quite different from those of any living member of the order, and are remarkable for the extreme shortness of their crowns. The nearest allies of these animals were the uintatheres of North America, distinguished by the presence of a large pair of tusks in the upper jaw,* and thetwogroups collectively constitute the order of short-footed ungulates.

One remarkable palate of a mandible from the London clay of Herne Bay, preserved in the museum at York, and described under the name of *Platychœrops*, has given rise to some amount of discussion as to its serial position. It has been suggested, however, that it belongs to a peculiar group of mammals from the North American Eocene, which combine many of the characteristics of the ungulates, carnivores, and rodents. Of the latter order there are but small traces in the lower British Tertiaries; but some lower jaws from the Hordwell and Headon beds have been referred to the genus *Theridomys*, which is of common occurrence in the corresponding continental strata, and indicates an extinct family of the order. Whales are likewise rare, but from the Barton beds there has been obtained a skull belonging to the peculiar group of zeuglodonts, which are not improbably the ancestral types whence the modern toothed whales have been evolved. Unlike all existing members of the order, these extinct cetaceans had double-fanged molar teeth, whose compressed crowns had the edges surmounted by well-marked serrations; and, what is more remarkable, their bodies appear to have been invested with a bony armour comparable to that of crocodiles.

The last of the Tertiary mammals that we have to notice are opossums (*Didelphys*), remains of which have been detected both in the Hordwell beds and in the lower Eocene sand of Kyson. It is almost superfluous to add that opossums, which in Oligocene and Eocene times were widely spread over Europe, are now confined to America, where they attain their greatest development in that half of the continent lying to the south of the Isthmus of Darien. The relegation of the originally European genus to the New World is somewhat analogous to the banishment of the nearest living allies of the British Jurassic mammals to Australia, and is a well-marked instance of that gradual disappearance of the lower types of mammalian life from the western regions of the Old World, with the development of higher forms, which seems to have been such a characteristic feature in the evolution of the present faunas of the globe. Since we have already discussed the mammalian fauna of the Jurassic rocks of Britain in our article on "The Oldest Mammals," we may be excused from further reference to that part of our subject on the present occasion.

* See the figure in a previous article on "Tusks and their Uses."

INSECT SECRETIONS.—VI.

By E. A. Butler, B.A., B.Sc.

(*Continued from page* 198.)

THE secretions formed by beetles of which we have hitherto spoken are of use only to their fabricators, but we have now to consider a family of beetles whose products have for a long time been turned to account by human kind, and made an important article of commerce. This family is the *Cantharidæ* or *Meloidæ*, some of the best known members of which are called blister beetles and oil beetles. The family is a very extensive one, containing more than a thousand species already described, which are world-wide in their distribution, though the majority have their home in tropical regions. Of this vast company we have only a very small sprinkling in Great Britain, a select group of nine species, distributed amongst three genera. Several of the nine are amongst our rarest insects, and not more than one or two are common. However, this small company contains the most useful insect of the whole family, the renowned Spanish fly, or blister beetle, *Lytta* or *Cantharis vesicatoria*.

Nothing more romantic than the life-history of the insects belonging to this family can be found throughout the whole range of insect life. It may be remembered that we have given details of two species of *Meloïdæ* in our articles on "Bee Parasites," viz., the common oil beetle, and the beetle named *Sitaris muralis* (see Knowledge, Vol. XV., p. 166). These may be taken as typical of the group, and the general history of a Meloïd may, therefore, be summarized as follows:—The eggs are extremely numerous, and on hatching produce very minute six-legged creatures, which have not merely the usual pair of claws at the end of each foot, but in addition a central pad, which looks like a third claw, whence these little beings are often spoken of as "triungulines" (three-clawed). They are also distinguished by possessing long bristles at the end of their bodies. They are very active, and their one business is to discover a suitable kind of bee, to whose body they may cling, so that they may be carried away by it, and obtain entrance into its nest. Here the little adventurer devours the bee's egg, and then becomes changed into a fat-bodied, short-legged creature, utterly unlike the little triunguline that produced it. The food of this clumsy larva—for larva still it is, notwithstanding its change of form—is the store that has been laid up by the bee for her own young. By the time this is finished, the larva has lost its legs and become barrel-shaped. But the cycle of changes is not yet complete; other phases have to be passed through before we arrive again at the point from which we started. In the next stage it is a six-legged grub again, similar to what preceded the legless barrel. After this it changes to an ordinary chrysalis, from which in due course the perfect beetle issues.

The great peculiarity in this marvellous history is the existence of two totally distinct types of larva, which succeed one another in time, viz., the active, running triunguline, which reminds us somewhat of the larvæ of those insects that have an incomplete metamorphosis, and the crawling caterpillar-like being, which is typical of the larvæ of those insects whose metamorphosis is complete. And here again there is a further complication, this form appearing twice, and its two appearances being separated from one another by an interval during which the creature passes into a form resembling the barrel-shaped chrysalis of a fly. Thus we seem to have in the total twice as many stages as are usually to be met with in the development of an insect.

But our present concern is chiefly with the secretions produced by these insects. The oil beetle receives its popular name from the fact that, when handled, it causes a deep yellow, oily liquid to exude from between the segments of its body, and from the joints of the limbs, a proceeding which makes it a decidedly unpleasant insect to have much to do with. Oil beetles may be found in early spring, crawling slowly about among the grass of meadows, and beside footpaths. They may easily be recognized by their dull bluish-black colour, rough, uneven surface, and enormously large abdomen, which is only very partially covered at its base by the shrivelled and crumpled elytra, or so-called wing-covers, though there are no wings to cover. This ponderous body (speaking of the female insect) trails along the ground as the creature goes on its toilsome way, seeking a suitable place for laying its eggs. The yellow exudation is of an acrid character, and has the power of raising blisters, if applied to the skin in sufficient quantity. For this reason, oil beetles have been used in medicine, especially for veterinary purposes, the chief supply having been obtained from certain districts in south-west Russia. A German writer states that a century ago the oil of these beetles was used in central Europe as a remedy for hydrophobia, and in Sweden it is said to have been employed for the alleviation of rheumatic pains.

While one species of oil beetle (*Meloë proscarabæus*) is a common insect with us, and may frequently be seen in grassy places in early spring, its more important relative, the true Spanish fly, or blister beetle of commerce (Fig. 17), is very seldom met with in this country, though there have been occasions, notably in the year 1837, when it has appeared in profusion in certain localities. Scientifically it is known, as we have already said, either as *Lytta vesicatoria* or *Cantharis vesicatoria*, the specific name having reference to its blister-producing properties. It is a beautiful insect, of a shining green colour, and with a large square head. By its colour, as well as by the facts that its body is comparatively narrow and parallel-sided, and that the wing-covers lie side by side and are long enough to cover the body, it may be easily distinguished from the oil beetles with their bluish-black, stout, oval bodies, and short elytra, which slope sideways away from each other, and so reveal the abdomen between them. It is abundant in many places on the Continent, and the market was first supplied from Spain, whence it became generally known as Spanish fly.

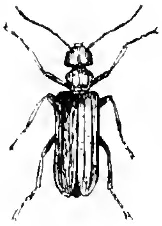


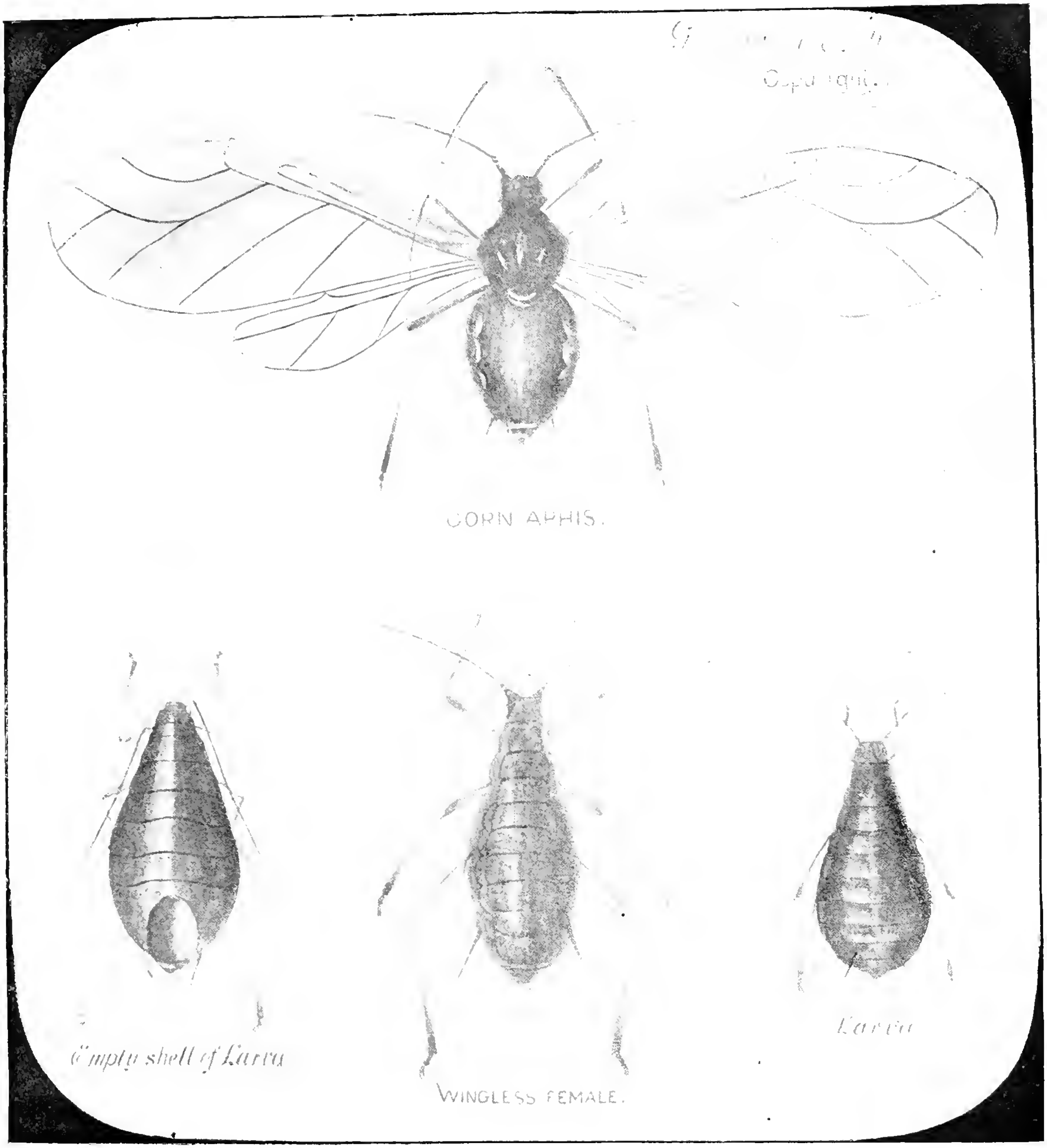
Fig. 17. Spanish Fly, or Blister Beetle.

Unlike the oil beetles, the blister beetles are arboreal in habits, frequenting a variety of trees, such as ash, privet, lilac, olive, &c. They appear about midsummer, and during the hottest parts of the day they descend from the trees, and that of course is the best time for securing them. Their presence is pretty easy to detect, for, apart from their brilliant colour, they emit a powerful scent. Indeed it is said that the characteristic substance to which they owe their valuable property is so volatile as to affect the air immediately around the trees, and thus make it an act of imprudence to sleep under those in which they are abundant. The active principle is called cantharidin, and many experiments have been made with a view to discovering in what part or parts of the insect it is produced, as well as whether or not its production is confined to the adult stage. In the year 1813 it was chemically examined by the French *savant* Robiquet, who obtained it from the beetles in the form of a white substance in flat crystals, which were found to be insoluble in water, but soluble in alcohol, ether, and other liquids. A chemical formula, $C_5H_6O_2$, has since been assigned to it. It has powerful vesicating properties, for the hundredth part of a grain, when enclosed in thin paper and applied to the lips, caused pain to be felt in about a quarter of an hour, and soon after little blisters appeared. When a salve was applied to these, the heat caused it to melt and run, with the result of carrying the vesicant with it, and thus multiplying the number of pustules, thereby increasing instead of allaying the discomfort.

The experiments of Beauregard were specially directed towards localizing the substance in the body of the insect, and they were carried out by making small plasters of different parts of the beetles and applying them to his own body. His main conclusions were that cantharidin occurred most abundantly in the blood and in certain parts of the reproductive organs in both sexes. Whenever any of the softer parts of the body, still wet and charged with blood, were applied to the skin, they soon produced blisters. Even the elytra, when separated from the living insect, and therefore still containing a small quantity of moisture within their tissues, were found to be capable of causing a similar result. They were applied to the arm by their inner surface, in which the skin would be thinner, and therefore the blood would be more easily able to affect the operator. The dry membrane which thus intervened between the vesicant and the skin of the arm of course retarded the process, but still, after the lapse of seven hours, a good blister was produced. When, however, the elytra were cut up in shreds, and dried with blotting paper, so that all moisture was removed from them, only a very slight effect was produced even by a prolonged application. Thus it was evident that the active principle was to be looked for in the juices of the wing rather than in its solid substance.

The strongly vesicating power of certain parts of the reproductive apparatus of course suggested that the function of cantharidin in the economy of the insect might be connected in some way with the reproductive process. But that such is not necessarily the case evidently follows from the fact that the insect possesses the property to a greater or less degree in all its stages, including those in which it is sexually immature. Even the eggs are possessed of the blistering power, though this perhaps is no more than might be expected, since the ovaries are strongly impregnated with cantharidin. In 1883, Beauregard took a portion of a freshly laid batch of eggs, and working them up into a paste with a little water, applied the little plaster so formed to his arm. After four hours, the smarting produced was sufficiently intense to lead him to stop the experiment. He therefore removed the plaster, and a few minutes after an enormous blister appeared on the spot, attesting the strongly vesicating property of the freshly laid eggs. In the larvæ the property was found to be much less intense. Ten larvæ, several days old, were crushed and made into a plaster, which was applied as before. Even after eight hours nothing more than a considerable inflammation was developed, and no blister appeared. When, however, a larger application of the crushed bodies of two dozen similar larvæ was made, a blister was produced after the lapse of the same time.

To collect the insects for medicinal purposes, a plan is adopted which closely resembles that known to entomologists as "beating." A large cloth is spread on the ground beneath the branches of the trees on which the insects are to be found, and then the branches are vigorously shaken, so that the beetles fall on to the cloth. Being but sluggish in their movements, they have little



APHIDES DESTRUCTIVE TO GRAIN.

Showing winged and wingless forms, viviparously produced larva, and empty skin from which an internal parasite has escaped through the hole at the end. In all of these the two cornicles, from which honey-dew issues, will be observed pointing backwards at the hinder end of the body. From a lantern slide lent by Messrs. NEWTON, of No. 3, Fleet Street.

Direct Photo Engraving Co., 9, Barnsbury Park, N.

chance of escape, and are easily gathered up as they fall. Of course they must be killed in such a way as not to damage their bodies, or in any way allow the valuable substance with which they are impregnated to escape, otherwise their commercial value would be impaired. Hence they are killed by means of a weak acid, either by plunging them into vinegar, or by exposing them to the vapour of acetic acid. The dead bodies, after being dried, are then stored.

But there are still difficulties to be contended with. As is well known, the dead bodies of insects are a peculiarly attractive bait to various small beetles, which are commonly known under the title of museum pests, and if these once obtain a lodgment amongst a store of dried Spanish fly, it is not an easy matter to dislodge them. It is vain to hope that the internal doses of cantharidin they are constantly administering to themselves by their ravages will have any evil effect, though this substance when taken internally by vertebrates appears to act as a dangerously irritant poison. When the museum pests attack the stores of blister beetles, the amount of damage done is measured simply by the matter actually devoured; for the cantharidin still remains uninjured in such parts of the damaged bodies as may be left, and for medicinal purposes it is by no means essential that the *dried* bodies should be perfect and entire, though, as we have already hinted, it is desirable that when freshly collected, and therefore moist, they should be in as perfect a condition as possible, lest exudation of fluid, and therefore loss of cantharidin, should take place. But the worst enemy to be encountered is damp, which, though it does not disintegrate the bodies, yet does far more harm than the above-mentioned devourers, since the characteristic properties of cantharidin are lost under its influence.

Some insects are gifted with the peculiar power of fashioning receptacles for their eggs, not out of extraneous and foreign materials, which would imply the exercise of a certain amount of intelligence and ingenuity, but from matter derived from their own bodies, and used in an involuntary and unconscious way. Special glands exist for this purpose, and open into the oviducts, so that the receptacle is formed within the body of the parent, and the insect never sees it till it is finished; hence the eggs are laid, not separately, but in sets, and, as it were, done up in parcels. This peculiarity is specially characteristic of certain groups in the order Orthoptera. In our own country, the cockroaches afford the best illustration of the practice, but in the tropics excellent examples are to be found in the various species of *Mantidæ*, or praying insects.

The egg-cases of the common household cockroach, or "black beetle" of the kitchens, may often be found lying about in the corners of cupboards, in houses where the insect is plentiful. The case is a reddish-brown, horny structure, about half an inch long, shaped something like a lady's handbag, and containing, as a rule, sixteen eggs, of which eight are placed on each side in perfectly regular order, lying parallel to one another. The eggs, of course, hatch within the case, and the young cockroaches issue from their birth-chamber at its sharp edge, *i.e.*, what would be the line of opening in the handbag aforesaid, where alone there is a junction. The material for these cases is supplied by a special gland appended to the reproductive apparatus, consisting of branched tubes, and called the colleterial gland, and the peculiar form is given to the case by the chamber on the walls of which the secretion is spread, and of which it therefore forms a sort of cast. When the whole structure is completed and properly equipped with its complement of eggs, it is still carried about by the mother for several days, during which time it may be seen protruding more or less from her body. It is finally deposited in some safe position, unless the creature is alarmed, when she will sometimes drop it at once.

Our wild cockroaches similarly form cases for their eggs, but as they are smaller than the domestic insect, the cases are much smaller too, and naturally, each species has its own peculiar form. Neat and shapely though these cases are, they are much surpassed in elegance by those formed by the exotic *Mantidæ*. These are large and predaceous insects with long and powerful fore-legs, which, when watching for their prey, they hold in front of them in the position that has been suggestive of an attitude of devotion, whence the name "praying insects," sometimes applied to them. The egg-receptacles of these insects (Fig. 18) are made of a clear, shining, pale yellowish substance, which is thin and semi-transparent, so that they look as if made of varnished paper or membrane. The surface is indented with a delicate tracery of reticulations, which throw it up into a series of minute rounded elevations. The cases are not left lying about on the ground, but are fastened by a little loop at the lower end to the twigs of trees and the stems of grasses.

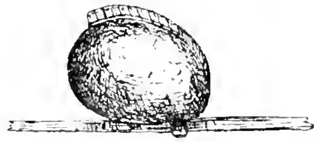


Fig. 18.—Egg-case of a species of Praying Insect attached to grass stem.

The principle of construction is much the same as in the cockroach-bags, and so far as external appearances are concerned, may be paralleled, if one may borrow a familiar illustration from the pastry-cook, by that of the old-fashioned "apple turnover." As in that article of diet there is a cover whose continuity is unbroken save along a line on one side, where the two edges have been pressed together, and as the ingenuity of the cook seems often to have been expended in crimping and otherwise ornamenting the rim at this line of junction, so we find in the *Mantis* cases a raised line where the two edges meet, and a very pretty row of markings along it. Within, a partition, which looks as though made of congealed froth, runs across from the line of junction towards the opposite surface, but without reaching it, and the eggs are placed in regular order on each side of that partition, so that they are back to back, and remind one of the arrangement of the cells in a honeycomb.

It is an obvious suggestion that the purpose of these receptacles is to protect the eggs from hymenopterous parasites, many of the minuter forms of which are quite satisfied with the contents of a single egg-shell as the total provision for their larval life, so that they pass through their early stages parasitically within the eggs. But that the cases do not always accomplish this purpose appears from a specimen now before me, in which many of the eggs have been devoured by parasites, some of which have reached their perfect condition, and their shining metallic green bodies are still to be seen amongst the remains of the eggs to testify to the fact of their former ravages.

Taking now a brief mental review of the numerous and varied facts we have described in this series of papers on "Insect Secretions," we may point out one or two general conclusions to which they seem to lead. In the first place, we have the fact that during the lifetime of many insects there occurs a period in which the creature becomes quite helpless, not simply by passing into a torpid condition or a condition of suspended animation, but by the actual loss of its limbs, and with them the power of locomotion and therefore of escape from danger, and by the abortion of its mouth organs and the consequent loss of the power to take food and sustain active life. Hence arises the necessity for special means of concealment and protection, that the race may not be exterminated when placed at so great a disadvantage with regard to its ever watchful and never resting foes. The necessary concealment or protection is afforded in many ways, occasionally by the use of foreign materials, but much more frequently by the production of a substance from within the creature's own body to serve as a cloak of invisibility or a chamber of safety. But as, in due course, deliverance from this chamber becomes necessary, it is equally imperative that another product should be elaborated for this purpose where mechanical means are not available.

Then, again, insects are usually very small animals in comparison with most of their assailants, and with smallness of size there is, of course, associated a corresponding helplessness against the larger and more powerful. And though in many cases their speed of locomotion is considerable when we take into account the size of the creatures concerned, yet the rate at which larger distances are covered is extremely slow in comparison with that exhibited by their pursuers, and hence escape by simple speed is usually out of the question; whence arises the existence of numerous secretions rendering them distasteful, or even physiologically hurtful as articles of food.

The development of the social instinct again, involving as it does the association of large numbers of the same species in one spot, necessitates the provision of suitable accommodation for the rearing of large quantities of young. And though this accommodation is frequently provided to a large extent by means of external and foreign matter, we see in the waxen cells of bees a product of the internal physiological processes of their own bodies used for this purpose. And even when the insects are not social, but only gregarious, there is, as we have just seen, provision for the large numbers of eggs produced, the provision on the part of the mothers of cases or sacs which shall supply the place of that maternal care and supervision which in the case of higher animals would probably be rendered.

The shortness of insect life is another important point. As few insects live for more than one season, and the period of activity of some of them lasts over no more than a few weeks, separated by an interval of many months from the next period of activity of the species, the continuance of the race is absolutely dependent upon the meeting and mating of suitable pairs during those few weeks. When the species is gregarious, or so abundant that large numbers are sure to be found within easy distance of each other, there is not likely to be much difficulty on that score. But when the species is solitary or scarce, and specimens occur only at considerable distances from one another, special aids seem to be needed to ensure the necessary pairings, and it may be that it is for such a purpose that some of the characteristic odours of insects exist.

Finally, in the case of the honey-dew of the aphides, none of the above heads seem suitable as an explanation of its existence. Here we have a material, not produced on certain special occasions, times of greater danger than usual, but continuously elaborated throughout life. A glance at the accompanying plate will show that the cornicles from which the drops issue are present in the larval forms as distinctly as in the nymphs or the adult insects. This fact, coupled with the above-mentioned difficulty of ranking honey-dew under any of the heads just enumerated, and with the statement made in a former paper, that no connection has been traced between the cornicles and any special glandular structure, lends support to the theory which makes it an excretion rather than a secretion; or, in other words, a substance elaborated to be got rid of rather than to be used. There is, further, the very exceptional circumstance, that it is a substance not merely got rid of by one kind of insect, but also eagerly sought after and used as food by another; and this fact is rendered more striking still by the immense differences, both in structure and life-history, that exist between the insects thus associated as producers and consumers, the aphides and the ants.

PHOTOGRAPHS OF THE MILKY WAY AND NEBULÆ.

By A. C. Ranyard.

We are indebted to Mr. W. E. Wilson for another photograph of the Hercules cluster, taken with an exposure of only fifteen minutes. The photographic action has not gone far enough to blot out and drown with nebulosity the prominence forms and strings of stars shown in the Henry and Lick photographs, reproduced in the April and May numbers of Knowledge for 1893. The sharpness and clear definition of these details, shown in Mr Wilson's photograph, speaks very highly for the optical perfection of his reflector, which was made for him by Sir Howard Grubb. Even the photographic reproductions, which I am able to put before the readers of Knowledge, will well repay a careful study and comparison with the longer exposed photographs reproduced in the last number of Knowledge, as well as with the Henry and Lick pictures. It seems to me, from a study of the photographic prints sent by Mr. Wilson, that there is ample evidence of more than one dark prominence-like structure, indicating that light-absorbing material, as well as luminous matter, is ejected in streams from the central region of the cluster, and that in rushing outward it experiences resistance. The photograph also shows the nebulous ligatures joining lines of stars, referred to in the last number, and confirms the suspicion that many of the star discs are not circular, but are elongated in the direction of the chain of stars. They appear more like patches of brighter nebulosity with a sensible area than like star discs.

The photographs of the dumb-bell nebula, also sent by Mr. Wilson, are well worthy of study. The dark gaps in the nebulosity are as interesting as the bright structure. This nebula seems to have a bright stellar nucleus, and a curious stratum of brighter nebulosity at the outside. With longer exposures the dumb-bell form is lost, and the nebulosity extends so as to fill an elliptic area.

We are indebted to Dr. Max Wolf, of Heidelberg, for the photograph of the region of the Milky Way about β Cassiopeiæ. The silver prints from the original negatives which he has sent over show some enormous dark branching structures outlined by stars. The collotype reproduction does not show them nearly as well as the silver prints, but there can be no doubt about their existence.

Notices of Books.

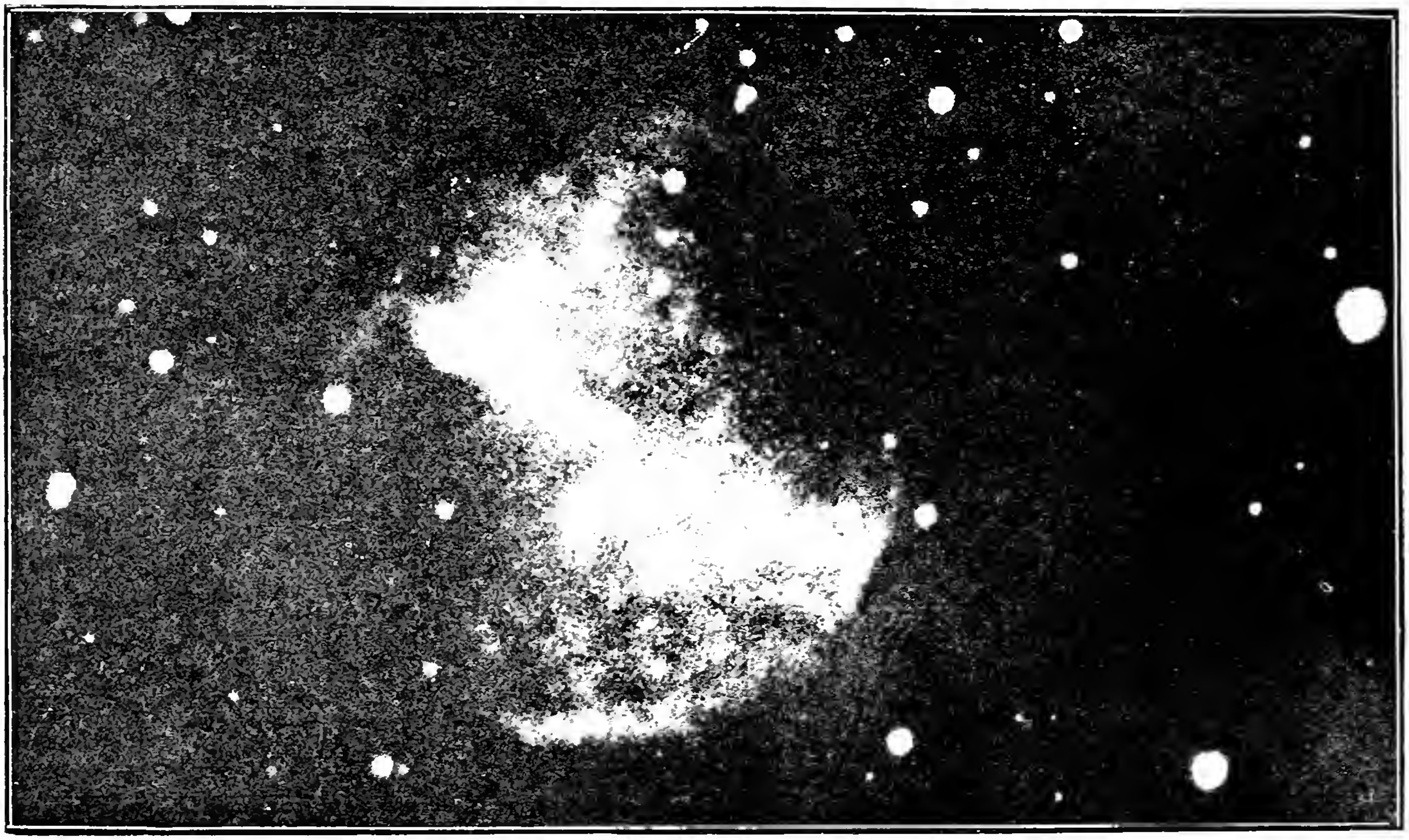
A Naturalist on the Prowl or in the Jungle. By E. H. A. (Thacker & Co., London, 1894.) E. H. A. has already attracted very favourable public notice by his lively books, "The Tribes of my Frontier," and "Behind the Bungalow," which introduce the reader to the human surroundings of an Anglo-Indian's life. In this book he brings before us

THE DUMB-BELL NEBULA.

From a Photograph by Mr. W. E. Wilson, taken August 6th, 1894, with an exposure of twenty minutes.

THE CLUSTER IN HERCULES (13 MESSIER).

From a Photograph taken 2nd September, 1894, by Mr W. E. Wilson, with an exposure of fifteen minutes.



THE DUMB-BELL NEBULA IN VULPECULA.

From a Photograph by Mr. W. E. Wilson, with a reflector of two feet aperture, and focal length of ten feet six inches. Taken 6th August, 1894, with an exposure of twenty minutes.

Direct Photo Engraving Company, 9, Eversholt Park, N.

in the same interesting and lively style the habits and manners of Indian birds and beasts, insects and crabs.

For a natural history book it is very light literature, but no one can read it through without picking up a great many facts which are set out with care and precision, and they are facts of a kind which only a naturalist who has himself observed in the field and jungle can supply to his readers. There are here and there a few thoughtful remarks and philosophical speculations, which appear in the midst of rather forced jokes and stories of the exaggerated type which have been described as the new humour; but anyone who has the patience to bear with the humorous, or intendedly humorous, passages will be well repaid for reading the book through. There are some eighty excellent illustrations prepared by Mr. R. N. Sterndale, author of "The Mammalia of India" and "Denizens of the Jungle." As a specimen of the forced humour which E. H. A. too frequently introduces, one may quote his description of hot weather in India:—"The weather is getting warm. This is, perhaps, not expressive enough, what I mean is that the atmosphere is getting like that which we may imagine to prevail under a pie-crust when the pie is in the oven; of course, I am writing from the coast. Up country, on the plains of the Deccan, the atmosphere of the oven outside the pie furnishes a better illustration. . . . Anything like a long walk in the morning endows you with a thirst which will not leave you all day. It is not a wholesome thirst either, not a demand of nature for refreshing forms of moisture, but a kind of glutinous thickness such as troubles the throat of the office gum bottle." But, nevertheless, the book contains eloquent passages. E. H. A. tries to induce his readers to observe nature rather than to aim at becoming a naturalist, whose sole object is to collect specimens and name them. Beware, says he, of the snare which lurks under the intoxicating pleasure of collecting, and set a watch upon yourself lest you degenerate into a collector, and cease to be a naturalist. As soon as you begin to feel that a rare bird or butterfly is not so much a bird or butterfly to you as a "specimen," you have caught the distemper, and must take measures to check it. The best remedy I know is to set aside one day in the week for a sabbath of peace and goodwill, on which the instruments of death must be laid aside, and an amnesty proclaimed to all creation. Then you may move among living things with heart free from guile and mind undisturbed by stratagems, and you will note many things in them which you never saw when you were scheming to compass their destruction. E. H. A. has a theory that the noises made by insects and tree frogs, and other living things whose voices fill the air of the tropics with a continual babel of sound, are made simply because the little creatures are happy, and not from any sexual impulse. His theory is that when an animal is well and happy, there is an overflow of nervous energy. The wagtails and redstarts let it off by shaking their tails, and the crickets and the frogs let it off in noise. "Do you think," says he, "that man is the only animal which feels the monotony of doing nothing?" All living things feel it till you get so low down in the scale of life that they can scarcely be said to feel anything at all.

Corea of To-day. (Nelson and Sons, London, 1894.) Most of the matter in this little book has been extracted from a larger book by G. W. Gilmore, who went to Corea as a teacher in the Royal College, founded by the Corean king in his capital for the education of the sons of the Corean nobles. Mr. Gilmore is an expert photographer, and some excellent reproductions of his Corean photographs are given. When Mr. Gilmore arrived in Corea he found that he and his co-teachers occupied an enviable position in Corean eyes, as men who had taken rank in a great foreign examination. In other words, they were looked upon as "gentlemen" in the Corean sense, and were expected to keep up the dignity of their position. Soon after their arrival a soldier was sent to each teacher, by order of His Majesty, to be a sort of personal attendant and messenger. If Mr. Gilmore went out shooting, the soldier in attendance always took the gun and insisted on carrying it till they reached the hunting ground. The distress of his soldier was quite pitiful when he took out two pieces, a shot gun and a rifle, so that he had to submit to one of them being carried by Mr. Gilmore. On another occasion one of the teachers took to gardening, and began to use a spade, when his attendant ran up and tried to take the spade out of his hands, remonstrating with him for doing coolies' work. The common people are extremely polite, and Mr. Gilmore describes them as always showing great kindness and distinction to foreigners. In summer the Coreans have a peculiar device for keeping cool. Next to the body they wear a framework made of split bamboo woven in fancy designs. This is made so as to be supported from the shoulders, and holds the clothes away from the person, so as to permit the air to circulate freely. Many interesting details are given with regard to the fashions of the people, their manners and customs, religions and superstitions, and the extraordinary absolute monarchical government, which seems to be entirely independent and uncontrolled by the will of the common people. Mr. Gilmore seems to have had exceptional opportunities of observing the Corean people. He tells his story well, keeping up the reader's interest from the first page to the last of his little book.

The Earth: an Introduction to the Study of Inorganic Nature. By Evan W. Small, M.A. (Cantab), B.Sc. (Lond). (Methuen & Co., London, 1894.) Taken as a whole, this is an excellent little manual for the general reader, as wel as for the student who selects it as a text-book in physiography. No book which ranges over so wide a series of subjects can be expected to be above all criticism Thus, in giving an account of the nebular hypothesis, Mr. Small says: "The cloudy patches of light in the heavens known as nebulæ (whose spectra, as shown by Huggins in 1864, consist of a few bright lines, indicating glowing gaseous matter) represent, according to this theory, the earliest stage in the process of world formation, and in the great nebula in Andromeda (as shown in a photograph taken by Mr. Isaac Roberts of Liverpool) we have an actual instance on a very large scale of some such process of cosmical evolution as is pictured in Laplace's theory. In this photograph we see a large bright central mass, surrounded by a series of successive rings of bright material (the outer ones becoming fainter), separated by dark spaces." Mr. Small is evidently not aware that the large majority of nebulæ do not give a gaseous but a continuous spectrum, and that the streams of matter about the Andromeda nebula are by many observers believed to be spirals and not circles. There is certainly no evidence in the photographs of ring within ring of nebulous matter, and the nebulæ surrounded by spiral streams of nebulous matter are very numerous.

A Journey in other Worlds. By John Jacob Astor. (Longmans, Green & Co., London, 1894.) Mr. Astor takes his readers to an imaginary Jupiter and an imaginary Saturn, and gives them a historical sketch of our own world in A.D. 2000. The value of such flights of imagination depends to a large extent on the knowledge displayed by the imaginative guide, and on the way in which he makes his narrative appear probable and consistent with known facts and received scientific theories. Mr. Astor supposes Jupiter to be passing through a carboniferous or Devonian period, such as existed on our earth, but neither the pictures nor the text exhibit much geological knowledge, and his knowledge of astronomical facts is still more meagre.

The following books have been received for notice :—

Knowledge through the Eye : or How to Illustrate Science and other Lectures by Means of the Optical Lantern. By Alfred P. Wire and G. Day, F.R.M.S. (George Philip & Son.)

The Romanes Lecture, 1894—The Effect of External Influences on Development. By August Weismann, M.D., Ph.D., D.C.L. (Henry Frowde.)

The Seismological Journal of Japan. Vol. XIX., 1894. (Yokohama.)

British Rainfall, 1893. By J. W. Symons, F.R.S., &c., and H. S. Wallis, F.R.Met.Soc. (Edward Stanford.)

Catalogue of Works on Astronomy, Magnetism, and Meteorology. (Dulau & Co.)

The Royal Natural History. Part 10. (F. Warne & Co.)

Things New and Old ; or Stories from English History. By H. O. Arnold-Forster. (Cassell.)

The Molecular Tactics of a Crystal. By Lord Kelvin, P.R.S. (Clarendon Press.)

The Sportsman's Handbook to Practical Collecting and Preserving Trophies. By Rowland Ward, F.Z.S. (Rowland Ward & Co., Ld.)

The London Matriculation Directory, 1893-4. (Univ. Corr. Coll. Press.)

Some recent Evidence in favour of Impact. By A. W. Bickerton. (Wellington, N. Z. : Samuel Costall.)

Venice. By Alethea Wiel. (T. Fisher Unwin.)

The Journal of the British Astronomical Association. Vol. IV., No. 9. (Eyre & Spottiswoode.)

Revolving Orrery. By J. C. Parvin. (G. Philip & Son.)

Theophrastus of Eresus on Winds and on Weather Signs. By Jas. G. Wood, M.A., LL.B., F.G.S., and Edited by G. J. Symons, F.R.S., F.R.Met. Soc. (Ed. Stanford.)

Syllabus of the Municipal Technical School, Manchester, for Session 1894-5.

Meteorological Observations for 1893, *made at Rousdon Observatory.*

Fertilizers and Feeding Stuffs. By Bernard Dyer, D.Sc., and Notes on the Act, by A. J. David, B.A., LL.M. (Crosby Lockwood & Son.)

Proceedings of the Society for Psychical Research. Part 26, Vol. X. (Kegan, Paul & Co.)

Catalogue of the Michigan Mining School, 1892-4, *and Announcements*, 1895-6. (Houghton, Mich.)

Newfoundland as it is in 1894. By the Rev. M. Harvey, LL.D., F.R.S.C. (Kegan, Paul & Co.)

The Royal English Dictionary. By Thos. T. Maclagan, M.A. (T. Nelson & Sons.)

Programme, &c., of Technological Examinations of the City and Guilds of London Institute, Session 1894-5. (Whittaker & Co.)

Illustrated Catalogue of Telescopes and Accessories. (E. G. Wood.)

Mr. W. H. Hudson gives a depressing list of "Lost British Birds," including the crane, white spoonbill, great bustard, bittern, marsh harrier, hen harrier, red night reeler, great auk, and avoset. This, he says, is the result of the efforts of "sportsmen" and the unprincipled collector.

Letters.

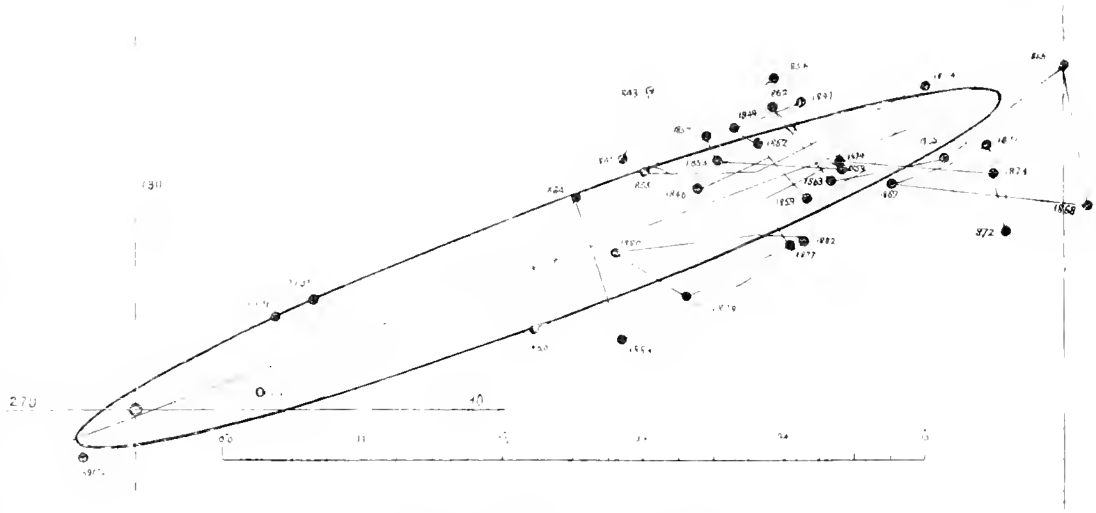
[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

ORBIT OF γ ANDROMEDÆ.

To the Editor of Knowledge.

Dear Mr. Ranyard,—. . . . . . Barnard has this year got a set of measures of γ Andromedæ with the thirty-six inch. I have put his last position on my original diagram of the apparent orbit, and enclose a photograph of it. As you will see, Barnard's place fits in beautifully with the ellipse already indicated. Yours very truly,

S. W. Burnham.



Projection of Orbit of γ Andromedæ.

THE LEONID MAXIMUM.

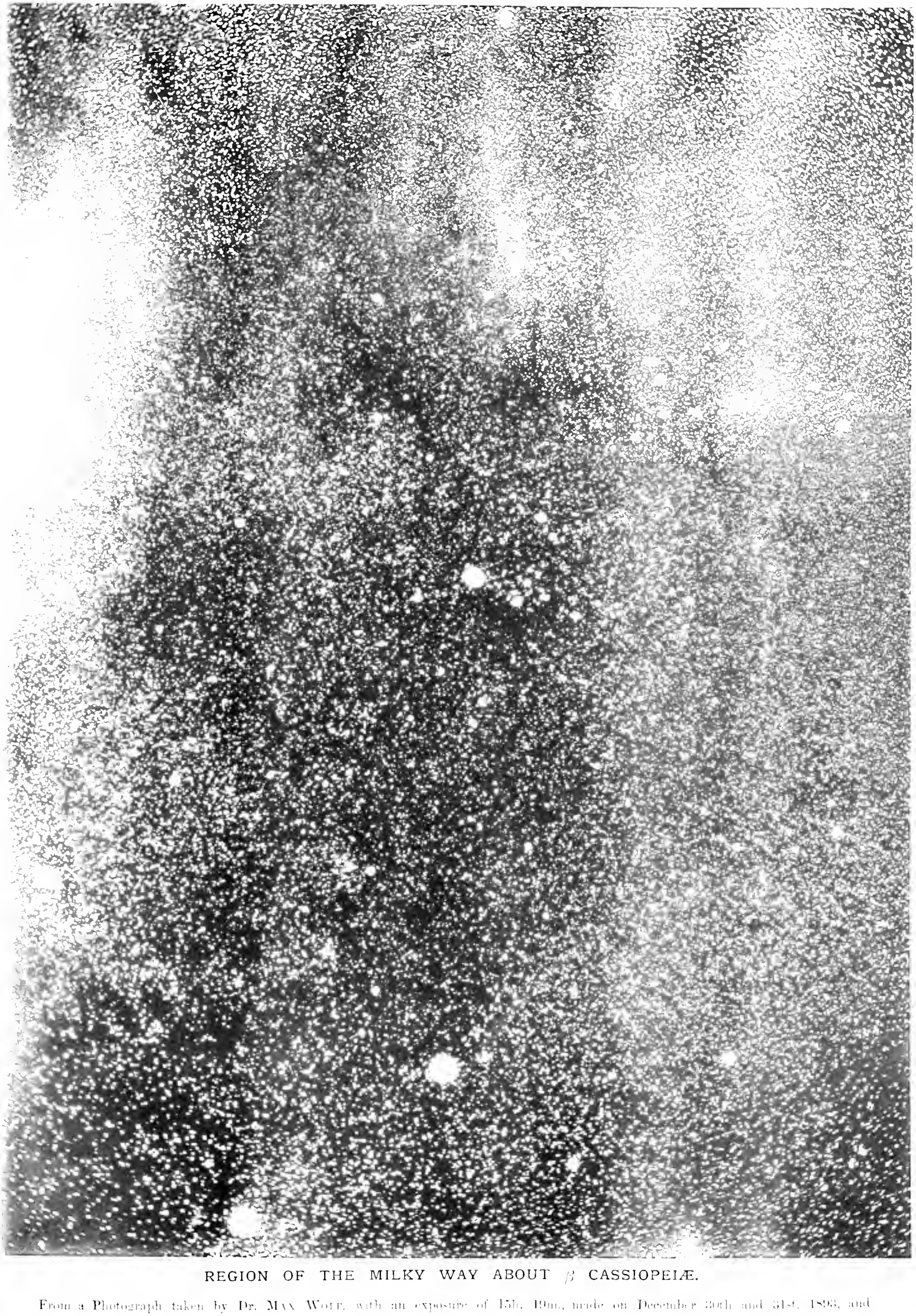
To the Editor of Knowledge.

Sir,—I think the answer to the question asked by Mr. A. Collison, on page 135, has not been fully given. What he really wishes to know is the time that the maximum of the shower will take place. The earth will be in the same longitude, 1899, November 13th, 13h., as it was in 1866, November 13th, 13h. 9m., when the shower reached its maximum that year ; but does not the time of maximum alter from year to year ? I suppose it will be possible to make a better forecast nearer the time. Is not 1900 just as likely as 1899 for the greatest shower ?

Yours respectfully,

West Hendon House, T. W. Backhouse.

Sunderland, 25th September, 1894.



REGION OF THE MILKY WAY ABOUT β CASSIOPEIÆ.

From a Photograph taken by Dr. MAX WOLF, with an exposure of 15h. 19m., made on December 30th and 31st, 1893, and January 1st and 2nd, 1894.

ON THE ORIGIN OF THE GOLD OF QUARTZ VEINS.

To the Editor of KNOWLEDGE.

Dear Sir,—Although the article by Mr. Henry Louis "On the Origin of the Gold in Quartz Veins," following one of mine on the same subject, does not call for a reply from me, since it is a very fair statement of another view of a matter on which widely different opinions are inevitable and legitimate, yet some of the observations in this interesting article suggest my adding a few words to what I have already written, in further elucidation of one or two points that were perhaps treated too briefly.

The hypothesis I endeavoured to state is not by any means essentially a "descensionist" one, since it allows of lateral transmission of solutions into incompletely filled up fissures, as well as entrance from above, for it derives the mineral matter of vein-stuff from the adjacent massive rocks—the rocks, in fact, traversed by the veins.

The volcanic evidence adduced against a plutonic origin for the gold of quartz veins may certainly be called negative, but from the nature of the case it has an important positive value, which is not lessened by one or two exceptional instances to the contrary. It is not disputed that some gold may exist at plutonic sources, and may therefore occasionally be thence brought to the surface by volcanic action, but it is the source of the great bulk of the gold which exists in quartz veins that is the question to be determined. A proportionally large space was occupied by this volcanic evidence because, so far as I know, it is evidence that has not been brought into the controversy by any other writer on the subject, therefore it seemed to deserve conspicuous notice.

The instances of Steamboat Springs and Sulphur Bank do not appear to me to have any contrary weight, for they do not afford examples of mineral matter brought up from deep-seated sources by volcanic action, but merely of such matter brought from the adjacent rocks by hydro-thermal action, exactly in accordance with one of my postulates. And with respect to the Mount Morgan gold-bearing quartz, even if it be the production of an old geyser, it is but siliceous sinter similar to that deposited around the geysers of the present day, and that is all derived by hot water from rocks near the surface which, though heated by volcanic action, may not be volcanic rocks A geyser, therefore, although its intermittent energy is doubtless due to volcanic action, is not volcanic in the sense of bringing to the surface mineral matter from the deep interior.

There is another point which seems to require explanation. The precipitation of metallic gold from a soluble salt is from soluble salts of gold in the sea that I suggested would be the result of the action of dead organic matter at the sea bottom, and would consequently only affect the amount of auric solution in the lowest water-stratum, and so, although the precipitation would be continuous in consequence of convection, it would only very slightly lessen the aggregate amount of gold in the entire oceanic volume of water. Thus the existence of a generally diffused solution of gold in the sea is not inconsistent with the precipitation supposed.

I am glad to find Mr. Louis so much in agreement with me, especially as to gold being taken into quartz veins by the same agency as the silica, and that the sedimentary rocks themselves contain gold. This last fact is to my mind a most pregnant one, since the materials of these rocks are deposited matter. I know of no other source for that deposited matter than the contents of the sea, and hence I am inclined to credit the sea-water with giving to its more bulky sediments the extremely small amount of gold they contain, even when their auriferous vein-quartz is included.

Respecting the final stage in the series of operations constituting the hypothesis I ventured to formulate, I may perhaps say that the separation of minerals by the segregation of their molecules from other associated mineral matter is such a common geological phenomenon that its employment to account for the separation of gold, and its consequent presence in the metallic state in quartz veins, does not seem to me to be unwarrantable.

As Mr. Louis justly says, the subject is a difficult one, but it has certainly greatly advanced in my own recollection. In the days of Murchison and Forbes the igneous origin of gold held the field, and the latter of these two high authorities (I know from personal intercourse with him) held that now almost obsolete theory even more strongly than would appear from his writings. We may, therefore, confidently hope that further investigation and further consideration will not fail to yield a satisfactory solution of this interesting, if at present somewhat obscure, problem.

Yours faithfully,

J. LOGAN LOBLEY.

THE PERIODICITY OF THE SOLAR SPOTS AND ITS CAUSE.

To the Editor of KNOWLEDGE.

DEAR SIR,—Probably it is hardly necessary to say that I am acquainted with Prof. Rudolf Wolf's labours on the solar spots, and I am certainly not prepared to reject the evidence he has brought forward of occasional irregularity in their periodicity. But it seems to me that this is perfectly consistent with my theory, that the periodicity of spots, which has only been noticed during the present century, is due to a swarm of meteors revolving round the sun in an elliptic orbit, with a period equal to the average period of the spots. Unquestionably, spots are also produced in other ways, or by other bodies than this supposed ring. Now these may sometimes come in a considerable number a little after a time of regular maximum, which would protract that maximum, as in 1883; or, on the other hand, near a time of regular minimum, when they would cover and mask its occurrence. The effect, indeed, would be somewhat similar to that of tidal action in the Mediterranean, which can only be evidenced by a long course of observation, being continually masked to appearance by local causes of rise and fall connected with the weather.

Yours faithfully,

Blackheath, W. T. LYNN.

September 4th, 1894.

[A meteor swarm which would, on its approach to perihelion, give rise to an appreciable solar tide, or to a difference of pressure in the vapours beneath the photosphere, would need to be of such mass that one would expect to find some trace of its perturbing influence in the motions of the planets; and, in order to account for the irregularities of Dr. Wolf's sunspot curve, we should need to conceive of several such swarms, of considerable magnitude compared with the swarm which Mr. Lynn suggests gives rise to the average length of sunspot periods. There are not only considerable differences in the length of successive sunspot periods, but the height of successive waves of the sunspot curve varies, and the form of the wave changes, groups of three or four similar waves or loops of the sunspot curve occurring successively. Such irregularities seem to me to point to complicated changes taking place within the sun, rather than to a combination of regular perturbations from without. Perhaps we shall some day get an inkling of the meaning of such irregularities, but I fear that we are very far at present from understanding what a sunspot is.—A. C. RANYARD.]

CELLULOSE AND SOME OF ITS MORE RECENT APPLICATIONS.

By Chas. A. Silberrad, B.A., B.Sc.

Though cellulose is an invariable constituent of plants, of whose cell-walls it forms the supporting frame-work, it is rarely found pure, as, except in the cellular tissue of the youngest shoots, it always contains more or less ash. Still, cotton-wool and Swedish filter-paper consist of the approximately pure substance, especially the latter after treatment with hydrofluoric acid, whereby all mineral matter is extracted.

However, the preparation of pure cellulose from any material containing it—*e.g.*, cotton-wool—is not a matter of great difficulty, it being only necessary to digest it alternately with bromine water and a dilute alkaline solution until the bromine water is no longer decolorized. The fibre is then boiled in dilute alkali and washed in turn in dilute acid, alcohol and ether, and finally dried.

Thus prepared, it contains a certain amount of hygroscopic moisture, amounting to from seven to nine per cent. of its weight; when this is removed, the simplest composition deducible from analysis is $C_6H_{10}O_5$, but it seems clear from its properties that its molecular weight must be many times that represented by the foregoing formula.

Solvents of Cellulose.—Cellulose is insoluble in all ordinary solvents, but is dissolved by certain reagents, of which the two following are the most important: (*a*) Schweitzer's reagent, which consists of an ammoniacal solution of cupric hydrate. From solution in this liquid the cellulose may be reprecipitated on addition of acids, alcohol, salt, or various other substances, in a gelatinous state, drying to a material closely resembling gum arabic in appearance. (*b*) A solution of zinc chloride in twice its weight of hydrochloric acid. This solvent behaves very similarly to the first mentioned, except that the cellulose is reprecipitated on dilution. Such solution and reprecipitation afford a ready means of purification.

The solvent power of the first named of the above liquids is the basis of the manufacture of the so-called *paper boards*. For this purpose sheets of unglazed paper are left in contact with the ammonio-cupric solution for a short time—just long enough for the fibres to be superficially attacked. The requisite number of these sheets are then placed one on top of the other, passed between rollers and dried; by this process they become united together into a board-like material, impervious to water, which property is retained at 100° Cent.

Action of Nitric Acid.—If cellulose, *e.g.*, blotting-paper, be simply immersed in ordinary strong nitric acid (specific gravity 1·42) it undergoes a curious transformation. Its composition is unchanged, but the strength of the paper is increased tenfold, while at the same time its linear dimensions are diminished ten per cent.

The action of stronger nitric acid and of mixtures of nitric and sulphuric acid in the production of gun-cotton and the various pyroxylines, as well as the preparation of collodion by dissolving the last named in a mixture of alcohol and ether, are too well known to need any further account here; but the peculiar properties of a mixture of camphor and pyroxyline may be worth noting, as it is of these two substances that *celluloid* consists.

Celluloid was first prepared by Hyatt, of Newark, U.S.A. It may be obtained either by direct addition of pyroxyline to melted camphor, or by strongly compressing the two together, or lastly by dissolving the two in some common solvent, as ether-alcohol.

The method usually adopted on the manufacturing scale is a combination of the second and third above mentioned. The pyroxyline is prepared by treating unsized paper with moderately strong nitric and sulphuric acids, whereby a product is obtained consisting of a mixture of the tetra- and penta-nitrates of cellulose.

The camphor is dissolved in the minimum quantity of alcohol, and this solution sprinkled upon the dry sheets of pyroxyline in such quantity that there is one part of camphor to two of pyroxyline. On the sheet so treated another is placed, and the same process repeated, and so on till a sufficient thickness is obtained.

There is thus produced a translucent mass which is worked between rollers, first in the cold and then at a higher temperature; it is next subjected to hydraulic pressure at a temperature of about 60° Cent., for twenty-four hours, and finally cut into sheets of the desired thickness and dried for several days at a moderate heat. The substance so obtained appears quite homogeneous, and may be cut and turned in the cold or moulded under pressure at a higher temperature.

It is very readily coloured by pigments or dyes, which may be either mechanically mixed in a state of powder or dissolved with the camphor in the alcohol.

Artificial tortoiseshell is produced on the same principle as damascene steel, *i.e.*, by welding together alternate plates of differently tinted celluloids.

As might be anticipated from its composition, it is extremely inflammable, but has been shown to be non-explosive under all conditions.

Action of Sulphuric Acid.—Vegetable Parchment or Parchment Paper.—If cellulose, *e.g.*, blotting-paper, be rapidly passed through moderately strong sulphuric acid (specific gravity 1·5—1·6), and then well washed in water, it acquires properties very similar to those of parchment. The resulting preparation is now extensively used under the names of vegetable parchment or parchment paper.

This change is due to the conversion of the cellulose on the surfaces of the paper into a peculiar modification known as amyloid, which may be precipitated pure in a gelatinous form by diluting a solution of cellulose in concentrated sulphuric acid.

If cellulose be left in contact with acid of specific gravity 1·5 for some time, it becomes friable, forming a substance called *hydro-cellulose*, which is soluble in alkalies. By means of this reaction the cotton may be separated from the wool in a mixed fabric, as the latter is unacted upon.

Action of Alkalies.—Mercerization.—If cotton cellulose be treated with a concentrated solution of soda or potash and then washed, it is found to have undergone a remarkable change in properties. From the name of its discoverer (Mercer) this change is termed *mercerization.*

The way in which Mercer was led to his discoveries is interesting as showing how one result may lead to another wholly unconnected with it. He was making a series of experiments to determine whether any alteration occurred in the composition of a solution on filtering it, and in the course of these he passed a strong solution of caustic soda through several layers of cotton-cloth. He certainly found a considerable change in the composition of the solution on filtering, but was able to fully account for it by what turned out to be the far more important change produced in that of the cotton-cloth, for this proved to be approximately expressed by the formula $C_6H_{10}O_5$ NaOH; and though, on washing, all the soda was removed, the properties of the fibre were found to have undergone a marked change. Their length was contracted to the extent of twenty per cent., while at the same time there was an increase of thirty to thirty-five per cent. in strength. A still more important alteration was the increased affinity for such dye-stuffs as will dye cotton without a mordant, *e.g.*, the diphenyl derivatives—Congo red and the benzidine dyes.

Cellulose Thiocarbonate.—Certain theoretical views led Messrs. Cross and Bevan to an examination of the action of carbon bisulphide on the mercerized cotton, with results which will probably have most important practical applications in the near future, and which have already formed the subject of at least one patent.

If the above-mentioned compound of cellulose and soda be exposed to the action of the vapour of carbon bisulphide, it is gradually converted into a yellowish mass which, when placed in water, swells up, and finally dissolves to form a solution of *Cellulose thiocarbonate.*

This same solution may be more readily produced by bringing together two parts of cellulose, one of caustic soda, two of carbon bisulphide, and eight of water.

From this solution the thiocarbonate may be precipitated in a pure state by addition of alcohol or strong brine, after which it may be redissolved in pure water to form a colourless solution of great viscosity. Thus, a four per cent. solution is as thick as treacle, while a bottle filled with one containing eleven per cent. of the thiocarbonate may be inverted for a considerable time without any risk of loss. But its most important property is its power of coagulation, which occurs spontaneously on standing for a considerable period, or immediately on heating above 60°, or by addition of an acid. This coagulation is due to the cellulose separating out in the pure state, forming a gelatinous mass which gradually shrinks, but in such a manner as to form *an exact miniature of the interior shape of the containing vessel*; all the sulphur and alkali are found in the liquid which separates from the shrunken mass. The cellulose thus reproduced varies in consistency according to the concentration of the original solution, but is always perfectly homogeneous: thus, it may be obtained in a form closely resembling the softer varieties of india-rubber, or in one practically indistinguishable from horn, and it is not merely in appearance that this latter resembles horn but also in its consistency, for it is hard and tough and perfectly adapted for turning. Finally, it is found to possess the same increased affinity for dye-stuffs that is exhibited by the original "mercerized" cotton.

The importance of the discovery is manifest, especially in view of the inevitably failing supplies of ivory, which have already resulted in the success of the ebonite and celluloid manufactures, over which it is clear that this preparation possesses many and great advantages; for none of the materials required in its production are expensive, and it is free both from the brittleness of ebonite and the inflammability of celluloid, while the readiness with which it can be obtained in any desired shape gives it a still more marked superiority over either of these products.

SYMPATHETIC EXPLOSIONS.

By C. A. Mitchell, B.A. Oxon.

In an explosion we have the sudden evolution of large quantities of gas which meet with external resistance. Thus, in the case of dynamite, the substance is suddenly decomposed into gases, which meet with the resistance offered by the surface of the earth on the one side and with that opposed by the weight of the atmosphere on the other.

Explosive agents are roughly classified as "high" and "low" explosives, the former term being usually applied to those exploded by detonators and used as destructive agents rather than for the propulsion of projectiles. Nitro-glycerine and gunpowder may be taken as representatives of the two classes.

Substances liable to explosion are, as it were, in a state of *unstable equilibrium*, and often a slight cause is sufficient to so disturb that equilibrium that a fresh arrangement of the particles takes place—in other words, an explosion. A somewhat analogous instance of instability is to be noticed in the case of water cooled slowly below its freezing-point without solidifying, as occasionally happens in bedroom jugs. When the jug is lifted the movement destroys the equilibrium and the water suddenly becomes ice. *Prince Rupert's drops* illustrate the same phenomenon. These are small pear-shaped globules prepared by allowing molten glass to fall from a short distance into cold water, which causes the exterior to cool more rapidly than the interior, and the mass is left in such a state of tension that, if the extreme tip of the drop be broken off with pliers, the whole flies to powder.

Explosive bodies differ very considerably in stability. The so-called iodide of nitrogen, a black powder formed by digesting iodine in a solution of ammonia, explodes when dry with the slightest touch. Nitro-glycerine is more stable and requires the blow of a hammer for its explosion. This substance is prepared by allowing strong nitric and sulphuric acids to act upon glycerine, care being taken to keep the temperature low. It is an oily liquid and is very poisonous. As an explosive it is uncertain and has been the cause of many accidents. When mixed, however, with an inert substance, such as sawdust, it is much more stable. This is the principle made use of in the manufacture of *dynamite*, which consists of nitro-glycerine absorbed by a porous siliceous earth called *kieselguhr*.

Dynamite is very stable under ordinary conditions, as was well shown in the experiments carried out in the Lauenburg Fabrik in 1876.* A barrel containing five hundred and forty kilograms† was dropped a distance of twenty feet on to a paved road, and in a second experiment a weight of ten kilograms was dropped on to a dynamite cartridge. In neither instance was there any explosion. The dynamite used burned quietly when thrown on a fire, but exploded powerfully even on an open surface when a detonating cartridge was exploded in contact with it. We have thus the curious phenomenon of a substance which burns quietly and withstands a heavy blow, but which disintegrates readily when another less stable body is exploded beside it. This is explained by the theory of an explosive wave which is communicated from the one explosive to the other. Where an explosive burns quietly there is much slower decomposition, and the particles first taking fire radiate their heat too quickly for the entire mass to be simultaneously raised to the temperature of explosion. If the heat cannot be dissipated sufficiently fast, as in the case of confined gun-cotton, an explosion follows just as when a detonator is used. Thus the unstable equilibrium may be disturbed either by heat or by communication of a mechanical vibration. This latter method of *sympathetic explosion*, as it has been termed, is now very generally used to effect explosion of charges of dynamite and gun-cotton.

That the deflagration of one substance can produce a sympathetic explosion at a distance has been illustrated by many accidents. The explosion of a quantity of nitro-glycerine in one shed has often caused the explosion of other materials some distance away. A remarkable instance occurred in 1888, in a factory at Wandsworth,

* *Ber. Deut. Chem. Ges.*, IX., 1802. † A kilogram = 2·2 lbs.

where the caps for toy pistols were made. It was believed that the explosion was owing to one of these *amorces*, containing more than the regulation amount of composition, having been cut with scissors, and thus causing all the rest to explode. The shed was wrecked, and three girls lost their lives. A similar case happened in France, where a child was killed by cutting open a cap, which caused two large packets to explode.

When an explosion is communicated from one cartridge to another there is a gradually weakening effect. This was proved experimentally, in 1872, by Captain Müntz, at Versailles. The explosion of the first charge excavated a funnel-shaped hole in the ground measuring ·9 metre* in diameter. The shock caused a second similar cartridge placed at some distance to explode, but in this case the diameter of the hole excavated was only ·66 metre.

Captain Colville found that there was a definite relation between the weight of the charge used and the distance between the cartridges. A charge weighing one kilogram, and containing seventy-five per cent. of dynamite, communicated its explosion on hard ground ·3 metre. Where D represents the distance in metres, and C the weight of the charge in kilograms, he showed that under these conditions D = 3 C. When the cartridges were laid on a rail, the distance to which the explosion could be communicated was increased, and D = 7 C. On the other hand, on soft or ploughed earth the distances were much less.

To explain this property of explosives, Sir Frederick Abel advanced the attractive theory of a sympathetic rhythmic vibration between the substance detonating and that detonated, analogous to the synchronous vibrations set up by sound waves. A certain note of a piano will often cause a glass to jingle, and if the glass be made to emit its note it will be found to be the same as the note of the piano—that is, each vibrates at the same rate. Sir Frederick Abel thus expresses his theory: "Vibrations produced by particular explosions, if synchronous with those which would result from the explosion of a neighbouring substance, will, by their tendency to develop those vibrations, either determine the explosion of that substance or at any rate greatly aid the disturbing effect of mechanical force suddenly applied."

Facts in support of this are that sometimes a feeble detonation will determine an explosion when a more violent one will not. Thus iodide of nitrogen will not cause compressed gun-cotton to explode, nor does nitro-glycerine cause the explosion of gun-cotton in sheets on which is placed the case of nitro-glycerine.

The interesting experiments of Champion and Pellet† tend, perhaps, to confirm this.

1. A very small quantity of iodide of nitrogen, detonated at one end of a long narrow tube, caused the explosion of a similar quantity of the same substance placed at the other end of the tube at a distance of seven metres. That the transmitted concussion was slight was shown by the insertion of a light pith ball in the middle of the tube.

2. Damp iodide of nitrogen was fixed to the strings of a bass viol. When it was dry the strings of a similar instrument were made to vibrate at a distance. A detonation occurred only when a note giving sixty vibrations per second was sounded. The G cord caused an explosion, while the E cord did not. The vibrations produced by metal plates acted in the same manner as strings.

From these results the observers came to the conclusion that explosion was due to vibratory motion independent of heat and shock.

This theory has not met with general acceptance. Eissler‡ is strongly opposed to it. He urges that all the experiments of Champion and Pellet may be explained by taking into account the vibrations of the supports and the resulting friction. Moreover, the characteristic feature of a given note has never been established, but only the fact that below a certain rate of vibration the explosive effect ceases. He explains the facts by the supposition of two orders of waves, one explosive and the other purely mechanical.

In substantial agreement with him, Berthelot§ also objects to the theory of sympathetic vibrations. He proves that the chemical stability of matter is unaltered by merely sonorous vibrations, even when the substances experimented on are as unstable as ozone, which is so readily changed into oxygen. Therefore, according to him, sonorous waves cannot be the real agents in chemical decomposition and explosion. His explanation is that "explosive matter detonates, not because it transmits the vibratory energy by vibrating in unison, but, on the contrary, because it stops it and appropriates the energy." With reference to Abel's experiments, he argues that if gun-cotton can explode nitro-glycerine, why cannot nitro-glycerine explode gun-cotton, assuming that the two compounds vibrate in sympathy; whereas this transformation of energy into work may be readily explained by a difference in constitution.

The same chemist made a large number of experiments to determine the velocity of the explosive wave in the case of different explosives. Long, narrow tubes, made of lead, tin, or Britannia metal were used, and the rate of propagation of disturbance through the tube measured. He found this to depend on—(1) The diameter of the tube; (2) the density of the explosive; (3) the resistance of the material of the tube. The explosive wave from compressed gun-cotton had a mean velocity of five thousand two hundred metres per second in lead tubes, and of six thousand metres per second in tin tubes. Liquid nitro-glycerine gave results varying from one thousand and seventy-eight to one thousand three hundred and eighty-six metres per second; while dynamite had a mean rate of two thousand five hundred and forty-three metres per second. It was found a matter of great difficulty to detonate the nitro-glycerine in such narrow tubes. A curious feature was, that whether the tubes were curved or straight, the results obtained were substantially the same.

* A mètre = 39·3 inches. † *Comptes rendus*, LXXV.

‡ *Modern High Explosives.* § *Les Matières Explosives. Comptes rendus*, 110, 314–320.

GLOBULAR STAR CLUSTERS.

By J. E. Gore, F.R.A.S.

The term "globular cluster" has been applied to those clusters of stars which evidently occupy a space of more or less spherical form. Some of these "balls of stars," as they have been called, are truly wonderful, and are among the most interesting objects visible in the stellar heavens. Good specimens of the class are, however, rather rare objects, and there are not many in the northern hemisphere. The most remarkable is that called "the Hercules cluster," but known to astronomers as 13 Messier, it being No. 13 in the first catalogue of remarkable "nebulæ" formed by Messier, the famous discoverer of comets. It was discovered by Halley in 1714. Messier was certain that it contained no stars! This wonderful object lies between the stars Zeta and Eta Herculis, nearer to the latter star. It may be seen with a binocular or good opera-glass as a hazy star of about the sixth magnitude. When examined with a good telescope it is at once resolved into a multitude of small stars, which can be individually seen, and even counted with large telescopes. The number of stars included in the cluster was estimated at fourteen thousand by Sir William Herschel, but the real number is probably much smaller. Were the number so great as Herschel supposed, I find that the cluster would form a much brighter object. It has been well photographed at the Paris and Lick Observatories and by Dr. Roberts.* Its globular shape is evident at a glance, and we cannot doubt that the stars comprising it form a gigantic system, probably isolated in space.

Most people might think that this cluster was a mass of double and multiple stars, but this is not so; the components, close as they are, are too far apart to be considered as true double stars. Mr. Burnham, the famous double star observer, finds *one* close double star near the centre, and notes the remarkable absence of close double stars in bright and apparently compressed clusters.

In the same constellation, Hercules, between the stars Eta and Iota, but nearer the latter, will be found another object of the globular class, but not so bright, or so easily resolvable into stars as the cluster described above. It is known as 92 Messier. Buffham, examining it with a nine-inch mirror, thought the component stars brighter but more compressed than in 13 Messier. This object was photographed by Dr. Roberts, in May, 1891, with a twenty-inch reflecting telescope, and an exposure of one hour. Dr. Roberts says: "The photograph shows the cluster to be involved in dense nebulosity, which on the negative almost prevents the stars being seen through it, and on the print quite obscures the stars. The stars in this, as in all other globular clusters, are arranged in various patterns, and many of them appear to be nebulous."

Another fine globular cluster is that known as 5 Messier. It lies closely north of the fifth magnitude star 5 Serpentis. It was discovered by Kirch in 1702, and was observed in 1764 by Messier, who found he could see it with a telescope of one foot in length, but could not resolve it into stars. Sir William Herschel, with his forty-foot telescope, could count about two hundred stars, but could not distinguish the stars near the central blaze. Sir John Herschel describes it as an excessively compressed cluster of a globular form, with stars of the eleventh to the fifteenth magnitude condensed into a blaze at the centre. Lord Rosse found it more than seven or eight minutes of arc in diameter, with a nebulous appearance in the centre. This cluster was photographed by Dr. Roberts with a twenty-inch reflector, in April, 1892. The photograph shows the stars to about the fifteenth magnitude, and "the cluster is involved in dense nebulosity about the centre. The nebulosity hides the stars even on the negative."

Another fine object of this class is that known as 15 Messier, in Pegasus, discovered by Maraldi in 1745. Sir John Herschel describes it as a remarkable globular cluster, very bright and large, and blazing in the centre. Webb found it a glorious object with a nine and one-third inch mirror. It was photographed by Dr. Roberts in November, 1890, with an exposure of two hours. He says: "The photograph confirms the general descriptions, and the negative shows, separately, the stars of which the cluster is composed distinctly through the nebulosity to the centre. Many of the stars have a nebulous appearance, and they are arranged in curves, lines and patterns of various forms, with lanes or spaces between them."

The cluster known as 3 Messier, in Canes Venatici, is another fine object of the globular class. Sir John Herschel described it as a remarkable object, exceedingly bright and very large, with stars of the eleventh magnitude. Admiral Smyth thought that it contained at least a thousand stars. Buffham found it resolved even in the centre with a nine-inch mirror. It was photographed by Dr. Roberts in May, 1891, with an exposure of two hours, and the photograph confirms the general descriptions given of the cluster, though "the print fails to show the stars that on the negative crowd the space covered by the dense nebulosity." Dr. Roberts remarks that "nebulosity seems invariably to be present in globular clusters."

We may also mention the globular cluster known as 2 Messier, situated a little north of the star Beta Aquarii. It was discovered by Maraldi in 1746. Sir John Herschel compared it to a mass of luminous sand, and estimated the stars to be of the fifteenth magnitude. Sir William Herschel, with his forty-foot telescope could "actually see and distinguish the stars even in the central mass." I estimate that this cluster contains about four thousand stars, or more than the number of stars visible to the naked eye at one time.

In the southern hemisphere there are some magnificent examples of globular clusters, and, indeed, this hemisphere seems to be richer in these objects than the northern sky. Among these southern clusters is the truly marvellous object known as Omega Centauri. Its apparent size is very large—about two-thirds of the moon's diameter—and it is distinctly visible to the naked eye as a hazy star of the fourth magnitude, and I have often so seen it in the Punjab sky. Sir John Herschel, observing it with a large telescope at the Cape of Good Hope, describes it as "beyond all comparison the richest and largest object of its kind in the heavens. . . . All clearly resolved into stars of two sizes, viz., thirteen and fifteen . . . the larger lying in lines and ridges over the smaller; . . . the larger form rings like lace-work on it." This wonderful object has recently been photographed by Dr. Gill at the Royal Observatory, Cape of Good Hope,† and also at Arequipa, Peru, with a telescope of thirteen inches aperture. On the latter photograph the individual stars can be distinctly seen and counted. The enumeration has been undertaken by Mr. and Mrs. Baily, and a mean of their counts gives six thousand three hundred and eighty-nine for the number of stars in the cluster; but they consider that the real number is considerably greater.

Another wonderful object is that known as 47 Toucani, which lies near the smaller magellanic cloud. Sir John Herschel describes it as "a most magnificent globular cluster. It fills the field with its outskirts, but within its more compressed part I can insulate a tolerably defined circular space of 90″ diameter, wherein the compression is much more decided, and the stars seem to run together, and this part has, I think, a pale pinkish or rose colour . . . which contrasts, evidently, with the white light of the rest. The stars are equal, fourteen magnitude, immensely numerous and compressed . . . Condensation in three distinct stages . . . A stupendous object."

There are a number of other globular clusters of smaller size in the southern hemisphere, but the above are the most remarkable.

The actual dimensions of these globular clusters is an interesting question. Are they composed of stars comparable in size and mass with our sun? or are the component stars really small and comparatively close together? This is a difficult question to answer, as the

* See Knowledge for May and June, 1893.

† See photograph of this Cluster taken at the Cape Observatory, published in Knowledge for June, 1893.

distance of these objects from the earth has not yet been determined. They may, on the one hand, be collections of suns similar in size to ours and situated at vast distances from the earth: or, on the other hand, the stars composing them may be comparatively small objects, lying at a distance from the earth not exceeding that of some stars visible to the naked eye. Perhaps the latter hypothesis may be considered the more probable of the two; but there is really no reason to suppose that these collections of suns are comparatively near our system. The probability seems to be in favour of their great distance from the earth, for in all these clusters the component stars are very faint. The question of the absolute size of the component stars is one which has not hitherto been sufficiently considered. Let us examine both alternatives, and let us take the cluster Omega Centauri, as one in which the number of the component stars has been *actually counted*. Assuming that the real number of stars included in this cluster is ten thousand, and that they are individually equal, on an average, to our sun in mass and volume, we may estimate the distance and dimensions of the cluster. Taking the stellar magnitudes of Omega Centauri as four (as estimated at Cordoba Observatory), I find that with the number ten thousand the average magnitude of the component stars would be fourteen. This agrees with Sir John Herschel's estimate of thirteenth to fifteenth magnitude. Now to reduce the sun to a star of the fourteenth magnitude, I find that—assuming the sun to be twenty-six and a half magnitudes brighter than an average star of the first magnitude, as shown by photometric measures—it would be necessary to remove it to a distance equal to seventy-nine million four hundred and forty thousand times the earth's distance from the sun—a distance so great that light would take no less than one thousand two hundred and fifty-three years to reach us from the cluster! Taking the apparent diameter of the cluster at twenty minutes of arc, I find that its real diameter, if placed at the above distance, would be four hundred and sixty-one thousand five hundred and forty times the sun's distance from the earth—a diameter so great that light would take over seven years to cross it! Supposing the ten thousand stars which compose the cluster to be equally distributed through this sphere, I find that the distance between the individual stars would be about twenty-one thousand times the sun's distance from the earth, or about four months' journey for light. This is, of course, an enormous distance—about seven hundred times the distance of Neptune from the sun; but still the distance of the nearest fixed star from the earth—Alpha Centauri—is over twelve times greater; and considering the vast extent of the visible universe, not to speak of infinite space, there is nothing to militate against the existence of a cluster of suns with the components separated from each other by the great distance just found.

The distance found above for Omega Centauri is certainly enormous, and might lead us to suspect that these globular clusters are external universes. Judging, however, from the average distance recently found for stars of the first and second magnitudes, the distance of ordinary stars of the fourteenth magnitude—on the supposition that they are of the same size and brightness, and that their light is simply reduced by distance—would be about ten times greater than that found above for Omega Centauri. If, then, we increase the distance of the cluster ten times, it will be necessary to also increase the diameter of the component stars to ten times that of the sun. This would give them a volume a thousand times greater than that of our sun—a result which is, of course, highly improbable.

If, on the other hand, we do not like to admit that each of the faint points of light composing the cluster is equal in volume to our sun, let us diminish the distance ten times. If we do so we must also diminish the diameters of the component stars ten times. This would make them about the size of the planet Jupiter, and it seems very improbable that such comparatively small bodies could retain their solar heat for any length of time They would probably have cooled down, as Jupiter has done—at least to a great extent—ages ago, and would not now be visible as a stellar cluster. Even this reduction of the distance to one-tenth of the value found above would still leave the cluster at an immense distance from the earth, a distance represented by one hundred and twenty-five years of light travel. A reduction of the distance to one-tenth of this again, or twelve and a half years of light travel, would make the components about the size of the earth, and that bodies of this small size could shine with stellar light seems to be an untenable hypothesis.

There is, however, another point to be considered with reference to the size of the bodies composing a globular cluster. This is the character of their light. I am not aware that the spectrum of a globular cluster has yet been thoroughly examined, but if that of Omega Centauri gives a spectrum of the first or Sirian type, it would modify the above conclusions to some extent. It now seems probable that stars having a spectrum of the Sirian type are intrinsically brighter than the sun. I have shown in a former paper that Sirius is about forty times brighter than our sun would be if placed at the same distance, although the mass of Sirius is but little more than twice the sun's mass. The components of a star cluster, therefore—if of the Sirian type of stars—might be as bright as the sun, and at the same time have a smaller mass and volume.

These considerations seem to me to warrant the conclusion that these globular clusters are probably composed of stars of average size and mass, and that the faintness of the component stars is simply due to their immense distance from the earth.

[Mr. Gore's suggestions for determining the distance of stellar clusters will be followed with interest by readers of Knowledge; but his conclusions, I venture to think, are doubtful, as they are founded upon an assumption which, it seems to me, we are not warranted in making—viz., that it is "an untenable hypothesis" that stars of the size of Jupiter or the earth could shine with stellar light, because they must have cooled so that they would now be dark stars, and consequently invisible to us.

Mr. Gore might possibly be warranted in coming to such a conclusion if he knew (1) that all parts of the stellar universe commenced to cool down at the same period; (2) that the cooling went on everywhere uniformly; and (3) that there were never any collisions between stars giving rise to the reheating of cooled masses.

Such collisions seem much more probable between the stellar members of a close cluster than between isolated stars. In fact, if the stars of the stellar cluster are moving under the influence of their mutual gravity, it seems impossible to conceive of a system of motion in which collisions would not occasionally occur, and the more compact the cluster the more frequently would such collisions happen, giving rise to a rekindling of the stellar brightness by the conversion of energy of translation into heat.

Mr. Gore seems to think that it is "highly improbable" that any star could have a volume a thousand times greater than that of our sun, while, on the other hand, he thinks it "an untenable hypothesis" that any bright star could have a diameter as small as that of Jupiter, or about a tenth of the solar diameter. But in the case of the

Pleiades cluster we have a range of apparent brightness which corresponds to at least twelve and a half magnitudes, that is, the brighter stars of the cluster give one hundred thousand times as much light as the smaller stars which, it will hardly be doubted, are at the same distance from us as the large stars of the cluster, and in the case of the cluster about α Crucis there is probably a range of at least fifteen magnitudes, which corresponds to a light ratio of one to a million.

If we adopt Mr. Gore's theory with regard to the great distance and size of these star clusters, we are carried back to the old theory, that clusters and nebulæ are distant galaxies, outside and unconnected with the Milky Way system; an assumption which has very generally been rejected since the publication of Herbert Spencer's paper on the "Nebular Hypothesis" in the *Westminster Review* for July, 1858, in which he showed that the general distribution of nebulæ and clusters corresponded with and was complementary to the general distribution of luminous stars, proving that the nebulæ and clusters were members of the galactic system—a fact which was brought out still more clearly in 1869 by Mr. Proctor's papers and charts illustrating the distribution of nebulæ and clusters, and which is now still further enforced by the beautiful charts of Mr. Sydney Waters, published in the last number of the *Monthly Notices*.

Assuming, then, that the star clusters are at the same distance from us as the Milky Way and the large stars associated with it, we must either believe that the first magnitude stars connected with the Milky Way are millions of times larger than our sun or that the small stars of the clusters are much smaller than the sun, and in some cases probably smaller than the earth, if they compare in brightness with our sun.—A. C. Ranyard.]

ON THE INHABITANTS OF SOME COMMON GALLS.

By the Rev. Alex. S. Wilson, M.A., B.Sc.

On certain plants swellings, excrescences, and deformities of various kinds occur, caused by the action of insects. The oak-galls imported in quantities from the Levant, and largely used in the manufacture of ink, are of this nature. Gall-making insects show a marked preference for the oak, but some species select the willow, poplar, and other trees, while others confine themselves to various species of shrubby or herbaceous plants. The study of galls opens up a singularly interesting chapter of natural history. To the entomologist they offer an inviting field for original research; for the botanist they have at least a pathological significance; some knowledge of them is of practical use to farmer and gardener; while the attractive appearance of some kinds is fitted to excite the curiosity of every observant lover of Nature.

Besides the insect which makes it, a gall is often tenanted by other species, termed inquilines, from the Latin *inquilinus*, meaning a lodger. Of this fact the writer had evidence afforded lately by finding on the common germander speedwell a gall, which, when opened, was found to contain four orange-coloured larvæ, along with three white ones which apparently belonged to another species altogether. The cuckoo's egg in the hedge-sparrow's nest at once rose before the mind, and it was difficult to resist the conclusion that we had before us evidence of a similar habit on the part of insects. To place the matter beyond doubt, it would have been necessary to rear the perfect insects from the gall. Unfortunately, an attempt to do so proved unsuccessful. On a former occasion, from an abnormally thickened twig of the pine which was placed under a glass shade we obtained after some days a whole swarm of midges. Some such method is followed when it is desired to rear the insects from the galls; the shoot or leaf which bears the galls is placed in water and covered with muslin, or, better, in a wide-mouthed bottle, having damp sand in the bottom. For this purpose the more advanced galls must be selected. It is a common experience in experiments of this kind that instead of a single species different kinds of fly emerge from the same gall, and it is not always easy to determine which is the original gall-maker. In this way it has been ascertained that the galls of the Cynipidæ are often inhabited by other species of Cynips, of Synergus, Amblynotus, and Synophrus. On one of the willows a gall which resembles a pine-cone grows; it is made by a large species of Cecidomyia, which inhabits the centre, and in the outer part numerous smaller species of Cecidomyia take up their abode. Certain saw-flies are inquilinous in the galls of the gall-gnats, and certain of the latter return the compliment. In many cases the inquiline causes the death of the original inhabitant, but in other instances a *modus vivendi* seems to be arranged, landlord and lodger contriving to exist together in harmony, sharing the substance of the gall for food. Certain kinds of beetle have also been found in galls, for whose presence it is not easy to account, seeing they are not gall-feeders. Both the gall-maker and its guests are liable to the attacks of parasitic insects, especially of ichneumon flies; these deposit their eggs in the larvæ within the gall. For this reason it often happens that from a gall one may fail to obtain any perfect insects except the parasitic species. Other hymenopterous parasites are the Proctotrypidæ and Chalcidæ; the larva of one of the latter preys on the larvæ of *Cynips glutinosa*, and its lodger, *Synergus faciatus*. It is otherwise with the Braconidæ and Ichneumonidæ occurring in the oak-apple; these are believed to be parasitic, not on the owner of the gall, but on the inquilinous Tortricidæ.

As the guests may belong to different species, and as not only the gall-maker but each of the lodgers may have their own specific parasites, we may have an extraordinary variety of insects inhabiting the same gall. From one of the willow-galls Mr. B. Walsh obtained sixteen different insects, preyed upon by eight others, twenty-four in all, representing eight orders—quite a respectable entomological collection.

The treasures of the hive are liable to be appropriated in a similar way by intruders, such as the fly Volucella, which effects an entrance more easily on account of its deceptive resemblance to a bee, but the honey gatherers would seem to have much less cause for complaint on this score than have the makers of the galls.

Dr. Adler arranges the inhabitants of galls under three heads—gall-makers, inquilines, guest flies or cuckoo flies and parasites. He also mentions commensals, under which may be included those beetles, already referred to, which do not feed on the galls, and also the larvæ of certain moths which Mr. P. Cameron describes as attaching themselves to the exterior of galls and feeding on them, but without interfering with the occupants. The larvæ of the inquiline usually develop more rapidly than do those of the gall-maker, and a saving of time may be one of the advantages which the inquilinous habit secures. Such at least appears to be the advantage in the case of the cuckoo; for the remarkable instinct of this bird, there can be little doubt, has reference to the shortness of its stay in this country. The young cuckoo, a few days after it is hatched, is said to eject the young hedge-sparrows from the nest, and thereafter enjoys the exclusive attention of its foster parents. Did the cuckoo require to build a nest and rear its young in the ordinary way, it is doubtful whether the latter would be sufficiently advanced to take their departure along with the other birds when the time for leaving our shores arrived.

The most perfect galls are made by the Hymenoptera, though those of the Diptera are perhaps more numerous. The Hemiptera, Lepidoptera, Coleoptera, and several other orders include gall-making species. A species of beetle or gall-weevil forms pseudo-galls on the willow; the leaves of the lime, poplar, elm and many other plants are galled by plant lice; the curiously shaped Chinese galls are also formed by one of the aphides (*Aphis Chinensis*). These grow on a species of Rhus and are of commercial importance on account of the high percentage of tannin they contain. Coccus galls on the Australian Eucalypti constitute what is known as vegetable coral; the male insect, as Mr. Froggat tells us in his recent paper, occupies a separate gall from the female. The larvæ of Lepidoptera are more frequently leaf-miners and leaf-rollers than gall-makers, but several moths have been reported as bearing this character; one forms a fusiform gall on a creeping plant in New Zealand: a lepidopterous gall from Patagonia has also been described by Mr. Cameron which closely resembles the oak marble gall of *Cynips kollari*. Mite-galls in the form of little tufts of hair, or thickened and blistered leaves, due to species of Phytopus, are of very frequent occurrence. Mites are not properly insects, but belong to the Arachnida; galls of theirs may be seen on the stitchwort, on the meadow grass and several others. Examples of "worm-galls" occur on some of the hawkweeds and on species of Plantago. Although mite and aphis galls are of common occurrence, they are not so perfect nor are their forms so characteristic as those made by Hymenoptera and Diptera; they are generally more or less open. This is also the case with many dipterous galls: those of the Hymenoptera, on the other hand, are completely closed.

Two families of insects stand out pre-eminently as gall-makers—the Cynipidæ among the Hymenoptera, and the Cecidomyidæ, a family of Diptera; the former, alongside of which we may place the allied Tenthredinidæ, or saw-flies, are the gall-wasps or true gall-flies, as distinguished from the Cecidomyias, which are the gall-midges or gall-gnats. The females in both groups are provided with a slender ovipositor; with this the punctures are made in vegetable tissues and the eggs introduced. How the presence of these should stimulate the tissues into abnormal growth is a question which has attracted a considerable amount of attention, and can hardly be said to be finally settled yet. It was formerly supposed that along with the egg the insect also injected some secretion into the wound, which acted as an irritant. This view gained plausibility from the ovipositor being merely a modification of the wasp's sting. Latterly, however, the irritant properties of the secretion have been questioned; it has been shown in many cases that the formation of the gall does not commence until after the larvæ are hatched, and Dr. Adler holds that the formation of galls must be attributed almost entirely to the action of the larvæ in feeding, aided possibly by their salivary secretions. That this is the true explanation of the formation of a large number of galls admits of no doubt; but if Prof. Trail's assertion that the galls of Cynips and Tenthredo are fully formed before the eggs they contain are hatched be true, then their formation must be due to some other cause than the activity of the larvæ.

Not only do different gall-makers select different plants, but they very often confine themselves to particular parts of the plant, such as the leaf, young shoots, stems, floral organs, or roots. The galls of the oak, which are exceedingly numerous, are mainly the work of Cynipidæ. *C. kollari* produces the marble galls often used to ornament rustic work; the oak-apple or sponge is caused by *Andricus terminalis*: the currant gall by *Spathegaster baccarum*: *Neuroterus lenticularis* gives rise to the button galls or oak spangles on the under sides of the leaves; the catkins are galled by *Andricus occultus*; *Dryophanta scutellaris* makes the succulent cherry-galls; and the large galls on the root of the oak are occasioned by *Aphilothrix radicis*.

The species of gall-fly are very numerous, and as each gall-maker follows its own pattern, their galls assume a great variety of shapes, as their common names indicate. But the same thing has happened here as was formerly found to be the case with parasitic leaf fungi; in a number of instances, two forms, which were at first described as distinct species, turn out to be only different phases in the life-cycle of one and the same species; and as the alternating generations produce totally different galls, we have the latter exhibiting the phenomenon of dimorphism. The currant-galls of the oak, which appear in spring, and the oak spangles, which are formed towards the end of summer, are believed to be related in this way. The brood which emerges from the former consists of both males and females; the autumnal galls yield nothing but females. Among twelve thousand specimens reared from the Devonshire gall, Mr. F. Smith found not a single male; and different observers relate a similar experience with other galls. There can be no doubt, therefore, that the gall-flies resemble the aphides in their power of multiplying both sexually and asexually. Before these facts were brought to light, it was impossible to explain how the fly which emerges from the currant-gall in June succeeded in surviving the winter and producing new galls in the spring, but it now appears that the spangle galls are carried down to the earth with the falling leaves, where they remain throughout the winter months, and from the impregnated eggs they contain, in due time the female brood emerges, which deposit their unimpregnated eggs in the currant-galls of spring. So far as known, this dimorphism is confined to the galls of Cynipidæ.

Irregular, egg-shaped swellings of a bright red colour on the leaves of willows are caused by a very common saw-fly, *Nematus gallicola*; but a much more familiar example is the mossy gall, or bedeguar of the wild rose. This gall, which is produced by a Cynipid (*Rhodites rosea*), is an arrested leaf-shoot; only the vascular fibres of the leaves are developed, and it is to these the gall owes its mossy appearance. The russet and carmine tints of these fibres give the gall a very beautiful appearance. Internally it consists of a number of cells massed together, in each of which is a larva. Galls of this description which are made up of a number of compartments are termed polythalamous; those having but a single larval chamber are monothalamous. When inquilines take possession of a many-chambered gall they often convert it into a monothalamous one, besides distorting its shape. Galls at first are solid, but as the larva eats away the interior they become hollow. The grubs of many gall-flies complete their metamorphoses within the gall, from which they only emerge after attaining the winged condition; others again, when full fed, pierce a hole in the gall, through which they descend to the ground, where they pass the pupa stage of their existence. In the highly developed galls of the true gall-flies, as many as seven different layers or tissues may be distinguished; the central mass constituting the food of the larvæ, and the outer layers being protective in function. The coloration of galls is perhaps also protective in some cases. Protection is needed especially against birds, some of which break open galls to get at the grubs they contain.

Besides the bedeguar a red globular gall, that of *R. eglanteriæ*, is common on the leaves of the dog-rose, and all our native roses are galled by Cynipids. In these rose-galls species of Periclistus take up their quarters as inquilines; ichneumons may also be present as parasites.

The galls of *Andricus saliens* are known in California as "flea seeds," from their jumping about on the ground: this results from the spasmodic movements of the larva inside the thin-walled cavity of the gall. Another Californian gall has been described as covered with mobile hairs, which are sensitive to touch like the leaves of the mimosa. Very remarkable, too, is the relationship subsisting between the Cynipidæ and figs. Certain species of saw-fly deposit their eggs in the seed-vessels of the florets in the interior of the wild fig. When fully developed the saw-flies emerge, covered with pollen obtained from the male flowers near the opening of the fig. Following an ancient custom, the Greeks and Italians hang up bunches of the wild fruits on their cultivated fig trees, and the pollen-covered flies which escape from them enter the cultivated figs and fertilize the female florets in their interiors. This operation is known as caprification. The figs of the wild variety might almost be described as galls, since they serve as hatcheries for the saw-flies. Each species of fig would further appear to have its own special saw-fly. The Dead Sea fruit, or apples of Sodom, "which tempt the eye but turn to ashes on the lip," are probably galls on a species of oak produced by *Cynips insana*, though some suppose that the reference is to the fruit of a species of Asclepias.

We come now to the galls of the Cecidomyidæ. In this country one has not far to seek for them; just at present the galls of *Cecidomyia urticæ* are very abundant on the common nettle. They grow on different parts of the plant as irregular swellings, sometimes on the basal lobes of the leaf, often as irregular masses on the inflorescence. When opened, each cavity is seen to contain a single white larva.

On the umbels of the wild carrot, which is just now coming into fruit, here and there one may find a fruit enlarged to twice the ordinary size. Each loculus of the two-celled ovary is occupied by a single orange-coloured grub of Cecidomyia. Older galled fruits which have been vacated are also to be seen, with two little round holes at their base, through which the larvæ have made their exit. This species completes its metamorphosis outside the gall, but numbers of the gall-midges spin their cocoons within it, and only leave the gall as winged insects. Swollen stems and leaves are very common on the lady's bedstraw and other species of Galium. These yellowish-green galls are produced by the gall-midge *C. galli*. *C. campanulæ*, as its name indicates, gives rise to globular and ovate galls on the harebell (*Campanula rotundifolia*). Other midges gall the flower-buds of the whin and broom, the ovary of the violet, the catkins of the birch, the leaves of the ash and willow, the leaf-stalks of the poplar, and the fronds of the bracken. It would occupy too much space to enumerate all our native plants on which these dipterous galls occur. Such a list will be found in Prof. Trail's papers in the *Scottish Naturalist*. Suffice it to say that one has only to look for them to find them, since they are borne by a large proportion of our native wild flowers. The species of Cecidomyia are usually named from the plants from which their galls are obtained. The gall on *Veronica chamædrys*, mentioned at the beginning of this paper, is one of the commonest; it consists of an arrested terminal shoot with closely overlapping leaves. Externally it is reddish in colour and covered with grey hairs; within is a padding of hairs, and in the axil of each leaf a cell is formed containing the orange larva of the gall-midge *C. veronicæ*. Whether any inquilines have ever been noticed in it or not, we have not been able to ascertain, and the evidence afforded by the white larvæ is inconclusive, for Mr. F. Binnie states that the larvæ of *C. trifolii*, which galls the clover-leaf, are white when young but gradually change to orange at maturity. But as the number of larvæ in the gall was larger than usual, the probability that the white ones belonged to a different species from the orange ones is considerable. Be this as it may, the gall in question, according to Prof. Trail, is really a mite-gall, which is taken possession of by the gall-midges; and if this opinion be correct, then our white and orange larvæ, whether of the same species or not, both partook of the cuckoo character. The galls on the wild thyme are of a similar description, and are tenanted by the orange larvæ of *C. thymicola*.

The reader who desires to pursue this subject will do well to consult the article on galls in the "Encyclopædia Britannica"; Mr. Cameron's volumes in the Ray Society's "Proceedings" on the British Phytophagous Hymenoptera; Dr. Adler's recently translated "Essay on Oak Galls"; and the articles of Prof. Trail before mentioned, to which we have been indebted in the preparation of this paper.

THE FACE OF THE SKY FOR OCTOBER.

By Herbert Sadler, F.R.A.S.

Sunspots and faculæ are still prevalent on the solar surface. The zodiacal light should be looked for before sunrise. Conveniently observable minima of Algol occur at 10h. 30m. p.m. on the 18th, and at 7h. 18m. p.m. on the 21st.

Mercury is not well situated for observation during October, as through the whole of the month he never sets much more than half an hour after the Sun.

Venus is still visible as a morning star, but is not very well placed for observation by the amateur, and her apparent diameter is rapidly decreasing. She rises on the 1st at 4h. 32m. a.m., or one hour and a half before the Sun, with a northern declination of 3° 36′, and an apparent diameter of $10\frac{1}{4}''$, $\frac{86}{100}$ths of the disc being illuminated. On the 7th she rises at 4h. 50m. a.m., or 1h. 22m. before the Sun, with a northern declination of 0° 39′, and an apparent diameter of 10″. On the 17th she rises at 5h. 22m. a.m., or 1h. 6m. before the Sun, with a southern declination of 4° 19′, and an apparent diameter of 10″. On the 31st she rises at 6h. 6m. a.m., or about three-quarters of an hour before the Sun, with a southern declination of 11° 1′, and an apparent diameter of $9\frac{3}{4}''$, $\frac{92}{100}$ths of the disc being illuminated. During the month she passes through nearly the whole of Virgo, being very near η Virginis on the 8th.

Mars is an evening star, and is excellently situated for observation, coming as he does into opposition with the Sun on the 20th. He is at his least distance from the earth (40,010,000 miles) on the 12th. On the 1st he rises at 6h. 32m. p.m., or 52m. after sunset, with a northern declination of 9° 36′, and an apparent diameter of 21·2″, the phase on the p limb being only 0·5″. On the 8th he rises at 6h. p.m., or 38m. after sunset, with a northern declination of 9° 16′, and an apparent diameter of 21·6″, the phase being imperceptible. On the 15th he rises at

5h. 25m. p.m., or 20m. after sunset, with a northern declination of 8° 52′, and an apparent diameter of 21·7″. On the 22nd he rises at 4h. 51m. p.m., as the Sun sets, with a northern declination of 8° 27′, and an apparent diameter of 21·8″, being now at his brightest (star magnitude —2·3). On the 31st he rises at 4h. 7m. p.m., with a northern declination of 8° 1′, and an apparent diameter of 20·4″. During October Mars describes a retrograde path from the confines of Cetus and Aries into Pisces, being about 20′ south of the $4\frac{1}{3}$rd magnitude star 0 Piscium on the night of the 24th. At about 9h. 20m. p.m. on the 17th a $10\frac{1}{2}$ magnitude star will be about $\frac{1}{4}$′ south of the planet's limb.

Jupiter is an evening star, and is becoming well placed for observation. On the 1st he rises at 9h. 23m. p.m., with a northern declination of 22° 59′, and an apparent diameter of $39\frac{1}{4}$″, the phase on the p limb amounting to 0·4″. On the 8th he rises at 9h. 1m. p.m., with a northern declination of 22° 59′, and an apparent diameter of 40·1″. On the 17th he rises at 8h. 28m. p.m., with a northern declination of 22° 58′, and an apparent diameter of $41\frac{1}{4}$″. On the 22nd he rises at 8h. 7m. p.m., with a northern declination of 22° 58′, and an apparent diameter of 41·9″. On the 31st he rises at 7h. 33m. p.m., or 3h. after sunset, with a northern declination of 22° 59′, and an apparent diameter of 43″, the phase amounting to 0·3″. During the month he is almost stationary in Gemini, a little to the N.E. of μ Geminorum. The following phenomena of the satellites occur while the Sun is 8° below and Jupiter 8° above the horizon:—On the 2nd an eclipse disappearance of the first satellite at 5h. 15m. 15s. a.m., a transit ingress of the shadow of the third satellite at 11h. 24m. p.m. On the 3rd a transit egress of the shadow of the third satellite at 2h. 0m. a.m., a transit ingress of the shadow of the first satellite at 2h. 32m. a.m., a transit ingress of the satellite itself at 3h. 51m. a.m., a transit ingress of the third satellite at 4h. 41m. a.m., a transit egress of the shadow of the first satellite at 4h. 47m. a.m., and an eclipse disappearance of the first satellite at 11h. 43m. 38s. a.m. On the 4th an occultation reappearance of the first satellite at 3h. 16m. a.m., and a transit egress of its shadow at 11h. 16m. p.m. At midnight on the 4th a $10\frac{1}{2}$ magnitude star will be between the second satellite and the planet, 1·1′ f Jupiter's centre, almost on the parallel. On the 5th a transit egress of the first satellite at 0h. 36m. a.m.; at midnight a $10\frac{1}{2}$ magnitude star will be between the third and fourth satellites. On the 6th a transit ingress of the shadow of the second satellite at 0h. 15m. a.m., its transit egress at 2h. 48m. a.m., and a transit ingress of the satellite itself at 2h. 54m. a.m. On the 8th an occultation reappearance of the second satellite at 0h. 32m. a.m. On the 10th a transit ingress of the shadow of the third satellite at 3h. 23m. a.m., and a transit ingress of the shadow of the first satellite at 4h. 26m. a.m. On the 11th an eclipse disappearance of the first satellite at 1h. 37m. 3s. a.m., and its occultation reappearance at 5h. 8m. a.m.; a transit ingress of the shadow of the first satellite at 10h. 54m. a.m. On the 12th a transit ingress of the first satellite at 0h. 12m. a.m., a transit egress of its shadow at 1h. 10m. a.m., and of the satellite itself at 2h. 28m. a.m.; its occultation reappearance at 11h. 36m. p.m. On the 13th a transit ingress of the shadow of the second satellite at 2h. 49m. a.m., its egress at 5h. 23m. a.m., a transit ingress of the satellite itself one minute later, and an occultation disappearance of the third satellite at 10h. 17m. p.m. On the 14th an occultation reappearance of the third satellite at 1h. 4m. a.m.; an eclipse disappearance of the second satellite at 9h. 55m. 23s. p.m. On the 15th an eclipse reappearance of the second satellite at 0h. 23m. 9s. a.m., its occultation disappearance at 0h. 27m. a.m., and its occultation reappearance at 3h. 3m. a.m. On the 18th an eclipse disappearance of the first satellite at 3h. 30m. 30s. a.m. On the 19th a transit ingress of the shadow of the first satellite at 0h. 48m. a.m., a transit ingress of the satellite itself at 2h. 3m. a.m., a transit egress of its shadow at 3h. 4m. a.m., of the satellite itself at 4h. 19m. a.m., and its eclipse disappearance at 9h. 58m. 51s. p.m. On the 20th an occultation reappearance of the first satellite at 1h. 27m. a.m., a transit ingress of the shadow of the second satellite at 5h. 24m. a.m., a transit egress of the shadow of the first satellite at 9h. 32m. p.m., and its transit egress at 10h. 46m. p.m.; an eclipse reappearance of the third satellite at 11h. 42m. 55s. p.m. On the 21st an occultation disappearance of the third satellite at 2h. 3m. a.m., and its reappearance at 4h. 51m. a.m. On the 22nd an eclipse disappearance of the second satellite at 0h. 31m. 4s. a.m., and its occultation reappearance at 5h. 32m. a.m. On the 23rd a transit egress of the shadow of the second satellite at 9h. 15m. p.m., and a transit egress of the satellite itself at 11h. 42m. p.m. On the 25th an eclipse disappearance of the first satellite at 5h. 24m. 1s. a.m. On the 26th a transit ingress of the shadow of the first satellite at 2h. 42m. a.m., of the satellite itself at 3h. 53m. a.m., a transit egress of its shadow at 4h. 58m. a.m., and an eclipse disappearance of the satellite at 11h. 52m. 23s. p.m. On the 27th an occultation reappearance of the first satellite at 3h. 16m. a.m., a transit ingress of its shadow at 9h. 10m. p.m., a transit ingress of the satellite itself at 10h. 20m. p.m., and a transit egress of its shadow at 11h. 26m. p.m. On the 28th a transit egress of the first satellite at 0h. 36m. a.m., an eclipse disappearance of the third satellite at 1h. 11m. 36s. a.m., its eclipse reappearance at 3h. 42m. 52s. a.m., its occultation disappearance at 5h. 45m. a.m.; an occultation reappearance of the first satellite at 9h. 43m. p.m. On the 29th an eclipse disappearance of the second satellite at 3h. 6m. 39s. a.m. On the 30th a transit ingress of the shadow of the second satellite at 9h. 16m. p.m., a transit ingress of the second satellite at 11h. 30m. p.m., a transit egress of its shadow at 11h. 50m. p.m. On the 31st a transit egress of the second satellite at 2h. 7m. a.m., and a transit egress of the third satellite at 10h. 33m. p.m. The following are the times of superior and inferior conjunctions of the fourth satellite with the centre of the planet:—Superior, October 9th, 1h. 36m. p.m.; October 26th, 6h. 30m. a.m. Inferior, October 17th, 10h. 34m. p.m.

Both Saturn and Uranus are invisible.

Neptune is an evening star, and is becoming well situated for observation. He rises on the 1st at 8h. 14m. p.m., with a northern declination of 21° 12′, and an apparent diameter of 2·6″. On the 31st he rises at 6h. 13m. p.m., with a northern declination of 21° 8′, and an apparent diameter of 2·7″. During October he pursues a retrograde path in Taurus, being very near the $4\frac{3}{4}$ magnitude star ι Tauri during the whole of the month. A map of the stars near his path will be found in the *English Mechanic* for September 7th, 1894.

October is a fairly favourable month for showers of shooting stars, the most marked display being that of the Orionids on the 18th, the radiant point being in VI.h. 8m. R.A., and + 15°.

The Moon enters her first quarter at 7h. 1m. p.m. on the 6th; is full at 6h. 41m. p.m. on the 14th; enters her last quarter at 6h. 56m. p.m. on the 21st; and is new at 5h. 57m. p.m. on the 28th. She is in apogee at 2h. a.m. on the 8th (distance from the earth 251,320 miles), and in perigee at 1h. p.m. on the 22nd (distance from the earth 229,260 miles). At 6h. 3m. P.M. on October 7th the 5th magnitude star A Sagittarii will disappear at an angle of 1°, and reappear at 7h. 1m. P.M. at an angle of 323°. At 7h. 14m. P.M. on the 10th the 6th magnitude star 50 Aquarii will disappear at an angle of 30°, and reappear at 8h. 25m. P.M. at an angle of 261°; and at 11h. 11m. P.M. the $6\frac{1}{2}$ magnitude star B.A.C. 7835 will disappear at an angle of 102°, and reappear at 11h. 58m. P.M. at an angle of 186°. At 2h. 45m. A.M. on the 15th the 6th magnitude star π Piscium will disappear at an angle of 36°, and reappear at 3h. 47m. A.M. at an angle of 266°; and at 5h. 53m. P.M. the 6th magnitude star 19 Arietis will disappear at an angle of 113°, and reappear at 6h. 27m. P.M. at an angle of 193°. At 4h. 13m. A.M. on the 16th the 6th magnitude star 27 Arietis will disappear at an angle of 115°, and reappear at 4h. 58m. A.M. at an angle of 202°. At 5h. 27m. A.M. on the 17th the $6\frac{1}{2}$ magnitude star 66 Arietis will disappear at an angle of 73°, and reappear at 6h. 31m. A.M. at an angle of 260°. At 3h. 5m. A.M. on the 18th the $5\frac{1}{2}$ magnitude star χ^1 Tauri will make a near approach at an angle of 165°. At 0h. 34m. A.M. on the 18th the $6\frac{1}{2}$ magnitude star B.A.C. 1648 will disappear at an angle of 45°, and reappear at 1h. 33m. A.M. at an angle of 289°. At 5h. 15m. A.M. on the 20th the $5\frac{1}{2}$ magnitude star 59 Aurigæ will disappear at an angle of 93°, and reappear at 6h. 29m. A.M. at an angle of 282°.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solutions of September Problems (F. H. Guest).

No. 1.—B to Q7.

Solved also by 1. K to Kt5.

Correct Solutions received from Chat and Crossgar (both solutions); J. E. Gore, W. H. Skelton, H. S. Brandreth, W. Willby.

No. 2.—Kt to Kt6.

Correct Solution received from Chat, W. Willby.

Additional solution of July Problem No. 1 received from E. Boustead.

W. H. Skelton.—In No. 2, after 1. B to Kt3, P to Kt5, 2. Kt to K6ch, K to B 3, there is no mate.

A. G. Fellows.—The family success in *Boys* Tournament is remarkable. We shall be glad to receive the problem composed with the Knowledge Prize set of men.

J. E. Gore.—Probably the diagrams you require could be obtained from the British Chess Company, 247, High Holborn. They usually cost about 1s. a hundred. Your last two problems suffer from the same evils of overcrowding and want of economy. No. 1 is quite spoilt by the *double threat*, which is only allowable when Black is *compelled* to avoid one of the threatened mates. The mates in this are also of little beauty, and some of the Pawns unnecessary. The other has two good mates with the Queen, but the problem would be much improved if you could abolish the Black Queen with its attendant Pawns, and also the Pawn at K7. It is not a bad plan for inexperienced composers to limit themselves to twelve or, at any rate, sixteen pieces. The best problems seldom have more.

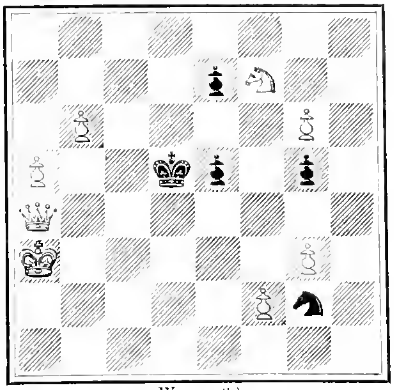
W. Willby.—The key is still weak, in that it moves a piece which is *en prise*, thereby depriving the Black King of half his liberty. Moreover, there is a bad dual after 1. . . P to K6, and also after several moves of the Black Queen. This last piece should be got rid of, as it leads to no fresh mate. It should be possible to get the four variations which you aim at by employing ten or, at most, twelve pieces.

R. Kelly.—Thanks for the problems. We shall be glad to insert the block problem in the November number. The three threat problems do not seem very happily constructed as regards economy of force. Many of the pieces do scarcely any work.

PROBLEM.

By B. G. Laws.

Black (5).



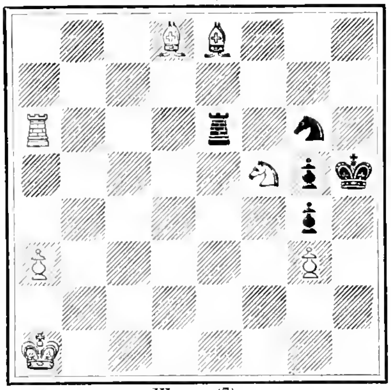
White (8).

White mates in three moves.

CONDITIONAL PROBLEM.

By W. De Morgan.

Black (5).



White (7).

White mates in three moves.

[On condition that when a Rook moves it becomes a Knight, and *vice versa*.]

The following game was played in the fifth round of the Leipsic International Tournament, between M. Janowsky, of Paris, and Mr. R. Teichmann, of London.

"French Defence."

White (M. Janowsky).	Black (Mr. Teichmann).
1. P to K4	1. P to K3
2. P to Q4	2. P to Q4
3. Kt to QB3	3. Kt to KB3
4. B to Kt5	4. B to K2
5. P to K5	5. KKt to Q2
6. B × B	6. Q × B

7. Kt to QKt5 (*a*)	7. Q to Qsq (*b*)
8. P to QB3 (*c*)	8. P to QR3
9. Kt to QR3	9. P to QB4
10. P to KB4	10. Kt to QB3
11. Kt to KB3	11. P to B5 (*d*)
12. Kt to QB2	12. P to QKt4
13. B to K2 (*e*)	13. P to QR4
14. Castles	14. Castles (*f*)
15. Kt to K3	15. Q to Kt3
16. Q to Q2 (*g*)	16. P to KB4
17. B to Qsq	17. P to Kt5
18. B to B2	18. P to QR5
19. P to QR3 (*h*)	19. P × BP (?)
20. P × P	20. Q to B2
21. P to KKt4 !	21. P to KKt3
22. Q to Kt2	22. K to Rsq
23. Kt to KKt5	23. Kt to QKt3 (*i*)
24. R to B3	24. Q to KKt2
25. R to QKtsq (*j*)	25. R to QR3
26. P × P	26. KtP × P
27. R to KKt3	27. Q to K2
28. R to KR3	28. R to KKtsq
29. K to Rsq	29. R to KKt2
30. QR to KKtsq	30. Q to KBsq (*k*)
31. Kt × RP (*l*)	Resigns

Notes.

(*a*) A move which has grown in favour of late years. The old continuation was 7. Q to Q2, P to QR3 ; 8. Kt to Qsq, in order to be able to meet 8 . . . P to QB4 by 9. P to QB3, the Knight ultimately finding a good square at K3.

(*b*) 7. . . . Kt to KBsq is the usual and better move.

(*c*) For now White should gain some advantage by 8. Q to KKt4. The omission of this move has been frequently noticed in this column. When possible it is nearly always a formidable move. In the present instance, if met by 8. . . . Castles, 9. B to Q3 would give White some attack ; while 8. . . . P to KKt3, 9. P to KR4 (!), would be good for White.

(*d*) The previous three moves on each side form the usual stereotyped procedure ; here it is customary to play 11. . . . P to QKt4, followed perhaps by Q to Kt3, thereby maintaining the pressure on the White QP.

(*e*) Owing to his omission on the eighth move, White's game is now rather cramped. If he play 13. P to QR4, Black might simply take the P, in order to attack subsequently the weakened QKtP.

(*f*) It was not necessary to commit himself by castling yet, as the King's Rook cannot be utilized at present. 14. . . . P to Kt5 seems preferable.

(*g*) Obviously if 16. P to B5, KKt × P. Hence Black's last move—and his next. White's next move is with a view to B to B2 and ultimately P to KKt4.

(*h*) White could not allow P to B6. Black's reply is very weak. 19. . . . P to Kt6 would be both immediately cramping and likely to prove useful in an end-game. With the White King out of reach there would be the chance of sacrificing a piece for the QBP or QRP in order to Queen the advanced KtP. As it is, White has his Bishop left on an attacking square, and speedily gets the better of the game.

(*i*) Apparently best. 23. . . . Kt to Qsq would give White too many sacrificial opportunities shortly. On his next move R to B2 seems more to the point.

(*j*) Finely played. He cleverly renders Black's QR inactive before proceeding to demolish him.

(*k*) There seems to be no defence. If, for instance, 30. K to Ktsq, R × RP wins.

(*l*) Prettily played. If now 31. . . . R × Q, 32. Kt to B6ch leads to a speedy mate, or if 31. . . . R × Kt, 32. R × Rch, K × R ; Q to Kt6ch, etc. M. Janowsky played the ending with his customary vigour.

CHESS INTELLIGENCE.

The International Tournament of the German Chess Association, held this year at Leipsic, was brought to a conclusion on September 15th. The result was a victory for Dr. Tarrasch, who thus won his fourth consecutive International Tourney, but this time only by the narrow majority of half a point. He lost games to Blackburne, to Mieses, through a blunder, and, apparently, also to Lipke in the last round. The prize-winners were :—1. Tarrasch (Nüremburg), 13½ ; 2. Lipke (Berlin), 13 ; 3. Teichmann (London), 12½ ; 4. Blackburne (London) and Walbrodt (Berlin), 11½ ; 6. Marco (Vienna) and Janowsky (Paris), 10½. The remaining competitors came out in the following order :—Berger, Shiffers, Schlechter, Mieses, Baird, Süchting, Zinkl, Weydlich, Mason, Seuffert and V. Scheve (retired). Mr. Mason's performance is most disappointing. On the other hand, Mr. Blackburne played well after a bad start, while M. Teichmann by his excellent performance showed that his two consecutive victories in the Divan Tournaments represent his true form. In the absence of Lasker, Tschigorin, Gunsberg, Bardeleben, Makovez, Winawer and others, the competitors cannot, of course, be regarded as representative of the chess talent of Europe. Still, the winner has maintained his reputation, and Lipke, Teichmann and Janowsky have certainly increased theirs. As at Dresden, Walbrodt and Marco were extremely difficult to beat, while Berger was as usual generally both willing and able to draw.

Contents of No. 107.

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AN ILLUSTRATED
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SIMPLY WORDED—EXACTLY DESCRIBED

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CONTENTS.

THE HOME OF THE RODENTS.

By R. Lydekker, B.A.Cantab., F.R.S.

Ranging over all the continents and most of the islands of the globe, and being represented even in marsupial-inhabited Australia, the rodents, or gnawing mammals, form such a thoroughly cosmopolitan group that it seems, at first sight, almost illogical to speak of one country more than another as being their home. Nevertheless, in the course of the present article we hope to be able to convince the reader that South America—whether we take into consideration the tropical forests of Brazil, the grassy plains of Argentina, or the desert wastes of Patagonia—has an undoubted claim to the title in question. We may add, however, that under the name South America we include both Central America and the West Indies, the whole of which form one zoological province.

In a previous article we have had occasion to allude to the chief peculiarities of the fauna of South America, and it was there stated that among the most characteristic forms of mammals were edentates, opossums, marmosets, and the New World monkeys, together with numerous rodents. It did not, however, come within the province of that article to take the latter group into detailed consideration, but as this is a subject of much interest from a distributional point of view, it may well form the theme of a separate essay. Probably the majority of our readers know what is meant by a rodent, or gnawing mammal; but should there be some among them whose ideas are somewhat hazy on this subject, it is to be hoped that their more learned brethren will pardon a few words in regard to the characteristics of the creatures in question.

As common and well-known examples of the rodent order we may cite squirrels, dormice, marmots, beavers, rats, voles, porcupines, and hares and rabbits, all of which are characterized by possessing a pair of chisel-shaped teeth in the front of each jaw, which are worn by use into a sharp, cutting, transverse ridge, and grow continuously throughout the life of their owners. It is with these chisel-like front or incisor teeth that the rodents perform that gnawing action (so markedly developed in the beavers and porcupines) from which they derive their name; and it is owing to the circumstance that the front of each tooth is faced with a plate of hard enamel, while the remainder consists of soft ivory, that these beautiful instruments maintain their cutting edges. These two pairs of front teeth are absolutely characteristic of all rodents, and in by far the greater majority of the order there are no other teeth in this region of the jaw. As if, however, for the purpose of hinting to us how these animals were originally related to mammals provided with a fuller set of teeth, the hares and rabbits, together with their near allies the picas or tailless hares, have a minute pair of somewhat similar teeth placed immediately behind the large pair in the upper jaw. Being perfectly useless to their owners, this second pair of upper front teeth evidently comes under the category of rudimental or vestigiary structures. Behind the front teeth of all rodents comes a long gap in each jaw, after which we reach the series of grinding or cheek-teeth, which are never more than six in number, and are frequently reduced to four, or even three. Consequently, no member of the order ever has tusks or canine teeth. Were it not that there are two groups of animals with a dentition of a similar type, these peculiarities in the teeth would absolutely distinguish rodents from all other members of the mammalian class. Of the groups in question, the one contains the wombats of Australia, which are broadly distinguished by the presence of a pouch for the young, while the second group is represented solely by the curious aye-aye of Madagascar, which agrees in its internal anatomy with the lemurs, and is accordingly assigned by naturalists to that group. With these exceptions, the dentition is absolutely characteristic of the rodent order; and as the reader is not likely to confound with them either of the creatures named, he may rely on the nature of the teeth in identifying the members of the order under consideration.

Having thus settled what constitutes a rodent, our next point is the classification of the order; for until we gain some insight into this, it is quite impossible to understand the especial richness of South America in regard to these animals. Rodents, then, are divided by naturalists into seventeen families, several of which are brigaded together into a small number of larger groups. Of these groups, the first is the squirrel-like rodents, which includes the four families of the African flying squirrels (*Anomaluridæ*), the squirrels and marmots (*Sciuridæ*), the sewellels (*Haplodontidæ*), and the beavers (*Castoridæ*). Now, of these four families, the only one occurring in South America is the second, and its representatives there are merely certain species of squirrels, which, moreover, do not range south of Paraguay; the whole of the marmots, prairie-dogs, susliks, chipmunks, etc., being totally unknown south of the Isthmus of Darien.

The second great group of the order, known as the mouse-like rodents, includes five families—namely, the dormice (*Myoxidæ*), the jumping mice and jerboas (*Dipodidæ*), the whole great mouse-tribe (*Muridæ*), as represented by mice, rats, voles, hamsters, and their kin; the mole-rats (*Spalacidæ*), and the American pouched rats (*Geomyidæ*). Of these, the only one represented in South America is the cosmopolitan mouse family. In this group, however, the true rats and mice of the Old World are totally wanting (except through involuntary introduction by man) as indeed they are throughout the New World; their place being taken by the white-footed mice, common both to North and South America, and nearly allied to the hamsters. In addition to these, there are a few genera belonging to the family which are quite peculiar to South America, one of the best known of these being the groove-toothed mice (*Rhithrodon*), a representative of which extends as far south as Tierra del Fuego.

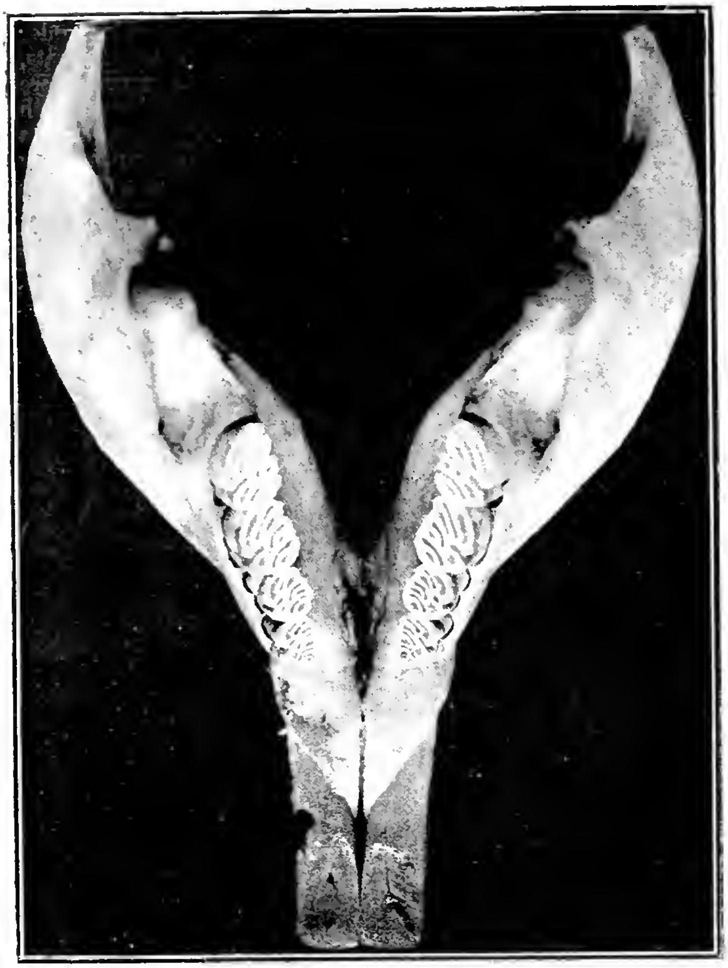


FIG. 1.—Upper Surface of the Lower Jaw of the Coypu, to show the chisel-like front teeth and the grinding molars.

By this time the reader will probably begin to think that, instead of South America being the home of the rodents, it is precisely the country where those animals are rarest, seeing that out of the nine families noticed above only two are represented there at all, and both of these somewhat poorly. His opinion will, however, at once change when we have considered the third great group of the order, which may be known as the porcupine-like rodents. The members of this group are readily distinguished from those of both the preceding sections by the structure of the lower jaw, although this difference can, of course, only be seen in the skeleton. Whereas in both the squirrel-like and mouse-like sections the hinder lower projection of the lower jaw, technically known as the angle, takes its origin from the inferior edge of the socket for the lower chisel-like teeth, in the present group the same projection arises from a prominent ridge running along the side of the jaw itself, as shown in Fig. 1. Of the six families into which the porcupine-like rodents are divided, four are exclusively confined to South America, while the fifth (*Octodontidæ*) is mainly South American and West Indian, although with a few representatives in Africa south of the Sahara desert. On the other hand, the porcupine family (*Hystricidæ*) is almost cosmopolitan, although the American representatives are so distinct from their Old World allies as to form a separate sub-family; while of the three genera constituting the latter, one is North American, and the others are mainly South American, although one has a single species ranging as far north as Mexico. Of the last group of the order, namely, the hare-like rodents, as represented by the hares and rabbits (*Leporidæ*) and the picas (*Lagomyidæ*), we have but little to say, seeing that its occurrence in South America is limited to two species of hares.

It will thus be seen that, out of a total of seventeen families, nine are represented in South America; and of these nine, four are absolutely peculiar to that country and the adjacent islands and isthmus, while a fifth has representatives elsewhere only in Africa, and a sixth (the porcupines) has two genera which are practically only South American, and are distinguished from all their allies by their prehensile tails. The significance of these remarkable facts in geographical distribution will be made apparent when we state that, of the other great zoological regions into which the globe has been mapped out, there are only two which have any families of rodents peculiar to them, the maximum number of such peculiar families being two. Thus Africa south of the Sahara, constituting the Ethiopian region of zoologists, has the African flying squirrels, which are nearly allied to the true squirrels, and are represented only by a single genus, with a comparatively small number of species; while North America, or the Nearctic region, has the sewellels, with one genus, and the pouched rats, with five.

Before entering on the significance of these facts, we must devote a short space to the consideration of some of the more remarkable of the South American types of porcupine-like rodents, by which alone the reader will be enabled to appreciate their peculiarities and numbers. Commencing with those families which are confined to the Neotropical region, as zoologists term South America, together with Central America and the West Indies, we have first of all the cavies (*Caviidæ*), which are heavily-built rodents, with four front and three hind toes, rudimental or short tails, and the molars divided by transverse folds of enamel into a number of thin plates lying parallel to one another, after the fashion shown in Fig. 2. The typical representatives of the family are the true cavies (*Cavia*), of which the guinea-pig is a domesticated descendant, having assumed a coloration quite different from the uniform olive-brown tint characteristic of its wild ancestors. Quizos, as these animals are called in the Argentine, may be found not only among aquatic plants in marshy districts, and skulking in the tufts of coarse grass on the pampas, but in the neighbourhood of human habitations will not unfrequently take up their residence under the floors of out-buildings, whence they issue forth to feed at night. All the true cavies are small and short-legged creatures; but the Patagonian cavy, representing the genus *Dolichotis*, is a much larger and taller animal, measuring nearly a yard in length, and standing over a foot at the shoulder. An inhabitant of the open districts of Patagonia and Argentina, the mara, as it is called by the natives, much resembles a hare in its movements. Unfortunately, the spread of cultivation has well-nigh exterminated this handsome rodent from most parts of the Argentine. Largest, not only among South American rodents, but likewise in the entire order, is the aquatic carpincho or capivara (*Hydrochœrus*), attaining a length of upwards of four feet. The most remarkable peculiarity of this animal is the large size and complex structure of the last molar tooth, which in the upper jaw may have as many as twelve plates, and is comparable in structure to the corresponding tooth of the Indian elephant. The carpincho is an inhabitant of the more tropical districts, not extending southwards of Uruguay. Nearly allied are the agutis (*Dasyprocta*) and pacas (*Cœlogenys*), collectively constituting the family *Dasyproctidæ*, which differ from the cavies in that the folds of enamel only form notches on the sides of the crowns of the cheek-teeth. The agutis are rather delicately-built animals, ranging from the confines of Mexico to Paraguay, and represented by an outlying species in the West Indies. The pacas, with nearly the same distribution, are, on the other hand, much larger and more heavily-built animals, characterized by the longitudinal rows of light-coloured spots on the fur, and the large bony capsules formed by the expanded cheek-bones.

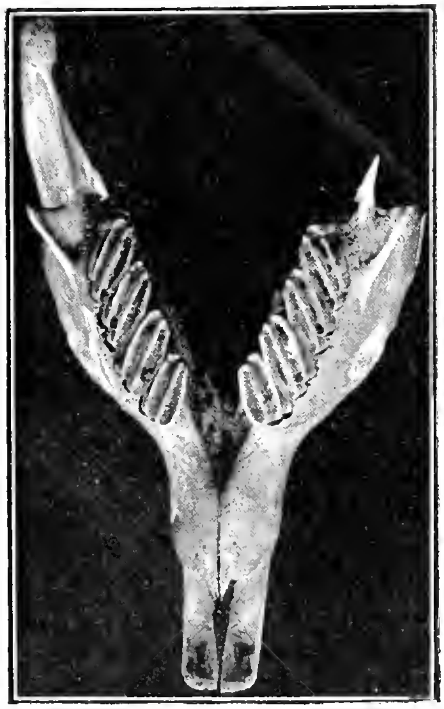


Fig. 2.—Upper Surface of the Lower Jaw of a young Viscacha. The hinder part of the left branch is broken off.

Another family (*Chinchillidæ*) is represented by the beautiful little chinchillas (*Chinchilla*) of the Andes, so esteemed on account of the marvellous softness of their pearly grey fur; by the much larger Cuvier's chinchilla (*Lagidium*), which is also an inhabitant of the Andes; and likewise by the well-known viscacha (*Lagostomus*) which lives in warrens in the Argentine pampas, and is remarkable for the habit of collecting all kinds of odds and ends round the entrance of its burrows. From the similarity of its habits, the viscacha is commonly believed to be a near ally of the marmot, with which, however, it has no close affinity. All the members of the family have long, bushy tails, very soft fur, elongated hind limbs, and the molar teeth divided by complete transverse folds of enamel into plates, as shown in Fig. 2. Sufficiently distinguished by their spiny covering, the porcupines (*Hystricidæ*) are represented in South America by two arboreal genera (*Synetheres* and *Chætomys*), differing from all their allies by their prehensile tails.

The largest of all the families under consideration is that of the octodonts (*Octodontidæ*) which, as already mentioned, has representatives in Africa, although the majority of the forms are South American and West Indian. In addition to other characteristics, these rodents have the crowns of the molar teeth marked by infoldings of enamel on both sides (Fig. 1), while there are generally five toes to each foot. In form they are generally more or less rat-like. Unfortunately, our limits of space permit only of a very brief reference to these forms. The typical representative is the degu (*Octodon*) of Chili and Peru, which is a rat-like animal with a long tail tipped with a brush. Other species inhabit Bolivia, which is also the home of certain allied rodents (*Habrocoma*) remarkable for having fur nearly as soft as that of the chinchillas. Nearly related are the burrowing tuco-tucos (*Ctenomys*) of South America, deriving their popular title from the bell-like cry uttered as they work beneath the soil, and their scientific name from the comb-like bristles with which the hind feet are furnished.

Passing over some smaller types, our next form is the coypu (*Myopotamus*), which is a large aquatic form, with beaver-like habits, found on both sides of South America, and commonly known as the nutria. Remarkable for the bright red hue of its front teeth, the coypu, except for its tail, is not unlike a beaver in general appearance, and is commonly regarded by settlers in the Argentine as a near ally of that rodent. In the West Indies the family is represented by the large arboreal forms known as hutias, most of which are included in one genus (*Capromys*); although, on account of the complex structure of its molars, one kind from Hayti and Jamaica is separated as *Plagiodon*. These animals may be compared to gigantic rats, one of them measuring twenty-two inches exclusive of the tail. Six other genera are also found in South America, most of them being smaller rat-like forms, in some cases (*Echinomys* and *Loncheres*) characterized by the admixture of flattened, lance-like spines among the fur.

Limits of space preclude any mention of the mouse-like members of the order peculiar to South America, and this omission is of less importance since it is not improbable that these forms are later immigrants from the north. Sufficient has, however, been said to show how extremely peculiar and numerous are the rodents of the Neotropical region, the whole of the genera belonging to the porcupine-like group found in that part of the world being absolutely confined to it, and the same being the case with several of the families. Not only are these rodents remarkable for the number of genera and species by which they are represented, but they are likewise noticeable for the large dimensions which many of them attain. Geological investigations have shown that allied rodents—one of which is stated to have attained dimensions equal to those of an ox—inhabited Patagonia during the middle portion of the Tertiary period, contemporaneously with the extraordinary ungulates alluded to in a previous article. It is, therefore, evident that all these mammals must have obtained entrance into South America contemporaneously, while they developed side by side during the period it was cut off from the northern half of the continent. What was the exact connection between these South American rodents and the allied African genera is at present uncertain, but there are many facts which point to a former intimate relationship between the faunas of all the southern continents, and their isolation from those of the northern half of the world.

Note.—In the September number of Knowledge, two wood-cuts illustrating Mr. Lydekker's paper on "The Ancient Mammals of Britain" have been transposed. Fig. 1 should be "last upper molar tooth of the Hyænarctus," and Fig. 2 should be "right upper molar tooth of Steno's Horse."

THE BACTERIA OF PHOSPHORESCENCE.

By C. A. Mitchell, B.A.Oxon.

That the flesh of certain animals, especially marine fishes, could often exhibit the phenomenon of spontaneous light was noticed as long ago as the days of Aristotle, but it is only within the present generation that the true cause has been made known.

In 1676, a Dr. Beale, of Yeavil, in Staffordshire, published in the *Philosophical Transactions* of the Royal Society a curious instance of the kind, and mentioned as a possible explanation that the stars were exceedingly bright on that night, and the weather warm and gentle. A woman of that town had bought a neck of veal, which seemed perfectly good in every respect. On the following evening, about nine o'clock, the neck of veal "shined so brightly that it did put the woman into great affrightment." She roused her husband, and he seeing whence the light proceeded endeavoured to extinguish it by beating the veal, and eventually plunging it below water: but in vain. At last he found he could extinguish the light by wiping the meat with a cloth. The next day the joint was cooked, and certain neighbours who had seen it giving light were invited to partake of it. All esteemed it as good as any they had eaten.

Many similar cases of meat becoming phosphorescent are on record. In 1492 it was a frequent occurrence in Padua, and during the early years of last century it became so prevalent in Orleans that several butchers were almost ruined, since their customers considered such meat unfit for food, and much of it was thrown into the river.* Coming to the present day, Nuesch describes how the whole of the meat in a butcher's shop became luminous in one night.

The first recorded experiments to determine the cause of such cases were made by Dr. Hulme in 1800, and from his results he was led to conclude :—

1. That putrefaction was not the cause, for as decay advanced the light gradually decreased. Moreover, in the case of phosphorescent meat there was no offensive smell.

2. That spontaneous light was a constitutional principle of some bodies, incorporated with their whole substance just as any other principle, and that it was probably the first principle that escaped after the death of marine fishes.

This plausible solution has since been displaced by the discovery that bacteria were invariably present in phosphorescent sea-water and on phosphorescent meat, and that directly or indirectly the light was due to their agency.

Bacteria is the generic term applied to certain low forms of vegetable life. They multiply by dividing up or "fission," and some also by the formation of spores. The *yeasts*, which increase by budding, are accordingly not bacteria, though they are sometimes classed with them. Bacteria are classified in two main groups :—*Coccaceæ* or spherical forms, and *Bacteriaceæ* or rod-shaped forms. To the latter belong the *bacteria* proper, straight rod forms in which spore formation is not known to occur; the *bacilli*, straight rod forms which form spores; and the *spirilla*, twisted forms not forming spores.

An artificial growth of these on nutrient gelatine, or some other suitable medium, is called a colony, and consists of a mass of the organisms. The appearance of the colony, which is often characteristic, is of importance in identifying the species of micro-organism of which it is composed.

At least six species of light-producing micro-organisms have been described, each having different properties by which they may be distinguished from one another. They all belong to the *bacteria* proper, though, from their length and breadth being often nearly the same, they have occasionally been described as members of the *Coccaceæ*. They fall naturally into two groups, of which the first includes the four following species:—(1) *Bacterium phosphorescens*, a motile organism pretty widely distributed; its average size is 1·7 μ.† long by 1·5 μ in breadth; (2) *Bacterium Pflügeri*, an organism about the same size as the preceding. It has rounded ends, and dividing rapidly, the cells usually appear almost round. It is the usual cause of the phosphorescence often observed on herrings and mackerel. (3) *Bacterium Fischeri*, and (4) *Bacterium balticum*, two species of similar size and form. They do not cause any fermentation as the first two do. All these may be grown on nutrient gelatine without causing it to become liquid; but for their successful cultivation they require the presence of the albuminoid substance *peptone*, and another carbon compound, such as glycerine or glucose.

In the second group are (1) *Bacterium indicum*, a motile rod of medium size, found in West Indian waters, and (2) *Bacterium luminosum*, the cells of which are shorter than those of the preceding bacterium. It occurs in the waters of the North Sea. These two species are able to flourish on *peptone* alone, and cause rapid liquefaction when grown on nutrient gelatine.

With regard to the conditions under which these various micro-organisms can produce light, it has been found that temperature has a good deal of influence. According to Ludwig, a piece of meat remained luminous as low as −14°.‡ Heated gently in a tube over a water-bath it was still phosphorescent at 30°, but at 40° had ceased to emit light. *Bacterium phosphorescens* thrives best between 15° and 25°, but Tilanus and Förster proved that it could live below zero. When kept at 35° for a few minutes its luminosity disappeared, but on cooling returned. If, however, it was kept at that temperature for fifteen minutes its power of producing light was permanently lost.

The other organisms show a difference in this respect. *B. Fischeri* gives no light at a temperature above 25°, while *B. indicum*, which thrives best at 30°, cannot grow below 15°. *B. luminosum*, on the other hand, is most luminous at 15°.

There is also a difference in the character and intensity of the light produced by the various species. *B. phosphorescens* gives out a greenish-yellow light, while that produced by *B. Pflügeri* is bluish-white and far more intense. By exposing a sensitive plate in an otherwise completely dark room, Förster succeeded in obtaining a photograph of a colony of this species by means of its own light. Fischer was able to do the same with colonies of *B. indicum*. It is, therefore, not surprising to learn that Ludwig, who examined spectroscopically the light produced by *B. Pflügeri*, obtained a spectrum rich in violet rays.

* "Lemery of Chymistry," 1720.

† 1 μ = $\frac{1}{1000000}$th part of a metre = $\frac{1}{25000}$th of an inch.

‡ All the degrees of temperature are on the Centigrade scale. To convert into Fahrenheit, multiply the number of degrees by 1·8, and add 32 to the product.

As to the manner in which the bacteria produce the light, there is still much research needed. As Hulme found in 1800 (and his observation has since been repeatedly confirmed) putrefaction does not assist phosphorescence. The light-producing bacteria are unable to do their work in a substance on which the putrefactive organisms are growing, and as soon as decay is fairly advanced the light altogether ceases.

The presence of oxygen appears to be an essential, for colonies will only give light on the surface of the culture medium, where they can have free contact with the atmospheric oxygen. This gas, however, is not essential for the life of the bacteria. They will grow in an atmosphere of hydrogen or carbonic acid gas, but under such conditions will not produce light.

Apparently it is not necessary for the colonies to be grown in the light of the sun, for cultivations made in complete darkness have been found to emit light as readily as those grown in daylight.

It has been suggested by Lehmann and Tollhausen that the light is produced by some molecular change within the cells of the bacteria—a sort of vital process—and the fact that all chemical reagents which destroy the protoplasm of the cell simultaneously stop the luminosity, lends some support to this theory. Thus, mineral acids, alkalies, and various disinfectants which are fatal to the bacteria, effectually destroy the phosphorescence produced by them. As was mentioned before, heat and cold have a similar effect.

An equally plausible theory, however, is that just as some bacteria produce ptomaines and albumoses, and others colouring matter, so the light-producing bacteria may produce substances with their molecules so arranged that we have the phenomenon of phosphorescence. If this be so, it is probable also that these products are readily affected by heat and chemical agents, and that then a fresh arrangement of the molecules takes place, and the substances lose their luminous properties. The experiments of Dubois* on the luminous mollusc *Pholas dactylus* tend by analogy to support this. From its luminous mantle he extracted two phosphorescent crystalline substances, to one of which he gave the name of *luciferase*. It was to these substances, which it secreted, he considered that the fish owed its luminosity.

When it has been decided whether the bacteria are in themselves phosphorescent, or whether they are so only by virtue of their products, there will still remain the further problem of the nature of the phosphorescence itself.

* Soc. de Bio., *Comptes rendus*, 1887.

THE DADDY-LONGLEGS.

By E. A. Butler, B.A., B.Sc.

The advancing autumn has brought with it the usual visitation of swarms of "daddy-longlegs," and it will no doubt be acceptable to the readers of Knowledge if we take the opportunity, while the discomforts of the visitation are still fresh in the mind, of setting before them an account of these fragile but none the less troublesome insects. The chief cause of the inconvenience to which they subject us in their adult state is the awkward way in which they tumble about, blundering up against us with the tickling sensation of buzzing wings and straggling legs, or immolating themselves in the gas or lamp flame, and startlingly dropping their singed and mutilated bodies on to the page which we may happen to be reading or writing. But, as we have had occasion to remark before, it often happens that the most harmful period of an insect's life is not that which is most prominently before human eyes; the greatest damage wrought by an insect pest is often done in secret, when the real cause of the injuries is generally unsuspected. Such is the case with the insect now before us, for the inconvenience caused during its period of publicity is as nothing compared with the havoc wrought by it during its earlier life of seclusion, when its aspect is so different from that of the well-known "daddy" that none who were not in the secret would suspect the identity of the two insects.

The "daddy-longlegs" with which we are most familiar is but one species of a large group, the family *Tipulidæ*, and of one very extensive genus in that family, the typical genus *Tipula*. Thus the name "daddy-longlegs" is, strictly speaking, not a specific designation, but a general term, and there are large numbers of insects to which it may be, and is, equally appropriately applied. Still, it is no doubt a single species which is usually understood by the term—a greyish-brown fly, with semi-transparent wings, the brown nervures of which stand out distinctly on the lighter background. The thorax is hoary beneath, and the six long legs are brown at the base and blackish towards the tip. To this species the name *Tipula oleracea* has been given. The great length and slenderness of legs in these creatures has recalled the corresponding feature in wading birds, and has led to their getting the name of "crane-flies." In France they are known as "tailors" and "seamstresses." The great length of legs is not altogether disproportionate; it finds correlated characters in the other parts of the body, and is no doubt of some assistance to the insects in walking in the grassy places that form their principal habitat.

We may now endeavour to get such an exact notion of the form and structure of our crane-fly as will be obtained by a close examination, assisted by the use of a hand-lens of low power. The single pair of wings marks it out as a dipterous insect, and we may at once notice that the wings are usually carried, when at rest, not folded together over the body, as would be the case with most flies, but widely open and slightly elevated on each side, as though to be ready for use at a moment's notice. Their extreme narrowness at the base, as well as for some distance along their length, is indicative of that feebleness of flight for which the insects are noted—a feebleness which is, however, perfectly compatible with a rapid and rattling vibration of the wings.

If this wing be compared with that of a strong flier, such as a bluebottle, a striking difference is seen. The bluebottle's wing is furnished with a sort of extra flap of membrane at its base, which, when the wing is extended, fills up the space between its broader part and the body; while in the crane-fly this space is quite open and unoccupied with membrane. This appendage to the true wing is called the "alula" or winglet. Projecting from the hinder part of the thorax into this open space is, on each side, a delicate little organ, the so-called "balancer," a sort of clubbed stalk, whose intimate structure is well worth careful study. Now it is a curious fact that in the two flies we have mentioned, these two parts, the winglets and balancers, appear in inverse ratio of size. The strong and vigorous bluebottle, which has a very large winglet of most exquisite structure, has a completely insignificant balancer, which requires close search to discover it at all; whereas the weakling crane-fly has no trace of a winglet, but has proportionately the largest balancer that is to be found amongst British Diptera. And this is only one illustration of the law of correlation of structures, of which many others may be observed in the same two insects. Consider, for example, the following details of symmetry and contrast: in the vigorous and active bluebottle we find a stout, heavy body, short legs, short, strong wings with large alulæ, a short compact head, insignificant balancers, and a body beset with stout bristles. In the fragile and weakly crane-fly all these points are reversed, and we find a long, slender, light body, very long legs, long narrow wings without alulæ, a long and tapering head, large and conspicuous balancers, and a smooth and bristleless body.

The shape of the thorax, strongly convex and humpbacked above, is worthy of notice, as representing in an almost exaggerated degree the general plan of dipterous structure in that part of the body. Remembering that each of the three pairs of legs represents a separate division or segment of the thorax, it will be comparatively easy to trace the limits of these regions, by following the junctions upwards from the points of attachment of the legs. It will thus be seen that the prothorax, or first region, is reduced to very small dimensions, forming no more than a sort of collar, just behind the head. The metathorax, or third division, a much larger mass, will be found behind; but when we have marked off these two parts, there still remains the greater portion of the thoracic mass, which is thus proved to belong to the second segment, or mesothorax. If we bear in mind that this is the division which, in insects generally, carries the fore wings, and that in flies the fore wings are the only pair developed, the reason for the great development of this part will be at once evident, for within its cavity are stored the muscles that are instrumental in working the wings. There is one feature of the mesothorax that is specially characteristic of the family we are now considering, a trivial feature no doubt, but one which is helpful in distinguishing *Tipulidæ* from other groups. Across the middle of the upper surface runs a V-shaped furrow, which is not to be found in other groups of flies, for the rest of the order either have a smooth surface here, or if a transverse impression is present, it is incomplete and not V-shaped. At each side of the thorax will be seen two narrow slits, one just above and behind the insertion of the first pair of legs, and the other at the base of the balancers. These are two of the spiracles, or entrances to the breathing tubes, which, as with insects generally, traverse all parts of the body and convey air to the system at large.

The head (Fig. 1) is most peculiar in shape, being prolonged into a sort of beak. The basal part is almost globular, and the compound eyes occupy a large part of the surface here. In life they are of a bright green colour, a very pleasing relief to the sombre tints of the rest of the body; unfortunately, however, the colour is fleeting, and passes away after death. At the end of the beak are two jointed organs, which, when not in use, are carried bent back underneath the head; these are the maxillary palpi. The upper part of the head carries the antennæ, a pair of long, jointed, tapering organs, with circles of delicate bristles at the junctions of the joints. The form of the antennæ decides at once to which of the two great divisions of flies the crane-fly belongs, viz., the Nemocera, or "thread horns." This, again, is another respect in which it differs markedly from the bluebottle and other flies of that robust type, which have short and most oddly-shaped antennæ. It is hardly necessary to say that no biting jaws exist in the perfect insect. No power of biting or piercing is possessed by it, and hence its harmlessness in this stage, whether to man, beast or plant.

Fig. 1. Head of Daddy-longlegs.

The legs, as already mentioned, are exceedingly long and slender, each of the divisions being elongated to a considerable extent; the tarsi, or feet, which are five-jointed, with the joints diminishing in length as they recede from the body, are even longer than the tibiæ. They are not only long and slender, but also very fragile and easily broken off, an accident to which the insects are extremely liable, but at the same time one which cannot be regarded as of a serious character, for the loss of even half the number of its legs does not prevent the insect from going about its business as though nothing had happened. Such losses can hardly be attended with much pain, and their chief influence would no doubt be felt in the difficulties in steering during flight, which would follow. Unlike crabs and lobsters, the daddy-longlegs does not possess the power of reproducing a lost limb, nor indeed would the power be of any avail if it existed, since the insect's adult life is too short to allow time for any such restored limb to grow.

Fig. 2.—Ovipositor of Daddy-longlegs.

The hinder part of the body differs markedly in the two sexes. In the male it is blunt and swollen, the enlarged part containing a complex reproductive apparatus; but in the female, it tapers regularly to a hard and sharp point. This acute tip (Fig. 2) is the hardest part of the body, and necessarily so, as it has to do the hardest work, and indeed the only serious work that devolves upon the fully-matured insect. It constitutes an egg-laying instrument of superior quality, and is composed of four pieces disposed in pairs. On the upper side are two long and pointed pieces which form the sharp tip, and are used as borers, and underneath these is the other pair, considerably shorter, broader, and blunter, their function being to guide the eggs in their passage into the hole prepared for them by the pair of borers. The whole apparatus, therefore, is something like a combination of an auger and a spoon.

The eggs are small, shining black, and slightly curved. When they are about to be laid, the mother insect behaves in a most remarkable manner—in a manner, indeed, that might have been thought impossible had it not been actually witnessed. It will be remembered that in those animals in which a distinct longitudinal axis of the body can be traced—such, for example, as vertebrates and arthropods—the almost universal position of that axis is horizontal, the chief exceptions being man and birds, whose use of only one pair of limbs in walking throws their axis into an erect or sloping position. So in insects and other arthropods, as the bipedal arrangement does not exist, one naturally expects to find the axis of the body placed horizontally when the animal is walking over a level surface, and in fact it is a most exceptional circumstance that any other disposition should occur. When, therefore, it turns out that the female daddy-longlegs, on its egg-laying expedition, actually struts about on its hind legs with its body placed in a perfectly erect position (Fig. 3), it will be admitted that we are justified in considering this most extraordinary behaviour. Considering the structure of the legs, however, it is evident that the proper balancing of the creature, if it had to depend on its hind legs only, would be a somewhat nice operation, and hence the pointed abdomen is requisitioned as an auxiliary, and is used as a third prop. Most ludicrous is the sight as the insect, rearing itself perfectly erect, and flourishing its four front legs in the air, goes hobbling along on its tripod, prodding its pointed body into the ground at every step, while the legs bend like springs as it does so. Such a sight may often be seen in the proper season on damp grassy spots where the insects are plentiful, and they may be watched with ease, for there is no fear of their shyly retiring from observation, since they are far too intent on their work to notice the presence of an intruder.

When a suitable spot has been found, the ovipositor is plunged into the ground and kept there while several eggs

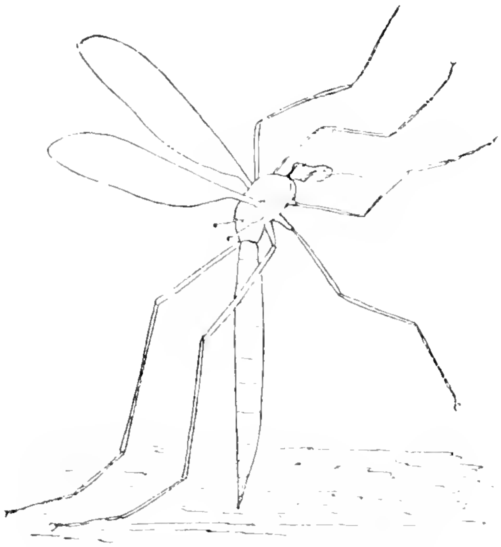


Fig. 3.—Attitude of female Daddy-longlegs, when on an egg-laying expedition.

are passed down into the hole. Sometimes, however, they are laid amongst the grass or leafage close to the surface of the ground, instead of being buried. As many as three hundred eggs may be produced altogether by a single female, but they are not all laid in the same spot, and it is difficult to say what determines the number to be included in a single set, unless it be the proportionate abundance of food. The different groups, however, are often laid tolerably close together, and in bad visitations this is necessarily the case. Kirby and Spence record an instance in which the immense number of two hundred and ten grubs were found in a square foot of turf during a terrible plague of them in Holderness in the year 1813.

From the black eggs are hatched thick, greyish, footless grubs, with an extremely tough skin. They are generally known to gardeners as "leather-jackets," or simply as "the grub." They are soft and flexible, but so tough that it is difficult to damage them by any means short of absolutely cutting the body in two or tearing it to pieces. This feature they possess in common with another subterranean grub, which the reader will be careful not to confound with the "leather-jacket," viz., the celebrated wireworm, or grub of skipjack beetles; this creature differs in being thin, hard, inflexible, and of a yellow colour. Though the "leather-jacket's" head is large, it is not generally seen, as it is almost entirely imbedded in the following segment. It is furnished with powerful jaws which are forked at the tip. The entrances to the breathing tubes are reduced to two openings placed at the tail end of the body; here are also some pointed hooks, which, like the head, are usually withdrawn within the adjoining segment when not in use. They are of assistance when the grub works its way through the soil.

This wretched grub is subterranean in habits, and if it does chance to come to the surface, it is only in the night time, or under the shelter of some friendly stone or pile of dead leaves. Its business underground is to devour the roots of plants, and this business it discharges most effectually. It possibly does damage also by loosening the soil round the roots as it works its way about. Its diet certainly seems to suit it well, for it is usually found in a very fat and flourishing condition. Its principal food appears to be the roots of grasses, but it is by no means confined to these. I have found it very destructive to certain garden plants, especially to blue lobelias used as an edging. Shortly after the young seedlings have been bedded out, they begin to look unhealthy and droop and wither. Frequently also the previously erect stems fall into a sloping position and wither away. On removing the soil from the base of the plant to investigate the cause of its drooping condition, a fat "leather-jacket" is found in the centre, just where the rootlets ought to be; the tenderer portions of these have all disappeared, and only the tougher and older parts are left, while many of the stems are seen to be gnawed round or cut completely through at the base, thus explaining their prostrate position and withered appearance. In such cases, unfortunately, one does not discover the enemy till the mischief has been done, and it is too late to save the plant. Of course, such damage is the more likely to occur where the bed is bordered by a grass plot.

This destructive work is carried on by the grubs more or less continuously during the summer months, from May to July, and sometimes they may be found at work even as early as February. During this time, far more than what is actually devoured is caused to perish through the removal of the roots. But it is only fair to remark that some slight plea of defence may be advanced, which will perhaps serve to take the edge off the charge of wholesale destructiveness which must otherwise be made. In eating the roots, the grubs inevitably swallow a good deal of earth, and, in fact, to such an extent is this the case, that so careful an observer as Réaumur thought they lived upon this rather than upon roots; hence they may perform to some slight extent a service similar to that carried out by worms, in the passing of earth through their bodies. Towards the end of summer the grub becomes a chrysalis while still buried in the soil. It now appears as a long, brown, narrow object, which shows indications of the parts of the future fly. The legs are present, but bent up at what will ultimately be their joints, in three parts, which lie parallel to one another on the under side of the head and thorax. The thigh points towards the tail, then the shank is bent back upon this, and finally the tarsus, or foot, points again in the direction of the tail. By this arrangement all the tarsi are made to lie on the outer side and to terminate at about the same level. Of course, these legs, being enclosed within the membranous skin of the pupa, are quite useless for purposes of locomotion.

When the fly is fully formed and ready to make its appearance in the air, the chrysalis works itself up through the soil to the surface by means of certain spines on the abdomen, which point outwards and slightly backwards. Using these somewhat as climbing irons and props, it works its way upwards step by step until all the fore part of the body is above ground. Its legs are now free from the soil, and when drawn out of their sheath, after the splitting of the skin, can be used to assist in extricating the body. But in order to give purchase to the struggling insect in its endeavours to get free from its case, the lower part of the chrysalis remains imbedded in the ground, and the body is withdrawn from the shell, which is left

CRANE FLY OR DADDY-LONGLEGS (*Tipula oleracea Linn.*), with Grub or Larva.

From a Picture by MISS ORMEROD.

projecting half-way out of the soil (Fig. 4). These empty cases may often be seen at the right season, still standing upright in the holes, as silent witnesses to past resurrections. The newly-extricated fly is at first soft, but soon hardens by exposure to the air, and proceeds to its appointed task—the perpetuation of its kind.

Fig. 4.—Pupa of Daddy-longlegs, with upper part projecting above ground.

The breathing arrangements of the pupa are as peculiar as those of the larva. We have already mentioned that the spiracles of the larva are reduced to a single pair, which are to be found on the last segment of the body. Similarly, the pupa has but two, but these are at the opposite extremity—a very desirable arrangement, as this is the part that is uppermost, and therefore nearest the air, when the insect works its way to the surface. They form two horn-like prominences, which project considerably from the head. Thus, in the daddy-longlegs, the same restriction and reversal of respiratory structure takes place as in the aquatic larva and pupa of the common gnat.

As these insects are so destructive, an important question arises as to the best means of reducing their numbers and checking their ravages. As damp soils, with plenty of loose straggling vegetation, especially grasses, are particularly favourable to their multiplication, it is evident that drainage and the clearance of weeds are two of the most important means of prevention. Untidy, shady corners will often harbour scores of specimens, while on open and cleared spaces in the immediate vicinity they may be sought for in vain. The larger insectivorous birds are certainly of great service in clearing the soil of the "grub"; indeed, according to the belief of Mr. Verrall, the English dipterologist, rooks are by far the best remedy. But perhaps we cannot do better than refer those who are practically interested in the matter to Miss E. A. Ormerod's "Manual of Injurious Insects," where they will find variety enough to make a choice rather embarrassing, since most of the remedies suggested have been found useful on occasion.

But we must caution our readers against putting too much faith in specific remedies, or expecting too much of them, since it is extremely difficult, if not impossible, to obtain an "infallible cure" for insect depredations of any kind. The circumstances of each different visitation, even of the same insect, often vary considerably, and what would be efficacious in one instance might altogether fail in another. Again, just as the satisfactory working of a small model of machinery is by no means always a guarantee that the same thing would work well on a larger scale, so insecticides that may be perfectly efficacious and very rapid in action when administered direct in the laboratory to an individual specimen, may fail altogether when the attempt is made to apply them promiscuously, and on such a scale as would be necessary in a large field, to say nothing of the great expense often involved in attacking such large areas. Of this principle, indeed, Miss Ormerod gives some remarkable illustrations in the book above referred to, appending to them the following pertinent remarks: "The above experiments are of much value by showing how little these remedies can be depended on, some of which have often been tried, and time, valuable for checking the attack at the beginning, thereby lost. It will be observed that the application that caused the most rapid destruction of life experimentally, failed to have any decided effect on the grubs in the ground, even when applied at a strength which, without the greatest care in using, would be destructive to the crop."

Probably natural agencies are, after all, the best to depend upon; but even in this category there are several that might have been thought available, but yet fail through the hardiness of the grub. For example, frost, which kills many insects, has little effect upon the hardy "leather-jacket." They may be frozen hard and stiff, and yet recover on being thawed, and proceed about their business as usual. In some experiments carried out for Miss Ormerod at Kew, specimens were exposed to an artificial cold of −10° F., or forty-two degrees below freezing point, and some were found to resist even this extremely low temperature, though most of them died. Therefore, evidently the frost of an ordinary winter cannot be expected to make much difference to their numbers. Again, it was found that grubs which had remained immersed in water for fifty-eight hours, and looked quite lifeless, recovered on being restored to the air, though an immersion of twice as long proved fatal. Hence floods, to be effectual in killing the grubs, must be of long continuance, and there must be no means of escape to drier quarters. Drought appears, however, to be much more reliable as a destroying agency.

THE CANALS OF MARS.

By E. Walter Maunder, *Hon. Sec. B.A.A., Superintendent of the Physical Department, Royal Observatory, Greenwich.*

SEVENTEEN years ago our knowledge of Mars appeared to be in a very satisfactory state. The principal markings had been often and long observed, and had been found to be permanent. The Kaiser Sea, the Oculus, the Maraldi Sea, had been observed by Hooke and Cassini, Herschel and Schroeter, Beer and Mädler, Dawes, Lockyer, Knobel and Green. The inference, from the annual waxing and waning of the white polar caps, that cloud, snow, and rain were features of the meteorology of the planet, had been confirmed by the testimony of the spectroscope, and that the white caps themselves were composed of ice or snow was a natural conclusion. It followed necessarily that there must be water on the surface of the planet, and the dark spots were considered as seas, leaving the brighter districts to be regarded as land. Mars was, in short, a smaller copy of our own world. "The analogy between Mars and the earth" was pronounced to be "by far the greatest in the whole solar system."

Schiaparelli's discovery of the "canals"—to use a term which, however misleading it has been, has now been too strongly sanctioned by custom to be easily changed—was the beginning of a new epoch in Martian observation, and its chief and most patent result has been to disturb our old conceptions of the analogy between Mars and the earth, and consequently to unsettle our notions of the physical condition of the planet. The reaction has gone so far that Prof. Schaeberle has reversed the old identification of the dark spots as seas, and claimed that the bright districts are to be thus regarded. The grounds for this change of view have not been generally accepted, and more is to be said for an objection raised by Prof. W. H. Pickering, that just as snow is not the only substance to give a bright white reflection—hoar-frost or cloud would serve as well—so water is not the only surface which would appear dark; forests and prairies would appear as at least sombre districts.

The "canals," however, have been the great element of disturbance. The report of their discovery was received in 1877 with very considerable mistrust. But time has been on the side of the patient and keen-eyed Italian astronomer. Each succeeding opposition has seen more of his "canals" identified by other astronomers; each construction of a new and more powerful telescope, each enlistment of a fresh earnest and skilled observer, has meant a further confirmation of his work. So that now there is a bulk of evidence in favour, not merely of some of Schiaparelli's "canals," but of his canal system as a whole, by no means lightly to be set aside.

The positive evidence has not, however, destroyed or overcome the negative. Both still hold the field, and both must be considered. The principal points against the actual existence of the "canals," as represented by Schiaparelli, may be summarized as follows:—

1. They are extremely narrow objects, approaching the theoretical limits of visibility, even when Mars is at its nearest approach. Thus a fine drawing reproduced in Flammarion's great monograph on "Mars," p. 568, shows "canals" of breadths not exceeding 0·04″ or 0·05″ of arc. The two branches of a *doubled* "canal" in one part of the sketch are distant from each other only 0·25″. Nor is this all. In his account of his 1888 observations (maximum diameter of planet, 15·4″), he states that in a set of canals on Mädler Continent he could make out, not merely the two banks of the canals, but also "very small undulations in their two banks, which could be distinguished from each other."

Fig. 1.—Herschel II. Strait, as seen by Beer and Mädler on October 14th and 19th, 1830. From Flammarion's "Mars," p. 566.

2. The distinctness of some of these objects, though so narrow, does not seem impaired by distance. Thus, in the opposition of 1877, the Indus was *better* seen by its discoverer when the planet had receded a great distance from opposition, and was very well seen when the planet was only 5·7″ in diameter, and the canal 0·2″ in breadth.

3. The great divergency between the descriptions of different observers. To take the one (and all important) feature of breadth. In the opposition of 1890, when Schiaparelli was observing "canals" down to a breadth of 0·05″, Holden and Keeler, at the Lick Observatory, always saw the canals as dark, broad, somewhat diffused bands. We may judge what is meant by "broad bands," for the record goes on:—"In bad vision they were drawn in that way by Schaeberle also. Under good conditions, however, the latter observer described them as narrow lines, a second of arc or so in width." A second of arc corresponded at this time to a minimum of 6 of a Martian great circle; that is to say, to about the breadth of Herschel Strait, and very nearly to that of the Mare Sirenum, the narrower end of the Maraldi Sea, or to nearly double the breadth of the Nasmyth Inlet, or the point of the Kaiser Sea, markings seen even by the earliest observers. If Schaeberle could describe markings of such dimensions—markings twenty times as broad as Schiaparelli's narrowest canals—as "narrow lines," what must have been the breadth of the "broad bands" of his two colleagues? It is clear that the phenomena observed by the Lick observers were quite of a different order to those recorded by Schiaparelli.

4. The greatness and suddenness of the changes remarked in the "canal" system. The "gemination" or doubling of the "canals" has been remarked "to take place in a relatively short space of time, and by a rapid metamorphosis. . . . Sometimes the metamorphosis has been completed in the interval of twenty-four hours between two consecutive observations. So far as the observer could judge, the phenomenon took place simultaneously along the entire length of the canal doubled." Schiaparelli himself draws attention to the strange and rapid changes taking place on the planet, and remarks: "Evidently the planet has fixed geographical details similar to those of the earth, with gulfs, canals, &c., on an irregular plan. There comes a certain moment and all this disappears, to give place to these grotesque polygons and geminations, which clearly represent approximately the former state; but it is a coarse, and, I might say, almost a ridiculous mask."

5. The "canals," when near the edge of the disc, are apt to be represented as much straighter than they could possibly be.

6. To these difficulties may be added that at the very time when to some observers the canal system was most developed, others have sometimes only been able to perceive the usual markings of the planet in their customary configuration.

How are we to explain these curious discrepancies?

First of all, many of these differences are to be explained by differences in "seeing" power, including in that term not merely atmospheric conditions, but instrumental and personal differences, such as the aperture of the telescope, its defining power, the magnification employed, and the keenness of sight and artistic skill of the observer. Two illustrations may be given of these. In 1892 a number of drawings by different observers were made of the De la Rue Ocean. The observers best equipped with instruments, and most favoured by observing conditions, recorded this ocean to be marked by the presence of one, two, three, or more islands. The better the conditions the more the number of islands represented; the smaller the aperture, and the less the experience of the observer, the fewer; so that the drawings showed every variety of representation,

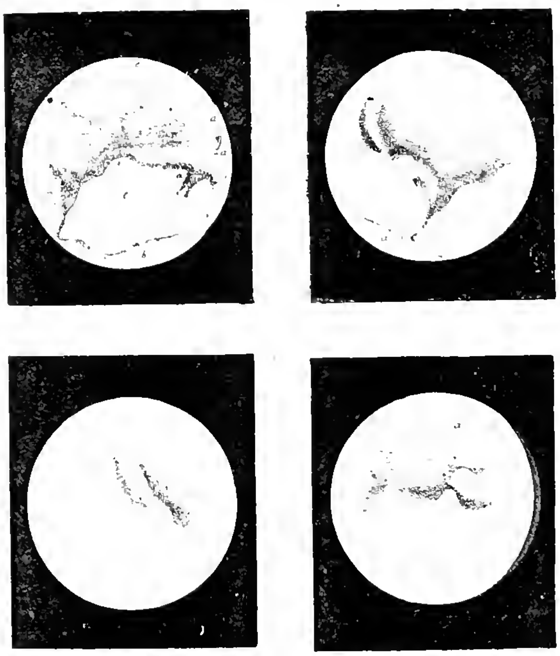


Fig. 2.—Drawings of Mars, by Dawes, in 1864-65. From Flammarion's "Mars," p. 187.

from an undivided greyish spot to an archipelago of five distinct and clearly separated markings.

Again, in Flammarion's "Mars," a series of representations are given of Herschel II. Strait. First in order of date come Beer and Mädler's drawings of 1830, in which we see the "strait" (Fig. 1), not as a strait, but as a snake-like inlet, ending in a dark round spot. In 1862 Lockyer (Flammarion's "Mars," p. 155) represents the terminal spot as a nearly rectangular marking. In the same year Kaiser gives the northern edge of this rectangular spot a shaded appearance, as if he suspected the presence of the two "estuaries" (*Ibid.*, p. 174). In 1864 (first sketch of Fig. 2) Dawes resolves this rectangular spot into the now well-known form of "Dawes' Forked Bay." In 1879 Schiaparelli (Flammarion's "Mars," p. 336) traces two canals flowing into the two arms of the Forked Bay.

These different aspects correspond precisely to the effect of improved "seeing," using that term in the larger sense

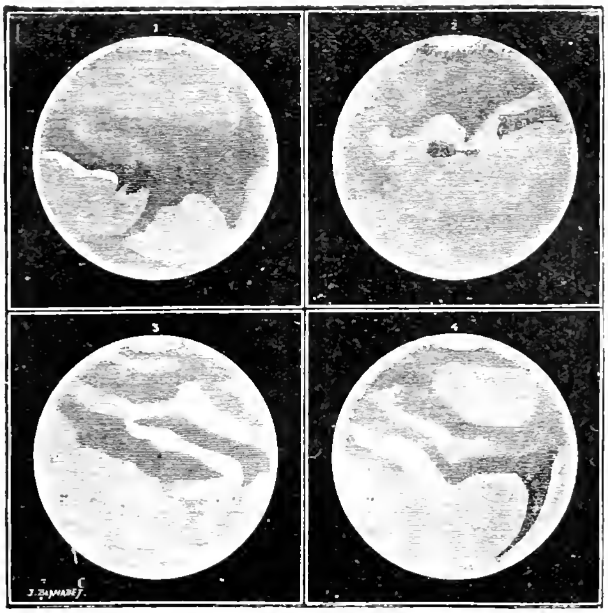


FIG. 3.—Drawings of Mars, by Green, in 1877. From Flammarion's "Mars," p. 274.

adopted above. For if a careful drawing be made of the district under the aspect which it presented to Schiaparelli in 1879, and the drawing be approached from a distance, it will assume in succession precisely the apparent phases delineated by the above-named astronomers; allowance being made for the effect of foreshortening due to the difference of presentation of the planet, and to the inevitable inaccuracies of the drawings of even the most skilful artists.

I ventured to lay stress, in my paper on "The Tenuity of the Sun's Surroundings" in the March number of KNOWLEDGE, on the fact, which we so easily overlook, that "the smallest portion of the sun's surface visible by us as a separate entity, even as a mathematical point, is yet really a widely extended area." The same truth applies in its degree to the planet Mars. We have no right to assume, and yet we do habitually assume, that our telescopes reveal to us the ultimate structure of the surface of the planet.

An illustration of this point was afforded me some time ago, when a question arose as to the limit of visibility to the naked eye of sunspots. I was astonished to find that a group of spots had been recorded as seen directly, when their total area was much less than that of many well-defined circular spots that had entirely escaped scrutiny. A few experiments convinced me, however, that the observation was perfectly correct, and that it was often possible to see a straggling group of small unimportant spots, when a single spot of considerably greater total area would be invisible.

I then tried how small an object could be detected without optical assistance, the objects being always black marks (Indian ink) on white glazed paper, illuminated by dull diffused daylight.

The limit of my vision for a circular dot ranged from a diameter of 30″ to 36″ of arc. One of 20″ was quite invisible; of 40″, distinctly seen. This was decidedly smaller than I had anticipated. But the limit for a straight line, to my surprise, was as low as 7″ or 8″; 12″ was easy and conspicuous. More than this, a pair of lines, each only 4″ in breadth, and the pair separated by say 20″, was visible as a faint single line; two lines, even of only 3″, meeting at a very acute angle, were visible after their separation had diminished below about 25″. In each case the object was unmistakably *discerned*, and appeared as a line or dot; it was not, of course, *defined* so as to be seen in its true form.

Further, a chain of dots, each of 20″, irregularly disposed along a straight line, the average interval between any two dots being three times the diameter of a dot, was easily seen as a continuous straight line, whilst a double chain of yet smaller dots, each 4″ in diameter, and the two chains some 40″ apart, was visible as a very faint continuous line.

The theoretical limit of visibility has been given as 40″ or a little greater, a limit with which the above observations are really in tolerable accord; for when the angular diameter of the object fell much below 40″ it was seen, not as a minute defined black dot, but as a grey diffused spot of about 40″ or 45″ in diameter. It would seem, then, that the smallest perceptible area is about 40″, but that if there be within any such given area a sufficiency of dark markings, however individually minute, to turn the white to a decided grey, then that area will be visible as a grey spot. Two lines or a number of dots, easily visible as one object when close together, can readily be made invisible by a greater angular separation.

It seems to me that these rough experiments have a decided bearing upon the "canal system" and the supposed changes of Mars. It seems a violent hypothesis to call in inundations extending over many thousands of square miles to account for merely temporary changes, for sooner or later the old districts take on the old configuration, more especially since, as I have already shown, the meteorology of Mars must necessarily be a languid one. Indeed, it may happen that whilst several independent observers have recorded a change, others equally skilled have seen the planet as before.

But if what we see is not the ultimate structure of the planet's surface, if, especially in the half-tone regions, like the De la Rue Ocean, we have an intermingling of minute areas of dark and light—be they water and land, forest and bare rock, prairie and sandy desert, or what you will—it is easy to see how enormous changes may apparently occur in a very little time. What we actually see is a greyish spot, contrasted with dark spots but little darker than it is, and with bright spots but little brighter. What is required, then, in the observer is not so much keenness of vision to detect minuteness of detail as power to appreciate delicate differences of tone. And the formation or dissipation of thin cirrus cloud above such a half-tone district will readily make it indistinguishable from one of the "continents," or from one of the "seas," as the case may be: cloud on Mars necessarily taking the form of our lightest and highest terrestrial clouds, rather than that of the densest and heaviest. When the difference of tone in two contiguous markings is but small, but a little defect in the transparency and steadiness of our own atmosphere will be sufficient to render them indistinguishable.

It is easy to see, if these causes are the principal reasons for the apparent changes on the planet, that different markings will have two or three forms under which they present themselves, but will not pass through an indefinite number of changes. This is actually the case in more than one locality. To take perhaps the best authenticated case, the marking to which reference has already been made, Herschel II. Strait is sometimes closed at its western end, and sometimes open, its southern shore being then a cigar-shaped island. The first sketch in Fig. 3, from Mr. Green's fine series of drawings, made at Madeira, in 1877, illustrates the latter phase; so do also the first, third, sixth, and seventh of M. Guillaume's sketches in Fig. 4. But more frequently the Phillips Island of Green's chart is seen, not as an island, but as an elbow-shaped promontory—the Deucalionis Regio of Schiaparelli.

The rough little experiments to which I have alluded may, I think, throw some light on the "canal system." It must not, of course, be imagined that a power of 100 on Mars when 20″ in diameter will show it with equal distinctness to the moon as seen without telescopic assistance; nor, if a line 8″ in breadth be visible to the naked eye, will a power of 400 show a line 0·02″ in breadth on Mars, even in the steadiest air. To begin with, all the contrasts on Mars are subdued. Then, the gain by increasing the power of the eyepiece is always less than the numerical ratio of the magnification, till a point is reached when it vanishes, either on account of optical limitations, defects of the instrument, or atmospheric conditions. But a narrow dark line *can* be seen when its breadth is far less than the diameter of the smallest visible dot. Further, a line of detached dots will produce the impression of a continuous line, if the dots be too small or too close together for separate vision. There are some intimations that this may be the next phase of the "canal" question, Mr. Gale, of Paddington, New South Wales, having broken up one "canal" into a chain of "lakes" on a night of superb definition, Mars being near the zenith, and Prof. W. H. Pickering, at Arequipa, having under equally favourable circumstances detected a vast number of small "lakes" in the general structure of the "canal system."

If this be so, if the canals are, generally speaking, beyond the limit of distinct definite vision, but producing the impression of lines, it will be readily understood how it is that different observers differ so widely as to their breadth and as to their character, whether diffused or sharp. If they are too narrow to be *definedly* seen, and yet broad and dark enough to make their presence felt, this is precisely what would ensue. The apparent breadth of the "canal" would vary with the definition each observer enjoyed, and with his personal idiosyncrasies. Indeed, one man might see the veritable "canal" itself as a hard, sharp, well-defined line—if that be its actual character—whilst to another, less fortunate in his climate, his telescope, or his sight, it would only be a diffused shade.

That the "canals" are actually very narrow may be inferred from another circumstance. When Dawes discovered his "Forked Bay," he looked particularly to see if he could detect any rivers flowing into these two seeming estuaries, but found none. Now I found that I required to take the distance between the points of the "Fork" on a drawing, not as 8″, but as more than twenty times as much, as fully 3° of arc in order to see the "bay" as Dawes described it. (This may serve to show how great is the difference between defining an object and merely discerning it.) The actual distance of the points in Martian longitude is 8°. It is practically certain that if the "canals" which flow into the "Fork" had had a breadth

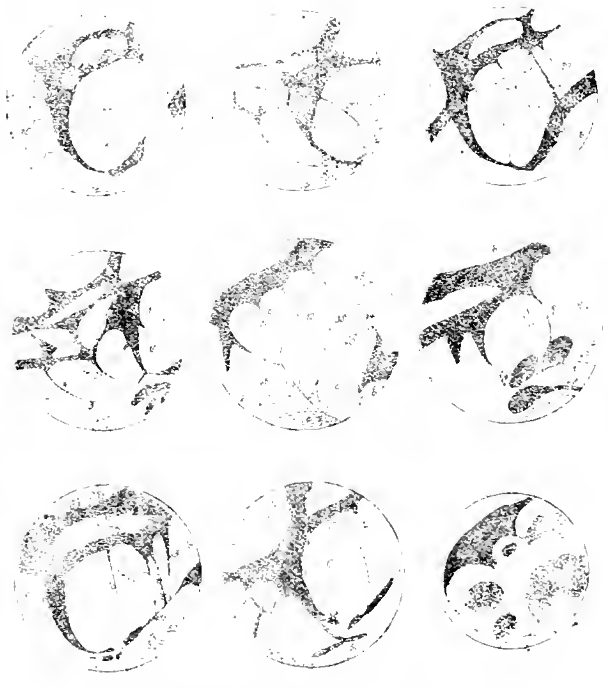


FIG. 4.—Drawings of Mars, by Guillaume, in 1890. From Flammarion's "Mars," p. 477.

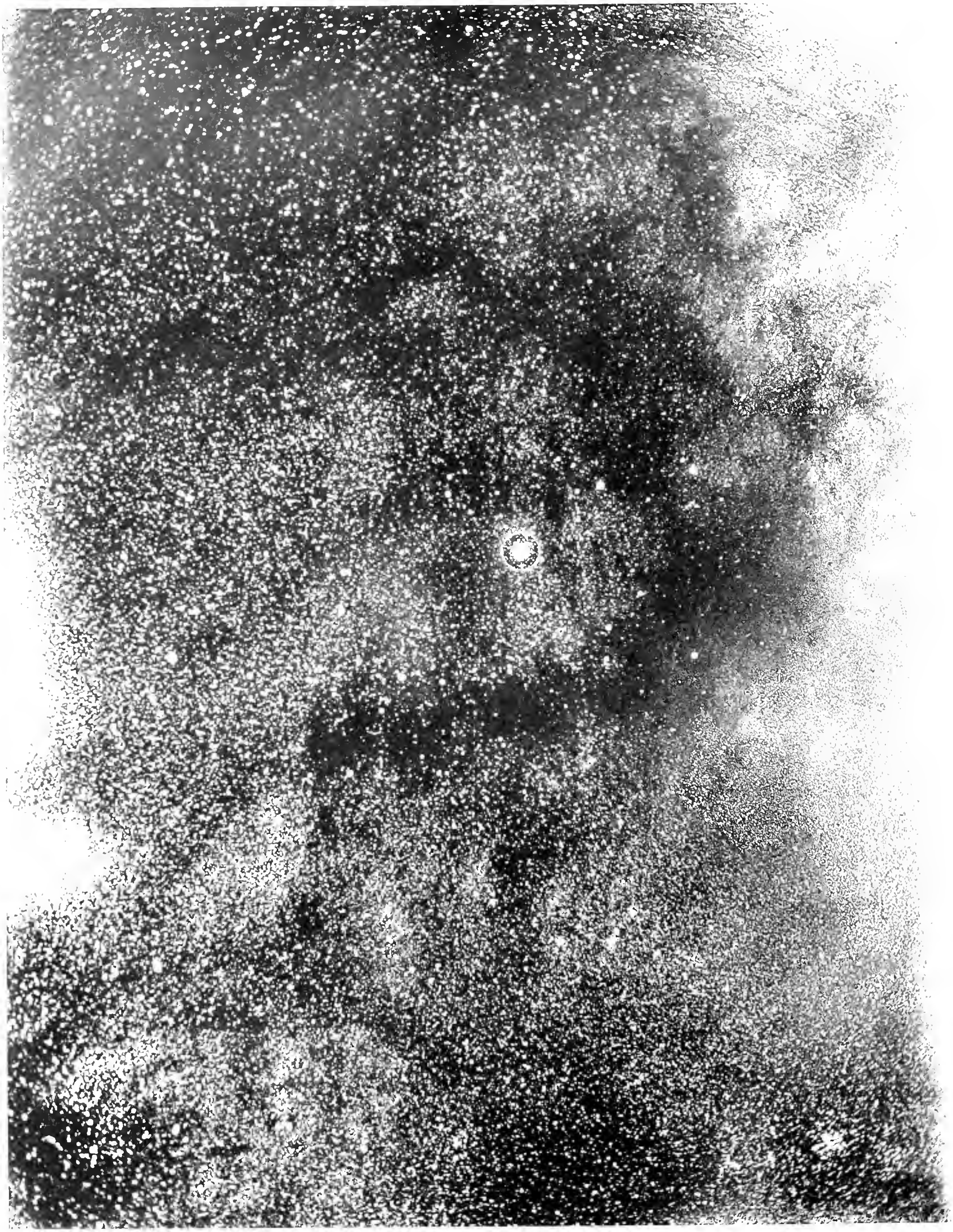
of one-sixteenth of that distance, or 0·5° of a Martian great circle, Dawes could not have overlooked them, provided the "canal" was as dark as the "bay." I am inclined to think that the actual breadth of the rank and file of the "canals" cannot exceed this limit, if they are truly continuous lines, and as dark in tint as the "seas." If they are fainter than the "seas," or discontinuous, then they must make up in breadth what they lack in darkness or continuity. Their angular breadth in a favourable opposition would then be about 0·1″, and they would be beyond the limits of *defined* vision, except on the rarest occasions.

The disappearance, reappearance, and duplication of the "canals" would easily explain themselves. If my theory is correct they are all always present, both the "canals" and their duplicates, but being so close to the limit of vision, a trifling circumstance will bring them within it, or remove them without it. Suppose we take the popular opinion that they are watercourses, then an increase in breadth no greater than our own rivers frequently show, an increase of turbidity, or a greater transparency in the atmosphere above a "canal," will bring one ordinarily invisible into view.

Whether this be so or not, I should like once again to emphasize what I feel to be an important point, not only with regard to the sun and to Mars, but to all the planets. We cannot assume that what we are able to discern is really the ultimate structure of the body we are examining.

NORTH.

WEST.



EAST.

REGION OF THE MILKY WAY NEAR ζ OPHIUCHI.

From a Photograph by Prof. E. E. Barnard taken at the Lick Observatory, July 6th, 1894, with an exposure of 3h 35m.

STRUCTURE OF THE MILKY WAY.

By Prof. E. E. Barnard and A. C. Ranyard.

I SEND to Knowledge a photograph which I have recently made with the 6-inch Willard lens. The picture is in

$$\alpha = 17h.\ 15m.$$
$$\delta = -25^\circ,$$

and was made July 6th, 9h. 30m.—13h. 5m., 1894, Standard Pacific time.

This picture shows the remarkable structure of that portion of the Milky Way near θ Ophiuchi—the large star near the middle of the plate. This is a very obscure region to the naked eye, made especially so by the great clouds to the east and south-east of it. It is essentially a region of vacancies. There is a great chasm here in the Milky Way which sweeps from the east of θ Ophiuchi, under it south, and then westward. Theta itself is in a region of stars and nebulosity. I would, however, question this nebulosity, as it may be only areas of very small stars. There are two peculiar narrow, interrupted vacancies running north and south on each side of θ; the western of these passes quite close to the star. About 2° north of θ is a singular small S-shaped vacancy, which is a very remarkable and striking object.

It will be noticed that in many of these vacancies there are "deeper depths" yet, which almost suggest that the appearance of diffused nebulosity over the region is real nebulosity, and that these dark and black places in it are thin places and actual holes.

This picture, taken in connection with Mr. Wesley's interesting paper in August Knowledge, will give much food for thought and speculation. I have no doubt Mr. Ranyard will be able to discuss this photograph in his usual thorough style, so I shall leave it with these brief references.

Mount Hamilton, August 20th, 1894.

The dark vacant areas or channels running north and south, in the neighbourhood of the bright star at the centre of the picture referred to by Prof. Barnard, seem to me to be undoubtedly dark structures, or absorbing masses in space, which cut out the light from a nebulous or stellar region behind them. On the glass positive sent by Prof. Barnard several of such dark areas or dark channels are recognizable in different parts of the photograph. There are three nearly parallel dark channels to the east of θ Ophiuchi, which throw out curving branches on either side, which are well shown in our plate. They appear to me to spring from the great dark chasm or rift which sweeps from the east of θ Ophiuchi to the south, and then under it to the westward. It seems to me that these dark structures most probably spring from the great rift, because the lateral branches all diverge in a direction away from the rift, and there is a resemblance in their spreading heads to the forms which solar prominences assume as the outrushing matter from the sun expands and suffers resistance from the medium into which it is projected. Several smaller dark channels may be traced diverging from different parts of the great rift: one from near its western end stretches downwards into a very complicated head, with diverging narrow branches.

It is comparatively easy to conceive of a narrow stream of dark nebulosity or foggy matter cutting out the light of a uniform background; while if the narrow dark regions correspond to thin places or holes in the nebulosity, they must be holes or thin places extending in a direction away from the earth. The probabilities against such a radial arrangement with respect to the earth's place in space seem to my mind to conclusively prove that the narrow dark spaces are due to streams of absorbing matter, rather than to holes or thin regions in bright nebulosity.—A. C. Ranyard.

Science Notes.

Mr. Richard Inwards delivered an interesting presidential address to the Meteorological Society on "Some Phenomena of the Upper Air." He described the experimental balloons which have been sent up in France by M. Hermite, carrying instruments so contrived as to register the various changes of condition through which the balloon passes. The results are most instructive. It appears that one of these balloons rose to a height of ten miles, when the pressure of the air was only 4·1 inches of mercury and the temperature −104° F. Though there are considerable variations in the temperature gradient below twelve thousand feet above the sea level, it seems that above that height the temperature decreases pretty regularly, falling one degree for every rise of three hundred and thirty feet into the air.

Our cup of tea hitherto has come to us as an unquestionable oriental, a thing unique in the flavour of the far East that it brings with it. But soon, it seems, all that will be changed, for America has discovered that she can grow tea as good if not better than that of India or China. Through private enterprise, aided by the Government, tea, reported by experts to be of very fine quality, has been most successfully grown at Pinehurst, near Charleston, U.S.A., and there seems to be no reason why its cultivation should not quickly become general in many districts.

In the chemistry section of the British Association, Prof. H. B. Dixon, in his opening address, gave an entertaining historical account of Oxford chemistry. After Boyle left in 1668, the impulse he had given to its study gradually died out. In 1683 we are informed that "the Oxford elaboratory was quite finished." In 1708 Richard Frewin is described as being Professor of Chemistry there. Uffenbach, after a visit to Oxford about that time, says he found the stoves in fair condition, but everything else in the "elaboratory" was in dirt and disorder. Frewin must have been a man of great facility, for in 1727 he was elected Camden Professor of Ancient History. Whether he still looked after the elaboratory, or whether it went professorless, is not stated. At all events, Frewin must have been a conscientious man in his way, in spite of that suggestive fact about the stoves, for on his election to the chair of History he seems to have made a genuine attempt to become familiar with the new subject, and we are told that he at once expended one hundred pounds in books on chronology and history to fit himself for his duties. The occupation of the chair of Chemistry seems in those days to have been mere by-play in the career of a man. Richard Watson, who ultimately became Bishop of Llandaff, was in 1764 appointed Professor of Chemistry at Cambridge. We are told that he knew nothing at all of chemistry; he had never read a syllable nor seen an experiment. So on his election he sent in a hurry to Paris for an "operator," and set to work in his laboratory. Clearly in those days there could not have been quite so much to learn as now, for fourteen months after we find him lecturing to a large audience.

The Physical Society is about to follow the example of the Chemical Society, and in January next will commence to publish a monthly pamphlet of abstracts of papers appearing in the principal foreign journals devoted to physics. There is an urgent need for a publication of this kind in each department of experimental science.

Prof. Burnham writes:—"A few weeks ago Messrs. Clark tried the new Yerkes 40-inch objective on stars for the first time. The result was very satisfactory. Alvan Clark thinks that this will be, when finished, the best large objective ever made. I hope to get off to New England in a week or two, and if the weather is good I shall have a chance to look through it."

Notices of Books.

The Rise and Development of Organic Chemistry. By Carl Schorlemmer, LL.D., F.R.S. Revised edition by Arthur Smithells, B.Sc. (Macmillan and Co., 1894.) This valuable book has long been out of print, though French and German translations of it have appeared in 1885 and 1889. Shortly before Prof. Schorlemmer's death he commenced to make corrections and additions for a new English edition, sending the manuscript to his old friend and pupil, Prof. Smithells, for correction in English. The book was not proceeded with very far when Prof. Schorlemmer died, and Prof. Smithells has since, at the request of the executors, completed it, and has added a most appreciative biographical notice of his friend. Carl Schorlemmer was born at Darmstadt in 1834. He commenced his working life in an apothecary's shop; his schoolfellow, Dittmar, had become assistant to Bunsen at Heidelberg, and, inspired by contact with Bunsen, Schorlemmer soon decided to give up pharmacy and devote his life to scientific chemistry. In 1859 he became assistant to Prof. Roscoe at Owens College, Manchester, and was soon, at Prof. Roscoe's request, appointed to a separate chair of Organic Chemistry.

We have received the following books, &c., for notice:—

Ponds and Rock Pools: with Hints on Collecting for and the Management of the Micro-Aquarium. By Henry Scherren. (Religious Tract Society.)

The Complete Poetical Works of Constance Naden. (Bickers & Son.)

Popular Astronomy. By Camille Flammarion, translated from the French by J. Ellard Gore, F.R.A.S., &c. (Chatto & Windus.)

A Laboratory Manual of Physics and Applied Electricity. By Ed. L. Nichols. Vol. II., Senior Course. (Macmillan & Co.)

Edible and Poisonous Mushrooms. By M. C. Cooke, M.A., LL.D. (S. P. C. K.)

Our Secret Friends and Foes (Micro-Organisms). By P. F. Frankland, Ph.D., B.Sc., F.R.S. (S. P. C. K.)

Fruit Culture for Profit. By C. B. Whitehead, B.A. (S. P. C. K.)

Text Book of the Diseases of Trees. By Prof. R. Hartig. English translation. (Macmillan & Co.)

Manual of Physico-Chemical Measurements. By W. Ostwald. English translation. (Macmillan & Co.)

From the Greeks to Darwin: an Outline on the Development of the Evolution Idea. By Henry F. Osborn, D.Sc. (Macmillan & Co.)

The Slide Rule: a Practical Manual. By Chas. N. Pickworth. (Emmott & Co., Limited.)

Photo-Micrography. By Dr. Henri Van Heurck, translated by W. E. Baxter, F.R.M.S., F.G.S. (Crosby Lockwood & Son.)

Fallen Angels: a Disquisition upon Human Existence. By One of them. (Gay & Bird.)

From Spring to Fall: or when Life Stirs. By a Son of the Marshes. (Blackwood.)

Amphioxus and the Ancestry of the Vertebrates. By Arthur Willey, B.Sc. (Macmillan & Co.)

Report on Meteorological Observations in British East Africa, for 1893. By E. G. Ravenstein, F.R.Met.Soc. (Geo. Philip & Son.)

Practical Physiology of Plants. By Francis Darwin, M.A., F.R.S., and E. Hamilton Acton, M.A. (Cambridge University Press, 1894.)

The Royal Natural History. Part 12. (F. Warne & Co.)

Science for All. Part 57. (Cassell & Co.)

The Universal Atlas. Part 1. (Cassell & Co.)

Index to World's Technical and Scientific Literature. Sections I., II., and III. (Romeike & Curtice.)

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of KNOWLEDGE.

DEAR SIR,—The article by Mr. Evershed in your October number recalls some questions that I tried to answer, and some experiments made by me some twenty years ago, and which, I think, tend to confirm his conclusions.

It seemed to me that in the production of light for illuminating purposes, we were, as a Chinaman would say, "burning our house down to roast the pig." In fact, we were using a large quantity of energy in heating up bodies so as to become luminous, and getting a very small amount of that energy utilized in the production of light. It occurred to me that if it were possible to set up in the molecules of the body used vibrations of a high light-giving order only, none or only a small portion of the energy would be wasted in heat radiation.

The method of electrical excitation in tolerably high vacua seemed the most promising one to follow, and I estimated the quantity of heat produced in gases in various tubes under various conditions of vacuum and current.

For my present purpose I need only say that the heat simultaneously given off was large, and I had not produced light vibration alone by any means.

On consideration of the experiments, I could see no difference in the light and heat-giving effects between the gas electrically luminous, and what one would expect to find if the same were rendered luminous by heating in the ordinary way. I concluded that whether a gas be excited electrically, or chemically, or by ordinary heating, its vibration is of the same kind, or at least there is nothing pointing to the contrary, and my expectations had been misled by the fact that gases under electrical excitation are usually very rare, whereas when ordinarily heated they are at atmospheric pressure, or thereabouts.

The exact manner in which heat, chemical, and electric excitations act on the molecules of a gas is unknown; but is there anything to show that the result of the action of one on a gas is different in kind to that of another? I expect not. I picture to myself the molecule of a gas, at ordinary temperatures, rapidly changing its shape to a small extent, in the manner of a soap-bubble just released from a pipe: under greater excitation, at higher temperatures, I imagine waves running over its surface, and under still greater excitation, ripples on these waves. It is these waves and ripples that produce heat and light through the medium of the ether—certain waves and ripples, fitting the size and elasticity of the molecule, being predominant, hence definite lines in the spectrum of each kind of molecule. I further picture these molecules flying about and colliding. The greater the vibration of the molecules, the higher the velocity in their respective paths; and the greater the velocity, the greater the collisions and consequent vibration. Thus give your molecules an impulse of vibration, or of translation, and the result in a short time is the same.

I can confirm Mr. Evershed's experiment with iodine vapour, in part at least, although I performed the experiment from another point of view. I imagined that if an absorbing vapour were viewed from the side, a spectrum, complementary to that seen by transmission, should appear. To this end, I enclosed iodine in a small cage of wire gauze with apertures at right angles to each other. I passed the rays from a lime-light through in one direction, focussing the image of the lime in the cage so as to get the most intense illumination, and viewed the transmitted light. The iodine was then vaporized by a flame below and the usual absorption spectrum viewed, and simultaneously the vapour was examined by a spectroscope pointed at right angles to the former. I saw no complementary spectrum, but only a very faint general illumination, too faint to call a continuous spectrum. The temperature was, however, low. I put my failure to see a complementary spectrum down to the probable fact that the vibrations set up by absorption, already faint, would be communicated to molecules outside those immediately absorbing from the lime-light on their way to the eye, and so the vibrations would be frittered down to too small an extent to be visible.

The faint general illumination seen by me, and the continuous spectrum seen by Mr. Evershed, were probably due to the closeness of the molecules, which in such case have not sufficient time between collisions to settle down into their natural periodic vibrations, as in the case of a solid or liquid. Many years ago, Prof. Lockyer showed the widening of the lines of hydrogen by increase of pressure, and Mr. Evershed's experiment with sodium vapour points to this explanation.

Owing to the large number of different periods in which the iodine molecule can vibrate, as evidenced by its absorption spectrum, it would appear probable that a less density of the vapour under examination would be necessary in order to give its specific spectrum than in the case of sodium, with its more simple vibrations.

Yours truly,

Rugby. G. M. Seabroke.

[Mr. Seabroke's experiments on the radiation from vacuum tubes electrically excited appear to show, as he says, that there is no essential difference in the radiation of a gas, whether it is produced electrically or otherwise. It is probably entirely a question of temperature, or, for any given substance, molecular velocity, and it appears to me that all ordinary cases of gaseous radiation can be explained in this way without resorting to the hypothetical phenomenon called "luminescence." Thus Prof. Smithells has shown that, in the case of flames tinted with metallic salts, where the radiation exceeds that of a perfectly black body raised to the average temperature of the flame (for the rays special to the metal or salt), this so-called "luminescence" of the salt may be really due to the fact that the *average* temperature is very much lower than the temperature of such molecules in the flame as are in the act of combining; and that the intense radiation, therefore, may after all be merely a heat effect, the extremely high temperature of the combining molecules being communicated to a certain proportion of the salt molecules. With regard to the iodine radiation, I do not think it is simply a question of molecular aggregation acting in the way Mr. Seabroke supposes. I have observed the iodine emission spectrum under a variety of conditions as to density, but in no case can I get any indication of a discontinuous emission, and think that this can only be obtained with higher temperatures than I have hitherto employed.—J. Evershed.]

GLOBULAR STAR CLUSTERS.

To the Editor of Knowledge.

Dear Sir,—With reference to your remarks on my paper in the October number of Knowledge, in which you say that my views carry us "back to the old theory, that clusters and nebulæ are distant galaxies, outside and unconnected with the Milky Way," I would like to say that I do not believe that the clusters and nebulæ are external galaxies. On the contrary, I say in my paper, "Judging, however, from the average distance recently found for stars of the first and second magnitudes, the distance of ordinary stars of the fourteenth magnitude—on the supposition that they are of the same size and brightness, and that their light is simply reduced by distance—would be about ten times greater than that found above for Omega Centauri." This, I think, clearly implies that I consider the globular clusters to be included within the limits of our sidereal system. If any external universes exist, which seems probable, I do not think that any of them are within the range of our largest telescopes. These views I have already expressed in my "Visible Universe."

That some of the brighter stars may be many times larger than the sun I admit, but that bodies of the size of the earth should retain for ages their solar brilliancy seems to me very improbable. Some of the fainter stars in the Pleiades may lie far beyond the cluster itself.

Yours faithfully,

J. E. Gore.

[The way in which star clusters are distributed in the heavens along the stream of the Milky Way, shows that star clusters are intimately associated with the Milky Way, and that they are at about the same distance from us as the nebulous stream. Herschel's "flat grindstone theory" of the structure of the Milky Way has, I think, now been very generally abandoned by modern astronomers, and the generally received idea is that the Milky Way stream has probably a roughly circular section, so that the most distant stars in the stream are probably not fifty per cent. more distant from us than the nearer stars in the stream.

If one part of the nebulous stream which encircles the heavens were ten times as far removed from us as another, we should expect to find the more distant part appearing narrower or fainter by reason of its distance; but there is no very great difference in the general breadth or brightness of different parts of the Milky Way stream. It seems therefore probable that the nebulous ring is not very far from circular, and that the earth is not very far removed from the centre of the ring; that is, one part of the stream is probably not two or three times as far removed from us as another. We cannot, therefore, assume that star clusters which are closely associated with the nebulous stream, or are distributed along its borders, are some of them ten times as distant from us as others.

Mr. Gore's reasoning with regard to the smallest conceivable size of luminous star depends upon the assumption "that they retain for ages their solar brilliancy"; but man has only observed them for a few years, and we have no evidence that they are not rapidly cooling and were not raised to incandescence by a comparatively recent collision. —A. C. Ranyard.]

HOW NOXIOUS GASES AND VAPOURS FROM ALKALI AND OTHER WORKS ARE UTILIZED.

By George McGowan, Ph.D.

Blue-books and reports generally are not always considered light and fascinating reading, but anyone who is interested in the progress of manufacturing chemistry will find much to repay him in a perusal of the "Report on Alkali, etc., Works" for last year (the thirtieth annual report), which was presented in the spring to the Local Government Board and to the Secretary for Scotland by the Chief Inspector, Mr. A. E. Fletcher. The heading "Alkali, etc., Works" comprises not merely alkali works proper, and works for the preparation of sulphuric and other common acids, but also those for tar distillation and for the manufacture ot cement, sulphate of ammonia, chemical manures, Venetian red, barium compounds, lead deposit, white arsenic, nitrate and chloride of iron, felt, zinc, etc. As a matter of fact, only a small minority of the works on the register are alkali works. It would, of course, be quite impossible to give within the limits of this article anything like a detailed account of the important work in which Mr. Fletcher and the other inspectors who are associated with him are engaged, but a few of the salient points in his report may be referred to with advantage.

To begin with, there are now no less than 1016 works of the above kind registered in England, Ireland and Wales, and 127 in Scotland; and in these 1703 distinct processes of manufacture are carried on which come under the Act of 1892 (*i.e.*, 1495 in England, Ireland, and Wales, and 208 in Scotland). In the course of last year 5332 visits were made to the various works by the inspectors, and 4974 tests were carried out. "The tests above referred to are the results of exact chemical determinations made of the amount of acid gas or other matter in a measured volume of the escaping air, taken either from the main culvert or, more usually, from the chimney itself. The analysis is either made on the spot by the help of portable apparatus arranged for the purpose, or the collected material is taken home for examination." The public generally will be glad to hear that "the amount of noxious gas (escaping), though now much below that of the legal standards originally imposed, still gradually diminishes year by year."

Take first the case of hydrochloric or muriatic acid, which is evolved in such enormous quantity in the manufacture of soda by the old or *Leblanc* method, and the escape of which, before the Alkali Acts came into operation, made the country into a desert for miles round an alkali work. By the Act it is obligatory to condense 95 per cent. of the hydrochloric acid generated—*i.e.*, the manufacturer may legally allow 5 per cent. of it to escape. But, taking the average of all such works, only 1·72 per cent. escapes in England, Ireland and Wales, and 3·32 per cent. in Scotland. This condensation has been found in the end to be greatly to the advantage of the manufacturer, from the value of the hydrochloric acid thus saved. To diverge for a moment from the subject in hand, this seems to supply an argument in favour of compulsory coal smoke consumption in works generally. The consumption of coal smoke is, of course, a much more difficult problem than the condensation of hydrochloric acid, and trade is at present not in a condition to bear unnecessary restriction or legislation; but even allowing for all this, the question is one which well deserves the practical attention of all who are interested in sanitation, affecting as it does the whole urban community more or less directly.

To return to Mr. Fletcher's report. In the two well-known methods of alkali manufacture, the newer ammonia-soda process has almost outstripped the older *Leblanc* process, so far as the production of the main article, soda, is concerned. But, as hydrochloric acid and bleaching powder are bye-products of the *Leblanc* method, while they are not obtained at all by the other, the former has maintained its ground by their help. Some seven years ago, as has already been described in Knowledge, a most ingenious scheme was worked out by Mr. Chance, of Oldbury, near Birmingham, for the recovery of sulphur from alkali waste, immense heaps of which used to be accumulated round alkali works (there being one and a half to two tons of waste for every ton of soda produced by the *Leblanc* method). This "waste" has constituted in many cases a standing nuisance, from the fact that it gradually undergoes decomposition by the atmosphere, and more quickly by the acid vapours still found to some extent in the neighbourhood of chemical works, the result being that it evolves that nauseous and poisonous gas, sulphuretted hydrogen. During the last few years many improvements have been made in this (now spoken of as the *Chance-Claus*) process. When it is mentioned that more than 5,000,000 cubic feet of mixed air and sulphuretted hydrogen (the latter being obtained from the "waste" by the above-mentioned method) are dealt with in this way every twenty-four hours at one of the larger English alkali works, when in full operation, some idea may be formed of the care required to keep the numerous stopcocks, pipes, and vessels tight—a task which is now satisfactorily accomplished. "The application of the process is now so far advanced that already apparatus for treating the whole of the tank waste of St. Helens and Widnes has been constructed. Most of that produced on the Tyne is also so treated, as is that at Oldbury and Wednesbury." About 35,000 tons of sulphur are now recovered in this way per annum. This constitutes a veritable triumph in manufacturing chemistry. And the process is susceptible of yet further improvement, as about 15 per cent. of the sulphur contained in the "waste" under treatment is still lost in the exit gases. None of it however, is allowed to escape into the atmosphere as sulphuretted hydrogen, those exit gases being mixed with air and then passed through a fire, with the result that all the sulphuretted hydrogen present is converted into the much less harmful sulphurous acid; and this latter is to some extent utilized in making sulphuric acid.

The sulphate of ammonia produced in Great Britain and Ireland amounted in 1893 to 152,762 tons (worth more than £2,000,000 sterling), an increase of almost 3000 tons over 1892. Three-fourths of this was got from the ammonia liquor of the gas works, the remainder being from shale, iron, coke and carbonizing works. The manufacture of this salt, which is of such supreme importance for agriculture, used to be most offensive, from the copious escape of sulphuretted hydrogen and other noxious gases. Mr. Fletcher now writes with regard to it:—"It is a matter of great satisfaction to be able to report that no complaint has been brought during the past year against any of these works," so much improved are the methods of treatment.

The arsenic works of Cornwall and Devonshire, where white arsenic is prepared in large quantity by roasting arsenical pyrites, were formerly the cause of frequent litigation This arose from the alleged destruction of cattle through eating grass said to have been poisoned by arsenic which had escaped condensation in the long flues used for the purpose (extending in one case to over half a mile in length). After ineffectual attempts had been made to obviate this evil by means of wash-towers, a *dry* filter made of brushwood, gorse, etc., was suggested, and this has been found to arrest almost the whole of the arsenic fumes in the escaping gases. In one case, where there was no such filter, a test of the chimney gases showed the presence of as much as 7·4 grains of arsenic in a cubic foot of the gases passing into the air, whereas, with dry filters of the kind, the average is now less than one-tenth of a grain per cubic foot.

The above remarks refer to but a few of the points, taken almost at random, in this most interesting report. Its author (or rather authors, for Mr. Fletcher's contribution is supplemented by other reports from the inspectors for the different districts) would be the last to claim that the work had by any means approached perfection. But the short sketch just given will enable the readers of Knowledge to appreciate the fact that an immense deal has already been done in the way of preventing the escape of noxious gases and vapours into the atmosphere, with a corresponding benefit to the health of the community and a large saving of valuable material. The climate of our country is too damp to allow of the air here being as clear as that of more southerly and drier regions: but we may at least look forward to the time when increased knowledge, and its judicious application, will bring about such an improvement in the air breathed by the people of our towns and manufacturing districts as to make life in these both pleasanter and healthier.

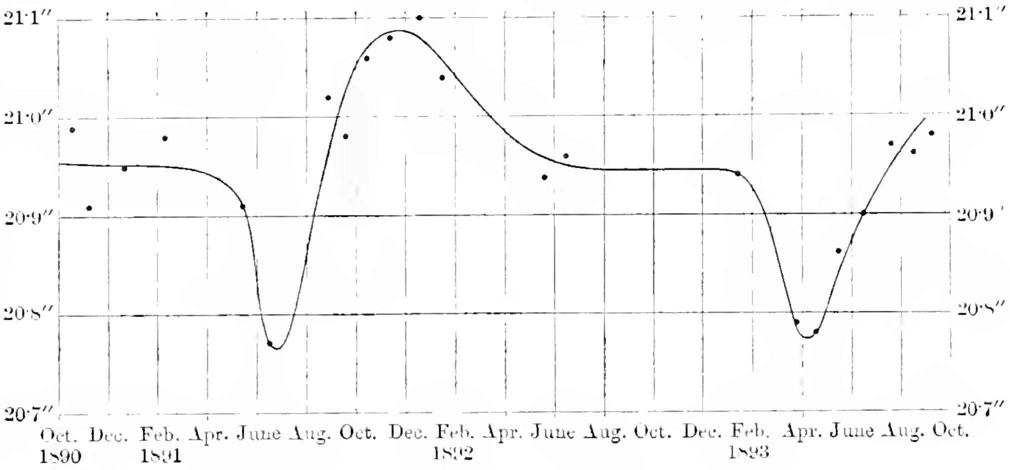
A CLASSIC DOUBLE STAR.

By Miss A. M. Clerke, *Authoress of "The System of the Stars" and "A Popular History of Astronomy during the Nineteenth Century," &c., &c.*

NOT far from seventy years ago, Friedrich Struve declared that the mathematical probability of a physical connection between the stars of 61 Cygni was actually greater than that of the sun rising the morrow morn. Yet these "odds beyond arithmetic" possibly misled him. It cannot, indeed, for a moment be supposed that the luminaries are of independent origin, or have had independent histories. Their common proper motion—the largest belonging to any known compound object—of itself establishes a close tie between them: it has, moreover, been learnt, since Struve wrote about them in 1827, that their apparent vicinity is real, their parallaxes being sensibly the same; finally, they are both yellow stars showing a spectrum of the second type. Their photometric magnitudes are 5·5 and 6·3.

Our records of them go back to 1753, when Bradley noted their separate transits; and an ample store of accurate determinations of their distances and position-angles has been collected since 1825. Yet no certainty has yet been obtained that they form a true binary system. They possess, as a matter of course, a certain amount of relative motion, otherwise nothing could prevent their falling together; it shows, however, no sign of the anticipated orbital character. The stars apparently travel along right lines, inclined to each other at an angle of about two degrees, the smaller with a velocity slightly inferior to that of the larger. The inference that they were separating never to be reunited was arrived at by Captain Jacob as early as 1858; and a fresh discussion, after sixteen further years of observation, led M. Flammarion to the same conclusion. Nevertheless, orbits for the pair, based no doubt in part upon illusory observations, were calculated in 1883 by Mr. Mann, of Rochester, New York, and in 1885 by the late Dr. C. F. W. Peters; but neither of them claims any longer a shadow of authority. At the same time, Prof. Hall's opinion, founded upon determinations made by him at Washington during the years 1879 to 1881, is slightly in favour of the star's binary nature; and an attempt to fix the centre of gravity of the system gave 3·4 to 1 as the proportion of the masses of its components. But no indications whatever of a definite orbit could be traced. Mr. Burnham, on the other hand, has no doubt that the march of both stars is absolutely rectilinear; that they are separating, and will continue to separate; and that the evidence of their present conjunction must, in the distant future, become wholly obliterated. If this be so, they were formerly much closer together than they now are, and each must, in all probability, have executed a hyperbolic sweep round their common centre of gravity. This little adventure might not be inconsistent with the state of things sketched out by Prof. Newcomb, since we are acquainted with comets which—without finally renouncing their allegiance to the sun—have described hyperbolas round Jupiter. Not that the two cases bear detailed comparison; but their likeness, though elementary, is instructive.

"The only conclusion open to us," remarked the last-named authority in connection with Mr. Burnham's verdict regarding the status of these stars, "is that each of them describes an immense orbit, which may be several degrees in apparent diameter, and in which the time of revolution is counted by thousands of years." An enormous mass would, however, be needed in order to control the velocity of 61 Cygni. For here an important distinction comes in. Only the small *relative* motion of its components has to do with determining the nature of their association; but the swift movement which they share must be accounted for in any attempt to divine the organization of a grand system including them as co-equal members. Their high rate of



Wilsing: Changes in Distance of the Components of 61 Cygni.

speed constitutes in itself a formidable problem. That part of it alone which lies across the line of sight amounts to thirty-five miles a second, or nearly twice that of the earth in its orbit. This, according to Prof. Newcomb, is beyond what can be swayed into a closed path by the gravitative force of the entire sidereal system; in other words, 61 Cygni must be reckoned a "runaway pair." Unless, indeed, a single mass comparatively close at hand be effective where the innumerable scattered bodies of stellar space are impotent. It may be worth while to take a glance at the conditions involved in this hypothesis.

Assuming 61 Cygni to revolve round a local centre in a period of ten thousand years, it follows, from the elementary principles of celestial mechanics, that the radius of its orbit, supposed to be circular, would be about 1752 thousands of millions of miles, while the mass occupying the centre would exceed that of our sun two and a third million times. The presence, however, of such an immense gravitative power, even if lodged in an obscure body, would assuredly betray itself otherwise than by the proper motion of one luminous couple. The sphere of its pre-eminent influence might well be twenty billions of miles in diameter, within which incomprehensibly vast region tides of movement should be raised, neither inconspicuous nor difficult of interpretation. But no such effects are traceable. The inference is irresistible that no obscure centre of overwhelming power exists in that neighbourhood; consequently, that the motions of 61 Cygni must be otherwise accounted for.

Now, however, a further complexity has been added to this already complex problem.

In the middle of 1889, as the upshot of a keen scrutiny with powers up to 1000 on the Lick thirty-six inch, Mr. Burnham recorded both the stars of 61 Cygni to be undoubtedly single. It is unlikely that they will ever appear otherwise. Nevertheless, one at least of them owns an attendant by no means insignificant in mass. That is to say, the evidence of this being the case is very strong; it would be premature to assert it to be conclusive.

The thirteen-inch International photographic refractor of Potsdam was placed by Dr. Vogel, in the autumn of 1890, at the disposal of Dr. Wilsing for the purpose of some experimental researches into stellar parallax; and, almost as a matter of course, their chosen object was 61 Cygni. Yet, the proved accuracy of the measures notwithstanding, only anomalous results were obtained. Now an anomaly often gives the clue to a discovery, and Dr. Wilsing soon found himself on the track of a curiously interesting one. His measurements were executed from the middle point of the line joining the stars under examination to two comparison stars, one situated nearly in the prolongation of the same line, the other at right angles to it. The parallaxes derived from both ought, of course, within certain narrow limits of error, to have been the same; yet they differed consistently and notably. After other tests had been applied in vain, direct determinations were carried out of the distances separating 61_1 from 61_2 Cygni at various successive intervals of time. And here at last the secret of the observed perplexing inconsistencies was found to lurk. The stars, it seems, alternately approach and recede from each other, in a period of twenty-two months, by the total angular amount of three-tenths of a second—a gross quantity in an investigation of so delicate a character. The fashion of this change, so far as it has yet been made known, is shown in the accompanying drawing by Dr. Wilsing. It will be observed that the swing backwards of the stars is much more quickly performed than their swing forwards, and this obviously through no accidental errors of measurement, but as a distinctive feature of the systemic movements unexpectedly betrayed. These, as Dr. Wilsing pointed out on the 26th of October, 1893,* must be due to the presence of one or more obscure companions to the bright stars. In due time we shall doubtless learn which suffers disturbance, or whether both alike are composed of a shining and an obscure body. In the latter case, the argument in favour of their permanent physical union will be strengthened beyond contravention.

The spectrograph will afford the surest criterion of the genuineness of Dr. Wilsing's discovery. Up to this, nothing has been ascertained regarding the motions of 61 Cygni in the line of sight. Its rays are too scanty, unless concentrated by a very powerful telescope, to afford satisfactory information on the point. None of the Potsdam instruments are adequate to the purpose; but with the Pulkowa thirty-inch, perfectly definite results ought to be attainable. A complete set of spectral photographs of both stars, with iron-lines for comparison simultaneously imprinted on the plates, seems a primary requisite for the pursuit of this important inquiry. The line-shiftings legible on them would possess a particular significance. It is, indeed, probable that the multiplicity of 61 Cygni might have been detected by the spectroscope alone. For the plane of the minor orbits traversed by some of its components appears to lie along the line of sight from the earth; and twice in every revolution, accordingly, nearly the whole of their velocity in those orbits—amounting probably to six or eight miles a second—must be directed towards or away from the earth. It is thus permissible to hope that many of the intricate questions relating to our classic double star are on the eve of receiving definitive replies.

THE KONISCOPE.

By Dr. J. G. McPherson, F.R.S.E., *Lecturer on Meteorology in the University of St. Andrews.*

Mr. John Aitken, F.R.S., has just given us the results of some careful observations on colour phenomena connected with cloudy condensation, and an account of his new instrument, for detecting the impure state of the air in rooms by means of colour alone, may be interesting to readers of Knowledge. No more painstaking or persevering physicist lives than the discoverer of the now acknowledged theory of the formation of dew. He has elucidated the formation of fog particles by the attraction of dust for water vapour, and has enumerated the particles of dust in a cubic inch of air, and this is another example of his assiduity and success.

If steam be blown into the air inside a glass vessel, the cloudy condensation will in time undergo a change. Of course, the dust particles in the air have seized hold of the water vapour of the steam to form visible steam particles, each dust atom forming a free surface for the adherence of the moisture. Particles fall and leave the upper part clearer, and particles fall to the bottom also. Yet the principal cause of the thinning change is in the smaller particles becoming absorbed by the larger ones. The smaller drops begin to lose their accumulated moisture, while the larger ones are still increasing in size, growing at the expense of the gradually diminishing smaller ones. In the end a comparatively small number of drops have absorbed the moisture which was previously distributed

* *Sitzungsberichte der Berliner Akademie der Wissenschaften*, xl., 879.

over a vast number of particles. The larger particles have devoured the smaller, and inanimate cloud particles have been struggling for "the survival of the fittest."

Steam escaping into the air has been observed to be coloured when seen against the sun. Sometimes in that case the sun appears like silver (light blue), blue or green. Mr. Lockyer saw the sun look vivid green through the steam of a little paddle-boat on Lake Windermere. Though the shadow of an ordinary steam jet on a white screen is nearly colourless, yet when it is electrified the shadow becomes of a dark orange-brown colour.

In studying the subject, Mr. Aitken has enclosed the steam jets in tubes. For a jet from a nozzle of one millimètre bore, a tube of seven centimètres diameter and about fifty centimètres long is employed. The steam nozzle should be placed outside the tube and a little to one side, so that the eye can be brought into a line with the axis of the cylinder. This is a beautiful experiment. When the amount of steam, dust, and other conditions are properly proportioned, the colours seen through the tube are very attractive. With ordinary condensation the colour varies from a fine green to lovely blues of different depths. The pale blues equal any sky blue, while the deeper blues are finer than the dark blues seen in the sky, as they have none of the cold hardness of the dark sky blues, but have a peculiar softness and fulness of colours.

Suppose, now, the tube is fitted up pointing to a clouded sky, and that the steam jet, under slight pressure, is blowing through it. If the exit end of the tube be open, very little colour is visible; but if the end of the tube be partially closed with a glass plate to prevent a draught, the tube looks as if filled with a transparent coloured gas. The first decided colour is generally green, then blue of different shades.

If, now, the number of the dust particles in the tube be increased, or the pressure of the steam be increased so as to command some negligent dust particles to seize the moisture and add to the number of cloud particles, thereby making the steam more dense, then the colour seen through the tube also changes. If the colour was green, it now becomes deep blue; and if the ordinary condensation gave blue, the dense condensation (a strange but unavoidable connection of words) produces a dark yellowish-brown. But between the blue and the yellow there is always an intermediate stage, when all colour disappears and the light is simply very much darkened. Condensation of the denser kind may be also produced by passing a flash of electricity through the jet, by a supply of cold air, or by placing an obstruction in front of the nozzle; for there are five ways of producing a denser form of condensation of steam.

From this it is seen that the colour produced by the small drops of water depends on the size of the drops, and the depth of colour on their number. The most probable explanation of these colour phenomena is that they are produced in the same way as the colours in plates, somewhat after the manner Newton thought the colour of the sky was produced. The order of succession of the colours in thin plates is the same as in these condensation phenomena. As no white follows the first blue, it seems probable that the first order of colours is not observed; that the two generally seen are the second and third.

These colour phenomena placed in Mr. Aitken's hands an easy and simple way of estimating, in a rough but useful way, the number of dust particles in the air of our rooms, and sanitary officers might with advantage employ the convenient apparatus. And Mr. Aitken invented the koniscope for the purpose. *Konis* is the Greek for dust, and *skopeo* means "I see"; so the instrument is for detecting the quantity of dust in air by sight—in fact, by the colour observed in the fog produced in the air by artificial means. The instrument consists of an air pump and a metal tube with glass ends (about the size of the one above described in the experiments). Near one end of the test-tube is a passage by which it communicates with the air-pump, and near the other end is attached a stopcock for admitting the air to be tested. Wet blotting-paper is attached to the inside, to make more uniform the field of colour. The instrument is not nearly so accurate as the dust-counter, but it is cheaper, more easily wrought, and more handy for quick work. All the grades of blue, from what is scarcely visible to deep black-blue, are attached alongside the tube on pieces of coloured glass, and opposite these colours are the numbers of dust particles in the cubic centimètre of the similar air, as determined by the dust-counter. While the number of particles was counted by means of the dust-counter, the depth of blue given by the koniscope was noted, and the piece of glass of that exact depth of blue attached. A metal tube was fitted up vertically in the room in such a way that it could be raised to any desired height into the impure air near the ceiling, so that supplies of air of different degrees of impurity might be obtained. To produce the impurity, the gas was lit and kept burning during the experiments. The air was drawn down through the pipe by means of the air-pump of the koniscope, and it passed through the measuring apparatus of the dust-counter on its way to the koniscope. It may be remarked that by a stroke of the air-pump attached to the koniscope, the air within the test-tube is rarefied and the dust particles seize the moisture in the super-saturated air to form fog particles; through this fog the colour is observed, and the shade of colour determines the number of dust particles in the air. When by the dust-counter the number of dust particles in a cubic centimètre of the air examined amounted to 50,000, the koniscope indicated that colour was just visible; when 80,000 were counted, the depth of colour was said to be "very pale blue"; when 500,000, "pale blue"; when 1,500,000, "fine blue"; when 2,500,000, "deep blue"; and when 4,000,000, "very deep blue."

When making a sanitary inspection, the pure air should be examined first, and the colour corresponding to that should be considered as the normal health colour. Any increase from the depth would indicate that the air was being gradually contaminated, and the amount of increase in the depth of colour would indicate the amount of increase of pollution. Mr. Aitken thinks that the koniscope will be serviceable for sanitary inspectors for investigating questions of ventilation in rooms lighted with gas, and for other purposes.

As an illustration of what this instrument can detect, he gives this experiment, to show how the pollution taking place in rooms by open flames may be traced. The room in which the tests were made was 24 by 17 by 13 feet. The air was examined before the gas was lighted, and the colour in the test-tube was very faint, indicating a clear atmosphere. In all parts of the room this was found the same. A small tube was attached to the test-tube, open at the other end, for taking air from different parts of the room. Three jets of gas were then lit in the centre of the room, and observations at once begun with the koniscope. Within thirty-five seconds of striking the match to light the gas the products of combustion had extended to the end of the room; this was indicated by the colour in the koniscope suddenly becoming of a deep blue. In four minutes the deep blue-producing air was got at a distance of two feet from the ceiling. In ten minutes there was strong evidence of the pollution all through the room. In thirty minutes the impurity at nine feet from the floor was very great, the colour being an intensely deep blue.

The wide range of the indications of the instrument, from pure white to nearly black-blue, makes the estimate of the impurity very easily taken with it, and as there are few parts to get out of order, it is hoped it may come into general use for sanitary work. Mr. Aitken was quite enchanted with the beautiful colours in his preliminary experiments, but he is even more pleased at the practical benefit which the koniscope may effect when thoroughly adjusted and intelligently used.

THE CLIMATE OF THE CAMBRIAN PERIOD.

By Prof. J. Logan Lobley, F.G.S., &c.

THERE is a widely-spread impression that the state of the surface of the earth and the prevailing climatal and atmospheric conditions of pre-Quaternary geological periods were quite unlike those that now exist, so much so indeed as to be altogether unfitted for the human occupation of the planet.

The vast number of extinct organic forms revealed by palæontological investigation, and the great divergence of many from those now living, as well as the late coming in of new species, have largely contributed to produce this belief; but, perhaps, it has been most encouraged by the fact of the vegetable origin of coal, since it has been thought necessary by some writers to assume such atmospheric and climatal conditions for the production of the Carboniferous flora as would be quite inimical to the existence of man. And yet the records of the rocks conclusively establish the great fact, that not only in Tertiary and Secondary times, but also in Palæozoic times—indeed, in the earliest Palæozoic times—general inorganic conditions were very similar to those of to-day.

As has been said by a recent writer on fossils, when referring to distant geological periods, "Flesh and blood were then what they are now, and fulfilled the same functions. Bones grew then as they grow nowadays. To those bones were attached muscles, which expanded and contracted just as muscles do now. Wings were used for flying, fins and paddles for swimming, legs for walking, teeth for masticating food, just as they are now. In fact, these primitive inhabitants of the antique world, however different in bodily shape from those we see around us now, lived under the same universal laws of physiology as we ourselves do."* To this it may be added, that these animals of the past lived, too, under the same general inorganic conditions as those in which we have our being.

But this conclusion, most momentous and far-reaching though it be, seems strangely overlooked by both text-book and popular writers on geology. It may, therefore, be well to briefly emphasize the undoubted teaching of the facts presented by a study of the Cambrian rocks.

These facts are some petrological and some palæontological.

The Cambrian rocks are not only of vast thickness, but they form extensive areas both numerous and widely dispersed. In the British Islands they are conspicuous in Wales, whence they take their name, in Shropshire, Cumberland, Scotland, Ireland, and the Isle of Man; and on the Continent of Europe we find them in France, Belgium, Germany, Bohemia, and Spain, and far north in Sweden and Norway. In the western continent they form large areas in Canada, Nova Scotia, and the United States; and when we turn to the east we see these ancient rocks in far Cathay, for the Sinisian formation of China was shown by Richthofen to be of Cambrian age.

These enormous accumulations of marine sediment are of very diverse character, presenting different lithological aspects in different areas, and consisting, even in the same area, of beds of greatly differing rocks. There are great masses of sandstones, compacted and cemented aggregations of grains of quartz derived from the destruction of still older quartzose rocks, and there are also thick beds of conglomerates made up of pebbles, every one of which has been a water-rolled angular hard-rock fragment. There are, too, immense accumulations of argillaceous rocks, consisting altogether of materials derived from the decomposition of the felspar of granites or other felspathic rocks, and there are, moreover, in America, calcareous rocks, the material of which is the same as that forming those newer limestones which have been the result of organic action. Volcanic rocks, in addition, are not wanting to furnish further evidence of what were the cosmic conditions of the globe in the Cambrian period.

But over and above all this, there are markings on Cambrian sandstones identical with those now produced by waves and ripples on sheltered shores and shallow-water bottoms, as well as—and these are very significant—cracks and pittings, only ascribable to the action of the sun and rain.

Such are, briefly stated, the main petrological facts of the Cambrian rocks, and from these facts the following conclusions may be drawn:—

Since the whole of the material of which these rocks of enormous thickness and of diverse mineral character has been accumulated by the deposition of derived matter on sea-bottoms exactly as marine sediments are now being accumulated, it follows that those agencies of Nature, which are the controlling forces of the physical cosmos, were acting in the same way as at present.

Not only do we see that the matter of the globe was the same in its chemical combinations and states of aggregation as now, but that the bulk of the water of the globe was in a liquid state, and that therefore the temperature over the greater part of the earth was, as at present, between 32° and 212° Fahr.

The derivation of the material of the sediments required the erosion of land surfaces by water agency, requiring rain, which again required the atmosphere to be charged with varying amounts of water-vapour, increased at one time by evaporation and at another time diminished by condensation. Thus there was rain that formed streams and rivers on the land, that wore down and destroyed rocks, the detritus of which was transported to the sea, in all respects exactly as at present. Thus, too, there were alternations of temperature to produce alternate evaporation and condensation, and those alternations were confined for the most part within very moderate limits as now.

Clouds, too, would form, wax and wane, and, with varying densities of aggregation of the watery particles, assume those beautiful forms we know so well, and float at various elevations in the atmosphere; and when these clouds broke or dissolved, blue skies and bright sunshine would alternate with shade even as now.

Again, the air would be put in motion by the varying temperatures, and consequently winds would sweep the land and ripple the sea, waves would beat upon the shores and roll rock-fragments into smooth rounded pebbles. These winds with the rotation of the earth would take the courses they now have, and so there would be then as now trade-winds and anti-trades as well as cyclones and hurricanes, and the monsoons and calms of the tropics. There would also be ocean currents, that would mingle the waters of the

* Rev. H. N. Hutchinson, "Creatures of Other Days," p. 2.

Cambrian seas as they now bring the heated waters of the Gulf of Mexico to the North Atlantic.

Still further, the sun and moon exerting their attractive force as now would raise a tidal wave that would in the narrow seas give with its ebb broad low-water beaches, and with its flow rolling high-water waves to attack the coast-cliff bases, and still further wear and round the shingle pebbles.

Climate would vary as at present, with latitude and distribution of land and sea, and so all the conditions would be present to give graduated temperatures analogous to those that now in various lands range from tropical heat to Arctic cold.

The seas of the Cambrian period were likewise, as those of our epoch, some deep and some shallow, for both deep-water deposits and shallow-water sediments make up the Cambrian rocks.

And throughout the millenniums of the Cambrian period night would follow day and day would follow night; daylight would lengthen and strengthen, and daylight would shorten and diminish; and in the temperate zones spring, summer, autumn and winter would complete the year, while in the tropics the rainy seasons and the dry seasons would alternate as now.

These conclusions might have been drawn from even the larger and more general phenomena of the Cambrian rocks, but the beds of water-rolled pebbles, the ripple-markings, the sun-cracks, and the rain-pittings confirm such conclusions.

The palæontological evidence—that is, the evidence of fossils—is as conclusive as the petrological evidence with respect to the character of the climatal conditions of the globe prevailing during the period of the deposition of the Cambrian rocks.

Although in the oldest of the Cambrians of the Longmynds of Shropshire and of North Wales the actual remains of animals are few and obscure, yet the paired or twin perforations in the sandstones can be none other than annelid borings, that tell of the existence of sand-worms, similar to those that abound on our present shores, and so confirm the evidence of tidal beaches furnished by the ripple-marks, sun-cracks, and rain-pittings. Casts of fucoids, too, tell of marine vegetation like that now growing on sea-bottoms.

But when we examine the Cambrians of Pembrokeshire, we find remains of Crustacea of large size, and although the great family, the *Trilobitidæ*, has no representatives in our present seas, yet trilobites in their general organization so closely resembled the lobsters and crabs of the present day that they must have required a generally similar environment. Dean Buckland long since observed that the eyes of trilobites indicate that there was the full light of day when they lived. These wonderful organs of vision were sessile and compound like those of the common crab, though the lenses were round instead of hexagonal as in our crustacean side-walking friend of the sea-shore, but the facets were so numerous that as many as fifteen thousand in each eye existed in some cases. Dr. Henry Woodward thinks the eye of the trilobite may best be compared with that of *Limulus*, and that there is an analogous development of visual organs amongst some of the pelagic *Amphipoda*, the *Hyperiidæ*, and in a very singular form brought home by the "Challenger," the *Thaumops pellucida*.

In other Cambrian rocks, the Lingula Flags, are abundant remains of *Lingulella*, a genus or sub-genus of a family of Brachiopoda now well represented by the *Lingula chinensis* of eastern Asiatic seas. This is perhaps a more telling fact than the occurrence of an extinct group of Crustacea, for not only was the living body of the animal similar, and therefore suited only to similar general conditions, but the peculiar thin horny shell of the lingula of to-day was exactly represented by the shell of the *Lingulella Davisii* of the Lingula Flags, evidencing similar materials in both the Cambrian and the present sea-waters of the globe, as well as the same physiological powers for its extraction and employment by the mollusc.

Perhaps, however, even a still more striking proof of the general cosmic conditions of the Cambrian period being the same as those of the present epoch is afforded by the occurrence in Cambrian rocks of species of a family of Lamellibranchiata, the Arcidæ, now abundantly represented by well-developed and, so to speak, robust species in our English seas. As I a long time ago pointed out, the Cambrian Arcidæ and the abundance of members of the family now, give a conspicuous proof of the marvellous continuity of biomorphic types, or general organic form and structure, from early geologic times to the present; and that great as is the generally interesting character of this wonderful fact in itself, its significance or indirect teaching is exceedingly great also, for it clearly indicates the continuity of general inorganic conditions which must have existed to allow of the uninterrupted succession of generally similar organisms, all requiring, therefore, a generally similar environment for their existence and welfare, as well as for the development of the type.

From the abundant evidence thus afforded of marine organic existence living in Cambrian times as it does to-day, we cannot doubt that the composition and density of the water of the sea were practically the same as now, and that both the sea and the atmosphere had the same relations to light, the same optic powers—the same absorptive, refractive, and reflective powers—as now.

The teachings, therefore, of stratigraphical geology, both petrological and palæontological, tell us in no uncertain way that the general inorganic conditions on the surface of the globe were during the Cambrian period very much the same as they are to-day. So clear and unmistakable is the evidence that we can with great confidence picture to ourselves the ancient Cambrian world.

We can see, as it were, its lands and its seas, its spreading plains and elevated uplands, and its broad and deep seas, with their shallower bays and gulfs. On the land, too, are rushing torrents, rippling streams, and larger and smoother flowing rivers, carrying eroded material to the Cambrian ocean, fringed by sandy shores and shingly beaches. And the sky above is now an unblemished azure, now flecked with cirrus, and now dark with nimbus. Rain falls, winds blow, tides ebb and flow, and we can see the broad expanse of waters in their calm majesty or angry with storm and tempest rolling mighty waves upon the Cambrian strand, and we can think of the millions of splendid sunrisings and gorgeous sunsets, and almost feel the heat of the noontide summer sun or the cold of the midwinter night.

We can even look through the clear salt water on to the ocean bed, and see the groves of algæ, with the trilobites and molluscs peopling those ancient seas, while along their coasts volcanic fires at intervals break forth, and lavas are outpoured that cover the surrounding rocks with basaltic or trachytic coatings.

But save for these volcanic outbursts, the crash of thunder, and the roar of wind and wave, a silent world it was. No lowing herds or roaring beasts of prey were on the land, and no birds sang their songs either on tree-top or high upon the wing. And how desolate was the unnavigated sea, for whales and porpoises, seals and sharks, and flying-fishes were not in its waters, and no sea-bird's mew was heard, for no stormy petrel, gull, or penguin was upon its surface.

This is no fancy picture of a world of the imagination, but a picture of an actual world, a world that has been, a world that lasted millions of years, and a world that, unlike the airy fabric of a vision, has left many wrecks behind.

THE FACE OF THE SKY FOR NOVEMBER.

By Herbert Sadler, F.R.A.S.

Sunspots and faculæ show few signs of decrease. Conveniently observable minima of Algol occur at 0h. 11m. a.m. on the 8th, 9h. 0m. p.m. on the 10th, 5h. 49m. p.m. on the 13th, and 10h. 42m. p.m. on the 30th.

Mercury is not favourably situated for observation during the first half of the month, being too near the Sun. After this date his position rapidly improves. On the 19th he rises at 5h. 47m. a.m., or 1h. 40m. before the Sun, with a southern declination of 12° 54′, and an apparent diameter of 8·2″, $\frac{28}{100}$ths of the disc being illuminated. On the 24th he rises at 5h. 37m. a.m., or nearly two hours before the Sun, with a southern declination of 13° 30′, and an apparent diameter of 7·0″, about half the disc being illuminated. On the 29th he rises at 5h. 43m. a.m., or two hours before the Sun, with a southern declination of 15° 15′, and an apparent diameter of $6\frac{1}{4}$″, $\frac{67}{100}$ths of the disc being illuminated. He is at his greatest western elongation (20°) on the afternoon of the 27th. There will be a transit of the planet across the Sun's disc on the afternoon of the 10th, unfortunately under very unfavourable conditions for observation in England, though things improve as we go west. At Greenwich external contact at ingress takes place at 3h. 55m. 40s. p.m., at an angle for direct image of 98° from the North Pole towards the east, and internal contact at 3h. 57m. 23s. The Sun sets at 4h. 16m. p.m. While visible Mercury describes a direct path in Libra, being near μ on the 23rd.

Venus is too near the Sun for observation in November. She is in superior conjunction with the Sun on the 30th.

Mars is an evening star, and is admirably situated for observation. He rises on the 1st at 4h. 3m. p.m., with a northern declination of 7° 59′, and an apparent diameter of 20·2″, the phase on the $n\,f$ limb only amounting to 0·2″. On the 7th he rises at 3h. 30m. p.m., with a northern declination of 7° 51′, and an apparent diameter of 19·3″, the phase amounting to 0·3″. On the 12th he rises at 3h. 10m. p.m., with a northern declination of 7° 51′, and an apparent diameter of 18·4″, the phase amounting to about 0·5″. On the 19th he rises at 2h. 40m. p.m., with a northern declination of 8° 1′, and an apparent diameter of $17\frac{1}{4}$″, the phase amounting to about 0·7″. On the 26th he rises at 2h. 10m. p.m., with a northern declination of 8° 23′, and an apparent diameter of $15\frac{3}{4}$″, the phase amounting to 0·9″. On the 30th he rises at about 1h. 55m. p.m., with a northern declination of 8° 40′, and an apparent diameter of $15\frac{1}{4}$″, the phase amounting to nearly 1″. Mars is stationary among the stars on the 22nd, and during the first three weeks of November pursues a short retrograde path to the west of δ Piscium; after that, he retraces his steps.

Jupiter is an evening star in the sense of rising before midnight. He rises on the 1st at 7h. 30m. p.m., or nearly 3h. after sunset, with a northern declination of 22° 59′, and an apparent equatorial diameter of 43″. On the 6th he rises at 7h. 8m. p.m., or $2\frac{3}{4}$h. after sunset, with a northern declination of 23° 0′, and an apparent equatorial diameter of 43·1″. On the 12th he rises at 6h. 42m. p.m., with a northern declination of 23° 1′, and an apparent equatorial diameter of $44\frac{1}{3}$″. On the 19th he rises at 6h. 12m. p.m., with a northern declination of 23° 3′, and an apparent equatorial diameter of 45·1″. On the 30th he rises at 5h. 25m. p.m., or $1\frac{1}{2}$h. after sunset, with a northern declination of 23° 7′, and an apparent equatorial diameter of 46″. During the month he pursues a short retrograde path in Gemini, to the north of μ and η Geminorum. The following phenomena of the satellites occur while the Sun is 8° below and Jupiter 8° above the horizon:—On the 1st an occultation reappearance of the second satellite at 9h. 11m. p.m. On the 2nd a transit ingress of the shadow of the first satellite at 4h. 36m. a.m.; a transit ingress of the satellite at 5h. 41m. a.m. On the 3rd an eclipse disappearance of the first satellite at 1h. 45m. 59s. a.m.; its occultation reappearance at 5h. 4m. a.m.; a transit ingress of the shadow of the first satellite at 11h. 4m. p.m. On the 4th a transit ingress of the first satellite at 0h. 8m. a.m., a transit egress of its shadow at 1h. 20m. a.m., a transit egress of its shadow at 2h. 24m. a.m.; an eclipse disappearance of the third satellite at 5h. 10m. 18s. a.m.; an occultation reapearance of the first satellite at 11h. 31m. p.m. On the 5th an eclipse disappearance of the second satellite at 5h. 42m. 7s. a.m.; a transit egress of the second satellite at 8h. 51m. p.m. On the 6th a transit ingress of the second satellite at 11h. 50m. p.m. On the 7th a transit ingress of the second satellite at 1h. 53m. p.m., a transit egress of its shadow at 2h. 25m. a.m.; a transit egress of the satellite itself at 4h. 29m. a.m.; a transit egress of the shadow of the third satellite at 10h. 0m. p.m., a transit ingress of the satellite itself at 11h. 19m. p.m. On the 8th a transit egress of the third satellite at 2h. 7m. a.m.; an occultation reappearance of the second satellite at 11h. 33m. p.m. At midnight on the 10th a $10\frac{1}{2}$ magnitude star will be between the second satellite and the planet, $1\frac{1}{4}$′ f Jupiter and 2′ north. On the 11th a transit ingress of the shadow of the first satellite at 0h. 58m. a.m., a transit ingress of the satellite at 1h. 55m. a.m., a transit egress of the shadow at 3h. 14m. a.m., a transit egress of the satellite at 4h. 11m. a.m., and an eclipse disappearance of the first satellite at 10h. 8m. 10s. p.m. On the 12th an occultation reappearance of the first satellite at 1h. 19m. a.m.; a transit ingress of the first satellite at 8h. 22m. p.m., a transit egress of its shadow at 9h. 42m. p.m., and a transit egress of the satellite at 10h. 38m. p.m. On the 14th a transit ingress of the shadow of the second satellite at 2h. 25m. a.m., a transit ingress of the satellite at 4h. 13m. a.m., a transit egress of its shadow at 5h. 0m. a.m.; a transit ingress of the shadow of the third satellite at 11h. 17m. p.m. On the 15th a transit egress of the shadow of the third satellite at 2h. 0m. a.m., a transit ingress of the satellite at 2h. 50m. a.m., and its transit egress at 5h. 37m. a.m.; an eclipse disappearance of the second satellite at 9h. 35m. 21s. p.m. On the 16th an occultation reappearance of the second satellite at 1h. 54m. a.m. On the 17th an eclipse disappearance of the first satellite at 5h. 33m. 31s. a.m.; a transit egress of the second satellite at 7h. 59m. p.m. On the 18th a transit ingress of the shadow of the first satellite at 2h. 52m. a.m., a transit ingress of the satellite at 3h. 42m. a.m., a transit egress of the shadow at 5h. 8m. a.m., and of the satellite at 5h. 58m. a.m. At midnight on the 18th a $10\frac{1}{2}$ magnitude star will be between the second satellite and the planet, $\frac{1}{2}$′ p Jupiter and 20″ north. On the 19th an eclipse disappearance of the first satellite at 0h. 2m. 1s. a.m., its occultation reappearance at 3h. 5m. a.m., a transit ingress of the shadow of the satellite at 9h. 20m. p.m., a transit ingress of the satellite itself at 10h. 8m. p.m., and a transit egress of its shadow at 11h. 36m. p.m. On the 20th a transit egress of the shadow of the first satellite at 0h. 24m. A.M., and its occultation reappearance at 9h. 31m. P.M. On the 21st a transit ingress of the shadow of the second satellite at 5h. 0m. A.M., a transit ingress of the satellite itself at 6h. 32m. A.M. On the 22nd a transit ingress of the shadow of the third satellite at 3h. 15m. A.M., its transit egress at 6h. 0m. A.M., and a transit ingress of the satellite at 6h. 15m. A.M. On the 22nd at midnight a $10\frac{1}{2}$ magnitude star will be 1·6′ *p* and 1·7′ south of the planet, between the third satellite and Jupiter. On the 23rd an eclipse disappearance of the second satellite at 0h. 10m. 34s. A.M., and its occultation reappearance at 4h. 12m. A.M. On the 24th a transit ingress of the second satellite at 7h. 40m. P.M., a transit egress of its shadow at 8h. 53m. P.M., a transit egress of the satellite at 10h. 17m. P.M. At midnight a $10\frac{1}{2}$ magnitude star will be 70″ *p* Jupiter and 20″ north, being between the second and third satellites, and closely *p* the second. On the 25th a transit ingress of the shadow of the first satellite at 4h. 46m. A.M., and of the satellite itself at 5h. 27m. A.M.; an eclipse reappearance of the third satellite at 7h. 42m. 47s. P.M., its occultation disappearance at 7h. 43m. P.M., and its occultation reappearance at 10h. 31m. P.M. On the 26th an eclipse disappearance of the first satellite at 1h. 55m. 59s. A.M., and its occultation reappearance at 4h. 50m. A.M.; a transit ingress of the shadow of the first satellite at 11h. 14m. P.M., and of the satellite itself at 11h. 53m. P.M. At midnight a $10\frac{1}{2}$ magnitude star will be 1·1′ *p* and 1·1′ south of Jupiter, between the fourth satellite and the planet. On the 27th a transit egress of the shadow of the first satellite at 1h. 30m. A.M., and of the satellite itself at 2h. 9m. A.M.; an eclipse disappearance of the first satellite at 8h. 24m. 27s. P.M., and its occultation reappearance at 11h. 16m. P.M. At midnight an 8·5 magnitude star will be $\frac{3}{4}$′ *p* the fourth satellite. On the 28th a transit egress of the shadow of the first satellite at 7h. 59m. P.M., and of the satellite itself at 8h. 35m. P.M. At about 10h. P.M. on the 29th a $10\frac{1}{2}$ magnitude star will be centrally occulted by the planet. On the 30th an eclipse disappearance of the second satellite at 2h. 45m. 43s. A.M., and its reappearance from occultation at 6h. 28m. A.M.

Both Saturn and Uranus are, for the observer's purposes, invisible.

Neptune is an evening star, and is very well situated for observation. On the 1st he rises at 6h. 10m. P.M., with a northern declination of 21° 8′, and an apparent diameter of 2·7″. On the 30th he rises at 4h. 17m. P.M., with a northern declination of 21° 2′. During November he pursues a retrograde path in Taurus, from the south to the south-west of ι Tauri. A map of the small stars near his path will be found in the *English Mechanic* for September 7th, 1894. At the beginning of the month he is only about 20′ south of ι Tauri.

November is a very favourable month for shooting stars. The most marked displays are the Leonids on November 13th and 14th, the radiant point being in R.A. 10h. 0m., and northern declination 23°. The radiant point rises at about 10h. 15m. A.M., but the Moon will be full at the time. The Andromedas occur on the 27th, the radiant point being in R.A. 1h. 40m., and northern declination 43°.

The Moon enters her first quarter at 3h. 16m. P.M. on the 5th; is full at 7h. 49m. A.M. on the 13th; enters her last quarter at 2h. 8m. A.M. on the 20th; and is new at 8h. 54m. A.M. on the 27th. She is in apogee at 10h. P.M. on the 4th (distance from the earth 251,320 miles), and in perigee at 8h. P.M. on the 16th (distance from the earth 228,190 miles). At 4h. 29m. P.M. on the 7th (8m. after sunset) the $6\frac{1}{2}$ magnitude star 70 Aquarii will disappear at an angle of 42°, and reappear at 5h. 42m. P.M. at an angle of 254°. On the evening of the 13th the full Moon will pass through the Pleiades. At 7h. 38m. P.M. the $4\frac{1}{4}$ magnitude star 23 Tauri (Merope) will make a near approach (3′ distance) to the northern limb at an angle of 336°; at 8h. 9m. P.M. the 3rd magnitude star η Tauri (Alcyone) will make a near approach (5′ distance) to the northern limb at an angle of 336°; at 8h. 29m. P.M. the $3\frac{3}{4}$ magnitude star 27 Tauri (Atlas) will disappear at an angle of 21°, and reappear at 9h. 14m. P.M. at an angle of 290°; at 8h. 50m. P.M. the $5\frac{1}{2}$ magnitude star 28 Tauri (Pleione) will disappear at an angle of 347°, and reappear 13m. later at an angle of 324°. At 7h. 9m. P.M. on the 15th the $4\frac{1}{2}$ magnitude star 136 Tauri will disappear at an angle of 119°, and reappear at 7h. 50m. P.M. at an angle of 224°. At 0h. 3m. A.M. on the 17th the $5\frac{1}{2}$ magnitude star 47 Geminorum will disappear at an angle of 162°, and reappear at 1h. 6m. A.M. at an angle of 249°. At 2h. 0m. A.M. on the 20th the $6\frac{1}{4}$ magnitude star 34 Leonis will disappear at an angle of 159°, and reappear at 2h. 46m. A.M. at an angle of 251°. At 5h. 57m. A.M. on the 23rd the $5\frac{3}{4}$ magnitude star B.A.C. 4531 will make a near approach at an angle of 214°.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of Problem (B. G. Laws).

Key-move.—1. K to Kt4.

If 1. . . . K to K5,	2. Q to B2ch.
1. . . . K to K3,	2. Q to B6ch.
1. . . . P to K3,	2. Q to Qsqch.
1. . . . K to Q5, etc.	2. Q to Q7ch.

Correct Solutions received from W. Willby, H. S. Brandreth, H. F. Culmer, A. G. Fellows, White Knight.

Solution of Conditional Problem (W. De Morgan).

Key-move.—1. B to K7.

If 1. . . . R × R,	2. B to B8, and 3. Kt to R6.
1. . . . R to Q3,	2. B to B8, Kt × Kt, 3. B × Kt.
1. . . . R to KB3,	2. R × Kt mate.
1. . . . R × B,	2. R to KB6 mate.

[Had there been no White Pawn at QR3, Black could play R to Kt3, threatening Kt to R6ch.]

Correct Solution received from W. Willby.

J. J. A.—Your solution to No. 1 arrived too late to acknowledge last month. The other solution was incorrect.

J. E. Gore.—Thanks for the problems. In No. 1 the key is too obvious, the piece moved being obviously useless where it stands. Could you not find a better key? The Pawn at Kt5 seems unnecessary. No. 2 is clearly solved in one move by 1. Kt to B5ch. There is no solution in two moves, on account of the check of the Black Rook. Of course a second key is a fatal defect. The problem referred to was inserted without due examination.

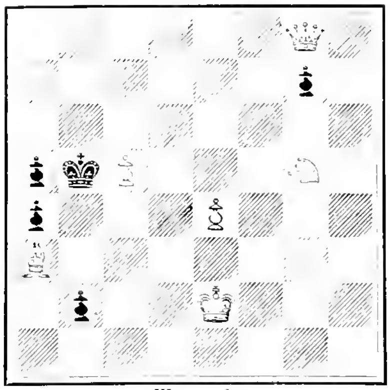
A. C. Challenger.—The problems received are good as usual. We shall be glad to publish them shortly.

A. G. Fellows.—Many thanks for the two problems, which will probably appear in the next number but one. It is to be feared, however, that most of our solvers will think them too difficult to attempt.

PROBLEM.

By Mrs. W. J. Baird.

Black (5).



White (6).

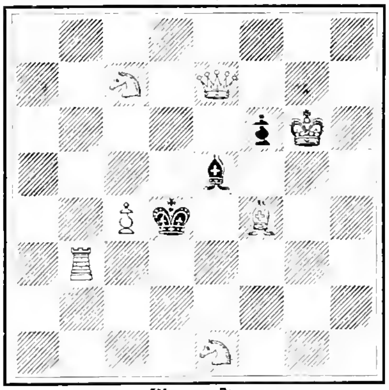
White mates in three moves.

PROBLEM.

By C. D. Locock.

(A modification of one by Mrs. Baird.)

Black (3).



White (7).

White mates in two moves.

PAWNS AND THEIR WEAKNESSES.

As it is probable that the majority of match games won by one first-class player from another depend for their result on the weakness of one or more Pawns, it may be worth while to consider briefly the particular weaknesses to which all Pawns are more or less liable. Such weaknesses may be either temporary or permanent. To the latter category belong *Pawns by their position liable to capture*, and especially—

I. *Isolated Pawns.*—The weakness here is obvious. A Pawn which cannot be supported by another Pawn is evidently subject to the concentrated attack of hostile pieces. The disease is aggravated if the opponent has no Pawn on the same file; for he can use the open file to double his Rooks on the Pawn in front, preventing its advance meanwhile either by blocking it with a piece, or by means of Pawns on the adjacent files. *Doubled* and isolated Pawns are usually indefensible, the owner being unable to defend them from behind with his Rooks. Of course, an isolated Pawn may be strong through the accidental peculiarities of the position. This is often the case with a well-supported Pawn at K5 or Q6, when the opponent's QP is unmoved; but *cæteris paribus*, and especially in an end-game, isolation in Pawns is a dangerous and usually incurable disease.

II. *Pawns too far advanced.*—Another generally permanent weakness, for the Pawns cannot retrace their steps, though in some cases it may be possible for adjacent Pawns to advance to their support. The weakness of advanced Pawns lies in their inability to advance further if attacked. Even if they cannot be captured they can be broken up and exchanged by the adverse Pawns, the opponent having the power of choosing his own time for the operation. If the advanced Pawn be a passed Pawn and well supported, of course the case is different; or if all the Pawns on that wing are completely blocked. In that case the advanced Pawns have usually the best position owing to the cramping effect which they exercise. Moreover, in an end-game a piece may be sacrificed for one of the opposing Pawns, in order to queen the advanced Pawn.

In a certain sense it may be stated that *every moved Pawn* is weaker than if it stood on its original square, for it loses the powerful option of moving either one or two squares, according to circumstances; but this axiom cannot, of course, be pushed to extremes.

(To be concluded.)

CHESS INTELLIGENCE.

Mr. Lasker is now in England, and has been giving simultaneous performances at various clubs. He has written to Mr. Steinitz announcing that his engagements do not permit him to play the much discussed return match till next October. The year's interval will, of course, be all in favour of the younger player. While Mr. Lasker was in Leipsic, attempts were made to arrange a match between him and Dr. Tarrasch; but Mr. Lasker very naturally replied that he could not engage in any match of importance until after his return match with Mr. Steinitz.

It is stated, on the authority of the Liverpool players themselves, that they are more than likely to lose their correspondence match with Mr. Steinitz. One game they have apparently given up as lost, and would not be sorry to draw the other, in which they seemed at one time to have some attack.

A match at Glasgow between the Liverpool and Glasgow Chess Clubs resulted in a win for Liverpool by $6\frac{1}{2}$ to $4\frac{1}{2}$, one game being left undecided.

Contents of No. 108.

NOTICES.

The numbers of Knowledge for January and February of this year can now be had, price One Shilling each.

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CONTENTS.

THE MYSTERIOUS BIRDS OF PATAGONIA.

By R. Lydekker, B.A.Cantab., F.R.S.

If I were asked to name one country more than another where there is a probability that unknown types of the higher vertebrates await discovery by the explorer or the naturalist, I should at once indicate the wilds of the interior of Patagonia. Still inhabited by wild and blood-thirsty Indians, and possessing a winter climate of especial severity, many of these districts are practically unknown to Europeans, while to the naturalist they are a veritable *terra incognita*. As a result of this freedom from European intrusion, the rhea, or South American ostrich, together with the vicuna, the Patagonian cavy, and the pampas-deer, all of which are on the verge of extermination from the pampas of the Argentine, still flourish in large numbers on the plains and mountains of Patagonia. Even this remote country is, however, slowly yielding to the advance of civilization, and large areas in the Chubut district and on the Rio Negro are already in the hands of the sheep-farmer; so that ere long we may expect the same destruction to overtake the native animal life which has already befallen that of the Argentine pampas. It, therefore, behoves the naturalist to use every effort to secure specimens of such animals as may prove to be new before they are swept away by the relentless hand of man.

That there may be new species of opossums, if not of other kinds of marsupials, as well as rodents, in Patagonia is, I think, highly probable; but what I wish to lay before my readers in the present communication is the evidence in favour of the existence in the interior of the country of a small bird more or less closely allied to the rheas, or South American ostriches, which are exclusively characteristic of the continent from which they take their name. Up to the present, European naturalists have had no suspicion of the existence of the bird in question; and since the ostriches and their allies form a group of especial interest both to the anatomist and to the student of the geographical distribution of animals, the discovery of a new species, if not a new genus, would be one of the most important events in the history of modern ornithology. I say *would be* with a purpose, because, unfortunately, we have no actual specimen of this presumed new bird, which is at present only known to us tangibly by a single egg.

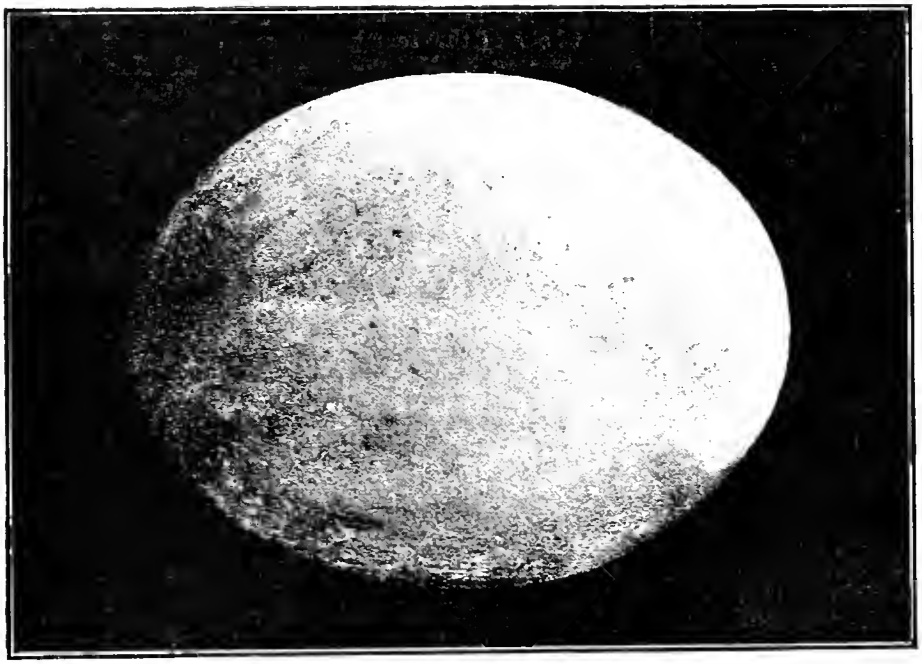
Before proceeding further, it is advisable to make brief mention of the known existing representatives of the ostrich-like birds, all of which are characterized by the want of the power of flight, and the absence of a keel on the front of the breast-bone. From the latter feature, the group to which they belong is scientifically known as the *Ratitæ* (from *ratis*, a flat-bottomed boat), in contradistinction to the *Carinatæ* (*carina*, a keel), which include the whole of the remaining birds of the present day. Commencing with the Australian and New Zealand representatives of the group, we have first of all the diminutive kiwis (*Apteryx*) of the latter country, distinguished from all their kindred not only by their small dimensions, but likewise by their elongated and slender bill, adapted for probing in soft ground for insect-food. As a physiological peculiarity of the kiwis may be mentioned the enormous relative size of their eggs, which appear nearly half as large as the bodies of the birds by whom they are laid.

Another group is formed by the cassowaries (*Casuarius*) and emeus (*Dromæus*), the former of which range over the Papuan islands and the northern part of Australia, while the latter are exclusively Australian. Both these kinds of birds are characterized by the feathers (which are more or less hair-like in structure) being apparently double, owing to the circumstance that the secondary or after-shaft of each is as large as the main shaft. They also possess the common feature of laying eggs of a dark green colour, with the surface of the shell peculiarly roughened. The cassowaries, of which there are nine or ten species, differ from the two kinds of emeu by the horny helmet crowning the head, by the great elongation of the innermost of the three toes, and by some portion of the neck being bare, and generally ornamented by pendant fleshy wattles.

As the emeus and cassowaries form one well-marked group of the ratite birds, so the ostrich and the rheas constitute a second section; the latter section being distinguished by the normal structure of the feathers, and the light colour and smooth surface of the shell of the egg. Towering high above his kindred, the African ostrich (*Struthio*) not only exceeds all other existing birds in height, but differs from the whole of the other members of the avian class, both recent and extinct, in the reduction of the number of toes on each foot to two. Now although English residents in South America, with that pertinacity for applying Old World names to New World animals for which they are so distinguished, will insist on calling rheas ostriches, the circumstance that they have three instead of two toes clearly shows that they have no right to that title. Rheas are represented by three species, namely the common rhea (*Rhea americana*), of which the eggs are pale straw-yellow when first laid; the long-beaked rhea (*R. macrorhyncha*), which is perhaps only a variety of the latter; and Darwin's rhea (*R. darwini*), distinguished by laying eggs of a very pale sea-green colour. Occasionally wholly white rheas are met with, but these are probably only albino individuals of the ordinary species. A strikingly handsome bird in its plumage of black and grey, the male rhea stands about four feet in height. The egg is a nearly symmetrical oval, with the ends usually pointed, and the longer diameter about six and a quarter, and the shorter three and three-quarter inches, the shell being marked by a number of small punctures. Occasionally, however, specimens are met with in which the form is more rounded.

From the foregoing observations it will be seen that the ratite birds of the present day, hitherto described, are included in only five genera, and that, with the exception of Australia, no country is the home of more than a single genus; while all, save the kiwis, are birds of large size.

Turning now to the evidence in favour of the existence of a hitherto unknown diminutive representative of the group in Patagonia, it may be mentioned in the first place that the whole of the information in regard to it has been supplied to me by Dr. H. P. Moreno, the learned director of the museum at La Plata, to whom I am indebted for the photograph of the egg herewith given. That gentleman tells me that, when exploring some years ago in the interior of Patagonia, he saw numbers of small flightless birds which he at first took to be young rheas. Struck, however, by seeing numerous parties of these birds, as well as by the absence among them of any of the ordinary rheas which might be their parents, he was soon led to discard this view. On asking the Indians by whom he was accompanied whether they knew the birds, Dr. Moreno was informed that they were perfectly familiar with them, and knew them to be a small kind of rhea. Being unfortunately unable to obtain specimens, Dr. Moreno on his return asked a friend, who had travelled in the same district, whether he had any knowledge of the birds. The reply was that, not only did he know them well and had often seen them, but that he actually had in his possession an egg which he had picked up. Naturally anxious to obtain such a treasure, Dr. Moreno asked if his friend would present the egg to the museum—a request which was promptly and graciously granted. From that time (some ten years ago) till the present day, that priceless and unique specimen has lain undescribed in the La Plata Museum, and the readers of Knowledge have consequently the pleasure of being the first to see a published figure. I am glad to be able to add that a beautiful wax-model has been prepared for me, which will, in due course, be handed over to the Natural History Museum.



Egg of the Dwarf Rhea. From the only known specimen, preserved in the Museum at La Plata. Natural size.

The specimen is entire, that is to say the contents have been dried up by exposure, and now form a hard substance which rattles when the shell is shaken. In form it is a short oval, with blunt ends, the longer diameter being three and a half, and the shorter nearly two and three-quarter inches. As shown in the photograph, the shell is marked by a number of small punctures, as in the egg of the common rhea; and the original colour was probably yellowish-white, although the shell is now stained dark in several places from contact with the soil. The shell is very strong and thick, and the egg bears all the indications of having been laid by an adult bird; while its perfect symmetry indicates that it is not an abnormally small egg of an ordinary rhea.

That the specimen is not the egg of any known South American bird may (on the assumption that it is a normal and full-sized example) be regarded as certain; while all its characters point to its being the egg of a ratite bird. This being so, and taking into account the statement of two independent European witnesses as to their having seen small rhea-like birds, which were perfectly well known to the Indians as adults, the presumption of the existence in Patagonia of a ratite of the approximate dimensions of a kiwi becomes so strong as to amount almost to a certainty. A further presumption is that this unknown bird is allied more or less closely to the rheas, but whether it belongs to the same genus cannot be ascertained until the acquisition of actual specimens. In the meantime I think we may provisionally call this unknown bird the dwarf rhea, or, scientifically, *Rhea nana*, although it is quite possible that it may represent a genus by itself.

This is at present all the available information concerning the mysterious bird of Patagonia, and one of my objects in noticing the unique egg in a popular publication like Knowledge is the hope that all my readers who have friends or relations in Patagonia may do all in their power to stimulate them to use every effort to obtain a specimen of the creature itself. If this should ever be accomplished, what is now to a great extent hypothesis would be converted into a certainty, and zoological science would be enriched by a most important addition.

THE RISE OF ORGANIC CHEMISTRY.

By VAUGHAN CORNISH, M.Sc., F.C.S.

ORGANIC chemistry, the study of the hydro-carbons and their derivatives, is a science of the present century. Some of the technical processes connected with the preparation of organic substances are, however, of very ancient origin—brewing, for instance, and the art of soap-making. It is the scientific aspect of the subject with which we are concerned in the present article, and which occupies the greater part of Prof. Smithells' new and enlarged edition of Schorlemmer's "Rise and Development of Organic Chemistry."

Lavoisier showed that the decomposition of sugar by fermentation proceeds according to the conditions of the law of conservation of mass, the carbonic acid and alcohol produced being equal in weight to the sugar from which they are formed. Early in the present century the Swedish chemist, Berzelius, showed that the composition of organic substances conforms to the laws of constant proportions and of multiple proportions, which Dalton and others had shown to be characteristic of mineral compounds. The way was now paved for the recognition of the study of organic materials as a part of the domain of chemistry conforming to the same laws as those which govern the chemical properties of mineral substances. Research in the organic branch of chemistry was immensely facilitated by Liebig's work in perfecting the principal process of organic analysis, the well-known "combustion" which is still the *pons asinorum* of the student's laboratory course. From Liebig's time the progress of organic chemistry has been marvellously rapid. The compounds of carbon are, for the most part, so "reactive" that the labour of the investigator is quickly rewarded by the production of some novel substance—often useful or curious—the discovery of which leads in its turn to the production of other bodies related to, but differing from it. The binding element in the majority of these is carbon. The carbon atoms seem to have an almost unlimited capacity for catching hold of and hanging on to one another, and at the same time they retain their hold upon one or more atoms of other elements with which they have been associated. Thus, in the laboratory of the plant or animal body, and in the laboratory of the chemist, are built up compounds of almost infinite complexity, though containing for the most part but few of the chemical elements. Carbon is present in all, hydrogen in almost all, and oxygen in a majority of cases. Nitrogen occurs frequently, and the other elements in smaller quantity and comparatively seldom. The known hydro-carbons—*i.e.*, compounds containing only hydrogen and carbon—number four hundred, whilst few of the elements except carbon combine in more than two or three proportions with hydrogen.

The total number of carbon compounds is said greatly to exceed that of all the other known chemical substances. Among the organic bodies which have been produced in the laboratory are many useful drugs and invaluable anæsthetics; dyes, of which many are brilliant and some are beautiful; and powerful explosives, the discovery of which has probably proved beneficial to manufacturers of war material. But in the limits of this article we must not diverge from science to technology.

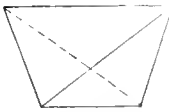
The facility with which chemists can transmute one carbon compound into another has led to great developments in our knowledge of the mechanism of chemical reactions, and of the chemical structure of substances. Chemical formulæ, from expressing merely the quantitative composition of compounds, were soon used to express the methods of formation and decomposition of organic substances. As knowledge advanced it was seen that the formulæ could be made to indicate the way in which the atoms were united one to another. It appeared from the study of organic chemistry that the attraction or union of an atom is not so much with all the rest of the molecule as with some neighbouring atom with which it is closely united or related. The *graphic formulæ*, with which modern chemical books are full, express, symbolically, the order or arrangement in which the atoms of the compound molecule are bound or linked together. To such perfection has the symbolical expression of the constitution of organic substances been brought, that the manipulation of these symbols often furnishes a valuable guide in the prosecution of new researches. No mode of expressing graphically *on paper* the composition of a molecule can, however, be expected to be quite satisfactory if it fails to take account of the fact that the atoms of a molecule are not all distributed, and do not all move, in one plane. The ordinary graphic formula of the text-book has the same faults as, say, the Bayeux tapestry, or a Chinese battle picture—it takes no account of perspective. The more recent use of *glyptic* symbols (which look like outlined figures of crystal form), or of actual models, is an important extension of this domain of scientific symbolism.

We must explain shortly how these developments have come about. The study of carbon compounds led to the discovery of *isomeric* bodies which differ in their properties, although their analytical composition is identical. These differences must, it seems, be explained on the supposition of a different grouping of the chemical atoms, and the phenomena of isomerism are to be classed along with those of allotropy, which are exhibited by several elementary substances, notably by carbon itself (*vide* KNOWLEDGE, 1892, "Carbon"). In the case of carbon compounds, it was found possible in many cases to express these differences by the graphic formulæ referred to above. Thus, there are two substances of very different properties, the percentage composition of which is expressed by the formula $C_2H_3Cl_2$—the symbols C, H, and Cl standing for weights of carbon, hydrogen, and chlorine, proportional to the weights of the atoms of these bodies. It was found that in one of the two substances whose composition is expressed as above, both chlorine atoms were bound up to the same carbon atom, whereas in the other the reactions showed that each carbon atom was in intimate connection with only one atom of chlorine. These facts are symbolized as follows:—

```
      H               H
      |               |
   H—C—H           H—C—Cl
      |      and      |
  Cl—C—Cl          H—C—Cl
      |               |
      H               H
```

But these graphic symbols are insufficient to explain some cases of isomerism. For such cases it is useful, instead of using the symbol —C— (with bonds above and below), to represent the carbon atom by a tetrahedron.

This symbol expresses the essential fact that the carbon atom has a fourfold power of union with other atoms, and we symbolically express the union by attachment to the *corners* of the figure. It is generally sufficient for the purpose in view if one or two carbon atoms are thus fully represented, the ordinary symbol being employed to show the functions of the other carbon atoms. The two substances, fumaric acid and maleic acid, have the molecular



composition $C_4H_4O_4$, and the study of their reactions shows that each has two groups CO_2H, in which the hydrogen is bound to carbon only through the connecting link of the oxygen atom, whereas the remaining two hydrogen atoms are united directly to carbon. Two graphic representations may be made, which in a condensed form appear thus—

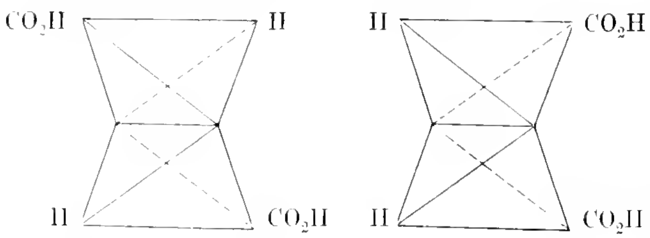
$$CO_2H \,.\, CH \,.\, CH \,.\, CO_2H$$

and

$$CH_2 \,.\, C \Big< \begin{matrix} CO_2H \\ CO_2H \end{matrix}$$

The latter symbol would indicate that *two* CO_2H groups are united to one carbon atom. The reactions of the substance so represented are, however, altogether against this supposition, and the graphic representation therefore fails. If, however, we represent the functions of two of the carbon atoms more fully by symbolizing these atoms as tetrahedra, we can represent very well the observed differences in the two acids, by taking account of the arrangement in the solid instead of regarding the apparent arrangement on the flat. In the symbols given below, the dotted lines of the tetrahedra indicate those edges which would be invisible if we were dealing with a wooden model, or with an opaque crystal of the same form.

Fumaric Acid. Maleic Acid.



A class of bodies which it is difficult to represent by any symbol are those known as *tautomeric*, in which one or more atoms appear to be in a state of alternating allegiance towards their more powerful neighbours. The hydrogen atom, which is the lightest and probably the fastest mover in the dance of atomic vibration, seems in some cases to have certain peculiar privileges of motion within the molecule, so that at successive moments it may be joined up to different atoms.

In the work of synthesizing or building up compounds which occur in Nature, the organic chemists soon outstripped their "inorganic" brethren. Lately, however, the French representatives of inorganic chemistry have again recovered the lead, and the diamond has been made, while starch and the albuminoids are still beyond the creative powers of the chemist. The early feats of organic synthesis were hailed as a triumph over the old belief in a mysterious *vital force*. All substances produced in the life-processes of animals and plants were supposed to owe their existence to the mysterious agencies of life, and to be inimitable by the chemic art. The synthesis of a host of such substances in the laboratory has shown that the mysterious powers of vitality were prematurely invoked, and that failure was pre-supposed when no true trial had been made. The case is somewhat analogous to the mistaken appeal to almost infinite periods of time as the condition of formation of the native crystals of ruby and diamond. In spite of all their past achievements, scientific men are ready enough, like other mortals, to cry out that their go-cart cannot get any further without the aid of some Herculean agency beyond their reach. As a matter of fact, however, the achievements of organic synthesis have only pushed the *vital force* theory a small distance further back, for none of the reproduced alkaloids, sugars, dyes, etc., are *organized* bodies, or show any sign or symptom of the germ of living power. Recent researches upon the molecular weights of organic substances (chiefly by Raoult's method, which is based upon the lowering of the freezing-point of solvents) appear to show that the simplest among the substances which are intimately associated with vital processes are of vastly higher molecular weight, and presumably vastly more complicated than any of the substances that have yet been synthesized. The great differences in the size of molecules is perhaps indicated by the phenomena of dialysis, so much used in physiological work for the separation of substances. Crystalloids, sugar for instance, will in solution pass through the pores of an animal membrane such as parchment, whereas *colloid* substances will not. It seems likely that in such substances, perhaps through the action of atoms such as those of carbon which have a power of multiplex combination, molecules or groups of atoms may "combine to net-like or sponge-like masses. . . . . We may perhaps further suppose that through the constant change of position of polyvalent atoms, these mass-molecules will show a constant change in the connected individuals, so that the whole . . . . is in a sort of living state.*

The idea thus brought forward may perhaps be expressed by saying that if ever chemists should succeed in obtaining albuminous bodies artificially, it will be in the state of living protoplasm." ("Rise and Development of Organic Chemistry," p. 261.) Now that an independent cell-life in the organism has been recognized, the distance seems but small which separates the organic chemist from the point where he may be expected to make his first serious attempt to ascertain if living matter can be produced otherwise than by the agency of living matter itself. Not every scientific man would be able to approach this world-old question without a preconceived opinion as to the ultimate answer which Nature has in store. Whatever be the answer which Nature has in store for us, it will be a duty to science to work at the problem until it is either solved in the affirmative or, like the transmutation of metals, found by experience to be beyond our power. Hitherto chemistry has not been in a position to attack the problem. The synthesis of organic compounds must be carried still further before science will have a bridge long enough to span the wide and formidable gap which divides our knowledge of the inanimate from that of the living world.

THE GLOW-WORM.

By E. A. Butler, B.A., B.Sc.

The townsman seldom has the opportunity, often enjoyed by those who live in country districts, especially in the southern parts of England, of seeing what cannot fail to be regarded as one of the most remarkable sights in Nature, a living animal glowing with light as if it were on fire. The production of light is so frequently a consequence of the phenomenon of combustion, that it is difficult to dissociate them in the mind, and to imagine the former without being impelled to think of the latter, or at least to imagine a considerably elevated temperature. The production of brilliant light without any sensible increase of heat is so unusual a circumstance that it is puzzling to understand how it can take place, and still more, how it can be

* "In crystals and in dead bodies generally, matter is in static equilibrium . . . . in living organisms the equilibrium is dynamic." (*Nature*, Nov., 1894.)

associated with a living animal frame. The glow-worm is by far the most important terrestrial animal in Great Britain that manifests this phenomenon of "phosphorescence," though amongst marine animals, and amongst terrestrial species belonging to warmer latitudes, the phenomenon is of very much wider occurrence. In fact, there are few classes of animals that do not contain species which are, at some season or other, more or less phosphorescent; fishes, insects, myriapods, crustacea, mollusca, sea-squirts, worms, cœlenterates, starfishes, infusoria, all include phosphorescent species. In fact, so common is the phenomenon amongst marine organisms, that apparently we have in it the chief source of light to those creatures that live in the abysmal depths of the ocean, where the light of the sun never penetrates. But while the sea teems with glowing animals, they are not nearly so numerous on land, and, as already mentioned, the glow-worm is, in this country, practically the only terrestrial phosphorescent species which is likely to attract general attention, the few centipedes, worms, &c., that are its only rivals, being far inferior to it in brilliancy.

But it is not only as a phosphorescent being that the glow-worm is remarkable. In a great variety of respects it is abnormal, and these peculiarities we will now proceed to recount. It may be a surprise to some of our readers to be told that the glow-worm is a beetle, *i.e.*, a member of the order Coleoptera, to which also belong the blister beetle, the bloody-nose beetle, the bombardier beetle, and others that we have recently described. It is most nearly related to that section of the order which includes the well-known "soldiers and sailors," the reddish and bluish-black, soft-bodied flying insects that are so common in summer, not only in the woods and fields, but in the streets of our towns as well. Usually it is not reckoned as belonging to the same family as these creatures, but is placed in a different one next to them. This family is called *Lampyridæ*, and the English glow-worm is known as *Lampyris noctiluca*. It is the only species of its genus with which we are favoured in Great Britain, and in fact almost the only representative of the whole family, for only one other species, belonging to a different genus, is known as British, and that is a rare one, having been found only in two localities, and in both cases in towns; so that, for all practical purposes, the glow-worm may be taken as our one British representative of the family *Lampyridæ*. The family, in fact, is characteristic of tropical rather than of temperate latitudes.

The family *Lampyridæ* is one of eight, which are distinguished by their soft and flexible skin, very different from what is found in the majority of the beetle order, which includes the hardest-skinned of all insects. This soft-skinned section is called Malacodermata, in consequence of this peculiarity. It is curious that these malacoderms, notwithstanding their soft and yielding skin, are yet fiercely carnivorous. It is pretty easy to recognize a beetle of this section by its very soft body, which often has fleshy protuberances at the side, and its flexible wing-covers, which are more or less delicately hairy, and sometimes become slightly distorted by bending and shrivelling when the insect is dead. Some of the species are exceedingly beautiful, being bright scarlet, or brilliant metallic green, or exhibiting combinations of the two. The glow-worm has no such brilliancy of natural colour to recommend it, but makes up for this deficiency by the soft beauty of the greenish glow that appears in its abdomen in the dark.

The sexes of the glow-worm are so different that it will be necessary to describe each separately, and we will take the female first, as it is the more familiar. The appearance of the female glow-worm is so different from that of adult insects generally, that it is difficult to believe in its maturity, and still more in its being a beetle; in fact, its coleopterous nature would not easily be demonstrable were it not for the appearance of the male. The female (Fig. 1) is an absolutely wingless, grub-like creature, with a small head, which is completely concealed beneath a semicircular projecting scale, representing the dorsal part of the prothorax of an ordinary insect. Behind this scale are ten segments, all except the first and last similar in form, and each broadest behind, so that the edges of the body become saw-like, with ten notches. The first of the ten segments, representing the mesothorax, is more rounded than succeeding ones, and the terminal one, like the prothorax, is semicircular. The colour is blackish-brown above, with the margins of all the segments, and some patches in the outer angles of the first two, more or less yellowish or reddish. The whole surface is rough, and covered with extremely short silky hairs. Above, the insect is flat, the dorsal layer of each segment forming a sort of shield projecting at the sides beyond the parts beneath, though not to so great an extent as the semicircular shield which covers the fore part. Each of these trapezoidal shields has a slight ridge down the middle. The under surface is very different, being convex and paler in colour; the last three segments are almost white, and it is in these that the glow appears. Three pairs of short legs are carried by the three thoracic segments, and the head bears the usual pair of compound eyes, which are of moderate size, and a pair of short antennæ. As the insect walks, its abdomen trails along the ground, the legs being too far forward and too short to enable it to be raised. It will thus be seen that the insect looks very much like a larva, the thoracic shield being the only characteristic that conveys any other suggestion to a cursory glance.

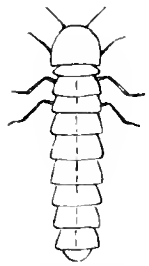


Fig. 1. — Female Glow-worm, magnified two diameters.

The female is the only member of the family to which the name of glow-worm would popularly be applied. It is usually to be met with in the summer months on grassy or mossy banks, where it lies awaiting the advent of its mate, and showing at night, on its under side, a greenish glow which proceeds from two bright spots on the last segment, and from the greater part of the two preceding ones. Of course, therefore, the full brilliance of the light can only be seen when the insect is lying on its back. When disturbed it feigns death, curving its abdomen downwards, and bending up its legs. When left to itself, it is not, as can readily be imagined, a very active creature, and will often remain in the same spot for hours, or it may be days, together. In the daylight, owing to the absence of the luminosity, it is seldom noticed except by those who are familar with its form. In country roads it is sometimes to be met with crawling along near the foot of the hedge, or crossing from one side of the road to the other, and it may also be found underneath stones.

The appearance of the male (Fig. 2) is entirely different, and it is rarely discovered in a similar way to its partner. As it has the ordinary wings and wing-covers of a beetle, there is no difficulty in recognizing it as such. But, at first sight, it would not readily be connected with its mate, because the body, wherein lies the chief resemblance, is concealed by the closed wings; but if the elytra and wings are removed, the close resemblance between the two insects is at once obvious. There is the same semicircular shield in front, the same segmented and notched body, with the same distribution of colour, and the same short legs and antennæ. It is the wings and elytra that make the male look so different. The elytra, or wing-covers, are long, narrow and parallel-sided, entirely concealing the body, and indeed projecting beyond it both at the sides and behind. They are of a greyish-brown colour, covered all over with minute pit-like depressions, and bounded by a raised rim all round; there are also two or three slightly raised parallel ridges on their surface, and the same clothing of minute and scarcely visible silky hairs covers them as is to be found over the rest of the insect. If we raise these wing-covers, we see a pair of smoky wings beneath them about twice as broad as the elytra, and slightly longer, so that they overlap one another when closed, and have to be slightly folded at the tip to get them beneath their covers. The nervures stand out distinctly as dark smoky lines, and at the extreme tip of the wing they meet to form a polygonal area which is destitute of nervures, so as to facilitate the slight folding that has to take place. The insect is a good flier, spreading its elytra, but using only its membranous wings for the purpose of flight. If placed on its back, it is said to right itself by slightly opening its wing-covers and thus getting its wings free, and so struggling over by their means. It is nocturnal in habits, and is therefore not often seen unless attracted by light. In places where they are common, an open window with a strong light burning inside will prove an irresistible attraction, and they may be easily caught as they fly towards the lamp.

Fig. 2.—Male Glow-worm, magnified two diameters.

In all the characteristics we have already described, the male, though so unlike his consort, in no respect differs from the ordinary beetle type. The only point which is at all exceptional is the large size and projecting form of the thoracic shield, but even in this respect the insect is not quite singular; other Coleoptera, such as the tortoise-beetles, show exactly the same arrangement. But there is a far more peculiar feature yet to be noticed, and that is the enormous size of the eyes. Of course, these cannot be seen from above, but if the insect be laid on its back, two large, round, black knobs will be seen almost touching one another, just in front of the first pair of legs and, therefore, under the thoracic shield. (Fig. 3.) A lens shows that they are covered with an immense number of hexagonal facets, and they are thus seen to be the compound eyes. They occupy almost the whole of the head, the mouth organs and antennæ being squeezed into a very small compass between them in front. As the insect lies in this position, another peculiarity is easily observable. A horny flap from the disc-like thoracic shield bends down on each side of the head, to which it fits so closely that the idea is irresistibly suggested of a broad-brimmed hat placed on the back of the crown and tied beneath the neck by a very wide ribbon. A similar arrangement is made in the female, but as the eyes are not nearly so large, the effect is not so striking.

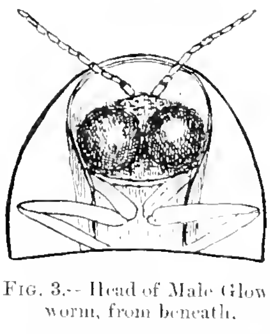


Fig. 3.—Head of Male Glow-worm, from beneath.

Luminosity is not the heritage of the female only; the male possesses the power to a slight extent, though his brilliancy is far inferior to that of his mate, and is chiefly confined to the two bright points on the last abdominal segment. Hence the pale area of the abdomen is not nearly so extensive in the male as in the female, and an inspection of the dead insect even would be sufficient to lead to the conclusion of its far inferior brilliancy. In neither sex is the luminosity an external feature. The seat of the activity which gives rise to the light is internal, and the light merely shines through the transparent skin beneath. The light-producing organs are situated in the last three segments of the body, and consist of two layers of yellowish-white, rounded cells, abundantly supplied with a network of air-tubes from the spiracles. The two layers of cells, though similar in form, appear to differ in constitution and in function, those of one layer only becoming luminous.

It cannot be said that anything very satisfactory has yet been determined with regard to the real cause or nature of the luminosity. According to some careful investigators, it results from a process of oxidation of some of the contents of the luminous cells, produced in them as the result of nervous stimulus. The oxygen required for this purpose, it is maintained, is supplied from the outer air, which, introduced at the very conspicuous spiracles placed at intervals along the sides, finds its way to the light organs through the air-tubes. Thus the intensity of the light depends upon the vigour of respiration, supplemented by nervous activity. It is, however, difficult to understand how so bright a light should be produced in this way without any appreciable rise in temperature. The light appears to be, to some extent, under the insect's control, and the advocates of the oxidation theory contend that the regular intermittence of light which is observable in some species is produced by an alternate opening and closing of the spiracles, or at least synchronizes with acts of inspiration and expiration. Other observers, again, while maintaining the oxidation theory, deny that nervous stimulus has any connection with it, and still others deny the oxidation theory altogether.

It is not difficult to determine one function of the light. When one considers the apterous condition, the brilliant light, and the ordinary eyes of the female glow-worm, and contrasts with these the winged condition, the feeble light and the enormous eyes of her partner, it is evident that these are complementary features in the two sexes, and there can be little doubt, therefore, that one function of the luminosity is to serve as a sexual attraction, and guide the roving male to his destined spouse. But there is no reason why it should not have other functions as well, and that such is the case would seem to be implied in the fact that the insect is luminous in all its stages, and therefore long before it is sexually mature. The suggestion has been made that the light is protective in function, being a sort of warning signal, like the brilliant colours of certain caterpillars. Considering the softness of the female's skin, and its sluggish habits, it would seem to need more protection than usual, and the suggested use of the luminosity is therefore, at the least, plausible. It is not unreasonable to suppose that a would-be captor would think twice before seizing on so dangerous-looking a morsel. On the other hand, the insect is carnivorous, and furnished with a tolerably effective pair of jaws, so that it may perhaps be able to give a better account of itself in a struggle than its soft skin would lead one to suppose.

In confirmation of the sexual function ascribed to the luminosity, the Rev. H. S. Gorham has pointed out that in the family *Lampyridæ* the eyes are developed in magnitude in proportion to the light displayed; those species that show but a feeble light have but small eyes, and *vice versa*. The antennæ also are developed in inverse ratio to the light, and it is well known that a great development of antennæ often exists in those insects that can perceive their mates at great distances; thus, when one power of discovery is lessened, another is increased to supply the deficiency. Thus the species may be divided into three groups: first, those with plumose antennæ and small eyes, and with light appearing in small spots only: secondly, those with simple antennæ, larger eyes, and a considerable amount of light, both sexes being winged; and thirdly, those with quite rudimentary antennæ, extraordinarily large eyes in the male, and most brilliant light, accompanied by an apterous condition in the female, or, at most, with rudimentary wings in that sex. Evidently, therefore, the light-giving power, eyes, antennæ, and wings, are all related in the progress of their development, and it can scarcely be questioned that such a relation indicates a causal connection.

We may now sketch the life-history of this curious insect. Shortly after pairing, the female deposits her eggs. They are of large size and pale in colour, and are either placed in the earth or on moss or grass or other low plants, adhering to the spot on which they are placed by means of the viscid liquid with which they are wet. Curiously enough, the eggs are luminous as well as the insect that produced them. It might be thought that, considering where they have come from, this is not to be wondered at, since the appearance might be due to the moisture that covers their surface. But this is not the case, for if washed in pure water and then dried they still remain luminous. According to Dubois, they may be kept in water for an hour without losing their luminosity, though after the lapse of that time the light begins to wane; but if they are taken out when this occurs, they soon recover their brilliancy. Alcohol rapidly suppresses the luminosity, and boiling water destroys it immediately. The luminosity belongs to the contents of the egg, and not to the shell, so that the light shines through the transparent egg-shell. When the egg is hatched, such luminosity as there is appears in the larva, but the empty egg-shell loses every trace of it. Now, since this luminosity appears even in the youngest eggs, before the segmentation of the yolk sets in, it is evident that it is not, in this instance, whatever may be the case with the adult insect, dependent upon nerves or air-tubes, or indeed any anatomical element whatever, though, of course, oxygen can pass through the thin egg-shell without any special means of conveyance. The luminosity of the eggs is, however, greatly dependent upon moisture, and gradually disappears as the moss amongst which they may be lying dries up; it can be restored again, if not too far gone, by the application of moisture.

The larva is extremely like the perfect female, the most noticeable difference being the smaller size of the head shield. It may be found, of various sizes and ages, during the winter and spring, and becomes full-grown about April. The small size of the young larvæ will serve at once to mark their immaturity, since, of course, the adult insect does not grow; but the full-grown larva is less easy to distinguish from the adult female. Besides the shape of the fore parts, there are also minute differences in the feet and antennæ, which aid in their separation. Like the perfect insect, the larva is carnivorous, feeding upon snails, especially those of the genus *Zonites* or *Helicella*, small, flat, shining kinds, often seen under stones, moss, &c., and in damp places generally. At the end of the body it has some seven or eight short white rods, which are usually kept retracted within the body, but can be protruded at will, and these it is said to use for cleansing the fore parts of its body, should any of the snail's slime adhere to it during the course of a meal. The coloration of the larva is a little more distinct and variegated than that of the adult female; the centre part of the back is darker, and each segment has a reddish-yellow patch at its exterior angle.

As the insect in its larval stage is so much like the fully-developed female, we need not be surprised to learn that the pupa stage is a very short one. Very little metamorphosis, whether internal or external, has to take place, and a very brief time is quite sufficient for this. In little more than a fortnight after the larva has ceased to feed, the perfect insect appears, and the pupa stage itself does not occupy much more than half of this time. The pupa of the female does not differ much in appearance from either the larva or the adult; it remains in a curved position, with legs bent up, very much as the larva or perfect insect would do if feigning death. In the male pupa a difference can be seen; the wings begin to appear, but, of course, as usual, they are of very small size. When the insect is ready to escape from its pupa-skin, the latter slits in front, and the beetle wriggles its way out, a soft and nerveless thing. But its skin soon gains strength and consistency, and then it is prepared to atone for its fortnight's fast, by renewing its attacks upon the snails.

It has already been mentioned that the glow-worm is not the only member of its family that is found in this country. At Lewes and Hastings another and smaller species has been observed, which is called *Phosphænus hemipterus*. It is similar in shape to the glow-worm, but has considerably longer antennæ. The female is quite apterous, but the male differs markedly from our common species, in that wings are absent, and the elytra are very short, not much more than a quarter as long as the body. Moreover, they are pointed behind, and their inner edges do not meet, but gape apart like those of the oil beetle we described a short time ago. Curiously enough, in this species it is the male that is usually found; the female is either much rarer, or manages to keep itself out of sight, for it is very seldom met with. The male is usually found crawling about on walls. This insect is pretty widely distributed on the Continent, but in this country it has been observed only in the two localities above mentioned, though there seems no reason why it should not occur elsewhere.

THE DISTANCE AND MASS OF THE BINARY STARS.

By J. E. Gore, F.R.A.S.

In a previous paper (Knowledge, November, 1891) I considered the mass and relative brightness of those binary stars for which a parallax had been found. In the present paper I propose to discuss the probable distance and mass of those binary stars for which a parallax has not yet been determined. The method of procedure I propose to adopt is to compute what is called the "hypothetical parallax" of the binary star—that is, its parallax on the assumption that its mass is equal to the mass of the sun—and then to find the stellar magnitude to which the sun would be reduced if placed at the distance indicated by this hypothetical parallax, assuming that the sun's stellar magnitude at its present distance is $-25 \cdot 5$. Comparing, then, the star's magnitude, as measured with the photometer, with the sun's reduced magnitude, it will at once appear whether the binary is brighter or fainter than it should be if placed at the distance indicated by the hypothetical parallax. I have computed the hypothetical parallax and the corresponding magnitude of the sun for all the binary stars for which an orbit has hitherto been computed, and I find that in the great majority of cases the star is brighter than the sun would be if placed at the distance indicated by the hypothetical parallax. This fact would imply that most of the binary star systems—at least those with spectra of the solar type—have a smaller mass than that of the sun, and are at a less distance than that indicated by the hypothetical parallax. This will appear from the following consideration. If p be the parallax of a binary star, a the semi-axis major of the orbit in seconds of arc, P the period in years, m and m^1 the masses of the components, and M the mass of the sun, we have the formula $m+m^1 = \frac{a^3}{p^3 P^2} M$, whence $p = \frac{a}{(m+m^1)^{\frac{1}{3}} P^{\frac{2}{3}}} M$. Now if $m + m^1 = M$, or the mass of the system is equal to the sun's mass, we have $p = \frac{a}{P^{\frac{2}{3}}}$, which is the well-known expression for the hypothetical parallax. But if $m+m^1=n$ M, we have, taking $M=1$, $n = \frac{a^3}{p^3 P^2}$. From this it follows that the larger the parallax p is, the smaller is the mass of the system, and conversely, the smaller the parallax the greater the mass will be. Now, as in most cases the binary is brighter than the sun would be if placed at the distance corresponding to the hypothetical parallax, it follows that to make the sun of equal brightness with the star it should be placed at a less distance than that indicated by the hypothetical parallax—that is, the parallax must be increased, and consequently the mass of the binary star diminished. This reasoning, of course, only applies to those binaries which have spectra of the solar type, for stars of the first or Sirian type are, as is well known, much brighter than the sun is in proportion to their mass.

Let us first consider the binaries having spectra of the solar type, in which I find some remarkable differences between the star's apparent brightness and the sun's corresponding magnitude, if we assume that they have the same mass as the sun. I have omitted those in which this difference does not much exceed two magnitudes.

γ Leonis.—This is the most remarkable of all the binaries, having spectra of the second or solar type. Its "relative brightness," calculated by a well-known formula, is very high, being about 93 times brighter than ξ Ursæ Majoris taken as a standard, and which has also a spectrum of the solar type, although slightly different according to the Draper Catalogue, the spectrum of γ Leonis being noted as of class K and that of ξ Ursæ as class G. According to an orbit computed by Dr. Doberck, the hypothetical parallax of γ Leonis is only 0·036″. Placed at this distance, the sun would shine as a star of only 8·29 magnitude. The magnitude of γ Leonis, as measured with the photometer at Harvard Observatory, is 2·24. There is, therefore, a difference of 6·05 magnitudes, which denotes that γ Leonis is about 263 times brighter than the sun would be if placed at the distance indicated by the hypothetical parallax. The sun placed at a distance corresponding to a parallax of 0·58″ would appear of the same brightness as γ Leonis. But if the star had so large a parallax it would probably have been detected ere this. With a parallax of 0·58″, I find that the mass of γ Leonis would be less than $\frac{1}{4000}$th of the sun's mass, which also seems improbable. It is, consequently, very difficult to give any satisfactory explanation of the great brilliancy of this binary star. The accuracy of the orbit computed for this pair (period 407 years) is of course very doubtful, as the arc described since its discovery has been small. Its slow motion, however, indicates that the period must be long. The spectrum is not exactly the same as that of the sun, and the star may be hotter and brighter.

π Cephei.—The spectrum of this star is, according to the Draper Catalogue, of the second type, but doubtful (H ?). According to an orbit computed by Prof. Glasenapp, its hypothetical parallax is 0·032″, which would reduce the sun to a star of magnitude 8·6. The star's magnitude measured at Harvard is 4·48, so that there is a difference of 4·12 magnitudes, denoting that the star—if of the same mass as the sun—is 44½ times brighter. To make the sun equal in brightness to the star, the parallax should be increased to 0·208″, and the mass of the binary system diminished to $\frac{1}{237}$th of the sun's mass. But as the spectra are not identical, perhaps the sun and π Cephei are not exactly comparable.

ω Leonis.—In this case the hypothetical parallax is, from Dr. Doberck's orbit, 0·022″, a parallax which would reduce the sun to a magnitude of only 9·36. The star's measured magnitude is 5·55, which gives a difference of 3·81 magnitudes. This would imply that the star is about 33½ times brighter than the sun, if both bodies were of the same mass. To make the sun equal in brightness to the star, the parallax should be increased to 0·127″, and the mass of the binary system diminished to $\frac{1}{195}$th of the sun's mass. The spectrum being, however, of class G of the Draper Catalogue, the sun being of class F, the two bodies are not perhaps strictly comparable.

β Delphini.—This is a binary star with a spectrum of class F, or that of the sun, so that the two bodies should be comparable in intrinsic brilliancy. From my orbit for this pair—which cannot be far from the truth—the hypothetical parallax is 0·052″, which would reduce the sun to a star of 7·49 magnitude. As the star was measured 3·74 at Harvard, we have a difference of 3·75 magnitudes, denoting that the binary—if of the same mass as the sun—must be nearly fifty times brighter. As the spectrum is of the same type this seems improbable, and we must conclude that the star's parallax is more than 0·052″. The sun, placed at a distance corresponding to a parallax of 0·292″, would shine as bright as the star appears to us. With this parallax, the mass of the binary would be reduced to [illegible]th of the mass of the sun. It seems improbable, however, that so comparatively large a parallax as 0·292″ should remain undetected.

τ Ophiuchi.—From Dr. Doberck's orbit of this pair, the hypothetical parallax is 0·033″. At the distance thus indicated the sun would be reduced to a star of 8·48 magnitude. The star's photometric magnitude is 4·93, which gives a difference of 3·55 magnitudes, denoting that the star would be—if of the same mass—about twenty-six times brighter than the sun. A parallax of about 0·17″ would make the sun equal to the star in brightness, and this parallax would reduce the mass of the binary to $\frac{1}{136}$th of the sun's mass.

ζ Aquarii.—This binary has the longest period yet determined, namely, 1578 years, according to Doberck. Of course, this great length of period renders the accuracy of the orbit very uncertain, but its slow motion and comparatively great distance between the components (a=7·64″) makes it an interesting object in the present discussion, particularly as its spectrum is that of the sun (F). With the above period and semi axis major the hypothetical parallax is 0·056″, which would reduce the sun to a star of 7·33 magnitude. As the photometric magnitude of the star is 3·81, we have a difference of 3·52 magnitudes, or nearly the same as in the case of τ Ophiuchi. To reduce the sun to the brightness of the star it should be removed to a distance corresponding to a parallax of 0·323″, and this would reduce the mass of the binary pair to $\frac{1}{192}$nd of the sun's mass. The uncertainty in the orbit, however, renders these results very doubtful.

ξ Scorpii.—From Schorr's orbit of the pair, I find a hypothetical parallax of 0·06″, which would reduce the sun to a star of 7·18 magnitude. As the star's photometric magnitude is 4·10, we have a difference of 3·08 magnitudes, denoting that the binary—if of the same mass as the sun—is about seventeen times brighter. A parallax of about 0·248″ would make the sun equal in brightness to the star, and this parallax would reduce the mass of the binary to about $\frac{1}{70}$th of the sun's mass. The spectrum is a doubtful one (F ?) of the second type, and perhaps the star may not be strictly comparable with the sun.

ι Leonis.—The hypothetical parallax derived from my orbit for this pair (the only orbit yet computed) is 0·07″. This would reduce the sun to 6·85 magnitude, and as the star was measured 3·98 at Harvard, we have a difference of 2·87 magnitudes, which indicates that the star is, for equal masses, about thirteen times brighter than the sun. To make the sun equal to the star in brightness, the parallax should be increased to 0·262″, and this would reduce the mass of the binary to about $\frac{1}{32}$nd of the sun's mass. The spectrum is of the G class in the Draper Catalogue.

35 Comæ.—An orbit recently computed by me gives a hypothetical parallax of 0·045″, indicating a distance at which the sun would be reduced to a star of 7·8 magnitude. The star's measured magnitude being 5·08, we have a difference of 2·72 magnitudes, which makes the star twelve and a quarter times brighter than the sun if the masses were equal. A parallax of 0·158″ would make the sun equal to the star, and this would reduce the mass of the binary system to $\frac{1}{13}$ of the sun's mass.

τ Cygni.—For this binary pair Mr. Burnham has lately computed an orbit, and found a period of 36½ years, with $a = 0·94″$. This gives a hypothetical parallax of 0·085″, and at the distance indicated the sun would be reduced to a star of 6·42 magnitude. The star's photometric magnitude being 3·94, there is a difference of 2·48 magnitudes, which would make the star 9·8 times brighter than the sun. A parallax of 0·267″ would reduce the sun to the brightness of the star, and this would diminish the mass of the binary to $\frac{1}{31}$th of the sun's mass. As the spectrum is of the same class (F) as the sun, the two bodies should be fairly comparable, but perhaps the stars composing the binary system may be slightly hotter, and of less density than our sun. This remark may also apply to ι Leonis and 35 Comæ.

The binary stars of the first or Sirian type are, of course, not comparable with the sun, as it is evident from the case of Sirius, and other stars of this type, that these stars are intrinsically much brighter in proportion to their mass than stars of the solar type. Of these Sirian type stars, the most remarkable is ϕ Ursæ Majoris. From Glasenapp's orbit for this binary pair, the hypothetical parallax is only 0·01″, which would reduce the sun to a star of 11·07 magnitude. As the star's photometric magnitude is 4·43, we have a difference of 6·64 magnitudes, denoting that the star is—if of the same mass as the sun—about 453 times brighter! As, however, we cannot compare its brightness with that of the sun, no estimate of its mass and distance can be made.

There is one binary star which forms a remarkable exception to those considered above. This is μ^1 Herculis. From the orbit computed by Leuschner (period 45·39 years; $a = 1·369″$) the hypothetical parallax is 0·107″. At the distance indicated by this parallax the sun would shine as a star of 6·0 magnitude. As the magnitude of the binary pair is about 9·5, we have here an exception to the general rule—namely, a star *fainter* than the sun would be if placed at the distance indicated by the hypothetical parallax. The difference is 3·5 magnitudes, denoting that the sun is over twenty-five times brighter than the star, for equal masses. To reduce the sun to a 9·5 magnitude star, the parallax should be reduced to about 0·02″, and this would *increase* the mass of the system to 155 times the mass of the sun. The star being so faint its spectrum has not been determined, but the binary pair forms a distant comparison to μ^2 Herculis, the magnitude of which was measured 3·49 at Harvard. Both stars, although relatively fixed, have a common proper motion through space, a fact which suggests a physical connection. According to the Draper Catalogue, the brighter star has a doubtful spectrum of the second type (class I ?). It does not follow, of course, that the fainter star (the binary) has a spectrum of the same type. Indeed, its bluish colour would suggest a spectrum of the Sirian type; but if of this type, it is difficult to understand why it should be so faint. If the binary pair is physically connected with the brighter star, both objects probably lie at practically the same distance from the earth. The difference in their brightness—six magnitudes—is, therefore, very remarkable, and would be still more so if the brighter star were of the second type and the fainter of the first.

THE DEGENERATION OF HUMAN STATURE.

By MISS C. S. BREMNER.

THE question is one that not only takes us back to the dawn of history, but to prehistoric times. If we consult the sacred writings of any people, the sagas of northern races, the legends and traditions common among southern ones, we almost invariably find the same general impression, not infrequently a precise statement, that the human race is diminishing in stature. All the legends point to heroes and demigods of immense stature. Buckle alludes to the same fixed ideas in early Indian history. The early Aryans were much more virtuous and happy than we their degenerate descendants; their stature was more exalted; the ordinary duration of life among them was about eighty thousand years. If a person led a saintly life, his days might be as long in the land as one hundred thousand years. Indeed one king and saint (one wonders if they were much the same in the good old times) began to reign at the age of two million years; he reigned six million three hundred thousand years. At the end of that time he seems to have grown weary in well-doing, for he abdicated the throne, lingering on some one hundred thousand years longer.

In the earlier portion of the Pentateuch, the life of man, we are told, extended to nine hundred years and more. This figure gradually decreases until we reach the time of David, when it is taken for granted that the years of man are seventy. Of the stature of the early heroes of the Pentateuch nothing is said. About the time of Moses we read that "in these days there were giants on the earth, the sons and daughters of Anak." The spies who went up to view the land of Canaan report very quaintly: "There we saw the giants, the sons of Anak, which come of the giants; and we were in our own sight as grasshoppers, and so we were in their sight." In Moab, we are told, "the Emims dwelt there in times past, a people great, and many, and tall, as the Anakims; which were also accounted giants, as the Anakims." Isolated giants are frequently spoken of, such as Og, king of Bashan, Ishbi-benob, who hoped to have slain David; better known than both these was Goliath, whose stature, we are told, was ten or eleven feet.

Nor were the Greeks of a parsimonious disposition when they described the strength and stature of their heroes. Homer grieved over the gradual levelling down of the men of his day. Hesiodus bewailed that his contemporaries had declined in stature compared with the men of the good old times. Herodotus, Pliny, Pausanias, and Plutarch have all given expression to a similar idea, the latter complaining that the rising generation resembled new-born babes. Virgil's opinion is well known. In one passage he says: "When the cultivator upturns with his plough the weapons and bones of his ancestors, he is dumbfounded, lost in admiration of their gigantic stature."

The results of recent scientific investigation neither tally with the ancient theory of stature degenerating, nor yet with the more modern one of a constant upward tendency. Dr. Rahon, a French scientist of considerable repute, has recently collected statistics on human stature, while working at the Musée Broca under Dr. Manouvrier, a well-known professor of anthropology. Yet, in estimating the value of the conclusions to which M. Rahon has come, it ought to be remembered that his investigations have been limited to one country—France. His master, Dr. Manouvrier, is the introducer of many corrections in the study of bones, both in the methods employed and in the co-ordination of calculations made, in scientific parlance, "the co-efficients of reconstitution." M. Rahon has based his calculations on some millions of prehistoric bones collected from all parts of France, and now preserved in the Paris anthropological museums.

To establish a term of comparison between men of former times and men living now, it was indispensably necessary to have precise knowledge of the height of the latter. Dr. Manouvrier, therefore, measured the bones of two hundred and five men and one hundred and nineteen women who had undergone dissection in the Paris School of Medicine. The average height thus obtained was 1·650 mètres for men, and 1·528 for women.

On the other hand, the average height of adult men measured in the French criminal identification department by M. Bertillon is 1·648 mètres, which is, moreover, the average French height, as ascertained in military recruiting. The criminal identification department gives 1·545 mètres as the average height of adult women.

Dr. Rahon's measurement of the bones of various prehistoric and ancient peoples supplies an interesting comparison. He studied, in succession, bones of the quaternary, neolithic, proto-historic periods, and of the Middle Ages, with the following results:—

1.—Quaternary Period.
5 male cases, average height 1·629m.

2.—Neolithic Period.
129 male cases, average height 1·625m.
189 female cases ,, ,, 1·506m.

3.—Proto-Historic.
215 male cases, average height 1·662m.
39 female cases ,, ,, 1·539m.

4.—Parisians of the Middle Ages.
(Cemetery of Saint Marcel.)
294 men, average height 1·657m.
101 women ,, ,, 1·555m.
(Cemetery of Saint Germain-des-Prés.)
140 men, average height 1·656m.
46 women ,, ,, 1·555m.

What conclusion, therefore, can be drawn from these figures based on serious and methodical investigation? Undoubtedly, we may conclude that all those who hold the opinion that our stature is appreciably smaller than that of our ancestors, labour under a delusion.

As a result of Dr. Rahon's investigations it may be definitely stated:—

(1) That the skeletons attributed to the most ancient representatives of the human race belonged to individuals of stature at most normal, if not small.

(2) That neolithic peoples—of the polished flint period, dating back more than three thousand years—constantly show us medium stature, lower than our present average height.

(3) That the various proto-historic peoples, Gaul, Frank, Burgundian, Merovingian, present an average stature superior to that of French people of to-day, but not so great as we have been led to expect; as a matter of fact, not exceeding 0·015 mètre.

In short, in spite of the armour of the Middle Ages, we must come to the conclusion, if we may trust to Dr. Rahon's statistics, that height has almost inappreciably diminished by 0·007 mètre. We have, therefore, no cause for discouragement: we need hardly cry out "degeneration" yet. If we diminish no more than this in the centuries, we have no reason to fear that our great-grandchildren will be dwarfs.

So far as women are concerned, the figures seem to point to an appreciable diminution in the difference of the stature of the sexes. The difference between neolithic man and woman is calculated at 0·119 mètre; proto-historic, 0·123; Middle Ages, 0·102; modern times (dissection), 0·122; ditto (criminal investigation), 0·103.

MECHANICAL FLIGHT.

By Thomas Moy.

Mr. Maxim having had his *little* joke, which was proof against bullets, and his *big* joke, which was proof against soaring, and the excitement anent both performances having now subsided, it may be opportune to take a calm bird's-eye view of the latter subject as it stands.

The two greatest obstacles in the way of the accomplishment of mechanical flight have been the balloon and the screw propeller.

The "life" of a balloon depends upon the quantity of ballast which it can carry, in addition to its live load. Gas must be lost with every variation of height and change of temperature; and this waste must be counteracted by throwing away ballast. For want of this knowledge, novices have sometimes gone up like a rocket and come down like a stick. A free balloon is integral with the air in which it is suspended. If a candle were lighted in the car, in a wind of fifty miles an hour, the candle would burn as steadily as in a room, so completely is it at the mercy of the wind.

The attempts to stiffen balloons and other gas bags, to fit them for propulsion, have all been failures. When I was in Vienna in 1873 — exhibition year — I attended meetings of the Aëronautical Society there, and found several ingenious attempts had been made to stiffen the fabric, to enable balloons to retain their shape, under propulsion, but the extra weight was always too great.

Dupuy de Lôme's expensive experiment in 1872 stands out as a warning. The hydrogen gas alone, to fill it once, is reported to have cost £360, and although the gas bag was pointed at each end, and was driven by a screw, it was only able to deviate five degrees from the direction of the wind, in a journey of ninety miles. The whole of the gas had then to be wasted, the bag and apparatus packed up, and all returned to Paris by railway. That was a long way off the accomplishment of aërial navigation, and we are not likely to get much nearer by means of propelled gas bags. In spite of the many failures in this direction, many people look upon it as the only feasible plan, and the United States Patent Examiners have refused Mr. Maxim a patent because he does not describe and claim a gas bag in his combination.

Just as one class of experimenters have inscribed "Finality Jack" upon the gas bag, so another and larger class have come to the conclusion that the screw is the best and only available propeller: among the rest, Mr. Maxim and Lord Kelvin.

This mistake has arisen from its *partial* success in water, in the propulsion of steam ships. I say "partial" success because there is such a thing as "slip." This slip of the screw is bad enough in water: it is ruinously wasteful in attempts at mechanical flight. It is the delusive estimate of the efficiency of the screw propeller in air which caused someone to express himself as follows, in a daily newspaper: "Inventors are constantly, to the amusement of practical engineers and mechanicians, inventing forms of flying machines, oblivious to the fact that every engineer of experience could produce at a few hours' notice the necessary form of machine, when the, at present, undiscovered and necessary materials are found." I withhold the name. This man evidently had settled it in his mind that all the apparatus required consisted of an aëroplane, screws, and a *light* motor; the error into which Henson fell in 1842, and Maxim fifty years after.

The following extract from a scientific journal is still more amusing:—"It is true that Mr. —— has recourse to a whirling propeller, which is about as foreign to a natural device as anything could well be. The neglect of rotary motion as a means of propulsion (except in the transference of wave motion) is one of Nature's most unaccountable proceedings. If it were not for the beautiful efficiency of her nerve and muscle motors, perhaps she would be driven to the continuous effort of the screw or wheel rather than the flappings and reciprocations of wings and legs she now adopts."

The assurance of this critic of Nature's methods will be obvious, if we substitute the Creator of Nature for "she."

One gentleman became so enamoured of the aërial screw, some few years ago, that he actually proposed to drive ships with aërial screws instead of marine screws. It is surprising that he did not propose to drive railway trains by the same means.

Now what is *slip?* Suppose a boat, when travelling in water at eight feet per second has a resistance of 62·5 pounds. Fit this boat with a small steam engine and a drum. Let this drum wind up a rope, the other end of which is made fast to some stationary object. Disregarding the weight of the rope, we may assume it to be five miles long. With a strain upon the rope of sixty-two and a half pounds exerted by the engine, the boat would cover the distance of five miles in an hour. There would be no *slip*. Now, instead of making the rope fast to a fixed object, let it be attached to a floating board, having a vertical immersed surface of one square foot. A strain or pull upon this surface of sixty-two and a half pounds would produce a speed of eight feet per second of both the boat and the board—that is to say, the board would "come home" towards the boat at the same speed that the boat would travel, thus winding in the rope at sixteen feet per second, and the rope would be all wound on the barrel when the boat had travelled but two and a half miles. In this case, half the power would be wasted in slip. For certain well-known reasons, the screw propeller is more efficient than a mere flat board would be, but the slip of the screw in water generally causes a loss of twenty to twenty-five per cent.

A screw bolt driven into a nut has no slip. A marine screw propeller, working in a *water nut*, produces slip and consequent waste of power. The *air nut*, however, is excessively yielding, and the slip is far too great for the propulsion of a successful aërial machine.

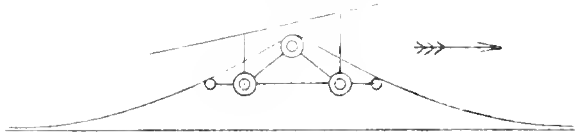
In the sixth annual report of the Aëronautical Society of Great Britain (1871) will be found a calculation by Mr. Wenham of the slip, with vertical screws in the air, in which he estimated that twenty-two horse-power would be required to raise a weight of two hundred pounds. My experiments have given better results than this, but even five horse-power to two hundred pounds indicates great loss by slip.

Comparing Henson's device of 1842 with Maxim's of 1892, one sees very little advance in the latter. Henson placed the axles of his screws in line with his aëroplane, and Maxim places his lower down. Of the two, Henson's appears the most logical arrangement. Henson and Stringfellow used cop-tube boilers, to prevent priming. Maxim's first boiler consisted of a crowd of tubes, which I know from experience would get uncomfortably hot; and he afterwards reduced the number considerably, and brought his boiler to a less complicated state, something like my 1877 patent. Mr. Henson's machine failed for want of propulsive power, due to slip. When started it slid backwards and injured its tail. Mr. Maxim's has failed for the same cause.

But it may be thought that I used common screws in 1875; this would be a mistake. My 1871 patent expressly describes *feathering* screws—that is, the pitch of the blades was very much greater on the descending side than on the ascending side, whereby a lifting force was obtained on both sides of the axle; one derived from the downward action, and the other from the forward motion.

My experiment with this machine was very much handicapped by having to sustain half the weight of two guide ropes, each one hundred and fifty feet long, and the reduction of power from the forward lamps extinguishing the lamps at the rear of the boiler. The machine was afterwards destroyed in a stiff gale, while moving it from the Rotunda in the Crystal Palace grounds to a new shed near the Penge entrance. I afterwards fitted two horizontal screws, twelve feet diameter, to the three-horse engine; but these only gave an upward thrust of one hundred and twenty pounds, thus again proving the importance of loss by slip.

I will conclude by suggesting that Mr. Maxim should take his machine to (say) Salisbury Plain; lay down his piece of railway without the top rails; lay down a rope on the ground, the longer the better; unship his screws and mount a drum, as shown in the sketch, passing the rope two or three times round the drum, and driving the drum by his engines. By this arrangement he will avoid slip, and, if his engines give out anything like three hundred horse-power, his machine will rise a short distance from the ground, as shown. The weight of rope looped up from the ground will limit the height, and the two small guide pulleys, fore and aft, will secure horizontal stability.



NOTICE.

With very great regret the announcement has to be made that Mr. Ranyard, owing to serious illness, has been unable to edit this issue. Mr. Ranyard has been brought to a very low and weak condition, and as he recovers a sea voyage will be necessary, but he hopes to resume his labours before very long. In the interim, Mr. E. W. Maunder has kindly offered to supervise the astronomical pages of Knowledge.

THE CENTRAL EQUATORIAL REGION OF THE MOON.

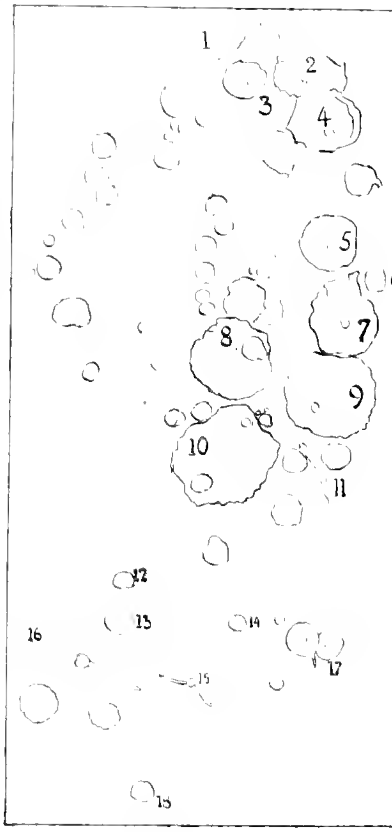
By T. Gwyn Elger, F.R.A.S.

The contrast between the northern and southern hemisphere of the moon, as regards the number and size of large ramparted enclosures, is evident on glancing at any map or photograph of its visible surface. Though the former includes many notable objects of this description, only a few of them can compare in dimensions or complexity of structure with those on the opposite side of the lunar equator. A distinction almost as striking exists between the two quadrants of this southern hemisphere, the south-western containing an almost endless variety and bewildering number of formations of a type which is much more scantily represented in the other quarter. The inequality in the distribution of the maria, or so-called "seas," is also very remarkable. If a great circle is drawn from about N. lat. 20° on the western limb, through the intersection of the first, or central, meridian with the equator, to the corresponding S. lat. on the eastern limb, the greater portion of the superficies north of this line consists of low-lying dusky plains, whose monotony is often unrelieved by any conspicuous object, while the region south of it, very distinctly brighter, is the area on which the results of those volcanic forces which have given to the moon its extraordinary aspect are developed to the greatest extent.

The beautiful plate which accompanies this paper, though only including a portion of the surface extending from S. lat. 30° to about 20° on the north side of the equator, admirably illustrates the distinction which has been referred to. Ptolemaus, the great central ring-mountain so prominently represented thereon, with the chain of irregularly-shaped formations running north from it, and the apparently inextricable confusion of *bizarre* groups flanking it on the west, may thus be compared with the smaller and generally different features portrayed on the northern half of the picture.

Ptolemaus is undoubtedly one of the most perfect and typical examples of a certain class of formations, termed "walled-plains," which can be found on the moon, and from its position, near the centre of the disc, can be more conveniently scrutinized and studied than almost any other. These formations differ from many which often bear a superficial resemblance to them, not only in extent, but in the hypsometrical relation which exists between their interior, or, as selenographers term it, "the floor," and the region beyond the limits of the circumvallation. In most other enclosures this floor is depressed, sometimes to the extent of many thousand feet, below the outside region, but in the walled-plain there is seldom any appreciable difference in level between the interior and exterior. Less marked, but still characteristic of these objects, is the nature of the rampart and its slopes, within and without. In many of the so-called ring-mountains, the latter are only slightly inclined outside, rising to the summit of the wall with an extremely gentle gradient, while they descend to the floor with a very steep declivity. The border of the walled-plain is also, as a rule, less continuous, being more frequently interrupted by gaps, crossed by transverse valleys and passes, and broken by more recent craters and depressions.

To return, however, to the notable object which figures so prominently on the plate. In order to appreciate its actual size and the scale of its surroundings, it must be remembered that a distance of one hundred and fifteen miles intervenes between the sides, or rather more than that from London to Birmingham; so that the whole of the principality of Wales, with one or two of the bordering counties in addition, could easily be accommodated within its limits. In fact, its dimensions are such that, though there are peaks on the rampart rising to four thousand, five thousand, and even six thousand feet; if it were possible for an observer to be stationed near the centre of this great amphitheatre, he might well imagine that he was standing on a boundless plain, for, except at one or two points on the west, there would be nothing to break the monotony of the prospect.



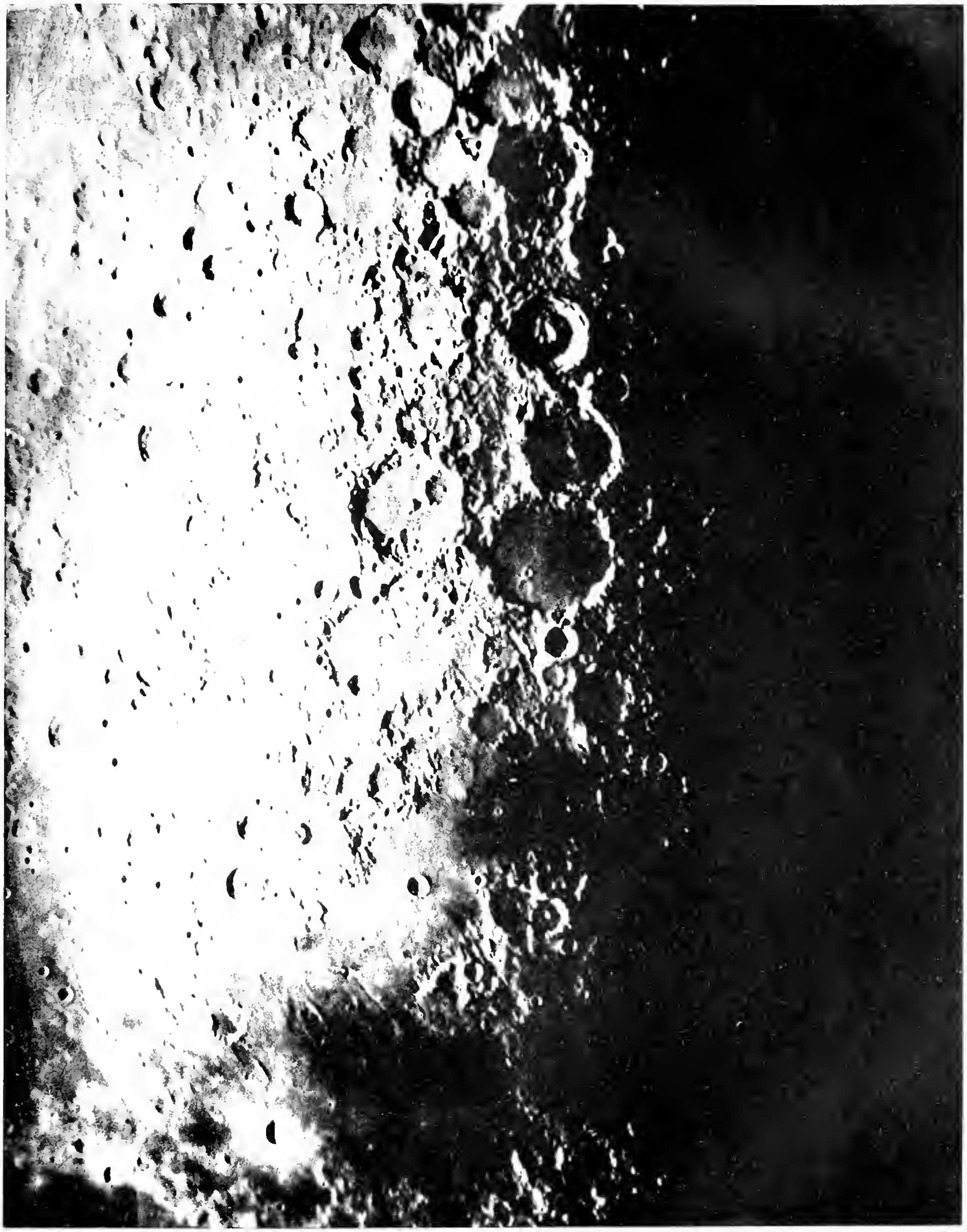
Index to Map.

1. Aliacensis.	10. Hipparchus.
2. Regiomontanus.	11. Herschel.
3. Werner.	12. Godin.
4. Purbach.	13. Agrippa.
5. Arzachel.	14. Triesnecker.
6. Alpetragius.	15. Hyginus.
7. Alphonsus.	16. Ariadaeus.
8. Albategnius.	17. Bode.
9. Ptolemaus.	18. Manilius.

At the particular phase represented in the plate, the sun has not long risen on Ptolemaus and the chain of great rings south of it; hence its rays fall very obliquely on the enclosed plain, and reveal details which, a few hours later, would be wholly invisible. Among the most noteworthy of these, is a number of shallow, circular, saucer-shaped depressions, about four or five miles in diameter, confined for the most part to the eastern half of it. Owing to their insignificant depth, they are so evanescent that, unless they are looked for at a very early stage of lunar sunrise, it is impossible to see them, though minute craters found within them can be traced long after they have disappeared. Objects of this kind, though not uncommon on the "seas," are nowhere so closely aggregated as here. They impress one with the idea that they represent old crater-rings, which are covered and partially

SOUTH.

WEST



EAST

SUNRISE ON PTOLEMAUS.

From a Photograph by the Brothers HENRY, with the thirteen-inch Photographic Refractor of the Paris Observatory

Direct Photo Engraving Company, 9, Barnsbury Park, N.

obliterated by the grey material (whatever this may be) of which the floor of Ptolemaus and other similar formations, including the "seas," are composed, which was once most probably of a semi-fluid or viscous consistency, though now probably everywhere consolidated. On the north-western side of the interior stands the only conspicuous object upon it, a bright deep crater about four miles in diameter; and south of it two large obscure rings, extending to the border, one of which in the plate is almost wholly obscured by its shadow. This crater, including its slopes, cannot be less than seven or eight miles across, and thus occupies an area fully as large as Vesuvius, though it does not resemble it in other respects—its flanks being much steeper and the opening on the summit more than double the diameter of the old crater-ring of Somma. Viewed under a somewhat higher sun than obtained when MM. Henry's photograph was taken, the interior of Ptolemaus is seen to contain a large number of small craters; and, under a still more vertical illumination, to be traversed by a curious arrangement of light streaks, the nature of which still remains enigmatical, though the fact that they are invariably associated with small craters, both here and elsewhere, points to an intimate physical connection.

Among other features in the vicinity, beautifully displayed in the plate, is a great valley, flanking on the west the bright circular formation Herschel. This elongated gorge, eighty miles in length and in places fully ten miles in width, is one of the finest on the moon, and is, perhaps, only surpassed by two others, one being the valley east of Ukert, and the second the great wedge-shaped depression that cuts through the lunar Alps west of Plato, which is shown with remarkable distinctness in a photograph of the moon two hundred and forty hours old, by MM. Henry, published in Knowledge in December, 1890. Herschel is a typical example of the "ring-plains," by far the most numerous of the large crater-like objects on the moon. Here we have a depressed floor, and a nearly circular, continuous and massive wall, surmounted by peaks considerably loftier than any on the circumvallation of Ptolemaus, which it adjoins. Hipparchus, whose low irregular outline can only be well traced under a rising or setting sun, comes out so plainly that the isolated sections of its apparently ruined border can be seen nearly as well-defined as they are in the telescope under good atmospheric conditions.

No portion of the moon, excepting in high latitudes in the south-western quadrant, exhibits to such an extent the mutual deformation and interference of formations, or so many departures from circularity, as that under consideration. There is scarcely a ring-mountain or enclosure of any description that does not appear to have been more or less modified in form by the propinquity of neighbouring objects. On the northern side of the equator very few examples of this appearance are found, except in the rugged highlands and in the vicinity of the lunar north pole, where the enclosures are more crowded. The region between Albategnius and Purbach is particularly noteworthy and suggestive on this account, as including a great number of small overlapping rings and fragmental craters, many of them grouped and massed together without any apparent governing principle, though on a closer scrutiny a tendency to a more or less linear arrangement in a meridional direction can be traced. This tendency is much more obviously displayed in the curious chain of seven or eight little misshapen ring-plains extending in a sinuous line from the foot of the *glacis* of Albategnius, towards Purbach. It can hardly be questioned that, like the smaller crater-rows, so plentifully found in almost every part of the moon, they occupy the site of a long-extending crack or fissure. It will also be noted that, with two or three exceptions, they have prominent central hills, and that the most southerly constituent of the chain consists of at least four inosculating rings of unequal size.

The sharpness and general excellence of MM. Henry's photograph is otherwise manifested by the ease with which many of those delicate cracks or furrows called "rills" can be followed. The well-known cleft passing through Hyginus, with its local expansions and contractions, is admirably distinct. The more attenuated but longer object of the same class running towards the east from Ariadaeus, and the very remarkable group of rills, all of considerable delicacy, situated on the grey plain west of Triesnecker are also plainly traceable.

Letter.

The Editor does not hold himself responsible for the opinions or statements of correspondents.

ON THE ELECTRIC ORIGIN OF THE SOLAR CHROMOSPHERE.

To the Editor of Knowledge.

Dear Sir,—The October number of Knowledge contains the summary of Mr. Evershed's very interesting experiments on the question whether gases can become luminous by heat alone. This question is a very difficult, and a very important one too, and the results given by the numerous observers who have studied it are not alike. Two leading spirits, Profs. Helmholz and Stokes, have set forth upon this subject quite different opinions.

From all the experiments it may be concluded, I believe, that gases can emit from the single elevation of temperature a continuous spectral light, as the solid and liquid bodies do; but does light, in the same conditions, show the characteristic lines? Some doubts are still allowed, for sodium vapour, the only one that has been studied, contains, as a rule, hydrogen in great quantity, and therefore is not absolutely pure; besides, the recipient used is either attacked by it, as porcelain, or else is porous for the gases of the flame, as hot iron.

These objections are raised with a view to obtaining explanations.

However, Mr. Evershed concludes from his experiments on sodium vapour that all the gases may generally give their characteristic vibrations by heat only, and he immediately applies this result to the solar chromosphere, the light of which might be due to the intense heat of the disc. Mr. Brester explains the chromosphere by chemical combinations, but, for my part, I have already owned the necessity of an electric action (1). As I have got to this result without touching the great question of the luminescence of the gases, I think I must expound it with some details.

The characteristic lines of the gases are due either to heat (I admit that heat may suffice) or to a chemical action, or to an electric action. But, *a priori*, chemical and electric actions bring in something more, that is, a chemical combination, an electric and magnetic field, and one understands that they may be attended by special vibrations. This induction is confirmed by all the facts of spectral analysis. With the same body, electricity gives lines that a chemical flame does not show; moreover, the induction spark does not give the same spectrum as the electric arc, and the addition of a condenser in the circuit of the spark causes the production of new and special lines.

(1) *Comptes rendus de l'Academie de Paris*, 27 November, 1893. Knowledge, December, 1893.

In that point of view, the characteristic hydrogen spectrum is particularly remarkable. It has never been obtained in chemical flames, even the hottest, and although thousands of attempts have been made under the most varied conditions(2). On the other hand, the smallest induction coil gives it easily, and, a point well worth noticing, the electric arc gives it also, but feeble and with difficulty; so that electric interference, even with a notable tension, appears necessary to its formation(3).

Now then, all the points of the chromosphere show this characteristic spectrum of hydrogen, so that we must conclude, as Mr. Fizeau, and, I believe, Dr. Huggins do, that the chromosphere is an electric flame; or, at least, this conclusion, which rests on a great number of varied experiments, is by far the most probable, in the actual state of our knowledge. But this point once admitted, I have been somewhat puzzled for a moment, because the electric flames of our laboratories have not that same shape, and spring up generally between two poles. Now, in the present case, where are the poles?

Quite naturally I have thought of the earth, which is the only celestial body we know (yet imperfectly), and which being a cooled sun, must, in all likelihood, present on a smaller scale the same phenomena as the incandescent stars do, on a larger scale.

And I have immediately been struck with the analogies between the solar chromosphere and our own atmosphere, looked upon from the point of view of its electric state. This odd and as yet unexplained phenomenon of the rapid increase of the electric potential with the altitude(4), which constitutes what is called atmospheric electricity, is general for all the earth. The fall of potential, as we know, is stronger in tropical regions; stronger also, all the other conditions being the same, in mountainous regions.

Now in the solar atmosphere the electric distribution is also the same, the fall of potential in each point being measured by the intensity of the light set forth: indeed, the chromosphere is brighter in the region of the spots, and, above all, shows very clear maxima over the faculæ which are just the lofty part of the surface of the sun. Then both electric phenomena have the same ways in both atmospheres, and this unexpected verification strongly confirms the admitted conclusion.

However, the terrestrial atmospheric electricity, the cause of which is still unknown, is probably due to the evaporation, the condensation and the relative motions of the atmospheric gases. The same causes exist also for the sun, and in larger proportions; and one may comprehend that the effects must also be more considerable.

One single remark more and I have done. The electric explanation of the chromosphere agrees very well with all the mechanical theories of the sun, and especially with that of Mr. Faye, which, in my judgment, best explains the whole of the phenomena. Likewise, in the study of the terrestrial tempests, the motions of the air, and the electric variations that attend them, are generally studied apart. In reality, the advancement of our knowledge of the solar atmosphere is closely bound up with the progress of terrestrial meteorology.

Yours truly,
H. Deslandres.

The Observatory, Paris.

(2) Prof. Hartley, in a recent study on the spectrum of the Bessemer flame (*Proceedings of the Royal Society*, Vol. LVI., No. 337, p. 193), has made this very interesting observation: "In the first period of the blow, the C line of hydrogen, and apparently the F line, were seen reversed during a *snow-storm*." Now, Prof. Hale, in the last number of *Astronomy and Astro-physics*, page 771, relates this new experiment and adds that the fact, it substantiated, is contrary to the electric explanation of the chromosphere. I have not the same opinion for several reasons:—1st, In this one experiment the rays are not brilliant, but black and reversed, which is not exactly the same; 2nd, a very strange condition, difficult to realize, the coincidence with a snow-sto m appears necessary. In a snow-storm the differences with the ordinary conditions are not in the com osition of the gaseous air, which is only relatively dry, but in the particular state of atmospheric electricity; so that electricity seems yet to bear a predominant part in the phenomenon. But, was snow falling on the flame? The note of Prof. Hartley gives no details, and the complete discussion is therefore difficult. In fact, till further experiments, I maintain my first conclusions: and this curious observation, such as I have understood it, suggests to me only the idea to study the Bessemer flame in various electric fields, in conditions as similar as possible to those of a snow-storm.

(3) The intense chromosphere lines H and K of calcium confirm the result to a certain point: very feeble in the chemical flame where Prof. Hale has recognized them, they are strong enough in the electric arc, and very strong in the induction spark, according to the experiments of Prof. Lockyer. The gradation is the same if we notice that chemical flames are the seat of weak electro-motive forces. We see that the production of these lines seems to require, as the electrolysis of the saline solutions, the use of a minimum number of volts; a small number for calcium, but a high one for hydrogen

(4) The difference of potential between the top and the bottom of the Eiffel Tower is often 10,000 volts.

Science Notes.

The Christmas course of lectures, suitable for children, at the Royal Institution, will be delivered by Prof. J. A. Fleming, F.R.S. The subject will be "The Working of an Electric Current," and the first lecture will be delivered on December 27th, at three o'clock.

Our contemporary *Nature* has completed its fiftieth half-yearly volume. Prof. Huxley wrote the first leading article in 1869, and he has also written the leading article for No. 1305, vol. 51, November 1st, in which he shows how firmly grounded is the theory of evolution.

The Museum of La Plata will shortly issue the second part of Mr. Lydekker's memoir on the fossil vertebrata of the Argentine Republic. It will be illustrated by over sixty folio plates, and deal chiefly with the Edentate mammals.

Nature for November 15th reproduces from *La Nature* some beautiful figures produced from ink, by Dr. E. Frouessart. A drop of ink is allowed to dry on a slip of glass, and observed under a microscope. They belong chiefly to the cubic system, and the writer of the original paper suggests that they are magnetic oxide of iron. But this question is not settled, they may be iron-disulphide.

Talking of "extinct monsters," it may be just as well to remind our readers that the animals so humorously introduced into *Punch's* "Prehistoric Peeps," by the artist, Mr. E. T. Read, are not in all cases founded on fossil remains, though many of them are. Truly, there are more things in Mr. Punch's mind than are dreamed of in our geological philosophy!

The German Emperor has lately presented to the Berlin Natural History Museum a very fine specimen of a Plesiosaurus skeleton (the first ever found in Germany), in which part of the outline of the creature is preserved on the rock, chiefly about the tail. It has been named after the Emperor by Prof. W. G. Dames, of Berlin, who will in February lecture on it to the Academic. The lecture will afterwards be published with a plate.

[The plate representing the "Daddy long-legs" in the November number of Knowledge was taken from a lantern slide kindly lent by Messrs. Newton & Co.]

The filtration of water, on a large as well as on a small scale, has acquired quite a different significance since the bacteriology of water has sprung into existence. (Surgeon-Major Johnston's short treatise on "the relative efficiency of certain filters for removing micro-organisms from water.") He has examined the Atkins' patent water filter, Maignen's table "filtre rapide," and the Nordmeyer-Berkefeld filter, and the Pasteur-Chamberland filter. The first two he considers useless for sterilizing water. The Pasteur-Chamberland filter is, in his opinion, the best and only one on which reliance can be placed for permanently sterilizing water. The investigations were carried on in the Public Health Laboratory of Edinburgh University.

Natural Science for the last two months gives some very interesting facts with regard to the way in which animals can gradually adapt themselves to new conditions, even when those conditions are at first fatal. From an account in the *Pittsburg Dispatch*, it appears that in the cold-storage warehouses in Pittsburg there were originally no rats nor mice. The temperature in the cold rooms was too low. But after a few months rats were at work in the rooms where the temperature was constantly kept below the freezing point, and they were clothed in long and thick fur. Cats were, therefore, turned loose in the cold rooms, but they pined and died. At last a cat with unusually thick fur was found which thrived there, and by careful nursing, a brood of seven kittens was developed. They have been distributed among other cold-storage houses of Pittsburg, and have created a peculiar breed of cats adapted to the conditions. The cats are now so acclimatized that they cannot live in the open air during the hot season.

"From the Greeks to Darwin; an outline of the Development of the Evolution Idea," is the title of an instructive work by the well-known palæontologist, Prof. H. F. Osborn, of the Columbia University, New York. Evolution, as a natural explanation of the origin of the higher forms of life, may have succeeded the old mythology in Greece, and *appears* to have first developed from the teachings of Thales and Anaximander (B.C. 611-547) with those of Aristotle. This great philosopher had a general conception of the origin of higher species by descent from lower species, and he even stated the theory of the survival of the fittest, though rejecting it as an explanation of the evolution of adaptative structures. He also believed that there was no fortuity in evolution, but that the succession of forms of life was due to the action of an internal perfecting principle originally implanted by the Divine Intelligence. What is this idea but the modern "law of progress," so strongly proved by the discoveries of palæontology? We would, however, humbly suggest that in these matters, as in others, the Greeks took their teaching from Egypt, where the problems of life and of creation had been deeply pondered over and partly explained to initiates of their sacred mysteries.

We have received a specimen from Messrs. Newton & Co. of their "spectrum top," which consists of a disc, half of which is white and half black. Over the white half are four groups of concentric lines. Upon being spun the black disappears, and the whole face is covered by four sets of circles, each of which assumes to the eye a peculiar tint. The hues appear to be dark from the centre when the top is spun from the right, and lighter when spun from the left.

Notices of Books.

By Order of the Sun to Chile, to see his Total Eclipse, April 16th, 1893. By J. J. Aubertin. Pp. 152. (London: Kegan Paul, Trench, Trübner and Co., 1894.) To the casual reader of astronomical literature who desires to know how an eclipse expedition appears to a layman's mind, we commend Mr. Aubertin's narrative. The author is an enthusiastic observer of the progress of astronomy, and, though in the evening of life, he journeyed to Chile in April, 1893, in order to witness the most impressive of celestial phenomena—a total eclipse of the sun. And just as an onlooker sees more of a fight than any of the combatants, so an intelligent spectator can take in the astonishing beauty of a solar eclipse better than the astronomer whose whole being, during totality, is wrapt up in the photographic camera or spectroscope of which he has charge. Mr. Aubertin was fortunate in selecting Chile as his destination, for he was not only able to observe the eclipse in all its fulness, but could also watch the proceedings of Prof. Schaeberle's party. His book contains a fine photograph of the professor, and four other plates—one representing a symmetrical corona of the familiar "Catharine wheel" type. After the eclipse had taken place, Mr. Aubertin made a pilgrimage to Arequipa, La Paz, and Cuzco, then to Lima and San Francisco, and then he crossed the line (for the sixteenth time) and returned home. The incidents of his journeys on sea and land are described with a certain amount of pleasantness, but we think the book will only be appreciated by a limited circle of readers. It will be more interesting to the author than to anyone else.

Forest Birds: their Haunts and Habits. By Harry F. Witherby. Pp. 98. (London: Kegan Paul, Trench, Trübner & Co., 1894.) Mr. H. F. Witherby's papers on popular natural history are well known to our readers. In the dainty little volume under review, some of these papers are printed with others contributed by the author to *Science Gossip*: the whole collection forming an interesting account of the haunts and habits of eight species of forest birds. The chapters of the book are not, however, merely reprints of articles, but rather the original papers rewritten for publication in book form. Mr. Witherby writes easily, clearly, and with the accuracy that comes from personal observation of the birds he describes. His book is embellished with thirty illustrations, most of them full-page plates, for which we have nothing but praise. They are among the finest specimens of process blocks that we have yet seen, and the paper upon which they are printed brings them out perfectly. The book is attractive as well as instructive, and is just the sort of volume to present to young beginners of the study of Nature, while children of an older growth will derive profit from its perusal.

Practical Methods in Microscopy. By Charles H. Clark, A.M. Pp. 210. (Boston: D. C. Heath & Co. London: Isbister & Co., 1894.) This is a practical handbook to the microscope, and, as a book containing descriptions of the many processes connected with microscopical researches, couched in simple language, and suitable for beginners and private workers, we heartily welcome it. The methods described are workable, and they refer to many branches of scientific study. The preparation and observation of sections of plants, animal tissues, and rocks are fully treated, as well as the preparation and examination of crystals and bacteria. There is also a chapter on photo-micrography. The theoretical principles involved in the construction of the microscope are briefly and accurately explained, and also the principal phenomena of polarized light, so far as they have practical application in the use of the microscope. These will lead the student to an intelligent understanding of the instrument he uses. The book is illustrated with forty figures in the text and seventeen fine reproductions of photo-micrographs. It is a work such as should be in the hand of everyone who purchases a microscope for serious study. There are several important treatises on various branches of microscopy, and many little books of mediocre quality, but we know of no volume so suitable for the self-taught student as the one before us.

Lectures on the Darwinian Theory. Delivered by the late Prof. A. Milnes Marshall, F.R.S.; edited by C. F. Marshall, M.D., B.Sc. Pp. 228. (London: David Nutt, 1894.) Of the late Prof. Milnes Marshall it may be truthfully said, as he himself said of Buffon, "he led many to think about and take an interest in natural history, and to add to it by their own observations, who would not otherwise have done so." An original thinker, an eminent investigator, a lucid writer, and an eloquent lecturer, he was an ideal exponent of scientific truths. The series of lectures recorded in this volume were delivered in connection with the Extension Lectures of the Victoria University during 1893, and they really constitute the most entertaining description of Darwinism that it is possible to obtain. The work opens with a historical account of the theory of evolution, and then in turn come artificial and natural selection, the argument from palæontology, the argument from embryology, the colours of animals and of plants, objections to the Darwinian theory, the origin of vertebrated animals, and the life and work of Darwin. Prof. Marshall had a thorough grasp of his subject, and he was an earnest disciple of Darwin. If he had lived to see the present volume through the press, some portions of it would doubtless have been amplified and altered; but even as it stands it is a worthy monument to his brilliant qualities, and an excellent statement of the development of the theory of evolution.

By Moorland and Sea. By Francis A. Knight. Pp. 215. (London: Elliot Stock, 1893.) Gentle reader, you should get this book. It is a book to read when light mental refreshment is required; a book to pick up when the dry bones of science have begun to pall upon your appetite; when you have had enough instruction and want to be entertained. The author is a keen and sympathetic observer of Nature—a naturalist with poetic fancy like Gilbert White and Richard Jefferies. There are now many writers on what may be termed the poetry of science, but none write more agreeably than Mr. Knight, or express their thoughts in a more attractive style. We have only one word of objection to this collection of papers originally contributed by the author to various journals: it is, that the two or three papers on subjects not connected with natural history would have been better omitted.

BOOKS RECEIVED.

A Treatise on Chemistry. By Sir H. E. Roscoe, F.R.S., and C. Schorlemmer, F.R.S. Vol. 1., The Non-Metallic Elements. (Macmillan & Co.)

A Laboratory Manual of Organic Chemistry. By W. R. Orndorff. (D. C. Heath & Co.)

Physiology for Beginners. By M. Foster, M.A., M.D., F.R.S., and Lewis E. Shore, M.A., M.D. (Macmillan & Co.)

Travels with a Sunbeam; or Elements of Astronomy. Parts 1 and 2. By Arthur Z. Dadı. (Birmingham: W. G. Moore & Co.)

By Vocal Woods and Waters. By Edward Step. (Bliss, Sands & Foster.)

On Pedal and Antipedal Triangles; being an attempt to investigate the Laws of their Evolution. By A. S. Ghosh, F.R.A.S. (Patrick Press, Calcutta.)

First Things First. By the Rev. G. Jackson, B.A. (Hodder & Stoughton.)

Life and Mind: on the Basis of Modern Medicine. By Robert Lewins, M.D. (W. Stewart & Co.)

The Vaccination Question. By Arthur Wollaston Hutton. (Methuen & Co.)

Brief Notes on the Physical and Chemical Properties of Soils. By R. Warington, F.R.S. (Chapman & Hall.)

Science for All. Part 58. (Cassell & Co.)

The Royal Natural History. Edited by Richard Lydekker, B.A., F.R.S. (Warne & Co.)

The Review of Reviews for November. (125, Fleet Street, E.C.)

The Eighth Annual Report of the Société Astronomique de France.

The American Geologist. (The Geological Publishing Co., Minneapolis).

The Journal and Transactions of the Royal Photographic Society of Great Britain. (W. Watson & Sons.)

Catalogue of Slides, Optical Lanterns, and Dissolving Views Apparatus. (E. G. Wood.)

Catalogue of Microscopes and Apparatus. (R. G. Mason.)

Catalogue of Microscopes and Apparatus. (R. & J. Beck, Ltd.)

THE INDUSTRY OF INSECTS IN RELATION TO FLOWERS.

By the Rev. ALEX. S. WILSON, M.A., B.Sc.

As fertilizing agents, insects perform an indispensable service to flowers; it is only a small proportion of the available species, however, that are utilized for this work. Many blossoms depend for their fertilization exclusively on a single order of insects; others avail themselves of only a few families, and in some instances a flower's visitors appear to be confined almost entirely to a single species of insect. Besides attractions such as honey, scent, and brilliant colours, most flowers exhibit contrivances for the exclusion of undesirable guests. And it is not simply creeping and gnawing kinds, whose visits are positively injurious, that are thus excluded; many winged and harmless species are also denied access. The size and shape of an insect may even be well adapted for the fertilization of a particular flower, and yet its visits may be discouraged. Since the chances of cross-fertilization increase with the number of visitors, it is clearly of advantage for flowers to be visited by the utmost possible variety of insects; any limitation might, therefore, be regarded as prejudicial. The disadvantage of restriction may indeed be more than counterbalanced, as Herman Müller points out, if thereby the attractiveness of the flowers for special insects be increased, but the benefit arising from the limitation of insect-visits perhaps admits of fuller elucidation than it has yet received. The exclusion of certain insects from a particular flower, we have been accustomed to ascribe to the fact of their size and shape being ill-adapted for its fertilization; but there are other reasons, and it is to these that we wish to direct attention in this paper.

To appreciate the significance of the restriction, it is only necessary to compare the relative importance of the number of visitors which a flower receives with the industry of the individual visitors. If all insects of suitable size and shape visiting flowers were equally industrious, then restriction would be disadvantageous. The fundamental reason for a limited selection is to be found in the circumstance that the efficiency of any set of fertilizing agents depends not so much upon their numbers as upon the number of separate flowers which each individual visits, or, in other words, upon their industry. Ten visits made by ten different individuals are far less effectual than the same number of visits performed by a single insect. A small number of bees, butterflies, or other systematic visitors will fertilize far more flowers than a much larger number of miscellaneous insects which only visit flowers occasionally and at random, even if the latter be equally adapted as regards bodily form. An insect in any case cannot effect cross-fertilization at all unless it visits at least two flowers. A plant will, therefore, lose rather than gain by attracting any species of which the individuals do not, during the time the plant remains in bloom, visit on an average at least two flowers apiece. The superiority of a small number of industrious insects over a larger number of indolent ones depends chiefly on the increased risk in the latter case of repeated visits being paid to the same flower. An individual bee of any intelligence will not, if it can help it, return to a flower from which it has already removed the nectar. If, however, there be a number of visitors, manifestly they cannot avoid entering many previously visited flowers, and in this way a considerable proportion of the visits are as good as lost so far as the blossoms are concerned. To illustrate the disadvantage arising from revisitation or overlapping, let us suppose that a certain area contains ten flowers; the visitation of the whole ten will be overtaken in a given time by a bee which makes ten visits in that time, assuming that the insect works intelligently so that no flower receives more than one visit. But ten miscellaneous insects, say flies, each visiting but one flower in the same period and working independently cannot, although the total number of visits is the same, overtake the whole ten flowers. Obviously there is nothing to prevent all the ten flies entering the same flower, and in that case the other nine would remain unvisited. Again, their visits might be confined to two, three, or more flowers, while the remaining ones were neglected. The ways in which the ten visits may be distributed are so numerous that it could only rarely happen that each fly went to a separate flower and the whole ten were visited. The first fly runs no risk of entering a previously visited flower; the value of its visit may, therefore, be represented as 1. The value of the second fly's visit is rather less, for although there are still nine unvisited flowers, it may chance to enter the same one as its predecessor, and the visit be lost. As there are ten flowers, the risk of this is $\frac{1}{10}$; the value of the second fly's visit is, therefore, diminished by that amount and only counts $\frac{9}{10}$. The third fly is also liable to enter the first visited flower, and there is the further contingency of its entering the same one as the second fly; the former risk, as before, is $\frac{1}{10}$; the latter $\frac{1}{10}$ of $\frac{9}{10}$, or $\frac{9}{100}$, which falls to be deducted along with $\frac{1}{10}$ from 1 to obtain the value of the third visit, which represents the average efficiency of the third fly. We have thus obtained the first terms of a decreasing geometrical series $1 \cdot + \frac{9}{10} + \frac{81}{100} + \frac{729}{1000}$, etc., the successive terms of which represent the value of each additional visitor. From the formula $s = \frac{ar^n - a}{r - 1}$, where s is the sum of the series, a the first term, r the ratio, and n the number of terms, we can obtain the value of s—that is, the number of flowers overtaken by n visitors. In like manner, insects which each visit two flowers furnish a corresponding series, 2, 1·6, 1·28, etc., and similarly with those having a higher rate of industry. Arranging these results, we get the following table, in which the first vertical column shows the number of insects engaged, and the upper horizontal line their rates of industry; the other figures indicate the average number of separate flowers overtaken in each case.

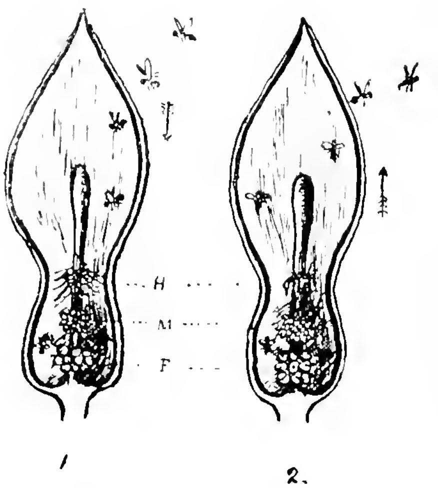
From this table it will be seen that while one flower is visited in the specified time by an insect whose industry is 1, and two by an insect with twice this diligence, two insects each with unit industry can only overtake on the average 1·9. It will also be seen that ten casual visitors only overtake 6·5 out of the ten flowers in their ten visits; the difference 3·5 represents the average loss from overlapping of agency or frequenting previously visited flowers.

	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	1·9	3·6	5·1	6·4	7·5	8·4	9·1	9·6	9·9	
3	2·7	4·9	6·6	7·8	8·75	9·4	9·7	9·9		
4	3·4	5·9	7·6	8·7	9·4	9·7	9·9	9·9		
5	4·1	6·7	8·3	9·2	9·7					
6	4·7	7·4	8·8	9·5						
7	5·2	7·9	9·2	9·7						
8	5·7	8·3	9·4	9·8						
9	6·1	8·6	9·6							
10	6·5	8·9	9·7							
20	8·3									
30	9·6									
40	9·8									
50	9·9									
100	9·9									

The efficiency of five insects whose industry is 2 is slightly greater, being 6·7; the total number of visits is the same in both cases, but more are overtaken in the latter, since each insect must visit two distinct flowers. Again, when two insects are engaged, each visiting five flowers in the specified time, they overtake 7·5 out of the ten flowers in their ten visits. Lastly, if we suppose only one insect to be employed with an industry of 10, then all the flowers are overtaken, assuming that it works intelligently and visits each flower but once, for a careless or unintelligent worker will lose as much as ten different insects do by overlapping. The above figures also show that eight visitors with an industry of 2 overtake exactly the same amount as five, each having an industry of 3: there is an extra loss of one visit from overlapping in the former case. As the result of these calculations we deduce the following conclusions:—

1. The maximum effect is obtained when one insect is employed to visit the whole ten flowers.
2. The industry of the individual visitors is of greater importance than their numbers.
3. When more than one insect is employed the efficiency is rapidly reduced at first, afterwards more slowly; this means that there is a premium on the higher rates of industry.
4. The effect of augmenting the industry diminishes as the number of insects employed increases; where the number of visits is greatly in excess of the number of flowers, overlapping must occur whether the excessive visitation be due to numbers or industry, and the advantage of the latter over numbers disappears. Hence industry becomes of paramount importance where insects are scarce.

It is, therefore, clear that there must be a strong tendency for the work of cross-fertilization to be left more and more to anthophilous species, to the exclusion of those insects which do not entirely restrict themselves to a floral diet. The visits of the latter are less valuable because of the inevitable amount of revisitation. If, however, the insects be very numerous in proportion to the flowers, numbers may be substituted for industry without loss of efficiency, and this consideration throws an interesting light on the peculiarities of certain blossoms. From our present point of view, entomophilous flowers may be arranged in two classes, according as they facilitate the work of their visitors or delay their operations. Where the number of insects is small relatively to the flowers, it is to the plant's advantage to expedite the work of its visitors. This is, no doubt, one reason for the presence of bright colours, scent, landing-stages, markings, or honey-guides, as well as for colour-changes such as are seen in Lantana, Hibiscus, Arnebia, and other changeable flowers, indicating to visitors, as Fritz Müller believes, those blossoms which have already been visited. Such contrivances for saving their visitors' time benefit the flowers in the long run, since the visitors are thereby enabled to overtake a larger number of blossoms: these facilities, in fact, increase their rates of industry. There are, however, other flowers which instead of promoting the industry of their visitors imprison their guests, detaining them for a day or longer. Such is the effect of the well-known mouse-trap arrangement of hairs in Aristolochia, Ceropejia, Arum, and a few others. Flowers of this class are frequented in great numbers by minute flies or midges, which hover in clouds near the plants. On account of their numbers, little or nothing would be gained by arrangements to facilitate speedy visitation, and as little is lost by the detention of such insects. These flowers rely on the numbers of their visitors, not on their industry, and hence honey-guides and other conveniences are mostly absent. Aristolochia is protogynous, the stamens not being matured until after the stigma has been pollinated, hence the necessity for detaining the visitors until the pollen is shed; were they allowed to depart before this happened, they could confer no benefit on the next flower they entered. Further, there is in Aristolochia a special provision against revisitation, for the flower-tube becomes inverted soon after the pollen is discharged. We can hardly be in doubt, therefore, as to what were the conditions out of which this curious mouse-trap contrivance arose; the number of insects must have been greatly in excess of the flowers, and they must have belonged to the class of unsystematic or careless workers. On the other hand, the arrangements for facilitating visits, so common in flowers, could only arise with the flowers greatly in excess of the insects, and with insects of industrious habits, given to flower visitation more or less continuous. Open shallow flowers with exposed honey or pollen, being accessible to all insects, attract a great variety of visitors but the overlapping of visits must be so great that only a small proportion of the visits can be effective.



Arum.

1 First or female stage. H, mouse-trap hairs; M, stamens not yet mature; F, pistils capable of fertilization.

2 Second or male stage. H, mouse-trap hairs withered; M, stamens discharging pollen; F, pistils fertilized in preceding stage.

Deep tubular flowers adapted to the proboscis of a bee or moth exclude short-lipped flies, and though attracting fewer visitors, yet attract a more industrious class, so that as regards cross-fertilization, the efficiency is as great or greater than in the case of shallow flowers with more numerous guests. The restriction is, therefore, advantageous, even apart from the circumstance that bees and butterflies are in respect of size and shape more desirable visitors. A difficulty is presented by very deep tubular flowers adapted exclusively to Lepidoptera, of which Lonicera, Lychnis, Gymnademia, and Habenaria are examples. *Angræcum sesquipedale*, an orchid belonging to Madagascar, with a spur ten or eleven inches long, is an extreme example of the same type. Flowers of this class exclude even bees. Now although as regards adaptation to flowers the Lepidoptera take the first place among insects, they are only of second or third rate importance as fertilizing agents. In this respect bees decidedly take the first place. They have, moreover, generally been accredited with greater diligence than butterflies. It is not easy, therefore, to see how the industry of individual visitors could be a factor in bringing about the adaptation of deep tubular flowers to the Lepidoptera. A little reflection, however, serves to show that the principle applies even here. It hardly admits of doubt that these very deep flowers are derived from ancestors which had their honey accessible to bees. Now we only need to suppose that the bees got into the way of avoiding the deepest flowers on account of the difficulty experienced in obtaining the nectar; not that fewer bees visited the deep-tubed flowers, but that each bee paid fewer visits to them. By this means not only would the total visitation of the deeper flowers be reduced and diligence in consequence gain ascendancy over numbers, but in relation to the deep flowers bees would become intermittent or casual visitors, and the value of their visits would be greatly reduced. Finding they enjoyed a monopoly of the nectar, butterflies would frequent the deep flowers with increased diligence, and their visits, from less overlapping, would become more valuable. Honey and pollen bestowed on casual visitors is for the most part wasted; and natural selection must inevitably lead to the exclusion even of bees, notwithstanding their exceptional industry, when they cease to visit any species of flower diligently.

The penalty of unused power is its removal; a door which a person does not often enter is likely to close against him permanently. This punishment has overtaken the bees, who now find the deep-tubed flowers their predecessors neglected closed against them for ever. This has apparently taken place in the Alps, where Müller found that many flowers, which in the lowlands are adapted to bees, have in the uplands become specialized for Lepidoptera. This result he ascribed to the scarcity of bees in the higher regions, but the scarcity of an insect can hardly account for its exclusion: rather we should expect this condition to bring about keener competition for the services of the insects, and increased attractions on the part of the flowers. The scarcity of bees cannot, therefore, be the direct cause of this change; it may, however, bring it about indirectly. As the number of bees diminishes they have a greater choice of flowers, and each honey-gatherer will naturally go to the deeper and more difficult flowers as seldom as possible. In relation to these flowers bees will thus acquire the character of casual or indolent visitors. At the same time, on account of diminished visitation, the balance is turned against numbers in favour of diligence. The butterflies meantime becoming more diligent so far as the deeper flowers are concerned, and the bees less so, we have the conditions fulfilled which lead to the exclusion of the occasional visitors, and more perfect adaptation to the habitual frequenters of the flowers. The same process in course of time would lead to still further specialization, such as is seen in Angræcum, from which the honey can only be removed by a moth having a proboscis nearly a foot in length. Butterflies and moths in some respects are, no doubt, preferable to bees as pollen-carriers; they are more purely suctorial, and do not consume such quantities of pollen as bees, neither do they use the mouth-parts for other purposes; a greater differentiation of these in relation to flowers has, therefore, been possible than in the case of bees. Müller states generally that, among anthophilous insects, intelligence keeps pace with the length of the proboscis and other marks of special organization. At this rate we should expect butterflies to excel bees in industry and intelligence. Some of the Lepidoptera are at least as quick at their work as the bee. Mr. Darwin mentions twenty visits per minute for a bee which he timed. One of the quickest workers among the Lepidoptera is *Macroglossa stellatarum*, which was seen by H. Muller to visit one hundred and ninety-four flowers on different plants in six and three-quarter minutes—that is, at the rate of 28·7 per minute. Our contention regarding the importance of industry would be borne out, however, even although the Lepidoptera were the less industrious of the two orders. Relatively to the deeper flowers, which bees rarely visit, they are the more industrious, and this is all we are concerned to maintain in seeking to account for the exclusion of the bee from deep flowers on the score of its inferior industry.

THE HAZING EFFECTS OF ATMOSPHERIC DUST.

By Dr. J. G. McPHERSON, F.R.S.E., *Lecturer on Meteorology in the University of St. Andrews.*

THE results of Mr. John Aitken's observations during a period of eighteen months, to ascertain the hazing effect of the dust-particles in the air without the aid of the dust-counter, show that, without counting the number of dust-particles, the transparency of the atmosphere is very much destroyed by the impurities communicated to it while passing over the inhabited areas of the country. He has shown that the thickness of a haze depends on the number of dust-particles present, on the degree of saturation of the air, and to some extent also on the vapour-pressure. Supposing we had two samples of air, both at the same temperature, and both having the same depression of the wet-bulb thermometer, if one of these samples be more hazed than the other it will be found to have more dust-particles in it than the other, and to be the thicker the greater the number of particles present. And for a given number of particles, the damper the air the thicker is the haze. These conclusions placed in his hands a means of comparing the amount of dusty impurity in different masses of air, or of different airs brought to us by winds from different directions.

He took Falkirk for his centre of observations. This town lies a little to the north of a line drawn between Edinburgh and Glasgow, and is nearly midway between them. If we draw a line due west from it, and another due north, we find that in the north-west quadrant so enclosed the population of that part of Scotland is extremely thin, the country over that area being chiefly mountainous, and there is not a town in it of any size within 70 miles, with the exception of Stirling. In all the other directions the conditions are quite different. In the north-east quadrant are the fairly well-populated areas of Aberdeenshire, Forfarshire, and the thickly-populated county of Fife. In the south-east quadrant are situated Edinburgh and the well-populated districts of the south-east of Scotland. And in the south-west quadrant are Glasgow and the large manufacturing towns which surround it. Therefore, Falkirk has round it three thickly-populated areas, while the fourth is very thinly populated. The result is that while the winds from the three districts bring air polluted in its passage over populated areas, the winds from the north-west quadrant come comparatively pure. If, now, the air that comes from these several districts be compared, the effects of the products of combustion on the clearness of the atmosphere can be determined.

Mr. Aitken adopted the plan of estimating the haze by noting the most distant hill that could be seen through the haze. The distance in miles of the farthest away hill visible is then called "the limit of visibility" of the air at the time. But as it is almost never possible to get a sufficient number of hills at different distances to work in this way, he estimated the amount of haze on some hill at a known distance, and calculated from that estimate the greatest distance at which a hill could be seen under the conditions. For the observations made at Falkirk only three hills are available, one about four miles distant, the Ochils about 15 miles distant, and Ben Ledi about 25 miles distant, all in the north-west quadrant. When the air is thick, only the near hill can be seen, then the Ochils become visible as the air clears, and at last Ben Ledi is seen when the haze becomes still less. After Ben Ledi is visible, it then becomes necessary to estimate the amount of haze on it, in order to get the limit of visibility of the air at the time. Thus, if Ben Ledi be half-hazed, then the limit of visibility will be 50 miles. In this way all the estimates of haze have been reduced to one scale for comparison.

After going over the hundreds of observations made in his note-book during these eighteen consecutive months, and rejecting all those which were unsatisfactory, from the conditions being uncertain, there remained two hundred observations, which he has classified and arranged for the determination of the hazing effects of atmospheric dust. As the density of the haze could only be compared on those days when the humidity was the same, the first thing was to arrange all the observations in tables according to the wet-bulb depression at the time. Tables were accordingly prepared, in one of which the observations made when the wet-bulb depression was 2° were entered; and so on for depressions of 3° up to 8°. The different observations in each table were at the same time entered in such a manner that all those made when the wind was north were put together, all those when it was north-east next each other, and so on.

I will now give an abstract of these tables. As the dryness of the air increases, the limit of visibility also increases. When the wet-bulb depression was 2°, the east wind had a limit of 10 miles, and increased to 22 miles when the air was dry enough to give a wet-bulb depression of 8°. The south wind increased from 8 to 32 miles, the west from 7 to 17 miles, and the north from 50 to 172 miles. There is a very great difference in the transparency of the wind from the different directions. In the north-west quadrant the winds made the air very clear, whereas winds from all other directions made the air very much hazed. The winds in the other three areas are nearly ten times more hazed than those from the north-west quadrant. When the wet-bulb depression is 2°, the wind from that quadrant is about 6·2 times clearer than air coming from the best of the other areas; and when the air is drier than gives more than 2 depression, the mean of all the observations shows that the air from the north-west quadrant is more than nine times clearer than that from the other directions. That is, the table shows that the air from densely-inhabited districts is so polluted that it is fully nine times more hazed than the air that comes from the thinly-inhabited districts; in other words, the atmosphere at Falkirk is about ten times thicker when the wind is east or south than it would be if there were no fires and no inhabitants.

It may be interesting to show how much the individual observations differed from each other. The limit varies considerably for the same wind at the same humidity. That is what might have been expected, because from the observations made by the dust-counter, the number of particles varied greatly in winds from the same directions, but at different times. This depends upon the rise and fall of wind, changes in the state of trade, season of the year, and other causes. During the last strike the dearth of coal would make a considerable diminution in the number of dust-particles in the air of large towns. With a north wind, the extreme limits of visibility are 120 to 200 miles; and a north-west wind from 70 to 250 miles. An east wind had as limits 4 to 50 miles, and a south-west wind 2 to 60 miles.

One interesting fact to be noticed is this: that as a general result, the transparency of the air increases about 3·7 times for any increase in dryness from 2 to 8 of wet-bulb depression. That is, the clearness of the air is inversely proportional to the relative humidity, or, put another way, if the air is four times drier, it is about four times clearer. It may be thought by some that the highest limit of visibility given in the tables is too great; that 250 miles is too great a distance for a mountain to be visible—that is, supposing it was above the horizon. This estimate has been made, as above explained, by determining the amount of haze on Ben Ledi, 25 miles distant from the place of observation, and as this mountain was occasionally estimated to be only one-tenth hazed, that gives 250 miles as the limit on these occasions. But in previous observations on the Rigi Kulm, in Switzerland, Mr. Aitken had often seen Hochgorrach so clearly that it did not look more than a quarter hazed. Now, as that mountain is 70 miles distant from the Rigi, it makes the limit of visibility on these occasions about 300 miles.

THE WEB OF THE GARDEN SPIDER.

By E. A. BUTLER, B.A., B.Sc.

THE accompanying photograph represents the geometric web of the common garden spider, *Epeira diadema*. The spider itself appears in the centre of the web, in its usual position, head downwards, and with its under surface towards the observer. It is engaged in manipulating some insect which has just flown into the snare and considerably damaged it, especially on the right-hand side. The insect has been completely disabled by a strong silken covering which has been wrapped round its body so as to enswathe it like a mummy. In order to do this the spider seized its prey, fastened threads to its body, and then rapidly twirled it round by skilful movements with its feet, a band of silk being at the same time drawn out from the spinnerets and wound round the body. This species of spider may easily be recognized by its yellowish or brownish body, which is adorned on the summit of the abdomen with some pure white markings, the most conspicuous of which are in the form of a cross. From this cross is derived the name "porte-croix," by which the spider is known in France.

No better example of the geometric web could be found than that of the garden spider, and it is so familiar an object, through its large size, and the abundance of the species that constructs it, that one is apt to associate, though wrongfully, this particular kind of web with spiders in general. There are many kinds of spiders that do not construct a snare at all, but hunt their prey and leap upon it. And of those that do construct a snare, it is only one family that adopts the geometric pattern. Still, as this family, the *Epeiridæ*, contains some of the largest, as well as one of the commonest species, the geometric style is the one usually thought of when spiders' webs are mentioned. The geometric web of *Epeira diadema* is spread perpendicularly over an irregularly polygonal area, the exact form of which is dependent upon the herbage and other objects amongst which it is placed. In addition to the strong threads that form its boundary, not shown in the photograph, it consists of a number of straight lines radiating from the centre to the circumference, and a series of lines crossing these. These latter do not form

Web of the Common Garden Spider.

what their first appearance no doubt suggests, a series of concentric circles, or rather polygons, but they are constituted by a single thread wound round and round in a spiral fashion. This first proceeds from the centre to the circumference in such a way that the distances between the successive turns is double what it will ultimately be, and then the coil is carried backwards from circumference to centre, half-way between the previously formed convolutions.

There is a considerable difference between the radii and the cross lines. The former are stronger, less elastic, and much less sticky than the latter, and are composed of a compound strand proceeding from more or fewer of the spinning tubes which open on the spinnerets. The cross lines are somewhat finer, and, when freshly formed, have a number of globules of viscid silk all along them, like glittering beads on a string. This beaded appearance can be traced, with the help of a lens, in one of the threads in the right-hand top corner of the photograph, but it can hardly be seen elsewhere, as the web was not a freshly-formed one, and these globules of viscid matter dwindle on exposure to the sun, apparently by evaporation, whence the necessity for frequent repair, and possibly even the construction of a new web. Since these beaded threads do not harden on exposure to the air as the radii do, it is they chiefly that are the agents of detention when an insect flies into the snare.

The method of construction of such a web is interesting, and we will follow it in detail. The outline enclosing the area to be filled is first formed, and for this purpose the wind is made to lend some aid. The spider sits upon a leaf or other support, exposing its spinnerets to the wind, and by this means a thread is gradually drawn out and floats behind the creature till the free end comes in contact with some object, to which it at once adheres. Others will be formed and fixed in the same way, or by the spider dropping from point to point and carrying its thread with it. This goes on till an irregular area is enclosed. The radii are the next parts to be made. Proceeding to the centre of the upper boundary, the spider attaches a thread to it and then drops down to the opposite one, where the thread is again fastened, and thus we have the first diameter. This thread can now be used as a climbing pole, and the spider swarms up it, and attaching a new thread at its middle point, climbs up the rest of the distance, drawing out the thread as it goes. On reaching the horizontal boundary it turns aside and travels a short distance along it, thus stretching the newly-made thread across in a sloping direction from the first point of attachment to the point it has now reached, where a new attachment is made. Returning to the centre, the spider carries another line up in the same way, fastening its free end a little further on, and so on till all the radii have been laid down.

The next business is to put in the spiral thread. This, as already mentioned, is of different texture from the radii, and commences at the centre. Fastening the beginning of its new and more viscid thread at the centre, the spider crawls from radius to radius, going round and round in a spiral direction, and as it crosses each radius it fastens there the thread that trails behind it, using its hind legs to assist in the process. Having reached the outermost limit of its web, it retraces its steps, but threads the maze backwards between the lines already laid down, fastening each strand as it advances, just as it did on the way out, till it reaches the centre. Thus the cross lines of the web are in the form of a double spiral, the coils of the return half lying alternately with the rest. As a snare, the web is now practically complete; but the spider will not unfrequently improve its elasticity and powers of resistance by biting out a small part in the centre, thus severing the connection of the radii with one another, and throwing the burden of resistance upon the cross strands. If any object now gets entangled in the web, the highly elastic cross strands yield to its struggles, carrying the stiffer but now disconnected radii with them, and thus there is less likelihood of the main threads snapping, a catastrophe which might be followed by the escape of the prey. Any entanglement of cross threads that may take place can soon be set right again, and the damage, so far from being a drawback, may actually be advantageous, as it will lead to the substitution of new and more viscid threads for the older ones that have lost a good deal of their original viscosity.

A newly-formed web will usually be found to be very regular, but as time advances irregularities soon begin to appear, through the interference of wind and weather, as well as of insects flying into it. One of the commonest irregularities is that which is exhibited in many parts of the web represented in the photograph; two consecutive threads of the spiral have coalesced to form a single one for the greater part of their length, separating from one another only near the ends when they slope off to their respective attachments to the radii. This evidences both their elasticity and viscosity, for being stretched they have met, and then have adhered together.

The web, as just described, is intended to serve as a snare for the capture of prey, and not as a place of abode, even though the spider may often be seen at its centre where the web is not viscid. The spiders of the family *Epeïridæ* usually construct a cell or nest in some concealed spot near the web, and this is the true place of abode. It is connected with the snare by a strong line running to the centre of the latter, which forms a kind of tight-rope along which the spider passes when the sudden appearance of a desirable victim in the snare demands its immediate attention. If the insect is not too large, it will be at once twirled round and enswathed in silk, whereby its struggles will be prevented, and yet it will be kept alive and fresh, so that its captor can at any time obtain for itself a supply of fresh provisions.

THE FACE OF THE SKY FOR DECEMBER.

By Herbert Sadler, F.R.A.S.

Both spots and faculæ are still very numerous on the Sun's disc. Conveniently observable minima of Algol occur at 7h. 32m. p.m. on the 3rd, 4h. 20m. p.m. on the 6th, 9h. 13m. p.m. on the 23rd, and 6h. 2m. p.m. on the 26th.

Mercury is a morning star, and but for his southern declination would be well situated for observation during the first half of the month. He rises on the 1st at 5h. 50m. a.m., or 1h. 56m. before the Sun, with a southern declination of 16° 6′, and an apparent diameter of 6·0″, $\frac{73}{100}$ths of the disc being illuminated. On the 9th he rises at 6h. 20m. a.m., or 1h. 36m. before the Sun, with a southern declination of 19° 34′, and an apparent diameter of $5\frac{1}{4}$″, $\frac{85}{100}$ths of the disc being illuminated. On the 14th he rises at 6h. 45m. a.m., or 1h. 15m. before the Sun, with a southern declination of 21° 28′, and an apparent diameter of 5·0″, $\frac{9}{10}$ths of the disc being illuminated. On the 19th he rises at 7h. 7m. a.m., or about one hour before the Sun, with a southern declination of 23° 0′, and an apparent diameter of $4\frac{3}{4}$″, $\frac{95}{100}$ths of the disc being illuminated. After this he is too near the Sun to be easily observed. While visible he pursues a direct path through portions of Libra and Scorpio into Ophiuchus, being 3′ south of the 2nd magnitude star β^1 Scorpii at 5h. A.M. on the 10th.

Venus is too near the Sun for observation in December.

Mars is an evening star, and can still be observed, though his apparent diameter is getting perceptibly smaller. He rises on the 1st at about 1h. 50m. P.M., with a northern declination of 8° 47′, and an apparent diameter of 15·0″, the phase on the *n f* limb amounting to nearly 1″. On the 10th he rises at 1h. 15m. P.M., with a northern declination of 9° 41′, and an apparent diameter of 13½″, the phase amounting to 1·1″, and the apparent brightness of the planet being about what it was in the middle of August. On the 17th he rises at 0h. 50m. P.M., with a northern declination of 10° 32′, and an apparent diameter of 12½″, the phase amounting to 1·1″. On the 24th he rises at 0h. 25m. P.M., with a northern declination of 11° 29′, and an apparent diameter of 11½″. On the 31st he rises at noon, with a northern declination of 12° 31′, and an apparent diameter of 10¾″, the phase amounting to 1·1″, and the apparent brightness of the planet being about the same as it was about the end of June. Mars describes a direct path from the confines of Pisces into Aries.

Jupiter is an evening star, and is very well situated for observation, being in opposition on the 23rd (distance from the earth about 386 millions of miles). He rises on the 1st at 5h. 21m. P.M., with a northern declination of 23° 7′, and an apparent equatorial diameter of 46″. On the 6th he rises at 4h. 58m. P.M., with a northern declination of 23° 9′, and an apparent equatorial diameter of 46½″. On the 16th he rises at 4h. 13m. P.M., with a northern declination of 23° 12′, and an apparent equatorial diameter of 46·8″. On the 24th he rises at 3h. 34m. P.M., with a northern declination of 23° 14′, and an apparent equatorial diameter of 46·8″. On the 31st he rises at 3h. 3m. P.M., with a northern declination of 23° 15′, and an apparent equatorial diameter of 46·7″. During the month the planet pursues a retrograde path in Gemini, to the west of μ Geminorum. The following phenomena of the satellites occur while the Sun is 8° below and Jupiter 8° above the horizon:—On the 1st a transit ingress of the shadow of the second satellite at 8h. 53m. P.M., of the satellite itself at 9h. 57m. P.M., a transit egress of the shadow of the satellite at 11h. 29m. P.M. At midnight an 8½ magnitude star will be between the third satellite and the planet. On the 2nd a transit egress of the second satellite at 0h. 33m. A.M., a transit ingress of the shadow of the first satellite at 6h. 40m. A.M.; an eclipse disappearance of the third satellite at 9h. 5m. 24s. P.M.; a central occultation of a 10th magnitude star at 7h. A.M. On the 3rd an occultation reappearance of the third satellite at 1h. 51m. A.M., an eclipse disappearance of the first satellite at 3h. 50m. 5s. A.M.; an occultation reappearance of the first satellite at 6h. 34m. A.M.; an occultation reappearance of the second satellite at 7h. 36m. P.M. On the 4th a transit ingress of the shadow of the first satellite at 1h. 8m. A.M., of the satellite itself at 1h. 37m. A.M.; a transit egress of the shadow of the first satellite at 3h. 24m. A.M., and of the satellite itself at 3h. 53m. A.M.; an eclipse disappearance of the first satellite at 10h. 18m. 36s. P.M. On the 5th an occultation reappearance of the first satellite at 1h. 0m. A.M., a transit ingress of its shadow at 7h. 37m. P.M., a transit ingress of the satellite itself at 8h. 3m. P.M., a transit egress of the shadow at 9h. 53m. P.M., and of the satellite itself at 10h. 19m. P.M. On the 6th an occultation reappearance of the first satellite at 7h. 26m. P.M. On the 7th an eclipse disappearance of the second satellite at 5h. 20m. 49s. A.M. On the 8th a transit ingress of the shadow of the second satellite at 11h. 29m. P.M. On the 9th a transit ingress of the second satellite at 0h. 12m. A.M., a transit egress of its shadow at 2h. 5m. A.M., and a transit egress of the satellite itself at 2h. 48m. A.M. On the 10th an eclipse disappearance of the third satellite at 1h. 5m. 13s. A.M., its occultation reappearance at 5h. 9m. A.M.; an eclipse disappearance of the first satellite at 5h. 44m. 21s. A.M.; an eclipse disappearance of the second satellite at 6h. 38m. 16s. P.M., and its occultation reappearance at 9h. 50m. P.M. On the 11th a transit ingress of the shadow of the first satellite at 3h. 3m. A.M., a transit ingress of the satellite itself at 3h. 21m. A.M., a transit egress of its shadow at 5h. 19m. A.M., and of the satellite itself at 5h. 37m. A.M. On the 12th an eclipse disappearance of the first satellite at 0h. 12m. 53s. A.M., its occultation reappearance at 2h. 41m. A.M., a transit ingress of its shadow at 9h. 31m. P.M., a transit ingress of the satellite itself at 9h. 47m. P.M., a transit egress of the shadow at 11h. 47m. P.M., and a transit egress of the satellite itself three minutes after midnight. On the 13th a transit egress of the shadow of the third satellite at 6h. 1m. P.M., an eclipse disappearance of the first satellite at 6h. 41m. 33s. P.M., a transit egress of the third satellite at 6h. 59m. P.M., and an occultation reappearance of the first satellite at 9h. 10m. P.M. On the 14th a transit egress of the shadow of the first satellite at 6h. 16m. P.M., and a transit egress of the satellite itself at 6h. 29m. P.M.; a transit ingress of the shadow of the second satellite at 2h. 5m. A.M., a transit ingress of the satellite itself at 2h. 26m. A.M., a transit egress of the shadow at 4h. 42m. A.M., and a transit egress of the satellite itself at 5h. 3m. A.M. On the 17th an eclipse disappearance of the third satellite at 5h. 4m. 34s. A.M.; an eclipse disappearance of the second satellite at 9h. 13m. 20s. P.M. On the 18th an occultation reappearance of the second satellite at 0h. 3m. A.M.; a transit ingress of the shadow of the first satellite at 4h. 57m. A.M., and a transit ingress of the satellite itself at 5h. 4m. A.M. On the 19th an eclipse disappearance of the first satellite at 2h. 7m. 20s. A.M., and its occultation reappearance at 4h. 28m. A.M.; a transit egress of the shadow of the second satellite at 6h. 0m. P.M., and a transit egress of the satellite itself at 6h. 10m. P.M.; a transit ingress of the shadow of the first satellite at 11h. 25m. P.M., and a transit ingress of the satellite itself at 11h. 30m. P.M. On the 20th a transit egress of the shadow of the first satellite at 1h. 42m. A.M., and a transit egress of the satellite itself at 1h. 46m. A.M.; a transit ingress of the shadow of the third satellite at 7h. 11m. P.M., a transit ingress of the satellite itself at 7h. 26m. P.M.; an eclipse disappearance of the first satellite at 8h. 36m. 2s. P.M.; a transit egress of the shadow of the third satellite at 10h. 1m. P.M., a transit egress of the satellite itself at 10h. 14m. P.M.; an occultation reappearance of the first satellite at 10h. 53m. P.M. On the 21st a transit ingress of the shadow of the first satellite at 5h. 54m. P.M., a transit ingress of the satellite itself at 5h. 56m. P.M. (here the satellite will possibly occult its shadow), a transit egress of the shadow at 8h. 10m. P.M., and of the satellite itself at 8h. 12m. P.M. On the 22nd an occultation reappearance of the first satellite at 5h. 19m. P.M.; at 10h. 20m. P.M. a 7½ magnitude star is 18″ north of the limb. On the 23rd a transit ingress of the shadow of the second satellite at 4h. 41m. A.M., and of the satellite itself at the same time (the satellite probably occulting its shadow). On the 24th an occultation disappearance of the second satellite at 11h. 40m. P.M. On the 25th an eclipse reappearance of the second satellite at 2h. 20m. 15s. A.M.; a transit ingress of the first satellite at 6h. 48m. A.M., and a transit ingress of its shadow at 6h. 51m. A.M. On the

26th an occultation disappearance of the first satellite at 3h. 55m. A.M., and its eclipse reappearance at 6h. 13m. 57s. A.M.; a transit ingress of the second satellite at 5h. 49m. P.M., of its shadow at 6h. 0m. P.M.; a transit egress of the satellite itself at 8h. 25m. P.M., and a transit egress of the shadow of the satellite at 8h. 37m. P.M. At 6h. P.M. the $5\frac{3}{4}$ magnitude star 3 Geminorum will be $1\frac{1}{4}'$ *f* and 6·0′ north. On the 27th a transit ingress of the first satellite at 1h. 20m. A.M., a transit ingress of its shadow at 1h. 20m. A.M.; a transit egress of the satellite at 3h. 30m. A.M., and a transit egress of its shadow at 3h. 36m. A.M.; an occultation disappearance of the first satellite at 10h. 21m. P.M.; a transit ingress of the third satellite at 10h. 41m. P.M.; a transit ingress of its shadow at 11h. 11m. P.M. At 8 p.m. a 10th magnitude star will be $\frac{3}{4}'$ south of the limb. On the 28th an eclipse reappearance of the first satellite at 0h. 42m. 43s. A.M.; a transit egress of the third satellite at 1h. 29m. A.M., and a transit egress of its shadow at 2h. 2m. A.M.; a transit ingress of the first satellite at 7h. 39m. P.M., a transit ingress of its shadow at 7h. 48m. P.M.; a transit egress of the satellite at 9h. 55m. P.M., and of its shadow at 10h. 5m. P.M. On the 29th an eclipse reappearance of the first satellite at 7h. 11m. 24s. P.M. The fourth satellite will be in superior geocentric conjunction at 8h. 33m. A.M. on the 15th, and at 5h. 34m. P.M. on the 31st; at inferior geocentric conjunction at 8h. 50m. P.M. on the 6th, and at 10h. 55m. A.M. on the 23rd; and in superior heliocentric conjunction at 1h. 34m. A.M. on the 14th, and 7h. 43m. P.M. on the 31st.

Saturn and Uranus are, for the observer's purposes, invisible.

Neptune is an evening star, and is excellently situated for observation, being in opposition to the Sun on the 6th, at a distance from the earth of about $2681\frac{1}{2}$ millions of miles. He rises on the 1st at 4h. 15m. P.M., with a northern declination of 21° 2′, and an apparent diameter of 2·7″. On the 31st he rises at 2h. 10m. P.M., with a northern declination of 20° 57′. A map of the small stars near his path will be found in the *English Mechanic* for September 7th, 1894. He describes a retrograde path to the S.W. of ι Tauri.

December is a fairly favourable month for shooting stars, the chief showers being those of the Geminids on December 9th to 12th, the radiant point being in R.A. 7h. 0m., and north declination 32°, rising about 4h. 10h. P.M., and setting at 1h. 40m. A.M.; and of the Andromedas, occurring on the evenings of the 26th and 27th, the radiant point being in R.A. 1h. 40m., and north declination 43°, the shower being circumpolar.

The Moon enters her first quarter at 0h. 15m. P.M. on the 5th; is full at 7h. 46m. P.M. on the 12th; enters her last quarter at 11h. 16m. A.M. on the 19th; and is new at 2h. 20m. A.M. on the 27th. She is in apogee at 7h. P.M. on the 2nd (distance from the earth 251,720 miles); at perigee at 3h. P.M. on the 14th (distance from the earth 224,670 miles); and in apogee again at midday on the 30th (distance from the earth 252,330 miles). At 9h. 8m. P.M. on the 8th the 6th magnitude star π Piscium will disappear at an angle of 55°, and reappear at 10h. 23m. P.M. at an angle of 238°. At 10h. 50m. P.M. on the 9th the 6th magnitude star 27 Arietis will disappear at an angle of 136°, and reappear at 11h. 13m. P.M. at an angle of 172°. At 11h. 17m. P.M. the $6\frac{1}{2}$ magnitude star 66 Arietis will disappear at an angle of 70°, and reappear at 0h. 29m. on the 11th at an angle of 251°. At 3h. 27m. A.M. on the 11th the 6th magnitude star 9 Tauri will disappear at an angle of 95°, and reappear at 4h. 22m. A.M. at an angle of 244°; and at 7h. 24m. P.M. the $5\frac{1}{2}$ magnitude star χ^1 Tauri will disappear at an angle of 88°, and reappear at 8h. 25m. P.M. at an angle of 232°. At 11h. 14m. P.M. on the 12th the $6\frac{1}{2}$ magnitude star B.A.C. 1716 will disappear at an angle of 152°, and reappear at 11h. 42m. P.M. at an angle of 196°. At 6h. 30m. A.M. on the 13th the 5th magnitude star 136 Tauri will disappear at an angle of 118°, and reappear at 7h. 18m. A.M. at an angle of 253°. At 7h. 3m. P.M. on the 15th the $4\frac{1}{2}$ magnitude star γ Cancri will be occulted at an angle of 120°, and will reappear at 7h. 50m. P.M. at an angle of 263°. At 10h. 47m. P.M. on the 18th the 6th magnitude star 89 Leonis will disappear at an angle of 63° (the star being below the horizon of Greenwich), and will reappear at 11h. 19m. P.M. at an angle of 251° (the star rising at the time). At 1h. 37m. A.M. on the 20th the 6th magnitude star B.A.C. 4200 will disappear at an angle of 159°, and reappear at 2h. 25m. A.M. at an angle of 265°. At 3h. 33m. A.M. the $6\frac{1}{2}$ magnitude star B.A.C. 4225 will disappear at an angle of 124°, and reappear at 4h. 42m. A.M. at an angle of 310°; at 7h. 4m. A.M. the 6th magnitude star *f* Virginis will disappear at an angle of 84°, and reappear at 7h. 57m. A.M. at an angle of 350°. At 7h. 9m. A.M. on the 20th the 3rd magnitude star π Scorpii will disappear at an angle of 150°, and reappear at 8h. 9m. A.M. at an angle of 258°. At 5h. 46m. P.M. on the 31st the 6th magnitude star 45 Aquarii will disappear at an angle of 55°, and reappear at 6h. 57m. P.M. at an angle of 235°. The following are near approaches. On the 4th the $6\frac{1}{2}$ magnitude star B.A.C. 7835 at an angle of 148°. At 4h. 30m. P.M. on the 10th the $4\frac{1}{2}$ magnitude star ζ Arietis at an angle of 155° ($2\frac{1}{2}'$ from the limb). At 8h. 40m. A.M. (in broad daylight) on the 22nd the 6th magnitude star B.A.C. 4722 at an angle of 212°.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solutions of November Problems.

No. 1.—By Mrs. W. J. Baird.

Key-move.—1. Kt to KB7.

If 1. . . . K to R3, 2. Q to R8ch.
1. . . . K to B3, 2. Q to B8ch.
1. . . . Any other, 2. Kt to Q6ch.

Correct Solutions received from J. T. Blakemore, White Knight, A. Louis, W. Willby, J. St. L. Kirwan, F. H. Bolton, E. W. Brook.

No. 2.—By C. D. Locock.

1. R to Kt4, and mates next move.

Correct Solutions received from J. E. Gore, J. T. Blakemore, Norman Alliston, White Knight, H. S. Brandreth, A. Louis, W. Willby, E. W. Brook, J. St. L. Kirwan, J. McRobert.

We note with pleasure some new additions to our list of solvers.

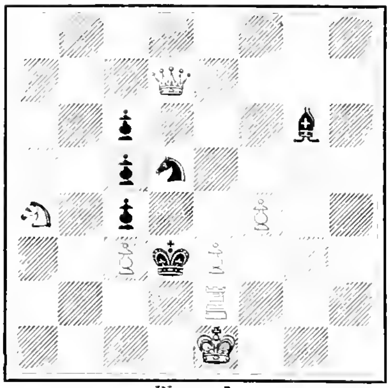
H. S. Brandreth.—And if the Pawn does not queen?

J. E. Gore.—Your two-mover No. 1 has now many solutions, *e.g.*, 1. Q × KP or 1. Kt moves anywhere discovering check. This should be corrected without increasing the force. No. 2 is clearly solved by B to R6ch or Q × R. There are also numerous duals.

PROBLEMS.

By A. C. Challenger.

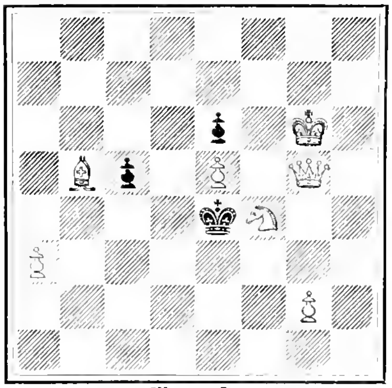
Black (6).



White (7).

White mates in two moves.

Black (3).



White (7).

White mates in three moves.

CHESS INTELLIGENCE.

Mr. Lasker has now nearly recovered from an attack of typhoid fever, which has prevented him from keeping various chess engagements. During his illness his brother, Dr. Lasker of Berlin, has been in London.

An interesting tournament is in progress at New York. Messrs. Steinitz, Pillsbury, Showalter, Albin, and Jasnagrodsky are among the competitors. Mr. Steinitz holds the lead, and should have no difficulty in keeping it.

A match between the Metropolitan and City of London Chess Clubs was played last month. There were fifty players on each side. The final score was: Metropolitan, 26½, City of London, 23½.

Sussex and Hants played their match in the Southern Counties Tournament at Portsmouth on November 3rd, resulting in a victory for Sussex. The important match between Surrey and Sussex takes place at Brighton on December 8th.

PAWNS AND THEIR WEAKNESSES.

(*Continued from page* 264.)

The two kinds of weak Pawns discussed in the last number were (1) isolated Pawns and (2) Pawns too far advanced. We offer here a few remarks on three other classes.

III. *Pairs of Pawns.*—It frequently happens in the close game that both sides have Pawns at K3, Q4, and QB4, while one side (say Black) has also a Pawn at QKt3. If White now play BP × P, KP × P; P × P, P × P, Black is left with a pair of Pawns at Q4 and QB4. These, as they stand, may be fairly strong, though White has open files in front of both. Nevertheless, such a pair of Pawns must be considered a permanent disadvantage, for the following reasons:—(1) If one is exchanged, the other is left isolated. (2) If one is advanced, a "hole" is left in front of the other, and this hole can be permanently occupied by a White piece, strongly placed in the centre of the board.

IV. *A Pawn supporting two others.*—Here there is clearly a "hole" in front of the supporting Pawn. This "hole" may be either temporary or permanent; if the opponent has Pawns immediately in front of the two supported Pawns, the weakness has every appearance of permanency. The category may even be enlarged. Generally speaking, it may be stated that every Pawn (unprotected by another Pawn) which cannot advance to the *same row* as its neighbours is weak. For instance, a player has a Pawn at QB4, a Pawn at QKt2 or 3, his QRP being either off the board or at QR4; the opponent has a Pawn at either QR4 or QB4. The result is that the Pawn at QKt2 or 3 is weak. If the opponent has not Pawns at both QB4 and QR4, the weakness may be only temporary, for the KtP may be advanced by the support of pieces. If, however, the opponent *has* Pawns at QB4 and QR4, the weakness is clearly permanent.

V. *Doubled Pawns.*—The weakness of these has already been treated of in an article entitled *More Chess Fallacies.* It need only be stated here that the weakness makes itself felt chiefly in the end game. In the middle game a doubled Pawn is frequently a very tangible advantage, especially if it can be *undoubled* at will.

Contents of No. 109.