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MAGAZINE OF SCIENCE.

SIMPLY WORDED—EXACTLY DESCRIBED.

Edited by A. COWPER RANYARD.

“ Let Knowledge grow from more to more.”

—TENNYSON

VOLUME XVI.

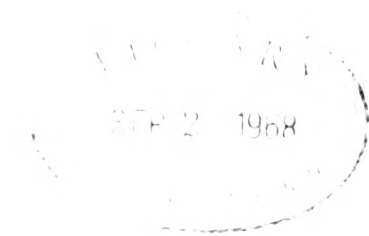
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THE DISASTER AT ST. GERVAIS.

A SUPPLEMENT.

By the Right Hon. Sir EDWARD FRY, LL.D., F.R.S., &c.

THE article which appeared on this subject in the November number of KNOWLEDGE has brought me some letters which appear to me well worthy of the attention of my readers, and with the permission of their writers, and with some slight alterations and additions kindly made by their hands, they appear below.

I am desirous also of availing myself of this opportunity to make a few additions and corrections to my article.

First, I may mention that three papers on the subject have appeared in the *Comptes Rendus*: one by M. Forel, in the number of the 18th July, 1892 (p. 193), another by MM. Vallot and Delebecque on the 25th July, 1892 (p. 264), and the third by M. Demontzey on the 8th August, 1892 (p. 305). The last paper mentions the fact that some workmen saw the moving mass from a distance in the clear moonlight, and they gave five minutes as the time it occupied in passing from the gorge of St. Gervais to Le Fayet, a distance of 1800 metres, or at the rate of six metres a second. The writer also mentions the fact that the passage of the torrent has stripped the beds of the streams of Biomassay and the Bon Nant of all the granite

blocks which for long have been found there, and that the torrent when entering the Bon Nant at Biomassay first drove right across the stream, and deposited materials of all sorts on the left bank at a considerable height.

Referring to what I said on p. 203, second column, as to the moving power of water, I think that it should be observed that the moving mass was by no means pure water, it was water, ice and mud, and I apprehend that the moving force of such a mass (which as a whole must be somewhat viscous) differs from that of pure water or any other true liquid.

Fig. 7 is so drawn as to represent the height of the water in the two communicating cavities as different. This is, of course, impossible, and I must ask my readers to make the necessary mental correction.

The following are the letters above referred to:—

From the Hon. Mr. Justice WILLS.

The accumulation of such a mass of water at such a height is a very remarkable fact. I have once or twice seen cavities in the névé on a scale comparable with that on which the two holes in question were, but only once or twice. One was a very remarkable case indeed—on September 15th, 1858, I was descending the glacier d'Orny with a friend and two guides; we were still on the névé, and I noticed a thing which looked like a dark patch on the ice at a short distance from us. I said I should like to go and see what it was. As I drew nearer I saw it was a hole and I took the precaution of continuing in the rope, which we had not yet taken off. On reaching the spot, I went to the edge of the hole on my hands and knees and lay down to look into it. As soon as my eyes got accustomed to the comparative darkness into which I was gazing I saw to my horror that we were all of us on the crown of an arch of ice which from side to side was, if my recollection serves me, some 30 yards across, and which, at the top and at the very spot on which I was lying, was not more than a foot or 18 inches thick. The chasm extended in length further than I could see in either direction, but this was the only spot in which the top had given way. It was of great depth, I should think 100 to 150 feet, and there were many places in which pendants of ice, evidently formed by drip, were hanging from the roof; others in which blocks that had had ice pendants hanging from them had fallen into soft snow, or else merely got gently dislodged, for the ice pendants were still unbroken and yet pointing in many directions. It was a scene of really awful magnificence, and made a great impression upon all of us. We had walked across the arch without a suspicion of a hollow beneath, and yet the hollow was sufficient to engulf an army; we saw no water there.

I saw a thing of the same sort once on our own Buet, where the glacier is on so small a scale that we never dream of being roped. I saw a similar dark spot, went to look at it, found it was the top of an arched cavity on a very inferior scale to that on the glacier d'Orny, but still calculated to teach one respect and caution. I had a ball of string with me, and I tied my stick to the end of it and let it down what proved to be 84 feet before it touched bottom. Here, again, there was no water.

Melting at 9000 feet in height is a totally different thing to melting at 6000 or 7000 feet, and I have never seen a large crevasse in the névé charged with water, nor do I remember to have read of one. The highest of such that I ever remember to have had my attention called to, was on the upper plateau of the glacier des Bossons, perhaps 8000 feet or even more above the sea. We lost a little dog who fell down the crevasse by jumping short, and we heard him swimming quite out of sight. We let down a porter—fortunately we were a strong party and could pull him up again—and he found the dog on a ledge of ice at the edge of a deep pool. The dead weight of a big man to haul up again by main force was something I shall never forget. The crevasse twisted, and at one moment his broad shoulders got jammed and I thought we should not get him out again. But whatever height this was, it was far below the limits (at that place) of the névé, and the ice had none of the characteristics of the névé.

There is, however, very likely more drainage on the glacier des Têtes-Rousses than on most glaciers of that height. I cannot say from personal recollection, as the only time I crossed a part of the glacier des Têtes-Rousses, on an ascent of Mont Blanc by the Aiguille de Gouté, my attention was not drawn to the point, but I think it very likely that a part of the drainage from the Aiguille de Gouté may fall on to its side and get into its interstices. The Aiguille de Gouté is too steep for a permanent glacier to form on those ridges and furrows which are so great a characteristic of its structure. Vast quantities of snow fall and lodge upon these ridges and furrows, and melt very

rapidly in fine and hot weather, especially in the long days of June and July. It certainly needs some such contribution to account for so vast a store of water from mere drainage at that height. The surface snow of the *névé* is porous, and though a cake of ice often forms at night, it is sure to disappear with a few hours of sunshine, and to leave free access to soft snow beneath, and the surface meltings, which are never very great on the *névé*, filter into this, and do not run off as they do off hard ice—such as you meet with in your way up the *Mer de Glace*, for instance.

The circumstance of this vast accumulation of water in such a place is so very exceptional that a notion has been suggested (I forget where I have seen it—my son says it is in Freshfield's paper) that there are underground springs there. It would be very curious if this really were so. The distribution of underground water has always seemed to me a very interesting subject, and one which remains to be efficiently treated. That water travels very far underground there can be no doubt. I have seen in the Bay of Bengal, about forty miles north of Sumatra, a little island called Pulo Rondo. It is not two miles round, and rises about 250 feet out of the sea. A broad stream of water flows from its highest part down into the sea. In shape the island is like a barber's basin turned upside down, and there is no gathering ground, or none but the very smallest, above the top of the waterfall. That water must travel at least forty miles underground if the fall is brought about by hydrostatic pressure. But there are other collections of water which it is very difficult to account for by any such simple means. I know a small and very deep lake, about 1000 feet higher than the Lac Cornu (which is behind the Brévent from Chamonix), and nearly 9000 feet high, above which there is no gathering ground the least adequate to explain its existence, and I have always thought the Lac Cornu itself much larger than the area of which it receives the drainage can account for. In 1872 I noticed, during the N.W. monsoon and after a long period of dry weather, a small stream of water within a very short distance of the top of Pedro tallagalla, the highest mountain in Ceylon. I have reason to think that there is no great intrinsic improbability in the notion of a spring even at 9000 feet, and my son says that in Freshfield's article he mentions that De Sansure noticed a stream of *puu* water issuing from the base of the glacier des Têtes Rousses. It is a very rare thing indeed for the meltings of a glacier, which have passed any distance under the glacier, to be clear when they issue. You know what the Arve is at Chamonix in summer; I am told that in winter, when its volume is enormously diminished, it is *ébouré*, which may and probably does mean that it has a nucleus of spring water, which is what flows in winter.

But whatever the source of the sub-glacial accumulation, I think two things are clear: (1) That those large tanks, so to speak, are due to the motion of the glacier and not to the mere action of water. Water would, no doubt, do some little melting at the sides and on the floor of its receptacle, but in so confined a space the melting would be trivial; and as the water was accumulating and not changing, the action of melting ice round it would be to lower its temperature greatly. Such sheets of water as the Marjelen See hollow out great vaults underneath the ice. I once saw there a block of many hundreds of tons, on which it was the nearest chance that four of us were not standing at the time, break off and fall into the lake, undermined. But then there is a lake nearly a mile long, above the freezing temperature, and with the surface warmed a good deal by the summer sun and the surface water between 32° and 39° sinking so as to keep the whole mass from getting down to the freezing point. In the cavities, in the present instance, the sun can have done nothing to warm the water after it got into them. (2) It is clear, I think, that the natural and usual drainage must have got blocked. As a rough general rule, where you have any very marked feature in glacial structure at any one time, you have it always. The séries of the Col du Géant are constant. Particular passages over bergschrunds or through great masses of crevasses, with a good deal of local variation, have yet a great amount of general constancy, and I suspect that whatever circumstances in the bed of the glacier, or what not, make a chasm, such as that in my glacier d'Orny, one year make it in a great many other years; and yet this accumulation is a new thing, or with the perpetual shifting of the ice, which takes place in motion some such burst would almost certainly have taken place before. That there *was* a channel between the two cavities, I should have very little doubt, especially considering that the lower cavity is at a place where the incline of the glacier becomes much steeper than before. Generally speaking, no doubt, the cracks below the lower cavity give abundant outlet for the water, but some movement of the glacier must have blocked them up—a thing which one knows perfectly well does take place in numerous spots from time to time—and then the accumulation became formidable. The roof of either cavity was, in the course of glacier motion, bound to come down some day, and that it should break suddenly was to be expected. The ice avalanches that one has to look out

for on the Petit Plateau, for instance, always happen without warning. That is to say, you see that the masses are getting dangerously near the edge of the cliff, but whether they will fall within five minutes or five days no human being can do anything more than guess. When the roof once did fall, being as it was very large the pressure on the containing system would be very great. In the instance I mention of the Marjelen See I was immensely struck with the commotion produced in the water, and yet there was an open lake a mile long with a long flat margin round a considerable part of it. It was half an hour before the recoil waves sent back from the end of the lake ceased to boom with ominous sounds against the ice cliffs, and the earlier recoils brought down fresh falls of ice. I am not the least surprised at the dam at the end being burst, and at the rush of water from above sweeping the lower hole pretty clear of water.

An illustration of the fact that drainage through the lower strata of a glacier sometimes gets blocked for long periods together occurs to me. When I first knew the *Mer de Glace* well, in 1857, there was, at the foot of the *Faenl*, in the angle between the glacier du Géant and the glacier de l'Echaud, a large lake certainly more than a quarter of a mile long. I have visited the same spot in fourteen different years since. I have never seen it so large again, and many years it has not existed at all. The difference is chiefly due to drainage.

I think your paper on the St. Gervais disaster, as far as I can judge from what has so far been ascertained, is quite right as to the *modus operandi*. If all be well, I hope to go and see the course of the torrent next autumn, and it is fairly certain that one year will make very little difference in the physical appearances. It is the second time I have known the broader valley below St. Gervais covered with *débris*. In 1852 there was a wonderful fall of *warm* rain over the whole range of mountains for nearly three days. I got to Chamonix on the third of these days, having come down the Great St. Bernard and through Martigny, and having met with floods which gave us some very long détours to make. Parts of the valley of Chamonix, but very much more the embouchure of the stream which comes from the Col du Bonhomme and receives all the lateral drainage from the Mont Blanc chain, were covered at least three or four feet deep with *débris* and glacier mud. Now, I fancy, the depth of deposit is nearly ten times what it was then. I am sure what I saw then was terrible enough. In one place we saw the actual birth of a torrent of mud, saw it burst out of the mountain side and spread over the cultivated patches above the hamlet of Le Tour.

From CHARLES TOMLINSON Esq., F.R.S., &c.

It may be thought presumptuous in me to form any opinion on the subject, seeing that I have not visited the spot, nor studied the phenomena *in situ* as you have done.

But I venture to remark that I miss from the account any reference to the hydrostatic force of water, which is sufficient of itself to do any amount of mechanical work without subsidiary aid of any kind.

A cubic foot of water weighs upwards of 62 pounds, and in consequence of the perfect distribution of fluid pressure in all directions the pressure on a square foot of water at the depth of ten feet is upwards of 623 pounds.

But the cavity containing the pent-up water which caused the disaster is estimated at a vertical depth of 130 or 160 feet, which gives a pressure on the lowest foot of water of 8060 and 9920 pounds, which pressure is repeated on every cubic foot along the lowest line but diminishes upwards to the surface cubic foot pressure of 62 pounds. Hence, we have a force acting day and night all the year round, which in time must break through any icy barrier that is likely to be opposed to it. The fall of ice from the roof could not act as a piston or lend any efficient aid to the result. There are also objections to the word "suction." My conclusion (subject to the objections noted at starting) is that hydrostatic pressure alone was the only moving originating cause of the calamity.

There are, however, a few other considerations which I take the liberty of adding to this proof which the Editor has been so good as to forward to me.

The warm weather that preceded the catastrophe would tend to fill up the sub-glacial reservoirs, and also to thin the outer wall of ice. If an opening had been made at the base of the deeper or 160 feet cavity (the velocity of the outflow being as the square root of the depth) the rush of water would have been thirteen times greater than at the top. But I imagine there was no point or line of least resistance at or near the base of the cavity but was spread over its whole surface, so that as the water accumulated, a moment arrived when the resistance was not equal to the pressure, and the whole exposed face of the icy barrier was burst open at once, and the contents of the reservoir, thus set free, proceeded rapidly on the work of destruction.

A VOLATILE SERIES OF METALLIC COMPOUNDS.

By C. F. TOWNSEND, F.C.S.

THE progress of chemical science is continually bringing to light new wonders and startling paradoxes. Nothing more remarkable and unexpected has occurred in the recent history of chemistry than the discovery of the compounds of nickel and iron with the gas generally known as carbon monoxide or carbonic oxide. The new compounds are called respectively nickel and iron carbonyls, and have evidently a great future before them. Judging from chemical precedent, one would quite as soon have expected oil and vinegar to form a homogeneous mixture as a combination of the bodies referred to. In fact, so anomalous did it appear when Mr. Ludwig Mond first brought the accidentally discovered nickel compound to the notice of the Chemical Society in the middle of 1890, that many almost refused to believe in the possibility of its existence. However, there is no doubt about it. Nickel carbonyl, a considerable quantity of which was exhibited at a *conversazione* of the Royal Society held in June last, and also at the meeting of the British Association, is obtained by merely passing carbon monoxide—a product of the incomplete combustion of coke or charcoal, and which may often be seen burning with a lambent blue flame at the top of a clear fire—over the finely divided metal, and condensing the resulting vapour in a tube surrounded with ice and salt. Its properties have been very fully investigated both by its discoverers, Messrs. Mond, Langer, and Quineke, and also by M. Berthelot, who published his results in the *Comptes Rendus*.

It is a liquid of very high refractive power and brilliant appearance, and considerably heavier than water, under which it may be kept without change, provided the vessel is completely filled and the water contains no air. It solidifies at 13° F., and boils at 109° F., and the vapour, if lighted, burns with a strongly luminous flame, which appears smoky in consequence of the separation of metallic nickel. The liquid is very volatile, and if the vapour is suddenly heated a sharp detonation is caused. A mixture of nickel carbonyl with air takes fire if brought into contact with a very hot body, and occasionally explodes. A mixture of the dry vapour and oxygen may be detonated by simple agitation over mercury, and strong oil of vitriol produces the same effect in a few minutes. The vapour, when heated to 358° F., splits up again into its original constituents, the metal and the gas, and the nickel deposits itself as a brilliant coating on the sides of the vessel. Advantage is taken of this circumstance to apply the carbonyl to nickel-plating, and a patent has been taken out by its discoverers for working it on a commercial scale. At the last meeting of the British Association, Mr. Ludwig Mond described the various uses to which the discovery might be put, and the possibilities which it opened up. The nickel-plating can be accomplished by simply exposing the goods, after being heated to the temperature just mentioned, to nickel carbonyl vapour, and solid articles can be similarly formed by passing the vapour through heated moulds. For this purpose, it is found advantageous to dilute the vapour considerably with air. Nickel can also be deposited on any substance by treating it with the liquid itself, or better, by nickel carbonyl dissolved in suitable solvents. These processes possess a great advantage over electro-plating, as not only metal, but any substance, however intricate in design or fragile in structure, can be coated with a brilliant film of nickel by its means

without the tedium and risk of first covering it with a surface of blacklead. Some very beautiful specimens of real flowers, plated with different metals, principally gold and silver, so as to bring out the various parts of their structure, were exposed for sale at the Frankfort Electrical Exhibition. A syringa blossom, for instance, would have its stamen and anthers plated with gold, its corolla with silver, and the stalk and calyx with copper. Needless to say, they found a ready market. The field before this new process is practically unlimited, for not only could it be applied to ornaments and articles of household use, but, if required, to delicate muslins, and dress or other fabrics.

The liquid nickel carbonyl is highly poisonous, and, if injected subcutaneously, acts very powerfully on the animal system, producing an immediate and remarkably prolonged fall of temperature. It might, perhaps, be introduced into medical practice as an antipyretic in the treatment of fevers, were it not for the difficulty of administering it in sufficiently small doses, and its intensely poisonous action. The carbon monoxide alone is the active agent in causing this effect, the symptoms being those of respiratory poisoning; and the blood of animals killed by it exhibits the same appearances as that of persons suffocated by inhaling the fumes of burning charcoal. This kind of poisoning is particularly dangerous, and in cases of recovery the effects do not wear off for several hours after. The red corpuscles of the blood owe their colour to a complex chemical substance known as hæmoglobin, which acts as the carrier of oxygen. In passing through the lungs oxygen is taken up, and it is converted into oxy-hæmoglobin, which, when placed so as to intercept the rays of light in the spectro-scope, gives quite different absorption bands to the hæmoglobin itself; from the lungs the oxygen is carried to different parts of the body to be exchanged for carbonic acid, which is brought back to be eliminated and again replaced by oxygen, thus completing the cycle. Carbonic oxide combines with the hæmoglobin to form carboxy-hæmoglobin, an exceedingly stable substance which can only be displaced by oxygen with the greatest difficulty. The consequence is that the blood is unable to perform its functions, and the animal rapidly dies from suffocation. The absorption spectrum of this last body is remarkably characteristic and quite unmistakable, forming an infallible test in case of suspected poisoning by charcoal fumes. The vapour of nickel carbonyl is as deadly as the liquid, and is dangerous in air even to the extent of only 0.5 per cent.

The extraction of the metal from its ores is another valuable use to which the discovery of this compound will almost certainly be put. The principal sources of nickel are the copper-coloured arsenical mineral which the German miners—after working it unsuccessfully for years in the hope of obtaining copper—called *kupfer-nickel* (*i.e.*, false copper), and in which the metal was first discovered by Cronstadt in 1751, and *spieß*, an impure residue formed at the bottom of the melting-pots in the manufacture of the bright blue pigment known as *smalt*, which is largely used by paper-stainers. Metallic nickel is obtained from these by heating them with charcoal in a furnace, but the product only contains about 60 per cent. of the pure metal. It appears now that it will be sufficient to pass carbon monoxide over the crushed mineral, and by simply heating the resulting nickel carbonyl to 358° F. chemically pure nickel will be deposited.

All attempts to obtain a similar compound with other metals for a long time proved unsuccessful. As it seemed improbable that nickel should be the only metal forming such a compound, the investigators persevered with the

work, and finally succeeded in volatilizing distinct quantities of iron in a current of carbon monoxide. The issuing gas burned with a yellowish flame, and if passed through a heated tube deposited a metallic mirror in the glass, which answered to all the tests for iron with unusual brilliancy. The quantity produced was, however, very small, and the process exceedingly laborious, for it took no less than six weeks to volatilize about thirty grains of iron. Even under the most favourable conditions the gas never contained more than 0.2 per cent. of the compound, but by varying the details of the process a much larger yield was obtained.

The iron carbonyl thus produced is a pale yellow viscous liquid, nearly half as heavy again as water. It distills without decomposition at 220° F., and solidifies below 68° F. into yellowish needle-shaped crystals. It decomposes slowly on exposure to air and, like the nickel compound, is completely broken up by heating its vapour to 356° F. On the other hand, it is much less active than its analogue and is not attacked by dilute oil of vitriol. Its composition was at first thought to be similar to that of nickel carbonyl, but on accurate analysis it was found to contain five proportions of carbon monoxide $[\text{Fe}(\text{CO})_5]$ instead of the four which constitute the latter $[\text{Ni}(\text{CO})_4]$.

Whilst engaged in some experiments on the utilization of water-gas (which is manufactured by passing steam over red-hot coke, and contains about 10 per cent. of carbonic oxide) for illuminating purposes by means of the Farneshelm system, in which a comb of magnesia is raised to incandescence by a number of fine gas jets, Sir H. E. Roscoe and Mr. Scudder noticed that a red deposit of oxide of iron was formed on the rods after the water-gas had impinged on them for a few hours. This was a very serious drawback, as the illuminating power became considerably reduced. As the experiments were being conducted in a steel works the first supposition naturally was that the stain was caused by fine particles of iron present in the atmosphere, but closer inspection showed that the deposit was of a "coralloid" structure and must, therefore, have been produced by the gas itself. In order to ascertain whether the iron existed in the gaseous state or was carried forward chemically, the gas was filtered through several tight plugs of cotton wool. No difference, whatever, was observed and it was concluded that the gas contained a very minute quantity of a volatile compound of iron. Shortly after it was subjected to various chemical tests, which left very little doubt as to its identity with iron carbonyl.

Coal gas has also been found to contain iron, derived, no doubt, from the slow action of the 7 or 8 % of carbon monoxide it contains on the iron of the mains and gas pipes. This accounts for the hitherto unexplained black stain so frequently observed on steatite and other burners. Compressed coal gas has begun to take the place of hydrogen in the production of lime-light, and the stain formed on the lime cylinders is very noticeable, being, it is almost needless to say, somewhat of a drawback to its use.

The discovery of this series of compounds is quite a revelation to the metallurgical chemist, and already explains many mysteries. In the cementation process for the manufacture of steel, bars of iron are embedded in powdered charcoal, and kept at about the melting point of copper (2192° F.) for eight or ten days. Steel, as is well known, is an alloy of iron, with a combination of carbon and iron, called carbide of iron, and the principle of all steel-making is the same: carbon must be added to soft iron in definite proportions. If the iron contains no carbon it is comparatively soft and malleable. Wrought iron contains less than 0.3 % of carbon; steel from 0.3 to

1.5 %; above this the metal takes the character of cast-iron. The charcoal which surrounds the bars of iron in the process just referred to, occludes a large quantity of air in its pores, which, when heated, forms carbonic oxide. This gas permeates the iron and gives up its carbon to the metal, returning again to take up a fresh supply from the charcoal, and thus acts as a carrier of carbon to and fro in the interstices of the iron, which it gradually converts into almost homogeneous steel, known technically as *blister-steel*, owing to its peculiar vesicular appearance caused by the penetration of the gas. These compounds must play a very important part too in the blast furnace, and in both the Siemens and the Bessemer process, especially the latter. Bessemer steel is made from cast-iron: the carbon and impurities are burnt out of it by driving a current of air through the molten metal. When this has been accomplished, a highly carburetted cast-iron, called *spiegel-eisen*, is thrown into the converter in properly regulated quantity, and the carburization of the iron is rapidly effected.

Renewed attention has recently been directed to some volatile compounds of platinum with chlorine and carbon monoxide, which are broken up by water with deposition of pure platinum, thus forming a possible way of extracting the metal from its ores. If any discovery of this kind were to facilitate the extraction of gold, which at its present rate can barely keep up with the demands of the increasing consumption, an immense boon would be conferred on the civilized world.

CATERPILLARS.—III.

By E. A. BUTLER.

(Continued from page 229, Vol. xv.)

IN some caterpillars the usual complement of ten prolegs is greatly reduced, only the last two pairs being present; thus all the six central segments of the body are left without means of support. This, of course, necessitates a special method of progression, the wave-like motion already described being clearly impossible. Caterpillars of this kind take a firm hold alternately with the two ends of the body, the central part being by turns arched up and extended, as the animal advances, not with the creeping motion of small paces, but with the stately gait of long strides. Thus, when the insect is in a fully extended position and wishes to advance, it clings tightly with its six true legs, and then, releasing its claspers and lifting the hinder part of the body, hooks them on again close up to the legs, thereby causing the intervening portion of the body to assume the form of a perpendicular loop: then, holding tightly by the claspers, it lifts the legs and advances the front part to the fullest extent, straightening out the loop and bringing itself again into its former horizontal position. From their peculiar mode of walking, by curves and loops, caterpillars of this kind are called geometers or loopers. They are always long, narrow, thin-bodied creatures, usually green or brown in colour, and often with the head divided on the crown into two prominences like faint indications of horns. They are noted for the extraordinary positions they assume, and the remarkable way in which they mimic little twigs or stems. When at rest, the body is usually kept straight and stiff at an acute angle to the twig, inclined to about the same extent as the twigs themselves are to the main stem, the mechanical difficulties of such a position being met to some extent by an exceedingly fine thread of silk stretching from the spinneret to the twig, or less frequently by the anterior legs clasping another twig in the neighbourhood. The silken thread provides means of

suspension in the air if a sudden displacement of the claspers should take place, and sometimes prevents a fall to the earth, and saves the consequent labour of getting over uneven ground to reach the tree trunk and then climbing, perhaps, many feet of rough bark before the former position can be regained, and at the same time it forms a considerable security against the fatal results which might follow from striking against intervening branches while falling with gradually increasing velocity.

The general resemblance to a small twig, caused by the cylindrical shape and the brownish colour, is often heightened by the presence on the back of excrescences of various kinds, similar to what may be seen on the twigs of the food-plant. A very abundant insect, the caterpillar of the brimstone moth (*Rumia crataegata*), a pretty sulphur-coloured moth with a few reddish patches and streaks, and a common inhabitant of gardens in summer-time, may be taken as an excellent exemplification of this. It is tinted with almost exactly the same mixture of purplish and reddish brown as the twigs of its commonest food-plant, hawthorn; its thickness is about that of the young twigs amongst which it lives, and halfway down its back it bears a wart-like excrescence which very closely resembles the knotty little protuberances seen in similar positions on short stumpy twigs of hawthorn. This same insect exhibits also another very beautiful arrangement whereby the resemblance to a twig is rendered still more perfect. When the two pairs of claspers are in position grasping a twig, it is evident that, if that part of the body which lies between them were of the usual shape, evenly cylindrical in outline, there would be a space between its under surface and the twig, which would be thrown into shadow, and the presence of this clearly-defined dark line of shadow just where the pretended twig ought to pass uninterruptedly into the parent stem would be a flaw which would detract from the perfection of the mimicry. Hence we find that the skin between these two pairs of claspers runs out into numerous little irregularities, forming flaps which reach to the twig itself, and therefore break up the shadow and soften the contact with the stem. If this irregularity of outline were found all along the body, it would hardly be safe to lay much stress upon its presence between the hind legs; but this is not the case. The fringe occurs only where the body comes into contact with the twig, and its presence just where it is needed, and its absence elsewhere, lend probability to the above explanation of its function.

A thoughtful consideration of cases such as this will serve to show what an endless field of investigation is opened up, when even the knobs and humps and excrescences of caterpillars are found to be not the mere meaningless freaks of some sportive and erratic force, as they at first appear, but exquisite adaptations whereby the organism has been brought more completely into harmony with its environment; adaptations, therefore, which have some bearing either upon its preservation amidst its present conditions of life, or upon its past history and the course of events which have constituted its life as a species.

In this latter connection we may refer to the caudal horns of the caterpillars of the hawk moths (*Sphingidae*). These insects have on the back of the last segment but one a curved horn, which contributes in no slight degree to the air of stateliness that characterizes them when they assume the sphinx attitude. The horn usually points more or less upward, and shows only a single curve, but in some cases, as in the death's head moth (*Acherontia Atropos*), it is depressed, and doubly curved into an S-shape. When a hawk moth caterpillar is first hatched, the horn is much longer, proportionately to the body, than when fully grown; it is also straight, almost erect, and

forked at the tip (Fig. 7), and its surface is beset with prickles. As the insect grows, the prickly tubercles on the horn become, in some species, less conspicuous, and finally entirely disappear, the horn becoming smooth and polished; in others they are retained throughout life.

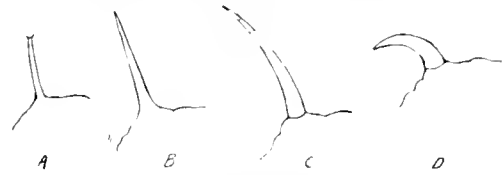


FIG. 7. Caudal horn of *Convolutus* Moth Caterpillar, at different stages. A, B, C, magnified 5, 3, and 2 diameters; D, natural size. The magnification is not sufficient to show the tubercles. (From Poulton.)

The forked appearance of the tip disappears after the second moult, and the horn curves more and more downwards. Not only is the horn of the newly-hatched larva thorny, but the whole surface of the body is covered with minute tubercles, each of which emits a small hair. In some species, such as the poplar and eyed hawk moths, these tubercles are retained throughout life, giving rise to that roughness of skin which is described as shagreening. In other cases, such as the privet hawk moth, they are lost after the early stages, and the skin becomes quite smooth. In this family of moths, then—a family which consists of insects whose general resemblance testifies to their real relationship—we see caterpillars that commence life with well-marked characters, which they afterwards lose to a greater or less extent. Such characters do not seem to bear any special relation to their present surroundings, and may therefore be fairly regarded as common ancestral relics, implying that the insects are descended from progenitors with forked and tuberculated horns. Some of the species, however, have advanced farther from this ancestral condition than others.

There is another family of large and handsome moths, very different in shape, style, and habits from the hawk moths, but nevertheless exhibiting some curious resemblances to them in the caterpillar condition. This is the family *Saturniidae*, or emperor and silk-producing moths, distinguished by the coloured or transparent, circular or crescent-shaped eye-spots in the centre of the wings. The family is very poorly represented in Great Britain, only two species, the Kentish glory and the emperor moth, being native with us. The former of these is in some respects very unlike its associates, and the caterpillar is quite distinct; but the emperor moth (*Saturnia carpinii*) may be regarded as a good illustrative type of the group. The caterpillars of this family are generally large and fleshy creatures, adorned with rows of rounded tubercles from which spinous hairs project. Our British species is a bright green insect with a row of pink tubercles on each segment. In some species there are not only the usual tubercles, but various spines or hornlike projections as well in different parts of the body. These show a tendency to be developed about the thoracic and caudal regions. In some cases the spines are single-pointed, but in others forked and tuberculated. Moreover, when the spines are large, the tubercles on the rest of the body are small, as though the spines were enormously-developed tubercles, which, by reason of their superior protective powers, could afford to dispense with their smaller and weaker brethren.

But the most remarkable facts of all are to be found in connection with the caterpillar of the Tau emperor (*Agria tau*), a species about 2½ inches in expanse of wings, and so

named from the white T-shaped mark contained in the blue "eyes" on its wings. This fine insect is found in several parts of the world, including some European countries, though not in Britain. The newly-hatched caterpillar is green with five red-forked and tuberculated horns (Fig. 8), two pointing straight forward above the head,

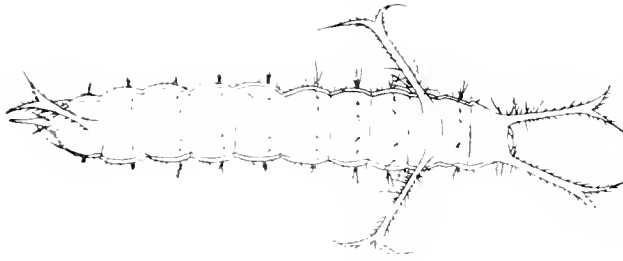


FIG. 8.—Young larva of Tau Emperor Moth, magnified 7 diameters. (After Poulton.)

two projecting from the sides of the thorax, and one pointing upward and backwards from the dorsal surface of the last segment but one, just the position of the caudal horn of the *Sphinxidae*. The hair-bearing tubercles on the rest of the body are also present, but small. This remarkable appearance is retained by the caterpillar during its first three stages, but at the next moult the whole of the apparatus of spines and tubercles suddenly and entirely disappears, the only trace of the former condition being a general shagreening of the body similar to that of some of the hawk moths. There are now also other resemblances to the *Sphinxidae*, such as the assumption of the sphinx attitude, and the presence of oblique coloured stripes on the sides. Facts such as these, pointing as they do to a kinship between the two great families of hawk moths and emperor moths, evidently impart a new interest to the caudal horn of the former, and suggest that it may be the solitary and modified remnant of a complete ancestral armature, a monument of bygone times, and a key to the past history of the race.

A curious point is suggested in connection with these horns, viz., as to the accommodation within the oval egg-shell for caterpillars of shapes so awkward for packing up into a small compass. The problem is not in all cases solved in the same way. Before hatching, the horn of the *Sphinxidae* is flexible, and is bent round along the sides of the egg-shell; but a different method of stowage is adopted in the case of *Agria tau*. Here there are five horns instead of one to be packed away, and they would evidently get rather in the way if dealt with in the same manner. Accordingly, it is found that they are not of full size in the egg, but appear as small curled tubercles, which expand to the full form and size after hatching, by the passage into them of blood from the body, in much the same way as the wings of a Lepidopterous insect are expanded after it has left the chrysalis.

From horns, tubercles, spines and tails the transition is not difficult to hairs—in fact it is not easy to say where spines cease and hairs begin: the structures are similar in plan, and differ chiefly in diameter and in the degree of flexibility or stiffness that results therefrom. Hairs and spines may be either simple or branched. Good examples of branched spines may be seen in the caterpillars of many butterflies, such as the tortoise-shells, peacock, red admiral, painted lady, and fritillaries. Densely hairy larvæ are specially characteristic of the group of moths called Bombyces (tigers, ermines, eggers, &c.). The common "woolly bear," or caterpillar of the garden tiger moth (*Actia tau*), may be taken as the most familiar example.

The hairs here emanate from small white tubercles placed on a velvety black body; in front and at the sides they are rust-coloured, but on the rest of the body black tipped with white. To the naked eye they seem to be simple, but the microscope easily shows them to be finely feathered (Fig. 9), with minute branches placed at considerable intervals alternately along the main stem. Their length is so great that their effect is to more than treble the insect's apparent diameter; they are, moreover, pre-eminently elastic and recoil powerfully when bent. When disturbed, the caterpillar rolls itself into a ring, and the hairs, then



FIG. 9.—Hairs of Caterpillar of Tiger Moth, much magnified.

radiating in all directions, make it a most difficult object to handle, their elasticity causing it to elude the grasp again and again, so that it is impossible to seize it firmly. Obviously, therefore, they are a valuable means of protection. The habit of rolling into a ring is closely connected with the hairiness of the larva, the one fact indeed being the complement of the other; as with the hedgehog, the only vulnerable parts are by this means protected, and it is easy to see that a smooth caterpillar would gain little by the device. Hence we find that the habit of rolling into a ring is very prevalent amongst densely hairy caterpillars, though not universal: moreover, it is a habit not entirely confined to such larvæ, though much commoner amongst them than in other groups. It is often said that hairy caterpillars are avoided by birds; but this again is not universally true. That extremely shaggy creature, the larva of the fox moth (*Lasiocampa rubi*), than which it is scarcely possible to imagine anything hairier, might, one would suppose, be a sufficiently disagreeable mouthful; yet the Rev. Harpur Crewe speaks of a bee-eater, which one autumn visited the Scilly Islands, as having lived principally upon these larvæ; it seized them with its beak, and then, beating them on the ground till they were dead, swallowed them whole.

The distribution of the hairs varies very much in different species. When they are fine and collected in closely-compacted tufts along the back, like a row of shaving brushes cut off flat at the top, they form what are called "tussocks" (Fig. 10). The most beautiful

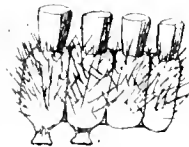


FIG. 10.—Central segments of body of Caterpillar with tussocks.

example of this is the caterpillar of the pale tussock moth (*Dasychira pulcherrima*), an insect of a very pale and delicate green colour, with velvety black crescentic bands at the junctions of the central segments. These black patches are not seen under ordinary circumstances, being concealed by the overlapping of the segments, but they are suddenly revealed when the insect bends its

head under in its terrifying attitude, and more distinctly still when it adopts its final refuge and rolls into a ring. On the back are four large dense tussocks of a bright yellow colour, in startling contrast to the black bands between them, which by the effect of irradiation make them look more conspicuous and larger than they really are; at the hinder end, in the position of a caudal horn, is a sort of tail consisting of a brush of rose-coloured hairs. This lovely caterpillar, one of the most exquisite of British species in the delicacy and purity of its tints, is common in most places, and may be found in the summer feeding on a variety of trees; to the country folk it is known as the "hop-dog." The hairs of

the tussocks very easily come out, though the tussocks themselves look solid and unyielding, and seem to be the most appropriate parts for an enemy to seize upon; but if they be roughly seized, their silkiness causes them to slide from the grasp, the caterpillar thus escaping and leaving with its would-be captor a little bundle of tickling hairs as the only trophy. Mr. Poulton has pointed out that the tussocks may in this way be of some protective value. He offered a "hop-dog" to a hungry green lizard. The animal was apparently experienced enough to know the deceptiveness of the tussocks, but, nevertheless, the promptings of hunger were imperative and it resolved to make a venture, but it carefully avoided the tempting tufts and kept trying for some minutes to find a more suitable point for attack; it finally seized the caterpillar on the back some distance behind the tussocks, whence the moral seems to be that a less hungry assailant would probably have left the hairy morsel alone. A somewhat similar caterpillar, that of the vapourer moth (*Orgyia antiqua*), on being offered to another and, as it proved, less cautious lizard, was at once seized by the tussocks, but its assailant had the mortification of losing its prey, and getting only a mouthful of hairs for its pains; these were by no means to its taste, and it thus learnt a lesson of prudence by the experiment, and made no attempt to mend its fortune by any other venture in the same direction.

(To be continued.)

THE NUMBER AND DISTANCE OF THE VISIBLE STARS.

By J. E. GORE, F.R.A.S.

THAT the visible stars are not uniformly scattered through space, and are not of uniform size and intrinsic brightness, is clearly shown by modern researches. Measures of stellar parallax show that some small stars (that is, faint stars) are actually nearer to our system than many of the brighter stars, while the period of revolution of some binary stars shows that their mass is relatively small compared with the brilliancy of their luminous surfaces. We may, however, perhaps assume that the stars out to some limited distance in space are scattered with some rough approach to uniformity. We can at least calculate the average distance between the neighbouring stars, which would give a certain number of stars in a sphere of given radius. This is easily done by supposing the stars placed at the angular points of a tetrahedron. A tetrahedron is a solid figure bounded by four equal surfaces, each surface being an equilateral triangle. It is clear that in such a solid each of the angular points is equidistant from the other three angular points of the figure.

If r be the length of the side of each equilateral triangle (or edge of the tetrahedron) it may be easily shown, that the volume of the tetrahedron is $\frac{1}{12} r^3 \sqrt{2}$. If we make $r=1$ the volume is $\frac{1}{12} \sqrt{2}$. Now it is clear that the number of equidistant points contained in a sphere of given radius will be equal to the number of these tetrahedrons which the sphere contains. If r be the radius of a sphere, its volume will be $\frac{4}{3} \pi r^3$, and if n be the number of equidistant points or stars contained in the sphere, we have $\frac{4}{3} \pi r^3 = n \times \frac{1}{12} \sqrt{2}$, whence $r = \sqrt[3]{\frac{3n}{32\pi}}$, and $n = r^3 \times 35.548$. From these formulæ we can compute the radius of a sphere containing a given number of equidistant stars, or the number of stars contained in a sphere of given radius.

This formula, however, only applies to a sphere of a

radius large in comparison with the distance between the stars distributed through it. For if we make $r=r=1$, or the distance between the stars equal to the radius of the sphere, the formula would give 35 equidistant stars in the sphere of unit radius. This number is evidently too great, as the number of stars which can be placed on the surface of a sphere of given radius, equidistant from each other and from the centre of the sphere, is only 12. The difference is clearly due to the fact that in this case the volume of the tetrahedron is so large in proportion to the volume of the sphere that the latter cannot be accurately divided into tetrahedrons. In the case, however, of a sphere whose volume is large in proportion to the volume of the tetrahedron formed by four adjacent stars, the formula will be approximately correct. Let us call the distance between two adjacent stars the *unit distance*.

Now considering α Centauri, for which the largest parallax has been found (about 0.76"), it is obvious at once that this star cannot be at the "unit distance" from the sun. For if α Centauri was at the "unit distance" we might expect to find some ten or eleven other stars with a similar large parallax. Such is, however, probably not the case, and we may therefore conclude that this star is comparatively near our system, and forms an exception to the general rule of stellar distance.

To make this point clearer, let us see what number of stars should be visible to the naked eye—say to the sixth magnitude inclusive—on the assumption that the distance between the sun and α Centauri forms the "unit distance" between two stars of the visible sidereal system, or at least that portion of the system which is visible without a telescope. To make this calculation it will of course be necessary to assume some average distance for stars of the sixth magnitude, based on actual measurement. Now Peters found an average parallax of 0.102" for stars of the first magnitude, Gylden found 0.083", and Elkin 0.089". These results are fairly accordant, and we may assume the mean of these values, or 0.09" as the mean parallax of an average star of the first magnitude.

With a "light ratio" of 2.512, the light of a first magnitude star is 100 times the light of a sixth, and hence the distance of an average sixth magnitude star would be ten times that of a first. Its parallax would therefore be 0.009". Hence the radius of a sphere containing all stars to the sixth magnitude inclusive would be $\frac{0.76}{0.009}$ or 84.4 times the distance of α Centauri. Hence we have $n = (84.4)^3 \times 35.548 = 21,372,000$, a number enormously greater than the known number of stars to the sixth magnitude.

This leads us to doubt whether the mean parallax of sixth magnitude stars is so small as 0.009". I find that the sun placed at the distance indicated by this parallax would shine only as a star of the eleventh magnitude; that is, a sixth magnitude star would be five magnitudes, or 100 times brighter than the sun placed in the same position. If of the same intrinsic brilliancy of surface, this would imply that an average sixth magnitude star has ten times the diameter of the sun, and therefore 1000 times its volume! Some sixth magnitude stars may possibly exceed our sun in size, but that the *average* volume of these small stars is 1000 times that of the sun seems wholly improbable. Certainly the calculated masses of those binary stars for which a parallax has been determined do not give any grounds for supposing that such enormous bodies exist among stars of the sixth magnitude.

Assuming, however, that the parallax of a first magnitude star is 0.09", and that of a sixth magnitude is one-tenth of this, or 0.009", let us see what number of stars should be visible to the sixth magnitude. As already stated, the number of equidistant stars which can be placed on the

surface of a sphere of unit radius is 12. Hence, on the surface of a sphere of double this radius, four times the number, or 48 equidistant stars may be placed; on a sphere of three times the radius, nine times the number, and so on. Now the sum of ten terms of this series $1^2, 2^2, 3^2, \dots$, etc., is 385, and as the twelve stars which may be placed on the first sphere nearly represent the number of stars of the first magnitude and brighter visible in both hemispheres, we have the total number of stars to the sixth magnitude inclusive, $385 \times 12 = 4620$.

Now the number of stars to the sixth magnitude in both hemispheres as observed by Heis and Gould, is 4181, and the number contained in the "Harvard Photometry" and the *Uranometria Argentina* is 3735, so that the number of stars computed on the above principle does not differ widely from the number actually observed.

Let us see, however, what the unit parallax would be for the observed number of stars to the sixth magnitude, assuming a parallax of 0.009" for stars of this magnitude. Taking the number as 3735, we have by the tetrahedron formula $r = \sqrt[3]{\frac{3735}{3}} = 4.7187$ times the average distance between the stars, and since $r = \frac{r_{\text{sun}}}{\text{parallax}}$, we have the "unit parallax" $= r \times 0.009 = 4.7187 \times 0.009 = 0.042468$; that is, the mean parallax of the nearest stars to the earth would be 0.042". Excluding stars with a large parallax, this may not perhaps be far from the truth. I find that in 31 binary stars brighter than the sixth magnitude (and for which a parallax has not yet been determined), the average "hypothetical parallax"—or the parallax on the assumption that the mass of the system is equal to the mass of the sun—is 0.068". If we assume the mass of each of these systems to be, on an average, twice the sun's mass, we must divide this by the cube root of 2. This gives for the average parallax 0.054", which does not differ widely from the unit parallax found above for stars of the sixth magnitude.

But we are still confronted with the difficulty that with a parallax of only 0.009", stars of the sixth magnitude would be on the average considerably larger than the sun. The same remark applies to stars of the sixteenth magnitude, for which the parallax would be (with the light ratio of 2.512) only 0.00099". Placed at this vast distance the sun would, I find, be reduced to a star of magnitude 21.3, and would, therefore, be utterly invisible in the largest telescopes yet constructed. It would be over 100 times fainter than a star of the sixteenth magnitude!

To reduce the sun to a star of the sixth magnitude, it should be placed at a distance corresponding to a parallax of 0.1". Unless, therefore, stars of the sixth magnitude are, on the average, considerably larger than our sun, we seem justified in thinking that their average parallax is not less than one-tenth of a second. But, as has been stated, this is about the average parallax of stars of the first magnitude, and it is difficult to believe that these bright stars are as far from the earth as the comparatively faint stars which lie near the limit of naked eye vision. There seems, however, no escape from the conclusion that sixth magnitude stars are probably nearer to us than their brightness might lead us to suppose, and to explain the difficulty with reference to the bright stars, we may perhaps assume that their brilliancy is due rather to their great size than proximity to our system. From the small parallax found for Arcturus, Vega, Capella, Canopus and other bright stars, we have good reason to think that these stars are vastly larger than our sun. Spectroscopic observations of ζ Ursa Majoris indicate that this second magnitude star has a mass about forty times the mass of the sun, and possibly other bright stars may have similarly large masses. Sirius and α Centauri, however, form notable exceptions to this rule.

Assuming an average parallax of 0.1" for stars of the sixth magnitude, the parallax of a star at the "unit distance" from the sun would—on the tetrahedron formula—be 0.47". This is about the parallax found for 61 Cygni, and does not much exceed that of Sirius. There are several other stars with a parallax of somewhat similar amount, and possibly there may be others hitherto undetected.

With a parallax of 0.1" for a sixth magnitude star, the parallax of an eleventh magnitude would be 0.01", and that of a sixteenth magnitude 0.001". Now, with the unit distance corresponding to a parallax of 0.47", let us see what would be the number of equidistant stars contained in a sphere of radius equal to the distance of a sixteenth magnitude star. We have $r = \frac{0.47}{0.001}$, or 470 times the distance between the adjacent stars. Hence $n = (470)^3 \times 35.548 = 3,690,700,000$, a number about 86 times greater than the number of the visible stars, generally assumed at 100 millions. According to Dr. Gould's formula (sum of stars to m^{th} magnitude inclusive $= 1.0051 \times (3.9120)^m$), the number of stars to the sixteenth magnitude would be 3,024,057,632, or about 30 times the number actually visible.

Probably, however, we are not justified in assuming a uniform distribution of stars to the sixteenth magnitude, most of these faint stars belonging to the Milky Way. Professor Celoria found that, near the pole of the Galaxy, a small telescope which showed stars to only the eleventh magnitude revealed as many stars as Herschel's gauging telescope of 18.8 inches aperture. Here, therefore, we seem to have the extension of our sidereal system limited to the distance of eleventh magnitude stars. Let us now assume a uniform distribution of stars to the eleventh magnitude. With a parallax of 0.01", and a "unit parallax" of 0.47", we have $r = (47)^3 \times 35.548 = 3,690,700$. The number by Gould's formula is 3,283,876. Both results are largely in excess of the number actually visible, and show, I think, that there is probably a "thinning out" of the stars before we reach the eleventh magnitude distance, at least in extra galactic regions. If we suppose that of the 100 millions of visible stars, 50 millions are scattered uniformly through a sphere, with a radius equal to the distance assumed for stars of the eleventh magnitude—the remaining 50 millions being included in the Milky Way—we have an average "unit parallax" for these 50 millions of about 0.11", which seems to indicate a "thinning out" of the stars towards the boundaries of the sidereal system. If this be so, we may conclude that the stars with a larger parallax than 0.11" are exceptions to the general rule of stellar distribution, and form perhaps comparatively near neighbours of our sun. These near stars seen from the outskirts of the visible universe might perhaps form a small open cluster. Thus the parallax of α Centauri being 0.76", the distance of a sixteenth magnitude star would be 760 times the distance of α Centauri, and it follows that the sun and α Centauri seen from a sixteenth magnitude star—equally distant from both—would appear as two faint stars about $\frac{1}{2}$ minutes of arc apart.

The above results are of course based on the assumption that the faint telescopic stars lie at a distance indicated by their brightness. Such, however, may not be the case. Many of these small stars may be in reality absolutely small. The apparently close connection between bright and faint stars, as shown by photographs of the Milky Way near α Cygni and α Crucis, suggests that bright naked eye stars and faint telescopic objects may, in some cases at least, lie in the same region of space. If this be so, the

* That is, the parallax of a star as seen from its nearest neighbour.

difference in the size of these distant suns must be enormous, and would lead us to the conclusion that possibly the Milky Way may not lie so far from our system as has been generally supposed. If, as has been suggested, there is any extinction of light in the ether, the faintest stars cannot be placed at a distance corresponding to their apparent brightness.

Science Notes.

In a letter recently received from Prof. G. E. Hale, he says that the contract for the Yerkes 40-inch refractor has been given to Messrs. Alvan Clark, and that Mr. Clark is now at work upon the discs doing the rough grinding. Messrs. Warner and Swasey have been given the contract for the mounting, and they expect to have it set up in Chicago before the summer is over.

Mr. Burnham has definitely decided not to devote himself again to astronomy professionally, but he will be given every facility for using the great instrument.

Prof. G. E. Hale has recently obtained, at the Kenwood Observatory, Chicago, a photograph of the spectrum of a solar prominence, showing 74 bright lines in the ultra-violet between λ 3970 and λ 3630. A 4-inch grating was used on a 12-inch refracting telescope, with glass objectives for the collimator and telescope of the spectrocope. In the photograph obtained all the lines are shown which have been previously photographed by M. Deslandres, of the Paris Observatory, with apparatus in which no glass is used; and in addition to these, 32 lines appear which have not been previously photographed.

Science Gossip contains a highly interesting paper by Mr. P. L. Simmonds, F.L.S., on animal plagues. After giving some statistics with regard to the enormous numbers of human beings and cattle annually lost by death from snake-bites, or from lions, tigers, wolves, and crocodiles, he gives an account of the rabbit plague in Australia. Speaking of India, he says that in 1889, 25,201 persons were killed by wild animals and snakes—chiefly the latter. In Australia it is reckoned that kangaroos consume on an average as much grass as sheep; hence it is very important that their numbers should be reduced. But rabbits (introduced by Europeans) are the chief plague. The extent of the evil may be imagined from the fact that 15,000,000 rabbit skins have been exported from New South Wales in one year; and that in the thirteen years ending with 1889, 39,000,000 rabbit skins were exported from Victoria. The property destroyed by rabbits is estimated by millions of pounds. In spite of the determined efforts that have been made by colonial governments and private individuals, there are some districts where it has become a question whether the farmers can keep up the struggle with them. The fencing off of small districts with wire netting seems to be the best means that has been tried of keeping them out of a particular district.

Since Darwin's investigations on so-called "carnivorous plants," a great deal has been written on the habits and powers of these remarkable organisms, but the question how flies, &c., were dissolved and digested seems to have remained unsolved. It is now maintained that digestion in the case of carnivorous plants is due to the activity of certain micro-organisms, which are always present in the sap of the mature plant, and that their secretions are favourable to the development of such minute organisms.

Dr. Francis Galton and other eminent anthropologists have issued a circular letter on behalf of the committee appointed by the British Association, for an ethnographical survey of Great Britain. It is proposed to take certain typical villages and their surrounding districts and to record the physical types of the inhabitants, their current traditions, the peculiarities of dialect, the monuments and other remains of ancient cultivation, and historical evidence as to continuation of the race.

A correspondent (Sereno E. Bishop) writes to *Nature* from Honolulu (November 8th) to say that during the last three weeks there has been a remarkable renewal of the "afterglow." It seems as if the dust floating in the upper atmosphere, which produces the afterglows, had been added to. Is this owing to the August eruption in Alaska, which is said to have distributed volcanic ash at a distance of 250 miles? The writer says that no such afterglow has been seen since 1886, or three years after the Krakatão eruption.

The famous German Professor Rudolf Virchow receives this year the Royal Society's Copley medal for his researches in pathology and prehistoric archaeology, Sir Joseph Hooker receives the Darwin medal, as being one of the earliest supporters of the author of "The Origin of Species," and Mr. J. N. Langley receives a Royal medal for his researches on the secreting glands and on the nervous system.

Norwich Castle, an ancient building of historical interest, has been acquired by the committee of the Norfolk and Norwich Museum with a view to the transfer of their valuable collections as soon as the castle has been fitted up for the purpose. When the scheme is completed, the trustees are to make over the building and collections to the Corporation, who have agreed to accept the trust, and to hold the castle and its contents for the benefit of the citizens of Norwich. It is to be hoped that the good example thus set may be followed in other places. The Castle Museum Committee are fortunate in having Lord Walsingham for their chairman. He is an ardent naturalist, whose important contributions to the British Museum of Natural History are well known.

From *The Geological Magazine* we learn that Bristol is following on the same lines. At a recent meeting of the shareholders of the Bristol Museum and Library a resolution was adopted for the transference of the institution to the Corporation of Bristol. By a generous offer of £3000 from Sir Charles Watken, together with a small endowment fund, the liabilities will be cleared off.

The December number of *The Field Club* contains the following story, from a correspondent, of a rat that has acquired the habit of catching trout: "Within a mile of where I now write, on the Braid Burn, which runs through Blackford Hill public park, Edinburgh, I have seen a rat—not the ordinary grey species, but the black, with short head, not unlike that of a guinea-pig—dive after and catch a trout, bring it to the bank, and devour it. An old quarryman, who worked by the stream, first told me of the rat's habit, and together we have watched him creep along the branch of an alder overhanging a small pool, sit immovable, as if part of the tree, until a trout swam within his ken, when, like a flash, he dived after his prey, and almost invariably succeeded in his sub-aquatic chase."

Not only is electricity being now largely used in the production of aluminium from clay, but in other directions also electricity is being made extremely serviceable. For example, the manufacture of caustic soda, which was hitherto a slow process, is being carried on from brine by the aid of electricity, chlorine and other chemical products being obtained at the same time. As compared with present methods, the new process is at least fifty per cent. cheaper, and much simpler. The chlorine, which is very valuable, is saved for the production of bleaching powder. It seems probable that the chemical industries of the country will be greatly modified and benefited by the electrical methods now being introduced.

At the recent anniversary meeting of the Royal Society, the president (Lord Kelvin) referred in his address to an extra number of the "Proceedings" (No. 310) which is devoted to a first report of the Water Research Committee on the present state of our knowledge concerning the bacteriology of water, by Professors Percy Frankland and Marshall Ward. This committee was appointed by the society, in alliance with the London County Council. The report is full of most valuable information regarding the vitality of micro-organisms in drinking water, to which in a large measure the spread of Asiatic cholera, typhoid fever, and other zymotic diseases is now known to be due.

Mr. W. H. Preece, the well-known electrician, has succeeded in sending a telephonic message from the shore of the Bristol Channel, near Cardiff, to the island of Flat-holm, three miles off, without the intervention of a connecting wire. This truly wonderful result seems to open out a great vista of future possibilities.

A highly interesting discovery of human remains has lately been reported from the Riviera. The caves in which the bones were found were discovered in 1872 by a M. Riviere, and since that date explorations have been vigorously carried on. The skeletons that have been discovered belonged to a long-headed (dolichocephalic) race, and the individuals they represent were evidently strong and muscular. Three more skeletons were discovered early last year, one of which represented a tall man, whose height was about 6 feet 6 inches; with these bones were found necklaces made of fish bones, canine teeth of stags, shells, &c. Some of the stone implements found with the bones were finely worked, but none of them polished, and some of the bone implements were very rudely made. Many mammalian bones were also found, but none of extinct species, or even of reindeer. But the absence of polished stone implements seems to indicate an early period in the stone age—say the beginning of neolithic times. There is still one cave unexplored, and the Prince of Monaco, whose property it is, has given orders that the work of excavating it is to begin next spring. One curious fact about the human bones here discovered is, that those belonging to adults are all found to have been painted red with peroxide of manganese; and the Marquis de Nadaillay, who reports the discovery in *Science* (September 23rd), says that a similar custom was observed by some Indian tribes.

The remains of ancient lake-dwellings, well known in Scotland and Ireland under the name of "crannogs," are very scarce in England. But Dr. R. Munro, in the *Times* of October 21th, calls attention to a newly-discovered example in Somersetshire. The discovery was made by Mr. Arthur Bulleid, of Glastonbury, whose observations are of special interest. The site of this ancient lake-village is about a mile north of Glastonbury, on the road to the village of

Godney. A number of low mounds were noticed here, each rising from one to two feet above the surrounding soil, and extending 20 to 30 feet across. Excavations having been made, some of the original piles were discovered. The total number of mounds is between sixty and seventy, and they extend over an area of some five acres. Each mound, it seems, contains a fireplace. The hearths were generally formed of large stone slabs, placed over a bed of clay, or of small stones embedded in it in the form of a pavement. An old seventeenth-century map of the district shows that it contained a lake called "The Meare Poole," into which three streams found their way. This pool was not far distant from the site of the present discovery. It is probable that the lake once covered a larger area. Bronze rings, fibulae, a brooch, and a few decayed iron objects have been found here; pottery is abundant; also articles of bone and horn, and some flakes and cores of flint. Articles of "late Celtic" date predominate, and at present nothing Roman has turned up. It is to be hoped that this interesting site will in time be thoroughly excavated.

There has lately been some discussion in one of our evening papers on a question of considerable importance to "the masses," viz., whether tinned meats, shell-fish, fruits, &c., are sometimes poisonous, and what are the causes that produce the poison. One cause is supposed to be the lead used in some inferior kinds of solder. The lead is believed in this case to be dissolved by meat acids, or the acids of fruit, as the case may be. Another supposed cause is the presence of bacteria in meat, shell-fish, &c., owing to insufficient boiling before the tin is soldered up. Another and more obvious cause is the occasional cracking or breaking of a tin, so that air gets in, and that of course would start decomposition. It is comforting, however, to find that one writer denies the possibility of lead poisoning, and maintains that every precaution is taken by the leading American firms to secure complete sterilization by means of the hot bath. In cases where air has afterwards got in through a crack, the smell ought to be a sufficient indication of the fact. The deaths from eating tinned foods appear to be a very small percentage when the millions who use tinned eatables are taken into account.

WHAT IS A NEBULA?

By A. C. RANYARD.

IN the article under the above heading published in the October number, it was shown that nebulae are as a general rule extremely transparent, and that the density of the larger nebulae must be very small, the density of the Orion nebula being probably less than one ten thousand millionth of the density of our air at the sea level. The Orion nebula shines with a faint green light, giving a gaseous spectrum, and if it were a quiescent mass of gas we should expect the cooler outer layers to absorb the radiations given out by the glowing gas within, and its greenish light would consequently not reach us.

Again, the great transparency of the Orion and many other nebulae would lead us to conclude that even its interior parts can radiate freely into space, and that consequently they would probably cool rapidly; but if the nebulous matter is cold, how can we account for its faint luminosity?

If we suppose a mass of hot gas consisting of a great variety of chemical elements to be projected into space, most of its chemical constituents would, as the gas cooled, be precipitated into a glowing mist, the particles of which

would, as the cooling proceeded, cease to glow, but they would still be surrounded by the more volatile gaseous constituents of the original nebulous mass. We should expect to find the uncondensed gases arranging themselves round the liquid or solid particles, forming a sort of atmosphere about them, very loosely packed, owing to the small attracting power of the particles. The particles would be moving with the general velocity of the vapour from which they were condensed, each carrying around it an atmosphere of uncondensed gas of considerable diameter, compared with the diameter of the solid or liquid particle, and wherever two streams of the original nebulous matter impinged upon one another, we should have far more frequent collisions of the atmospheres surrounding the particles than collisions of the particles themselves. The collisions of the particles themselves, if moving with planetary velocity, as supposed by Mr. Lockyer in his meteoric hypothesis, would give rise to a continuous spectrum, but the much more frequent collisions of their atmospheres, would, it seems probable, give rise to a gaseous spectrum, even though the matter of the nebula were extremely cold.

Before endeavouring to make a further step in the

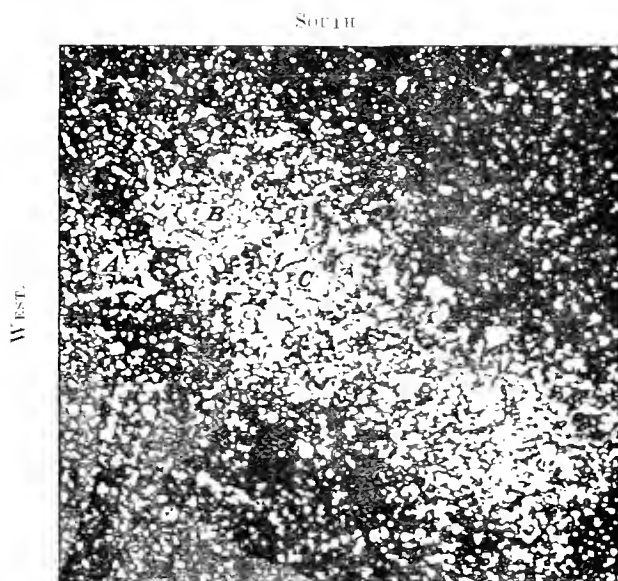


FIG. 1.—Block etched by a photographic process from the central region of Prof. Barnard's photograph, enlarged about three diameters.

enquiry "What is a Nebula?" I will ask the reader to devote a little time to a careful examination of the remarkable photographs reproduced in our plate. Near the centre of Prof. Barnard's large photograph is a bright nebulous patch, thickly strewn with stars, and within the bright region, or projected upon it, is a darker patch with straggling arms or projections, which appear to have sprung from the dark area and spread out in their upper parts somewhat after the manner of solar prominences, though on a vastly larger scale. Again, within the dark area there are two black or nearly black starless regions, which appear like holes in the stellar cluster and its associated nebulous matter, except that one star is seen projected upon the larger of the two black regions.

The question whether the dark structure is nearer to us than the bright nebulous cloud and its associated stars—that is, whether it is only by chance seen projected upon the bright background, or whether the dark structure is surrounded by the nebulous haze and stars, and is

only partly seen through the bright nebulous matter—is one of very great interest and importance in determining the theory which we may be led to adopt in order to explain the phenomena observed.

The facts referred to in the paper on "Dark Structures in the Milky Way," published in the December number of KNOWLEDGE for 1891, would lead us to conclude that the dark and bright structures of the part of the Milky Way there described are all at about the same distance from us, and are intimately associated together. The dark arch and dark tree-like structures, referred to in the December number, 1891 (Fig. 5, page 232), spring from a large dark area in Sagittarius, about ten degrees to the south of the region shown at the centre of Prof. Barnard's photograph, which we are now discussing, and the dark structures there appear to have been projected into surrounding bright nebulous matter. Similarly, in the case now before us, the dark structures seem to be intimately associated with lines or streams of stars in the stellar cluster, and the stellar cluster appears to be associated with a general nebulosity which seems to be brightest where the stellar points cluster most thickly.

One of the most remarkable of these branching lines or streams of stars is situated between the dark structures marked *a* and *b* in Fig. 2. It is best seen in the enlarged copy of Prof. Barnard's photograph, and is marked with

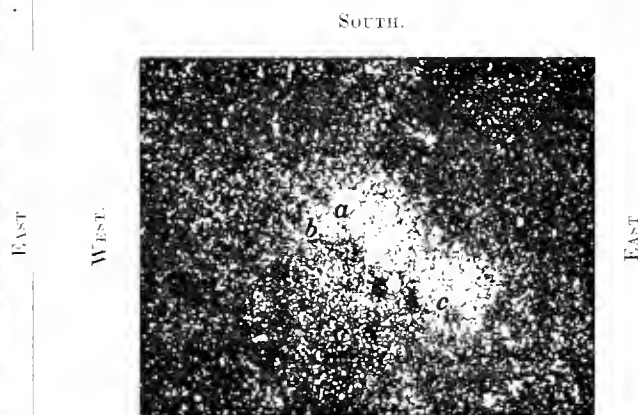


FIG. 2.—Block etched by a photographic process from the central region of Prof. Barnard's photograph. The same scale as the original.

the letter *A* in Fig. 1, but it can be distinctly traced in Prof. Max Wolf's photograph. It seems to afford evidence of a stream of matter which has rushed outward from the dark region, for it forks or branches in a direction away from that region, as also do the dark structures marked *a* and *b* in Fig. 2, and the almost linear dark branching structure marked *C* in Fig. 1. So also does the dark structure marked *c* in Fig. 2, for it is connected with the central dark region by a narrow dark stem, which, after having attained a certain height, spreads into a broader head, from which diverge narrow branching streams which fork outwards. Stretching westward from the base of *c* is a remarkable line of stars, with an adjacent narrow black channel. In view of these facts, we are led to the conclusion that there is an intimate connection between the dark structures and the stellar cluster, and that the dark region is probably surrounded by bright nebulosity.

It seems to me that the easiest explanation of the two black holes is to assume that they correspond to the places where two dark structures similar to *a*, *b* or *c* (Fig. 2) stretch out from the central mass in a direction towards the observer, and that they reach to the surface of the

surrounding cluster and nebulosity, while the structures *a*, *b* and *c* are seen through a certain depth of nebulosity, so that they appear veiled and less black than the summits of the dark structures which extend in a direction towards us.

If we adopt this explanation of the facts observed, we are forced to conclude that the ejected matter, when it is first shot outwards from the central region, is dark or opaque, and that it afterwards becomes luminous and gives rise to the stellar points which we have spoken of as stars, though they may really correspond to considerable areas of flocculent nebulous matter, giving much less light, area for area, than the photosphere of our sun. According to Prof. E. C. Pickering's estimate of the sun's light in stellar magnitudes, our sun, if it were removed to a distance where it would appear to shine like a star of the fourteenth magnitude, would (if there were no absorption of light in its passage through space) have an apparent diameter of only the fifty-thousandth part of a second, but the smallest stars shown have in these photographs an apparent diameter of at least fifteen seconds of arc, so that it is possible that the bright regions we are referring to, and which we have hitherto spoken of as stars, may have diameters many thousand times greater than that of our sun, and may be many million times less bright, area for area, than the solar photosphere.

The branching character of the dark prominence forms, and the spreading nature of their summits, indicates that they are projected into a resisting medium, and that in expanding they are doing work against resistance; consequently if the dark prominences are composed of gaseous matter, they must cool as they expand. It seems also highly probable that matter shot up from the interior of a cluster or nebula, which is cooling into space, would be hotter than the matter which has been in the exterior parts of the nebula or cluster for a considerable time. We are therefore, no doubt, warranted in concluding that the ejected matter, as it first issues in a hot condition, is dark and opaque, and that as it cools it becomes luminous and comparatively transparent, or transparent in the interspaces between highly luminous regions.

It seems to me that the phenomena we observe are very much what we might expect to see if a mass of mixed vapour at a high temperature were projected into a region occupied by cooler vapour, or any resisting cooler medium, such as a cloud of dust: the elements having the highest evaporating and melting points would first condense into a luminous mist, the particles of which would act like floating bodies on a stream, and be swept aside into the eddies and vortices surrounding the main current of the outrushing gas. To judge of large things by comparatively small, we see the same tendency to collect into flocculent masses in the willow-leaf and rice-grain structure of the solar photosphere, and in our own "mackerel" clouds in a gale of wind. According to my theory, the dark structures of the Milky Way and nebulous clusters are the stellar analogues of the solar spots.

When a large sunspot is near to the centre of the sun's disc, and we are able to look down into it, we do not see the heated central body of the sun, nor do we see the bright shell of photosphere which, it is only reasonable to assume, is shining both upwards and downwards on the opposite side of the sun. We are, no doubt, looking into a deep mass of heated vapour, and the wave lengths, which are radiated by the hotter and deeper strata, are entirely swallowed up and absorbed by cooler vapour at a higher level, or, to speak with greater caution, such a large

proportion of the radiated energy is swallowed up that the intensely heated gaseous mass looks comparatively black beside the relatively cooler incandescent mist into which the outer gaseous matter condenses where it can radiate freely into space; and this is the case even though a portion of the light of the incandescent mist is absorbed by vapours above it, as is evident from the channels cut out of its continuous spectrum. In the same manner, we should expect the intensely heated gas issuing from the hotter parts of a nebula or cluster to appear black and opaque compared with the relatively cooler matter composing the outer parts of the nebulous mass or cluster. In the case of the sun, where there is a rapid fall in the temperature as we pass upward through a few thousand miles, we should expect the incandescent clouds of condensing vapour to form a comparatively thin spherical layer corresponding to the photosphere; but in the case of vast streams of heated gas which are carried to enormous distances from the heated region from which they are ejected, before they become sufficiently cooled for any part of the constituent vapours to condense into a white-hot mist, the conditions of cooling would be altogether different. The condensing gas is probably much rarer than in the sun at the level of the photosphere, and it seems not improbable that in the nebula the regions of most rapid cooling and condensation would be intimately associated with the vortices formed in the surrounding medium, where the most rapid contact of heated and cooled material would take place, and where the most rapid compression and expansion of gases causing changes of temperature would also be localized. Such at least seems to me to be the most probable solution of the great riddle presented to us in the complicated phenomena observed.

It seems certain that the stars of irregular star-clusters cannot be moving under the action of gravity so as to form a permanent system with motions about the common centre of gravity of the cluster. It is possible that the individual stars of such a cluster might exist for a limited time until a collision took place and they were shot forth again on a new orbit; but it is also possible that the stars of such clusters are not bodies similar to our sun, but that they correspond to regions of rapid condensation where a white-hot mist is formed in a gaseous medium pervading the whole region of the cluster. The curvilinear streams of stars with forking branches which have been noted in so many clusters (see Miss Clerke's "System of the Stars," p. 213), seem to indicate that they are intimately associated with streams of gaseous matter projected into a resisting medium, and recent photographs also seem to point to the conclusion that all star clusters are nebulous.

THE LATE MR. MATTIEU WILLIAMS.

MANY of our readers will hear with sincere regret of the death of Mr. W. Mattieu Williams, who was formerly, during the editorship of Mr. Proctor, a very constant contributor to the pages of KNOWLEDGE. Mr. Williams was born in 1820, and was at the time of his death in his seventy-third year. He left school at the early age of eleven, and was apprenticed to a Mr. Street, an optical instrument maker in London. During this hard-working period of his boyish life he attended a mechanics' institute in the evenings, and taught himself French and German. On coming of age he inherited a small sum of money, which enabled him to go to Edinburgh to study chemistry, and he subsequently further continued his education by making a tour through the principal countries of Europe on foot. In 1854, on

* See *The Old and New Astronomy*, page 777.

the foundation of the Birmingham and Midland Institute, Mr. Williams was appointed master of the industrial department, a position in which he greatly developed his powers of lecturing. Besides his work at the institute he

time of his death he was at work at a book upon the brain, which it is understood will shortly be published by Messrs. Chatto and Windus. He leaves a widow and three sons.



The late Mr. W. MATTIEU WILLIAMS, from a photograph taken shortly before his death.

practised as a consulting chemist and commenced writing science articles.

During one of his summer holidays he visited Norway, and walked through a considerable portion of the country, then comparatively little known to English tourists. He published the results of his experiences in 1859, under the title of "Through Norway with a Knapsack," a book which was illustrated by the late Mr. John Steeple from sketches made by Mr. Williams during his walk. It passed through more than one edition. At a later period he again described Norwegian travelling in a book entitled "Through Norway with Ladies."

In 1870 Mr. Williams published a volume of philosophical speculations on the cause of the sun's heat, and other cosmical problems. The volume was issued under the title "The Fuel of the Sun," and was widely read. Mr. Williams assumes the existence of a universal atmosphere, and that the density of the atmospheres surrounding the various planets depends upon the amount of the universal atmosphere which the planets can, by reason of their mass, condense about their surfaces. Though none of Mr. Williams' speculations have been generally adopted by astronomers, the book is very suggestive, and many able writers have acknowledged their indebtedness to it.

Mr. Williams was a lucid and most interesting lecturer on the chemistry of common life. In the early volumes of KNOWLEDGE he wrote an excellent series of articles under the title "The Chemistry of Cookery," which were widely quoted at the time, and were afterwards collected and published as a small volume. He also wrote "Science in Short Chapters," a "Simple Treatise on Heat," the "History of the Manufacture of Iron and Steel," and an excellent little book entitled "The Philosophy of Clothing." He was a frequent contributor to the *Gentleman's Magazine* on scientific subjects, and was the author of a system of shorthand entitled "Shorthand for Everybody." At the

Letters.

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

To the Editor of KNOWLEDGE.

SIR,—Having noticed in your last number some remarks upon the so-called "horned toads" of Mexico, you will perhaps allow me to mention my experience of their habits.

While staying at San Diego, in Southern California, I drove some miles inland, on the borders of Mexico, with my son. On a sandy waste we saw numbers of these toads, running with great rapidity, and burying themselves in the sand by means of a lateral wriggling movement. We captured three, and placed them in the empty basin of a fountain until we left for San Francisco, *en route* for England. They soon became very tame; but the largest (presumably a male) was so troublesome in spirting out what looked like blood that we left him behind. The other two we brought to England, where they lived for several months.

The blood appeared to come from small orifices directly above and behind the eyes, and the discharge was so forcible and profuse as to cover my son's naked fore-arm quite up to the elbow. Great prostration followed, and lasted for a day or two.

The "horned toad" has the chameleon-like faculty of rapidly changing his colour to that of the soil upon which he may be placed.

The two smaller animals never exhibited the "spirting."

Yours faithfully,

Wilmer Road, Bradford. G. W. GRAEHAM, M.D. (Lond.)
December 6th, 1892.

To the Editor of KNOWLEDGE.

Mackay, Queensland,

October 15th, 1892.

DEAR SIR,—In the September, 1892, number of KNOWLEDGE, in an article by R. Lydekker on "The Oldest Fishes and their Fins," the *Ceratodus Forsteri* of Queensland is repeatedly called "Barramunda." The aboriginal word Barramundi simply means large fish, and is indiscriminately applied throughout Australia to whatever fish happens to be the largest in that particular locality; but the name should be legitimately restricted to the *Osteoglossum Leichardti*, Leichardt having been the first to describe this fish by that name. I append tracings of *Osteoglossum L.* and *Ceratodus F.*, and beg to refer Mr. Lydekker to Saville-Kent's "Food-fishes of Queensland," 1889, which could probably be obtained from the Queensland Agent-General in London. Your obedient servant,

J. EWEN DAVIDSON.

PERIODICAL COMET DUE IN 1893.

To the Editor of KNOWLEDGE.

SIR.—Only one of the known periodical comets is due to return next year. This was discovered by Mr. Finlay, at the Cape of Good Hope, on the 26th of September, 1886, and passed its perihelion on the 22nd of November following. As soon as the orbit was calculated by Dr. Holetschek, it was noticed that the elements bore a striking resemblance to those of the comet of De Vico, which, after its discovery in 1811, was found to be moving in an elliptic orbit, with a period of only about five and a half years, but

has not since been seen, unless possibly once by the late M. Goldschmidt, of Paris, on the 16th of May, 1855. The orbit of De Vico's comet is very similar (so far as it could be determined by Le Verrier from all the observations available) to that of one discovered by La Hire in 1678, and it is not unlikely that the comets are identical. It was for some time thought that Finlay's comet might be identical with De Vico's; but the definitive calculation of Prof. Krüger (*Astronomische Nachrichten*, No. 2781) showed that that view was untenable. The orbits of both comets, however, agree in having very small inclinations to the ecliptic, and perihelion distances from the sun exceeding by only about a sixth part the mean distance of the earth. According to Prof. Krüger's calculations, the period of Finlay's comet is about 6.67 years, so that a return will be due in the summer of 1893. It does not appear that it was ever seen before its discovery in 1886.

Blackheath, Yours faithfully,
December 3rd, 1892. W. T. LYNN.

THEORY OF THE SUN.
To the Editor of KNOWLEDGE.

SIR,—In the excellent notice of my theory published in the last (December) number of your magazine, Miss Agnes M. Clerke remarks that if my explanation of the prominences as *eranescent illuminations caused by rapidly propagated chemical action in tranquil matter* were true, the prominences would give a continuous spectrum. Hydrogen, she says, "ignited by combustion shows no trace of its characteristic lines." That objection, though in contradiction with a generally accepted statement of Plücker (*Pogg. Ann.*, 116, p. 48) that the flame of a mixture of oxygen and hydrogen, when the latter is slightly in excess shows the two lines H α and H β , seems at first to be strengthened by a recent note of Prof. Liveing—"On Plücker's supposed detection of the Line-Spectrum of Hydrogen in the Oxy-hydrogen Flame" (*Phil. Mag.*, Oct. 1892). But the negative results obtained by Prof. Liveing (suppose they prove really that such an eminent observer as Plücker has mistaken lithium and zinc lines for hydrogen) have, I think, no sufficient bearing on the question moved by Miss Clerke. They only prove, says Prof. Liveing himself, "that the temperature of the oxy-hydrogen flame alone is not sufficient to cause hydrogen to emit the rays we see produced by an electric discharge in that gas."

If therefore we assume the temperature in prominences higher than in the oxy-hydrogen flames of Prof. Liveing, we see no reason why chemical action should not cause the hydrogen to produce lines there. But there is still a second reason why the remarkable statement of Prof. Liveing has no direct bearing on the constitution of prominences; and that reason is, that whatever may be the chemical processes in the solar atmosphere (oxygen and water having never been surely detected there), they cannot have any resemblance with the oxy-hydrogen flames tested by Prof. Liveing.

My explanation of the prominence lines as produced by chemical action is, moreover, strongly supported by the countless well-known observations of lines in flames burning by chemical processes. I need not insist on that well-established fact, but I only wish to state how unexpectedly the recent work of E. Wiedemann, R. V. Helmholtz, W. H. Julius, and others on "luminescence," and especially that of E. Pringsheim on the line spectrum of sodium-vapour, have given a strong support to my idea. According to the experiments of W. Siemens (*Wied. Ann.*, 18, p. 311) and Pringsheim (*Wied. Ann.*, 15, p. 428, 1892), *heat alone is not sufficient to cause gases to produce lines; either electricity or chemical action must*

co-operate. No clearer experimental illustration could have been given of the meaning of my theory of the luminous phenomena in the solar atmosphere.

May I add here that among the numerous observations of prominences published since my theory was written, there are again a great many in close agreement with my theory of a tranquil sun. So, for instance, I found in the "Memoire della Societa degli Spettrosi Italiani," vol. 21, 1892, the description of an enormous prominence, which, according to M. T. Fenyi, could not possibly have been caused by a material eruption or explosion, but seemed to that eminent Hungarian observer produced and very rapidly moving by a sudden and local outbreak of "electricity."

I finish with an expression of gratitude to Miss Clerke and to you for the trouble you have taken in noticing my theory. Dr. A. BRESTER, Jz.

Delft (Holland), Dec. 20th, 1892.

[It seems to me that prominences of the eruptive type afford evidence of actual motion which can hardly be doubted. Not only do we observe very striking displacements of the prominence lines in the spectrum which indicate motion of the luminous matter in the line of sight away from or towards the observer, but we actually observe rapid motion across the line of sight. The velocity of the motion corresponds roughly with the velocity of a projectile shot upwards under the influence of solar gravity, being sometimes a little *more rapid* than projectile motion; as we should expect if the matter shot upwards was passing through a resisting medium, because in being shot upwards it would need to pass through the lower portion of its upward path more rapidly than a projectile moving in free space, which is shot to the same height above the sun.]

I would refer Dr. Brester to papers of mine and of the late Mr. Proctor, dealing with the upward motion of prominences, published in the *Monthly Notices of the Royal Astronomical Society*, Vol. XLI., p. 77. On the other hand, the motion of eruptive prominences is sometimes a little slower than free projectile motion would be, probably because the prominence observed is either on this side or on the more remote side of the sun's limb, and the matter is not being shot upwards at right angles to our line of sight. If the phenomenon observed were due to the mere change in place of electrical illumination, we should expect the velocities observed to correspond with electrical velocities, rather than with the velocities of projectiles moving under solar gravity. On the other hand, the quiescent cloud-like prominences sometimes appear to form, and grow larger, without any visible connection with the lower chromosphere. It may be that the lines of connection (the stems of the banyan-trees, as Prof. Young aptly calls them) are so faint or thin that we do not notice them, or that there is an electrical or other physical change going on which renders matter luminous that previously existed in the same region in a non-luminous state.

Dr. Brester's letter was received just as KNOWLEDGE was going to press, so that there has been no time to submit it to Miss Clerke. —A. C. RAYNARD.]

LEMURS.

By R. LYDEKKE, B.A. Cantab.

IN a previous article we have had occasion to refer to Africa as an archaic kind of land containing types of mammalian life which, while formerly widely spread over the Old World, are now restricted to that continent. If this preservation of ancient types be

highly characteristic of continental Africa, still more markedly is it so of the large island of Madagascar, lying off its eastern coast. In Africa itself many of the ancient types are more or less closely allied to other living mammals, and most of them belong to orders which are abundantly represented in other parts of the world. Very different is, however, the case with Madagascar, of which the great peculiarity is that it has preserved to us a whole fauna of those remarkable animals known as lemurs, which are represented elsewhere only in Africa and the Oriental region, and there by a comparatively small number of species belonging to genera totally distinct from those found in Madagascar. To put the matter more clearly, it may be stated that out of a total of thirteen genera of living lemurs no less than eight are absolutely confined to the island of Madagascar, while the remaining five are distributed over Africa, India, and the Malayan islands; two out of the five being African, one Indian, and two Malayan. The disproportion is, however, not even adequately expressed by the above statement, since, while most of the Malagasy genera are represented by a considerable number of species, of those found in other regions only one has more than two species, while two out of the other four have but a single species each. Lemurs are, indeed, in every sense the characteristic mammals of Madagascar, being far more common in its woods and coppices than are squirrels in those of this country. So common are they said to be in certain parts of the island that, according to the French traveller, M. Grandidier, it is impossible to beat through a single copse without turning out at least one of these strange creatures.

In order to arrive at the true reason of the present distribution of any group of animals, it is always necessary to consult the records of geology; and it appears from these that while lemurs were unknown both in Europe and North America during the pliocene and miocene divisions of the tertiary period, when we reach the upper part of the eocene epoch we find their remains occurring in company with those of the extinct anoplotheres and palæotheres, or other allied animals, in both the eastern and western continents. It is, however, hardly necessary to observe that the whole of these early lemurs belonged to genera which are quite distinct from any of those living at the present day, although one of them appears to have nearly been allied to the African group.

The discovery of these extinct lemurs, which is but comparatively modern, at once reveals the fact that this group of animals is a very ancient one, which was formerly widely spread over the globe, and was represented by at least one species in our own island. Not many years ago it was sought to explain the present peculiar distribution of lemurs by the supposition that a large island or continent formerly existed in the Indian Ocean; and the name Lemuria was suggested, appropriately enough, for this hypothetical land. From this presumed ancestral home it was considered that the lemurs had spread on all sides, some to find a refuge in the Malayan islands, others in the forests of Ceylon and southern India, but the larger number in Madagascar and Africa. Unfortunately, however, for a very pretty theory, the geologists had a word to say on the matter; and this word was to the effect that Lemuria could not possibly have existed at the time its presence was required for the needs of the theory.

With our fuller knowledge of fossil lemurs any such hypothetical land is, however, quite unnecessary to explain the present distribution of the group. At or about the time these animals existed in Europe there is little doubt that they were also spread over Africa, which there is good evidence to show was formerly connected by land with

Madagascar. We do not, indeed, yet know how the ancient lemurs of Europe got into Africa, but when once there it is certain that they were ultimately cut off from Europe by a sea which stretched from the Atlantic to the Bay of Bengal in upper eocene times. For some time afterwards, during which Africa and Madagascar still had a free communication, the large mammals characteristic of miocene Europe were unknown in the lands to the south of this great sea, where lemurs and other lowly animals flourished in security. During some portion of this period Madagascar must have become separated from Africa, while an upheaval of land once more brought Africa into connection with Europe and Asia, and thus allowed it to be overrun by the great hooved and carnivorous mammals which had hitherto existed only to the north of the dividing sea. This incursion of large quadrupeds at once put a final stop to the supremacy of the lemurs in Africa, where only a few species have since managed to survive by the aid of their nocturnal habits. In Madagascar, however, where there are still no large quadrupeds, and where the only carnivores are certain civet-like animals, the lemurs have continued to flourish in full exuberance, and the existing state of that island thus offers to our view a picture of what must have been the condition of Africa previous to the advent of its present fauna from the north. The few lemurs now inhabiting the Indian and Malayan region are, doubtless, also survivors from the original central home of the group, which have found safety in the dense forests of the regions they inhabit.

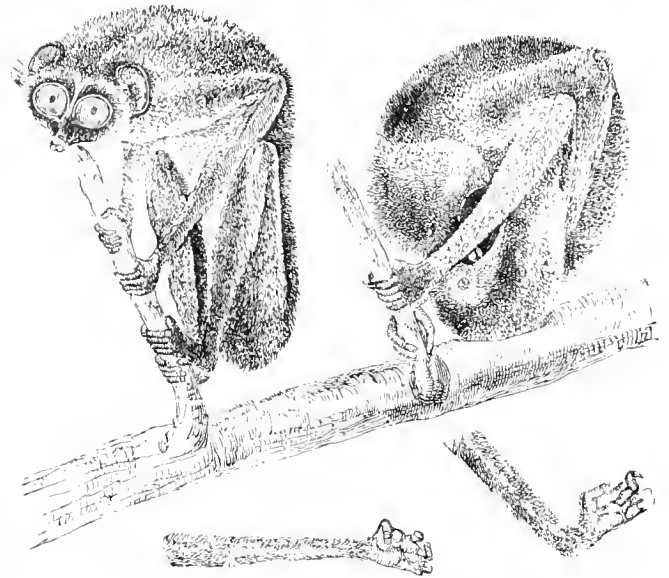


FIG. 1. The Slender Lemur, in waking and sleeping postures, with figures of the arm and leg. (From Sir J. E. Tennent's "Ceylon.")

A good deal more might be said on the subject of the past and present distribution of lemurs, but by this time the reader will probably be impatient to know something of the characteristics of the animals thus designated by naturalists. Of course comparatively little can be said on this subject in an article of the present length, and it unfortunately happens that the lemurs, as a whole, do not present any very strongly marked single external feature by which they can be distinguished at a glance from all other mammals. It is, however, only with some of the lower monkeys of the New World that they could possibly be confounded by observant persons (although we have heard

of some members of the family being mistaken for sloths); but the distinct geographical distribution of the two groups renders it unlikely that any confusion is likely to arise between them. The nearest relations of the lemurs are undoubtedly the monkeys, and most naturalists in this country are now agreed in regarding the former as representing a primitive group of the order (*Primates*) which includes the latter. Lemurs may always be distinguished from monkeys and apes by certain features in their skulls, as well as by several peculiarities in their internal structure; but as these require a certain amount of anatomical knowledge for their proper comprehension, we must ask our readers to take it on trust that such differences do exist. Externally lemurs differ from ordinary monkeys by their more or less fox-like and immobile countenances, but since the marmosets of South America (which are a lowly type of monkey) resemble them in this respect, this character does not afford an absolute distinction between the two groups. All lemurs are further characterized by having the second toe terminating in a long pointed claw, as shown in the right hand lower figure of our first illustration, whereas in ordinary monkeys the same toe has a flattened nail. Unfortunately, however, the marmosets have also a pointed claw on the toe in question, so that this character does not afford an absolute point of distinction between the two. On examining the upper teeth of the lemurs it will, however, be found that, except in the aye-aye of Madagascar, the first pair of incisor or front teeth are separated from one another in the middle line by a distinct gap, whereas in all monkeys they are, as in ourselves, in contact. Now as the aye-aye differs from all monkeys in having its first upper incisors of the chisel-like form characteristic of rodents (rats, beavers, &c.), the upper front teeth of the lemurs will serve to distinguish them absolutely from the whole of the monkeys.

In appearance the various kinds of lemurs differ greatly from one another, some of them looking not unlike monkeys; while others, as the one represented in Fig. 1, are characterized by their long and slender limbs, enormous eyes, and general ghostly form. Then, again, while some of them are furnished with long tails, others are destitute of these appendages; and the common cat-lemur of Madagascar is distinguished from all the rest by the bold alternating rings of black and white with which the tail is ornamented. The last-named species is further peculiar in living chiefly among rocks, whereas the others are arboreal and mainly nocturnal in their habits. It is from these nocturnal habits, coupled with the large eyes, ghostly appearance, and stealthy movements, characteristic of many of the species, that Linnæus was induced to propose the name of lemurs (from the Latin term for evil spirits) for this group of animals—a name which, in the absence of any vernacular title, has been adopted as their ordinary designation.

None of the lemurs are of large size, the length of the head and body in the largest species being only about two feet, and some of them are not larger than rats. They are all excellent climbers, and the majority spend the day sleeping either in the hole of a tree, in a specially constructed nest, or rolled up in a ball after the manner shown in our first illustration. Their food consists of leaves and fruits, birds and the eggs, reptiles and insects, and occasionally honey or sugar-cane; and most of them spend the whole of their time in trees, rarely, if ever, descending to the ground. Some of the larger species inhabiting Madagascar are, however, an exception in this respect, as well as in their diurnal habits, and they may sometimes be observed in numbers jumping across the plains from wood to wood in their own

peculiar fashion, when it is necessary to seek fresh food. From the structure of their brains and other parts of their organization, it is evident that the lemurs hold a very low place in the mammalian class, although their near relatives, the monkeys and apes, occupy the highest position. It is probable, indeed, that the modern lemurs are the descendants of the ancient ancestral stock from which monkeys have originated, and since they themselves are also nearly related to the so-called insectivores (shrews, moles, hedgehogs, &c.), while the latter may have been directly descended from marsupials (opossums, &c.), we see how very close is the connection between the very highest and the very lowest representatives of the mammalian class. The low position of the lemurs in the zoological scale is in harmony with their antiquity and their peculiar geographical distribution, and it is noteworthy that both in Madagascar and in Africa lemurs are accompanied by certain insectivores of a very low degree of organization, and unlike those found in any other part of the world.

The limits of this article render our notice of the various kinds of lemurs necessarily very brief, and our chief attention will be directed to some of the more peculiar and interesting forms. Among the Madagascar lemurs are included a group known as *inlris*, or, in the vernacular, *sifakas*, and containing the largest of all these animals. These *sifakas* are distinguished by the circumstance that all the toes of the foot, except the first, are united together at their bases; and they are further characterized by their parti-coloured fur, in which white, black, and various shades of brown and orange predominate. Most of them have long tails, but in one species this appendage is represented by a mere stump. They live in small parties in the woods of Madagascar, and feed entirely upon vegetable substances. By the aid of their powerful limbs they are able to take enormous flying leaps—sometimes as much as thirty feet in length—from tree to tree, and passing from one clump of trees to another on the ground they hop on their hind limbs, with their arms raised above their heads, in a series of short jumps, when they are said to present the most ludicrous and grotesque appearance. They are largely diurnal in their habits, although sleeping during the heat of the day.

The true lemurs, which are likewise confined to Madagascar and some of the adjacent Comoro islands, differ from the *sifakas* in having thirty-six in place of thirty teeth, by their perfectly free toes, and their less elongated hind limbs. They all have long tails, and the best known species is the above-mentioned cat, or ring-tailed lemur, easily recognized by the feature from which it derives its second name. This animal, which is often exhibited in menageries, is about the size of a domestic cat, and is peculiar in frequenting rocks rather than trees, in at least certain districts in Madagascar. The black lemur, in which the male is black and the female red, is a nearly allied species; and there are also several others. The females of these lemurs have a peculiar habit of carrying their young clinging to the under surface of their body, with the head on one side and the tail on the other; but this strange position is only maintained for a certain time, after which the young creature mounts upon its parent's back, where it remains until able to shift for itself.

A third group is formed by the *galagos*, which differ from the true lemurs in having two of the bones of the ankle greatly elongated, so as to make this segment of the limb much longer than ordinary. They all have long and bushy tails, and are mostly of small size, some of them being even smaller than a rat. The *galagos* are divided into two groups—one confined to Madagascar and the other to Africa.

The former, or dormouse lemurs, are peculiar in that during the hot dry season several of the species undergo a kind of hibernation, coiled up in the hollow of some tree, and in order to prepare themselves for such a protracted fast they accumulate on their bodies a large store of fat. The true African galagos, in addition to other features, differ from the last in that their large ears are capable of being partially folded up, somewhat after the fashion obtaining in the common long-eared bat. Like the dormouse lemurs, they are purely nocturnal, and when on the ground they hop after the manner of kangaroos, the elongation of the bones of the ankle doubtless subserving this kind of movement.

Widely different from all the above are the curious slow-lemurs of Asia and Africa, of which an Asiatic species is represented in Fig. 1. These lemurs are characterized by the index finger of the hand being either very short or rudimentary, and likewise by their tail being similarly abbreviated. The Asiatic representatives of this group, of which there are two genera and about four species, have the usual three joints to the index finger, which is, however, extremely short, and no trace of a tail. It was one of these lemurs which doubtless suggested to Linnaeus his name for the whole group, as their movements are slow and deliberate in the extreme, their eyes large, and their habits completely nocturnal. The Asiatic forms are known by the name of loris. The common loris, with some allied species, extends from Burma through the Malayan region to Siam and Cochin China, and is a solitary animal inhabiting the depths of the forests. The strange and weird little animal represented in our first illustration is an inhabitant of southern India, and is commonly known as the slender loris. It differs from the common loris by its much larger eyes, which are separated from one another only by a very thin partition, as well as by its slender body and limbs; and in consequence of these and other points of difference is referred by naturalists to a distinct genus, of which it is the sole representative. This beautiful little creature is about the size of a squirrel and is of a yellowish-brown colour. It occurs in the forests, usually in pairs. Sir E. Tennent observes that "the naturally slow motion of its limbs enables the loris to approach its prey so stealthily that it seizes birds before they can be alarmed by its presence. During the day, the one which I kept was usually asleep in the strange position represented in the figure: its perch firmly grasped with both hands, its back curved into a ball of soft fur, and its head hidden deep between its legs. The singularly large and intense eyes of the loris have attracted the attention of the Singhalese, who capture the creature for the purpose of extracting them as charms and love-potions, and they are said to effect this by holding the little animal to the fire till the eyeballs burst." I once brought a pair of these little creatures from Madras to Calcutta, and during the voyage they lived chiefly on plantains and bread-and-milk.

In West Africa the slow-lemurs are represented by the potto and the smaller awantibo, both of which differ from the loris by the reduction of the index finger to a mere stump, and also by the presence of a distinct tail, which is of greater length in the former than in the latter species. These animals resemble their Asiatic cousins in their habits, but are even more deliberate in their movements;

and while the potto appears to be not uncommon, the awantibo is of extreme rarity.

The whole of the preceding species are included by naturalists in a single family, but the two following representatives of the group are so different from all the others that each is made the type of a distinct family. The first of these two aberrant creatures is the weird tarsier, of the

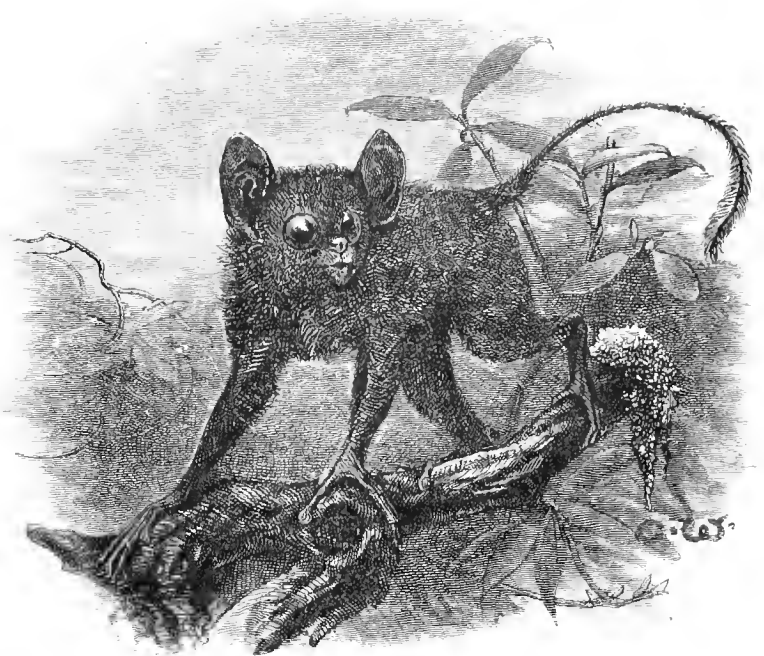


FIG. 2.—The Tarsier. (From Guillemaud's "Cruise of the Marchesa.")

forests of Sumatra, Borneo, Celebes, and some of the Philippine islands. This animal derives its name from its greatly elongated ankle (*tarsus*), and is rather smaller than an ordinary squirrel, with large ears, enormous eyes, and a long tufted tail. Dr. Guillemaud, who when in Celebes was fortunate enough to obtain a living tarsier, writes that "these little creatures, which are arboreal and of nocturnal habits, are about the size of a small rat, and are covered with remarkably thick woolly fur, which is very short. The tail is long and covered with hair at the root and tip, while the middle portion of it is nearly bare. The eyes are enormous, and indeed seem, together with the equally large ears, to constitute the greater part of the face, for the nose and jaw are very small, and the latter is set on, like that of a pug dog, almost at a right angle. The hind limb at once attracts attention from the great length of the tarsal bones, and the hand is equally noticeable for its length, the curious claws with which it is provided, and the extraordinary disc-shaped pulps on the palmar surface of the fingers, which probably enable the animal to retain its hold in almost any position. This weird-looking little creature we were unable to keep long in captivity, for we could not get it to eat the cockroaches which were almost the only food with which we could supply it."

Our brief account of the lemurs appropriately closes with the strangest of them all—the now well-known aye-aye of Madagascar. This remarkable animal, whose systematic position was long a puzzle to naturalists, was discovered as far back as 1780, but for eighty years after that was only known in Europe by the single specimen then obtained. The aye-aye differs from all other lemurs in

* Messrs. Murray have kindly lent us this figure.

having but eighteen teeth, but its most marked peculiarity is to be found in the circumstance that the single pair of front or incisor teeth in each jaw have chisel-shaped crowns like those of rats and beavers, and grow continuously throughout the life of their owner. Another peculiarity occurs in the extremely long and attenuated third finger of the hand, which surpasses all the others in length, although the whole hand is remarkably elongated. It also differs from other lemurs in that all the toes of the foot, with the exception of the first, have pointed claws, and thus resemble the second toe of the ordinary kinds. In size the aye-aye may be compared to a cat, and it has a rounded and somewhat cat-like head, with a short face, and large naked ears. The tail is long and bushy, and the general colour of the fur dark brown.

The aye-aye represents the extreme development of the lemur type, and it is evident that its peculiarities of structure are correlated with equally well-marked traits of habit. Unfortunately, however, from the nocturnal habits and rarity of the creature itself, as well as from the absence of a sufficient number of competent observers in its native haunts, we are by no means so well acquainted with the habits of this strange creature as is desirable. It appears, however, that the aye-ayes live either in pairs or alone in the bamboo forests of Madagascar, and that they are in the habit of constructing ball-like nests of leaves placed in the forks of trees, to which they retire for their diurnal slumber. The strong incisor teeth are certainly used for ripping up the hard external cases of the sugar-canes, on which these animals delight to feed; and it is said that they are likewise employed to tear away the bark and wood from the trunks of trees, and thus expose the burrows of wood-eating larvae, which are then extracted by the aid of the thin middle finger. If any of our readers who may have friends living in Madagascar can induce them to try and obtain more particulars in regard to the aye-aye, they will be conferring a real benefit on science.

THE FACE OF THE SKY FOR JANUARY.

By HERBERT SADLER, F.R.A.S.

SOLAR spots and faculae show no diminution in number. The following are conveniently observable minima of two Algol-type variables:—Algol, January 8th, 10h. 35m. P.M.; January 11th, 7h. 24m. P.M.; January 14th, 1h. 13m. P.M.; January 29th, 0h. 17m. A.M.; January 31st, 9h. 6m. P.M. U Cephei, January 3rd, 7h. 17m. P.M.; January 8th, 6h. 57m. P.M.; January 13th, 6h. 37m. P.M.; January 18th, 6h. 16m. P.M.; January 23rd, 5h. 56m. P.M.; January 28th, 5h. 36m. P.M. A maximum of the beautiful red variable U Orionis is due on the 16th.

Mercury is a morning star throughout the month, but owing to his great southern declination he will be liable to be obscured by mists near the horizon. He rises on the 1st at 6h. 18m. A.M., or 1h. 50m. before the Sun, with a southern declination of $21^{\circ} 23'$, and an apparent diameter of $6\frac{1}{2}''$, $\frac{8}{100}$ ths of the disc being illuminated. On the 7th he rises at 6h. 34m. A.M., or 1h. 33m. before the Sun, with a southern declination of $22^{\circ} 37'$, and an apparent diameter of $5\frac{1}{4}''$, $\frac{7}{100}$ ths of the disc being illuminated. On the 12th he rises at 6h. 46m. A.M., or 1h. 18m. before the Sun, with a southern declination of $23^{\circ} 19'$, and an apparent diameter of $5\frac{1}{2}''$, $\frac{8}{100}$ ths of the disc being illuminated. On the 17th he rises at 7h. A.M., or 1h. before the Sun, with a southern declination of $23^{\circ} 31'$, and an apparent diameter of $5\frac{1}{2}''$, $\frac{7}{100}$ ths of the disc being illuminated. After this he approaches the Sun too closely to be observed. He is at

his greatest western elongation ($22\frac{3}{4}^{\circ}$) on the 1st. During the time he is visible he passes from Ophiuchus into Sagittarius, without approaching any very conspicuous star.

Venus is a morning star, but is rapidly decreasing in brightness. She rises on the 1st at 5h. 46m. A.M., or 2h. 22m. before the Sun, with a southern declination of $21^{\circ} 10'$, and an apparent diameter of $11\frac{3}{4}''$, $\frac{8}{100}$ ths of the disc being illuminated, and her brightness being about what it was at the end of last January. On the 12th she rises at 6h. 13m. A.M., or 1h. 51m. before the Sun, with a southern declination of $22^{\circ} 40'$, and an apparent diameter of $11\frac{1}{2}''$, $\frac{9}{100}$ ths of the disc being illuminated. On the 31st she rises at 6h. 38m. A.M., or 1h. 5m. before the Sun, with a southern declination of $22^{\circ} 0'$, and an apparent diameter of $10\frac{3}{4}''$, $\frac{9}{100}$ ths of the disc being illuminated. During the month she passes through Ophiuchus into Sagittarius, but without approaching any conspicuous star very closely.

Mars is still visible in the evening, but is now getting a very insignificant object in size, and rapidly decreasing in brightness. On the 1st he sets at 11h. 34m. P.M., with a northern declination of $1^{\circ} 2'$, and an apparent diameter of $7.6''$. He is still markedly gibbous. On the 15th he sets at 11h. 30m. P.M., with a northern declination of $5^{\circ} 0'$, and an apparent diameter of $7.1''$. On the 31st he sets at 11h. 31m. P.M., with a northern declination of $9^{\circ} 14'$, and an apparent diameter of $6\frac{1}{4}''$. He describes a direct path through Pisces during the month. On the evening of New Year's Day he is about $3'$ north of the 6.4 magnitude star L1 261. At about 5h. 10m. P.M. on the 14th he will probably occult the 6th magnitude star L1 1299.

Jupiter is still the most conspicuous object in the evening sky. On the 1st he sets at 0h. 47m. A.M., with a northern declination of $5^{\circ} 4'$, and an apparent equatorial diameter of $40\frac{3}{4}''$. On the 31st he sets at 11h. 6m. P.M., with a northern declination of $6^{\circ} 33'$, and an apparent equatorial diameter of $37''$. During the month he describes a short direct path in Pisces. On the evening of the 8th he will be about $\frac{1}{4}^{\circ}$ north of the $5\frac{1}{2}$ magnitude star 80 Piscium. On the 23rd he will be occulted by the Moon, but the phenomenon will not be visible in these latitudes. The following phenomena of the satellites occur while Jupiter is more than $8'$ above and the Sun $8'$ below the horizon. On the 1st a transit ingress of the third satellite at 8h. 39m. P.M., and its egress at 11h. 7m. P.M. On the 3rd a transit ingress of the first satellite at 9h. 2m. P.M.; of its shadow at 10h. 23m. P.M.; and a transit egress of the satellite at 11h. 16m. P.M. On the 4th an occultation disappearance of the first satellite at 6h. 22m. P.M., and its reappearance from eclipse at 9h. 54m. 15s. P.M. On the 5th a transit egress of the first satellite at 5h. 45m. P.M.; of its shadow at 7h. 5m. P.M.; and an occultation disappearance of the second satellite at 9h. 30m. P.M. On the 6th an eclipse reappearance of the third satellite at 6h. 9m. 53s. P.M. On the 7th a transit egress of the second satellite at 7h. 13m. P.M.; a transit ingress of its shadow at 7h. 23m. P.M., and a transit egress of the shadow at 9h. 51m. P.M. On the 10th a transit ingress of the first satellite at 10h. 58m. P.M. On the 11th an occultation disappearance of the first satellite at 8h. 18m. P.M. On the 12th a transit ingress of the first satellite at 5h. 27m. P.M.; of its shadow at 6h. 48m. P.M.; a transit egress of the satellite at 7h. 41m. P.M., and its shadow at 9h. 1m. P.M. On the 13th an eclipse reappearance of the first satellite at 6h. 18m. 58s. P.M.; an eclipse disappearance of the third satellite at 8h. 23m. 13s. P.M., and its reappearance at 10h. 11m. 39s. P.M. On the 14th a transit ingress of the second satellite at 7h. 18m. P.M.; its egress at 9h. 52m. P.M.; and the transit ingress of its

shadow at 10h. 2m. P.M. On the 16th an eclipse reappearance of the second satellite at 6h. 34m. 31s. P.M. On the 18th an occultation disappearance of the first satellite at 10h. 15m. P.M. On the 19th a transit ingress of the first satellite at 7h. 24m. P.M.; of its shadow at 8h. 44m. P.M.; and a transit egress of the satellite at 9h. 38m. P.M. On the 20th an occultation disappearance of the third satellite at 6h. 46m. P.M.; an eclipse reappearance of the first satellite at 8h. 14m. 4 ts. P.M.; and an occultation reappearance of the third satellite at 9h. 16m. P.M. On the 21st a transit egress of the shadow of the first satellite at 5h. 25m. P.M., and a transit ingress of the second satellite at 9h. 59m. P.M. On the 23rd an occultation reappearance of the second satellite at 6h. 43m. P.M.; its eclipse disappearance at 6h. 51m. 29s. P.M.; and its eclipse reappearance at 9h. 11m. 39s. P.M. On the 26th a transit ingress of the first satellite at 9h. 22m. P.M. On the 27th an occultation disappearance of the first satellite at 6h. 43m. P.M., and its reappearance from eclipse at 10h. 10m. 26s. P.M. On the 28th a transit egress of the first satellite at 6h. 6m. P.M., and a transit egress of its shadow at 7h. 21m. P.M. On the 30th an occultation disappearance of the second satellite at 6h. 51m. P.M.; an occultation reappearance at 9h. 25m. P.M., and an eclipse disappearance of the satellite at 9h. 29m. 1s. P.M. A transit ingress of the shadow of the third satellite at 6h. 28m. P.M., and a transit egress at 8h. 28m. P.M. on the 31st. The following are the times of superior and inferior conjunctions of the fourth satellite:—Superior, January 9th, 4h. 2m. P.M.; January 26th, 10h. 56m. A.M. Inferior, January 18th, 3h. 14m. A.M. Jupiter is in quadrature with the Sun on the 6th.

Saturn is an evening star for the greater part of the month, rising on the 1st at 0h. 15m. A.M., with a southern declination of 2° 43', and an apparent diameter of 16'4" (the major axis of the ring system being 39½" in diameter and the minor 6"). On the 31st he rises at 10h. 14m. P.M., with a southern declination of 2° 41', and an apparent diameter of 17'3" (the major axis of the ring system being 41½" in diameter, and the minor 6½"). He is in quadrature with the Sun on the 2nd. Titan is at his greatest eastern elongation at 47h. P.M. on the 5th, and at 38h. P.M. on the 21st. Iapetus is in inferior conjunction at 19m. A.M. on the 4th, and at his greatest western elongation at 107h. on the 24th. Saturn is almost stationary in Virgo during the month, in a region almost destitute of naked-eye stars.

Uranus does not rise till an hour after midnight at the end of January.

Neptune is excellently placed for observation, rising as he does at 1h. 48m. P.M. on the 1st, with a northern declination of 20° 15', and an apparent diameter of 2'7". On the 31st he rises at 11h. 48m. A.M., with a northern declination of 20° 12'. During the month he describes a very small retrograde path to the N.W. of the 5¼ magnitude star Weisse's Bessel², *inv.* 650. A map of the small stars near his path will be found in the *English Mechanic* for October 28th, 1892.

January is a favourable month for shooting stars, the most noted shower being that of the *Quadrantids*, the radiant point being in R.A. 9h. 12m., and 53° north declination, the greatest display being visible during the morning hours of January 1st to 3rd.

The Moon is full at 1h. 44m. P.M. on the 2nd; enters her last quarter at 10h. 28m. P.M. on the 9th; is new at 1h. 28m. P.M. on the 18th; and enters her last quarter at 6h. 27m. A.M. on the 25th. She is in apogee at 7h. A.M. on the 12th (distance from the earth 251,600 miles), and in perigee at 2h. A.M. on the 28th (distance from the earth 229,360 miles).

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

Solution of December Problem:—

1. R to B6, and mates next move.

CORRECT SOLUTIONS received from J. C. KNOCKER, H. S. BRANDRETH, and ALPHA.

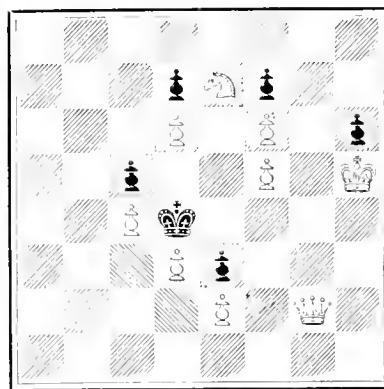
J. C. KNOCKER.—Your solution is perfectly intelligible.

J. N. BABSON (Montreal).—Thanks for the pamphlet.

PROBLEM.

By J. N. BABSON.

BLACK.



WHITE.

White to play, and mate in three moves.

The above elegant composition is taken from a pamphlet entitled "Pleasant Hours with the Chess Board," being a selection of problems by Mr. Joseph Ney Babson, of Montreal. The author intends to publish a selection of three hundred of his problems of all kinds during the winter. The price is two dollars. Subscriptions should be sent to J. N. Babson, P.O. Box 127, Montreal, Canada. The pamphlet referred to contains a few specimens of the composer's skill. One or two appear to be incorrectly printed. The problem given above is described as "a neat little mate in three for those who do not care to wade into difficulties." It is not, however, quite so simple as it looks.

The following is one of the two games played by telephone on December 17th, between the British Chess Club, London, and the Liverpool Chess Club.

QUEEN'S FIANCHETTO DEFENCE.

WHITE (British C. C.).

BLACK (Liverpool C. C.).

- | | |
|------------------|-------------------|
| 1. P to K4 | 1. P to QKt3 (a) |
| 2. P to Q4 | 2. B to Kt2 |
| 3. B to Q3 | 3. Kt to QB3 |
| 4. P to Q5 (b) | 4. Kt to K4 |
| 5. B to K2 | 5. P to K3 |
| 6. P to QB4 | 6. P x P |
| 7. BP takes P | 7. Kt to KB3 |
| 8. Kt to QB3 | 8. B to Kt5 |
| 9. Q to Q4 | 9. Q to K2 |
| 10. B to KB4 (c) | 10. B x Ktch |
| 11. P x B | 11. P to Q3 |
| 12. B to Kt5ch. | 12. Kt (K4) to Q2 |
| 13. Castles (d) | 13. Castles QR |
| 14. P to B3 | 14. Kt to B4 |
| 15. B to Kt5 | 15. P to QR3 |
| 16. B to QB4 | 16. P to R3 |

- | | |
|-------------------|------------------|
| 17. B × Kt | 17. P × B |
| 18. P to Kt4 (c) | 18. K to Ktsq |
| 19. Kt to K2 | 19. Q to K4 |
| 20. Q to Q2 (f) | 20. P to KR4 |
| 21. P × P (g) | 21. R × P |
| 22. Kt to Kt3 | 22. R to R2 |
| 23. QR to Ksq | 23. QR to Rsq |
| 24. R to K2 | 24. R to R5 |
| 25. Kt to B5 | 25. R to B5 |
| 26. Kt to Q4 | 26. P to Kt4 |
| 27. B to Kt3 | 27. R to R4 |
| 28. R to Ktsq | 28. R to Kt4 |
| 29. R (K2) to Kt2 | 29. K to Rsq (h) |
| 30. B to Qsq | 30. R × R |
| 31. R × R | 31. R to R5 |
| 32. B to B2 (i) | 32. K to R2 |
| 33. Q to B2 | 33. Q to B5ch |
| 34. K to Kt2 | 34. B to Bsq |
| 35. Kt to K2 (j) | 35. Q to R3 |
| 36. Q to Kt3 | 36. K to Kt2 |
| 37. Q to B2 | 37. B to R6 |
| 38. R to Kt8 | 38. B to Q2 |
| 39. R to Kt2 | Drawn Game (k). |

NOTES.

(a) From which it was conjectured by the London players that Mr. Owen was at the Liverpool board.

(b) Premature perhaps: the Pawn should be quietly defended.

(c) To prevent B to QB4. If Black reply 10. Kt to Kt3, White intended to continue with 11. B to Kt5.

(d) A necessary consequence of their previous move, which was played without due consideration. Two Pawns being threatened, castling was compulsory.

(e) White having attained their object in doubling the adverse Pawns (apparently the only thing they had to play for) proceed to ensure their continuance in the double state. But they overlooked something, as will be seen later on (*vide* Note g).

(f) Better than 20. Q to K3, because of the reply 20. QR to Ksq, threatening to win a Pawn by 21. P to Kt4; 22. B to Kt3, Kt × B; 23. P × Kt, B × P, etc.

(g) If now 21. P to KR3, Black wins by 21. P × P; 22. RP × P, R × R; 23. R × R, Kt × P! White are now virtually on the defensive for a few moves, but it is nothing very serious, provided that they are not tempted to weaken their centre by P to KB4.

(h) Both sides were pressed for time about here.

(i) A necessary preliminary to their next move.

(j) With a view to a sortie of the Queen *via* Kt3 to Kt8, but they find afterwards that there is nothing to be gained by this process. Another line of play was 35. Kt to Kt3, K to Kt3; 36. P to R4, P × P; 37. Kt × Kt, P × Kt; 38. B × P, with the advantage. The London players had analyzed this variation three moves previously, when the Black Bishop stood at Kt2, and perceived that 38. B × P would be answered by 38. . . . B × QP. They failed to notice afterwards that Black's 34th move did away with this objection.

(k) White were now perforce content to accept the draw which they had refused a few moves back.

The score of the above game is from the *Standard*; we believe, however, that it is not quite correct in the order of some of the moves.

CHESS INTELLIGENCE.

The return match by telephone between the Liverpool Chess Club and the British Chess Club, London, took

place on December 17th. As in the previous match, two consultation games were played. At one board Messrs. Blumberg, Cairns, Ferguson, and Wellington, on the part of Liverpool, opposed Messrs. Heppell, Hoffer, Lord, and Trenchard of London. Liverpool played the Ruy Lopez, which was defended regularly, and resulted in equality. The London players, in endeavouring to force the draw, injudiciously allowed exchanges which resulted in Bishops being left of opposite colours, a fact which speedily decided the game in favour of Liverpool. Evidently the ancient superstition concerning the invariable drawing tendency of Bishops of opposite colours still lingers in the minds of first-class players.

In the other game Liverpool was represented by Rev. J. Owen, Messrs. A. Dod, Kaizer, and Dr. Sugden; the London players being Messrs. Donisthorpe, Guest, Hirsch, and Looock. This game, which resulted in a draw after six hours' play, is given above. The match resulted as last year in a victory for Liverpool. Without in any way wishing to detract from the merits of this result, it may be mentioned that the London players were much disturbed by their unquiet surroundings, and wasted much valuable time in refuting the suggestions of certain irresponsible spectators. We understand that they manage these things better in Liverpool.

On November 28th, Cambridge University (past and present) defeated a team representing the British Chess Club by 6½ games to 2½. The London Club was not very strongly represented throughout.

The Handicap Tournament at the British Chess Club resulted in the victory of Mr. Trenchard, who defeated Mr. Donisthorpe, the winner of the other section, after losing the first game and drawing the second.

Surrey and Sussex played a match, 20 a side, on November 28th, at Brighton, the result being a tie.

On December 10th, the British Chess Club, who are unusually active this season, defeated the Athenæum Chess Club by 6 games to 4.

There will be an Amateur Tournament at Cambridge, commencing on January 3rd. The entrance fee is two guineas. Applications should be made immediately to the Rev. A. B. Skipworth, Tetford Rectory, Horncastle.

Mr. C. T. Blanshard is bringing out a translation of Dufresne's "Examples of Chess Master-play," a collection of 74 match-games played in the years 1887-90. The notation will be English, and the price 2s. Mr. W. W. Morgan is the publisher.

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THE EXTINCTION OF ANIMALS.

By R. LYDEKKER, B.A. Cantab.

IF it be true that, as compared with the pre-glacial epoch, we are living in an impoverished world so far as the larger forms of animal life are concerned, it is even more certain that our immediate descendants will be the heirs of a still more depopulated globe. Already the bison has disappeared from the American prairies, while of the vast swarms of antelopes and other large mammals which half-a-century ago peopled the plains of Africa scarce a tittle remains, and a few are well nigh, or even totally, extinct. A few years ago, indeed, it appeared that we were likely ere long to witness the complete extermination of many species of the larger African mammals; but, although we can never expect to see them again in their original multitudes, several of the South and East African governments are now taking measures to ensure the preservation of a few of the various species, and there is accordingly some hope that although the nineteenth century will ever deserve the reproach of posterity, as having been the one during which the world was to a great extent depopulated of the larger forms of animal life, yet that it will escape the crowning shame of having actually exterminated a host of species. Still, however, the indictment against our generation is heavy

enough in all conscience; and there is no reasonable doubt but that the destructiveness which is so characteristic of human nature—whether civilized or otherwise—has led to the total extinction of two species of large African mammals within the last thirty years, while a third is only too likely to share the same fate. On the other hand, it must not be assumed that all the animals known to have become extinct within the historic period have succumbed directly to this demon of destructiveness. In certain cases, as we shall see in the sequel, the introduction of other animals by human agency has been the involuntary means of leading to the final extinction; while occasionally, as in the case of the great auk, a catastrophe of Nature has accelerated the climax. In other instances, it would appear that a species has been gradually dying out from unknown natural causes, in the manner which appears to be natural to all forms of animal life, where species and genera, like individuals, have but a certain allotted span of existence.

In the present article we propose to notice the chief animals, exclusive of invertebrates, which are known to have been exterminated, or are just verging on extinction, within the historic period; but before doing so we may briefly allude to a few others which urgently require protection, unless they are to share the same fate. Foremost among these are the African elephant and the so-called white, or square-mouthed, rhinoceros of the same country. Till within the last few weeks there were, indeed, strong grounds for believing that the latter magnificent animal, which at present is represented only by a few skulls and horns in English collections, had already disappeared; but we are rejoiced to hear that a few individuals still linger on in a remote corner of Eastern Africa, where it is to be hoped they will receive immediate and adequate protection. The walrus of the polar regions is another animal whose numbers have been woefully diminished of late years, and which likewise stands in urgent need of protective legislation, while a similar remark will apply to several species, or local races, of seals. In countries like New Zealand, where there were originally no native carnivorous animals, many of the indigenous creatures now stand in great jeopardy by the introduction of the latter, and it is only too likely that the flightless kiwi of those islands, noticed in our article on "Giant Birds," will eventually be exterminated by half-wild cats and dogs. The curious tuatara lizard of the same country is also likely to be killed off by pigs. In the Samoan Islands a similar fate long threatened the tooth-billed pigeon (*Didunculus*)—the nearest living ally of the dodo—but the impending destruction was fortunately averted by the bird having forsaken its original habits and taken to perching on trees.

Strictly speaking, the moas of New Zealand come within the category of animals exterminated within the historic period, since they were almost certainly killed off by the Maories; but as we have no direct historic evidence of their existence, no further mention of them will here be made. We shall commence our survey with three species which were the first to succumb.

When the Dutch Admiral Van Neck visited Mauritius in the year 1598, he found that island inhabited by a number of ungainly, flightless birds, which he called walkvogel (disgusting fowl), but which were afterwards termed by the Portuguese dodo (from *doubto*, a simpleton). Subsequently, many living examples of this bird (the form of which is probably well known to our readers) were exhibited in Holland, and their portraits painted by the two artists Savary. The museum at Oxford also once possessed a stuffed specimen, which, with the exception of the head and a foot, were eventually destroyed, as being

too much decayed to be worth preserving! In the year 1601 a Dutch ship captured twenty-four dodos for provisions, and others soon followed suit, so that at this time the bird was still common. It had, however, disappeared before the close of the century. The last notice of the living bird occurs in the journal of the mate of the *Berkley Castle* in 1681; and from the absence of any mention of it by Leguat, who visited the island in 1693, we may presume that it was already quite extinct. Although the numbers carried away by ships doubtless largely aided in its extermination, Prof. Newton, of Cambridge, is of opinion that the dodo was finally killed off by the pigs which had run loose over the island.

Near akin to the dodo was the taller and more lightly-built pigeon-like bird formerly inhabiting the island of Rodriguez, and known as the solitaire (*Prophaps*). Our sole knowledge of this bird in a living state is derived from the accounts of Leguat, who founded a colony on the island in 1691, and who has left us not only a good account of its habits, but likewise an excellent portrait. When the solitaire became extinct is uncertain, but there is some evidence that it may have lingered on in the more remote parts of the island down to the year 1761. These birds were flightless, and the males much larger than the females, their rudimentary wing having a peculiar horny ball-like excrescence. Up to the year 1864 our museums possessed only a few bones of these strange birds, obtained from caverns in Rodriguez; but during the transit of Venus expedition a large number of remains were obtained, from which several more or less nearly perfect skeletons were set up.

Mauritius and Rodriguez also possessed another large flightless bird, known as the *Aphanapteryx*, and belonging to the rail family. By the fortunate discovery of an old painting, we learn that this bird had a long recurved bill and a brownish-red plumage. It was living in 1615, but seems to have disappeared by Leguat's time.

Another extinct Mauritian bird was the géant (*Leguatia*), which was a kind of coot, described by Leguat in 1695 as being equal in size to a goose. When it died out is unknown.

Our next instance of extermination relates to a very different kind of creature, viz., the great northern sea-cow (*Delphinus*), a near ally of the existing dugongs and

party were wrecked on Behring Island, where they remained for some ten months, it does not appear that they inflicted much damage on the sea-cows; but soon after, various fur-hunting expeditions were fitted out to Alaska, the members of which depended solely on these animals for food. So incessant, indeed, was the persecution of the unfortunate creatures, that by 1754 they had been exterminated on Copper Island, while by 1763 nearly all had been killed on their other haunt, and the last individual of their race is supposed to have perished either in 1767 or the following year. Up to 1883 three skeletons in foreign collections and a few ribs in the British Museum were all that remained of the rhytina; but since that date numerous remains have been obtained from the peat of Behring Island. Fortunately, the excellent description left by Steller, and some drawings which have come down to us from the navigator of Behring's party, give us a very good idea of the external form of the giant sea-cow.

Continuing our chronological survey, the next exterminated animals that claim our attention are the gigantic land tortoises of the Mascarene Islands, that is to say Mauritius, Rodriguez, and Réunion. In Mauritius these tortoises were first discovered by Van Neek, the discoverer of the dodo, in 1529, who relates that some of them were of such huge dimensions that six men could be seated on their shells. In Réunion, the voyager Bontehoe writes that he took twenty-four giant tortoises from beneath a single tree, in the year 1618; while Leguat, in 1691, states that in Rodriguez there "are such plenty of land-turtles in this isle that sometimes you see two or three thousand of them in a dove, so that you may go about a hundred paces on their backs." The Réunion tortoises, of which not a single specimen remains in our museums, seem to have been the first to disappear, although at what date is uncertain. Down to the year 1710 these reptiles were still abundant in Mauritius, but by 1761, when vessels were employed in transporting them to that island from Rodriguez as food, they had probably become scarce; while in both islands the whole race became extinct early in the present century, mainly owing to the ship-loads which were carried away for food; although pigs have largely aided in the work of destruction by devouring the eggs and young. It may be added that giant tortoises were formerly widely distributed



Skeleton of Northern Sea-Cow.

over the world; but that within the historic period they have existed only in the Mascarenes, in Aldabra, to the north of Madagascar, and in the far distant Galapagos group. In Aldabra, whence they have been introduced into the Seychelles, they are now becoming very scarce, although we believe they receive some kind of protection. The Galapagos tortoises are, however, only too likely to share the fate of those of the Mascarenes, all the larger specimens having been already killed off. Indeed, it is highly probable that the Abingdon tortoise, remarkable for the extreme thinness of its shell, specimens of which were obtained in 1875 for our national collection, may already be numbered with the extinct.

With the pied starling (*Fregilupus varius*) of Réunion we return once more to birds. This beautiful species, the sole representative of its genus, and distinguished not

only by its pied plumage, but likewise by the presence of a coat of feathers on the head, is said to have been very bold and confiding in its disposition, and is believed to have been exterminated about fifty years ago.

Within the last few years a species of ke-ke parrot (*Nestor productus*), formerly inhabiting Phillip Island, near New Zealand, is likewise believed to have become extinct.

Our next species is one which may possibly be still existing, although, if so, it must be of extreme rarity. This is the gigantic blue coot (*Notornis Mantelli*) of New Zealand, which is almost the sole representative of its genus, although it has near allies in the purple water-hens (*Porphyrio*). This huge flightless bird was first made known to science on the evidence of some bones obtained from the volcanic sands of Waingongoro, in the North Island, and described by Sir R. Owen as belonging to an extinct form. Their discoverer, Mr. W. Mantell, succeeded, however, in obtaining the skin of an example which had been caught alive and eaten by some sealers in the South Island, some time in 1877; this skin, together with that of the second specimen, being now mounted in the British Museum. The second living specimen was taken in 1869, and a third in 1881, both in the South Island; but whether any others still survive is more than doubtful. As the fossilized remains of this species are not uncommon in the superficial deposits of both islands, we may probably refer its extinction in the North Island, and its extreme rarity in the South, to the Maories. If it still linger it is probable that wild pigs, dogs, or cats will ere long put a term to its existence. An allied species (*N. albus*), distinguished by its plumage, formerly inhabited Norfolk and Lord Howe Islands, but is now extinct.

With the great auk, or gare fowl, we come to a species completely exterminated in modern times, and of which the accounts are fairly complete. This bird, the largest member of its genus, and totally unable to fly, was restricted to the shores of the North Atlantic, ranging in Europe from Iceland in the north to the Bay of Biscay in the south, while in America it extended from Greenland to Virginia. These southern limits mark, however, only the winter range of the species, which was somewhat migratory in its habits. Its breeding-places were but few, the chief being the rock called Geirfuglasker off the coast of Iceland, and Funk Island on the Newfoundland coast; both these spots being bare, barren rocks very difficult of access. In spite of its slow increase (but a single egg being laid at a time), the great auk existed in countless numbers on Funk Island, where it was discovered by Cartier in 1534. Here for nearly two centuries it formed an unfailling food-supply for all vessels visiting the neighbouring seas; and it might have lived till now had not the custom arisen of men being landed on the island to spend the summer in slaying these birds for the sake of their feathers. It is said, indeed, that the auks were actually killed by millions, being first driven into stone enclosures, and then bludgeoned. When the bird disappeared from the American side is not quite clear, although it was probably somewhere about the year 1810. Four years later it had also ceased to exist on the opposite side of the Atlantic, the last European pair having been killed in the summer of 1844. What led to its rapid and final extermination in Europe was the sudden subsidence of the Geirfuglasker in 1830, which compelled the birds to seek other and more accessible breeding-places, where they were less protected from molestation. The last British example was killed in Waterford harbour in 1831. In addition to bones obtained from Funk Island, the great auk is now represented in collections only by some seventy-six skins, nine skeletons, and sixty-eight eggshells.

Before noticing the few remaining birds on our list, we may refer to two South African mammals which are now almost certainly extinct. The first of these is the fine antelope known as the blaubok (*Hippotragus leucophaeus*), a near ally of the handsome sable antelope and roan antelope, characterized by their large scimitar-like and backwardly-sweeping horns. Indeed, the roan antelope is often confounded with the blaubok, although the latter was a considerably smaller and otherwise different species. When the blaubok was killed off cannot now be ascertained, but it was certainly abundant at the Cape in the first half of this century. Unfortunately, the British Museum has not a single specimen of this antelope, although a head is preserved in Paris.

The second African mammal is the quagga (*Equus quagga*), a near relative of the zebras, but distinguished by the hinder portion of the body being devoid of stripes. This animal was described by Sir Cornwallis Harris in 1839 as existing in immense herds, although its distribution was always very local; but of late years there is no definite record of a single specimen having been seen. If, as is probably the case, it is truly extinct, there is no record of the date of its disappearance. Of the almost total extermination of the square-mouthed rhinoceros, mention has been already made.

Curiously enough, the northern sea-cow was not the only animal discovered on Behring Island in 1741, during Behring's involuntary sojourn, which appears to have since become extinct. This second species was Pallas's cormorant (*Phalacrocorax perspicillatus*), the largest representative of its genus, and distinguished by its lustrous green and purple plumage, and the bare white spectacle-like rings round the eyes. This bird, which weighed from twelve to fourteen pounds, had small wings and was a poor flyer, with a stupid, sluggish disposition. Steller relates that it occurred in great numbers, and was extensively used as food by the members of Behring's party. About 1839, Captain Becher, of the "Sulphur," received as a great rarity a present of one of these fine birds from the Governor of Sitka, by whom some other specimens were sent to St. Petersburg; but since that date nothing has been heard of the species, which probably became extinct within about a century of its discovery. Dr. Stejneger, who visited Behring Island in 1882, instituted a careful search after this bird in vain, although he was rewarded by finding some of its bones buried in the soil. The species is now represented only by four mounted specimens, one of which is in our own national collection, and a few bones.

Another bird that appears to have become extinct within the last half-century is the beautiful black and golden sickle-bill, or mano (*Diapornis pacifica*), first brought to Europe by Captain Cook after his discovery of the Sandwich Islands, to which group it was restricted. This bird belonged to the family of honey-suckers, and was remarkable for the length of its curved bill. The brilliant yellow feathers from the back of the bird were used by the Hawaiian chieftains in the manufacture of their gorgeous feather-cloaks; and as one particular cloak, according to Mr. Scott Wilson, measures four feet in length and more than eleven feet round the base, it may be imagined what a number of birds of eight inches in length—and these only yielding the particular feathers on the back—would be required for its construction. Indeed, the manufacture of this particular cloak is stated to have lasted through the reigns of eight chieftains; and it is to the destruction thus caused that Mr. Wilson attributes the extinction of this beautiful bird, now represented in our museums only by some four stuffed examples.

In the Antilles a remarkable furrowing petrel, known as the diabolon, is also believed to be now extinct.

With the handsomely marked Labrador duck (*Campotornis labradorius*) we bring to a close our list of animals which can be pretty definitely affirmed to be extinct, although there are a few others over which the same fate is impending, even if it has not already befallen them. This duck was not unlike the common long-tailed duck (*Harlela glacialis*) in general coloration and size, although without the long tail of the latter. In the male, the body and primaries are black, and there is also a ring round the neck and a stripe down the head of the same hue; while all the remainder is white. During the breeding-season this species inhabited Labrador, but in winter its range extended as far south as New Jersey. According to Mr. F. A. Lucas, to whom we are indebted for much information concerning the extinction of several of the species noticed in this article, the Labrador duck was never common, and as no example has been seen since 1879 it may fairly be presumed to be extinct.

In conclusion, we may refer to a very remarkable mammal of which but a single example has hitherto come under civilized human ken. As most of our readers are probably acquainted, at least by name, with the large spotted South American rodent, known as the paca—a distant cousin of the familiar guinea pig—we shall assume that they know what we mean when we talk of a paca-like animal. Now, on a certain occasion somewhat more than twenty years ago, the inhabitants of Montana de Vitoc, in Peru, were surprised to find at daybreak a large rodent with the general appearance and coloration of a paca walking unconcernedly about the courtyard of a house. The creature differed, however, from a paca in having a tail of considerable length, as well as in its smaller ears and cleft upper lip; while dissection revealed other internal points of distinction. Now the curious part of the matter is that none of the natives of Peru had ever previously heard of or seen a similar animal (for which, by the way, the name of *Dinomys* was suggested), and from that day to this nothing more has been heard about the creature. Can it be that the specimen then seen and killed was the last survivor of its race, and that the *Dinomys*, whose existence was thus strangely revealed to us, must also be numbered with the extinct?

FLUORESCENCE AND PHOSPHORESCENCE.

By VAUGHAN CORNISH, M.Sc., F.C.S.

WHEN we view by reflected light the three following objects, a film or leaf of gold, a solution of sulphate of copper, and the leaf of a plant, we see that their colours are yellow or orange, blue, and green respectively. If, however, we view these bodies by transmitted light (i.e., look through them at the light), we shall find that the thin gold film appears blue-green instead of yellow, whilst the solution of copper sulphate and the leaf of the plant appear of the same colours, viz., blue and green, as when seen by reflected light. It will be understood without explanation that the light transmitted by a body consists of all or part of the rays which have escaped reflection. In the case of a thin film of gold the rays of the orange end of the spectrum are reflected, and other

rays, the blue and green which have escaped reflection, are transmitted through the film. The colours of the object as seen by reflected and by transmitted light are, approximately, complementary colours.

How is it that in the case of a liquid, such as a solution of copper sulphate, and again in the case of the leaf of a plant, the colour as seen by reflected and by transmitted light is the same? The following experiment will serve to explain the action on light of the solution of copper sulphate.

The clear solution is placed in a vessel the sides and bottom of which are carefully blackened, and the mouth of the vessel is illuminated by ordinary white light. On looking into the vessel the contents appear, not blue, but black. If a blue tinge be distinguished, it is owing to the sides of the vessel not being perfectly protected with the required coating of dull black. In this case the copper sulphate, though illuminated by white light, does not give its well-known bright blue reflection, but reflects practically no light at all. If, however, a little finely-powdered chalk be introduced into the copper sulphate, the contents of the vessel immediately reflect the familiar bright blue colour.

What happens, obviously, is this: the light falling on the particles of white chalk is reflected back to the eye of the observer. In its passage into and out of the copper sulphate solution the light has been deprived by absorption of the orange part of the spectrum, and the blue rays alone emerge. Thus the colour of a solution of copper sulphate is the same whether light falls on it or comes through it, because there is, practically, no true reflection at all, but absorption only. When light falls on a vessel containing the liquid the blue colour is due to light from the background, or from solid particles in the liquid; the orange part of the reflected light being absorbed by the copper sulphate, and blue only passing. We see, therefore, that the colour of copper sulphate is always due to absorption and not to surface reflection.

In the case of a green leaf which shows the same colour by reflected and by transmitted light, the explanation of what goes on appears to be very similar to the last case. The light penetrates some little way below the surface of the leaf, and is there reflected back through the semi-transparent material. The chlorophyll absorbs the red rays and allows only the green to pass out again. With the leaf, as with the copper sulphate, there is no true surface reflection, such as is given by the gold film. The colours of most bodies, except the metals, are due to absorption, certain rays being absorbed and extinguished by the body.

A very interesting class of optical phenomena is presented by certain substances in which the absorbed rays, or some of them, are not extinguished, but are modified so as to emerge with a colour different from that which they originally possessed. The colour of a ray depends upon the period of vibration, the violet rays vibrating more rapidly than the blue, and the blue more rapidly than the red, which have the longest period of vibration. The rays of colour of shortest vibration period are termed the more refrangible rays from the fact that, in passing through a prism or lens, they are bent further out of their original path than the rays of longer period (the less refrangible), such as the red rays. Substances of the class to which we have referred (which are termed *fluorescent* substances) change rays of higher to rays of lower refrangibility, e.g., violet to blue. A good example of the action of such sub-

* The action at the surface of a film of gold is evidently somewhat complicated. Thus polarized light falling obliquely on a gold surface varies in colour after reflection with the inclination of the plane of polarization and the plane of incidence. The experiment is easily tried. If a sovereign be examined with a Nicol's prism, turned so as

to cut out the light polarized in the plane of incidence, it appears whitish, like a bad shilling made of lead or pewter; but if the Nicol's prism be turned at right angles to its first position, the sovereign resumes its golden yellow appearance. — A. C. RAYBARD.

stances is furnished by a solution of sulphate of quinine. To a superficial observer the solution appears clear and practically colourless. If, however, the eye be placed nearly on a level with the surface of the liquid on which a ray of white light falls, and a black screen be placed behind the vessel which contains the liquid, a bright blue colour is seen on the surface, and for a short distance below the surface of the liquid. The singular thing about the phenomenon is that this blue colour is not due to the absorption and emission of blue rays, but of rays of another colour, viz., the more refrangible violet rays. This can be shown by examining with the spectroscope the light transmitted by the solution. It is found that it is not the blue but the violet rays which are wanting from the spectrum. If the white light of the sun be caused to pass through yellow glass the emergent light produces no fluorescence in a solution of sulphate of quinine, the active violet rays having been removed by the yellow glass. Sunlight may, however, be passed through a violet glass without diminishing its power of causing a fluorescence in the quinine. It is possible to quench entirely a beam of white light by interposing first a violet-tinted glass which absorbs all rays but the violet, and then a yellow glass which quenches these violet rays. Such a combination is impervious to white light, but if a vessel containing a solution of sulphate of quinine be introduced between the two glasses, light at once shines through. This is because the violet rays falling on the sulphate of quinine are changed to blue rays, which the yellow glass has no power to absorb.

The properties of fluorescent substances have been applied to the important problem of mapping the ultra-violet portion of the solar and other spectra. The radiation of hot bodies, as has long been known, is not confined to the visible rays of the ordinary spectrum as perceived by the eye when light is passed through a prism. A thermometer, or a thermopile, placed beyond the visible red is still affected by the radiation which is not visible to the eye. The heating effect of the "ultra-red" rays is, in fact, very great. In the same way it has been found that there is radiation beyond the limit of the deepest violet which is visible to the eye. The ultra-violet radiation has but little heating effect, but is potent in producing chemical change. This portion of the spectrum of the sun can be made visible and "mapped" by the use of a fluorescent substance. The fluorescent substance placed in the invisible ultra-violet shines with a blue light readily perceived by the eye. The band of blue light is crossed by dark lines corresponding to the dark lines of the ultra-violet part of the solar spectrum. The dark lines are due to absorption of particular rays in the solar atmosphere. Where these lines occur there is no radiation, no ultra-violet ray, and consequently nothing to cause fluorescence. The blue band is therefore crossed by dark lines, the position of which can be measured as in ordinary spectroscopic work.

In most cases fluorescence lasts only so long as the substance is exposed to the radiation, but in some substances the emission of light continues after the exciting radiation has ceased to act. This phenomenon of persistent fluorescence is termed phosphorescence. It is well seen in the behaviour of the sulphides of the alkaline earths, which, after having been exposed to light, continue to shine for a long time in a darkened room. Many substances, however, which shine in the dark are not truly phosphorescent in the sense defined above, their "glow" depending on some slow chemical action, as in the case of common yellow phosphorus (*vide* KNOWLEDGE for June, 1892, "*Phosphorus mirabilis*").

It remains to enquire into the mechanism of the phenomena of absorption, fluorescence and phosphorescence.

According to the undulatory theory, light is the effect of a wave motion in a fluid medium. The character of the wave motion is not greatly different from that of waves in water. According to the molecular theory of the constitution of matter, substances are made up of small particles, termed molecules, which are in a constant state of vibratory and other motion. The mass of the molecules and the period of vibration is different in the case of different substances. We have to explain what takes place when the wave motion which constitutes light falls on a body composed of such vibrating molecules. Sir G. Stokes has furnished the explanation in the form of a simple analogy. Suppose a fleet of ships of different sizes to be lying at rest on a calm sea. Suppose a series of waves to pass over the surface of the sea without wind. The waves may be supposed to be the effect of a distant storm. Each ship will begin to oscillate. The time of oscillation, swing, or vibration will depend upon the size and mass of each ship, and may, or may not, in any particular case be the same as the periodic time of the waves themselves. The duration of a single oscillation of a ship may be the same as that of the wave, or it may be greater. In no case can it be less. The oscillating ships become themselves centres of disturbance from which waves are propagated over the sea. The periods of these waves may be the same as or greater than those of the original waves, but cannot be less.

The waves from the distant storm correspond to the light waves from a luminous body. The ships of various tonnage correspond to the molecules of different substances. Those ships which vibrate in a slower period than that of the original waves, and themselves cause fresh waves of the slower period, correspond to the molecules of a fluorescent substance. They act like the molecules of sulphate of quinine, which, when agitated by the rapid wave of violet light, take up themselves a slower period of vibration, and set in motion the surrounding ether waves of this slower period, which affect the eye with the sensation of blue light.

Properly speaking, these ships correspond more closely to the molecules of a phosphorescent body, since they would continue to vibrate for some time after the subsidence of the disturbing waves.

If we suppose that there are ships in our imaginary fleet which take up the same period of vibration as that of the disturbing waves, and if we suppose that these ships come to rest directly the disturbing waves cease, then we have the analogues of the molecules in the film of gold of which we spoke at the commencement of this article, for the molecules at the surface of the film of gold reflect the waves of a particular period, being set in motion in that period themselves, as is indicated by the fact that the light which passes through the film is robbed of just those rays which are reflected at the surface.

THE TEL-EL-AMARNA TABLETS.

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

TEL-EL-AMARNA is the Arabic name for a village in Egypt situated on the east bank of the Nile, halfway between Minieh and Assiout, and about 180 English miles south of the ancient city of Memphis. It comprises a number of straggling Arab dwellings erected in a wilderness of sand and ancient ruins. About five years ago, some peasant women, searching, it is said, for fire-wood, but more probably for inscribed

scarabei or other Egyptian antiquities, with which practice has made them familiar, came upon a number of inscribed clay tablets. In the aggregate, some 320 of these documents were unearthed, and forwarded to the dealers of Cairo for disposal. A cursory examination sufficed to determine the fact that, although discovered on Egyptian soil, the writing on the tablets was neither hieroglyphic nor hieratic, but in the old Babylonian cuneiform character. The dealers communicated with the Government of the Khedive, with the result that the whole of the find was secured. Of the 320 letters, 82 were forwarded to the British Museum, 160 (mostly fragments) to Berlin, 60 were retained in the museum of Gizeh, and the remainder found their way into private hands.

Much interest attaches to the discovery of these tablets. The ruins amid which they were found form the site of the city and temples erected by the heretic King Khu-en-aten, a Pharaoh who, under the title of Amenophis IV., reigned in Egypt B.C. 1500. Among the tablets are a number of letters received by Amenophis III. and Amenophis IV. from reigning kings of Babylon, and reports from governors of outlying Egyptian provinces, as also copies of letters sent in reply. The whole of the writing on the tablets is in the Babylonian cuneiform, or wedge writing, and many are docketed with the date and from whom received in the Egyptian hieroglyphic character. The peasants who found them may be said to have stumbled on the ruins of the Foreign Office of the Egyptian Government of 3400 years ago, and accidentally to have brought to light an interesting political, social, and dynastic correspondence, covering the years from 1500 B.C. to about 1450 B.C., carried on between the Pharaohs of the fifteenth dynasty and the rulers of Syria and Chaldea. Valuable information is also found in the tablets concerning the Hebrews and their semi-conquest of ancient Phœnicia (Canaan), recorded in the books of Joshua and Judges.

To understand the references in the letters, it is desirable to recall the leading circumstances of the period to which the tablets refer. Amenophis III., who reigned thirty-five years, had married an Asiatic wife, the Princess Thi, and it was probably owing to the influence of this lady that Amenophis IV. discarded the religion of his ancestors in favour of that of his mother. After the death of his father, Amenophis IV. openly avowed his attachment to sun worship, introduced the Aten (sun's disc) into the ritual, and built the city, palaces, and temples now in ruins at Tel-el-Amarna.

Among the tablets in the Berlin Museum are six from Babylonian kings to Egyptian Pharaohs; in the Gizeh collection, two; and in the British Museum are three. These letters supply considerable information concerning the political relations existing between the Pharaohs of Egypt and the kings of Western Asia, besides details of the commercial relations between the countries, and offensive and defensive alliances, marriage customs, religious ceremonies, and court intrigues.

Of great interest are seven letters from the King of Mitani, a country east of the Euphrates, and near the Hittite fortress of Carchemish. Most of the letters from this king are in the Assyrian dialect of the cuneiform, which differed from the Babylonian cuneiform as Cornish from Lancashire, or Irish from Scotch. Carchemish was a Hittite fortress. From this spot we have in the British Museum some half dozen monumental fragments inscribed in a hieroglyphic character that has never yet been deciphered, and suggesting that the Hittite branch of the Semitic race, like the ancient Egyptians, possessed a sacred hieroglyphical form of writing of which the key is yet to be discovered. One of the Tel-el-Amarna tablets,

from the Hittite prince Arzapi, is written in the dialect of the ancient Akkadian, or Mongol tongue of Mesopotamia. This ancient language occupied, for the Babylonian student, the same position in education as the Latin tongue does at the present day with us. Among the tablets in the British Museum, from the great library at Nineveh, are school books of the time of Ashur-bar-ni-pal, B.C. 668, containing Akkadian words, with their Babylonian equivalents written in parallel columns. It may be mentioned, in passing, that it is a question if modern Chinese has not been developed from this old Akkadian.

The Tel-el-Amarna letters being all in the cuneiform character were considered as unlikely to be readily deciphered at the Egyptian court. Hence it was the custom of the Babylonian kings to send interpreters with them, and reference is made to such messengers in several of the letters. But a scribe able to read and write the Babylonian cuneiform was undoubtedly kept by the Pharaohs for purposes of translation and for inditing replies. Some of the tablets are copies of such replies, written in cuneiform, but retained for reference, just as we in the present day preserve copies of important correspondence.

One of the most suggestive of the series secured by the British Museum is a letter from Burraburiyash, a Babylonian king of Karaduniyash, addressed to Amenophis IV. It commences by stating that Burraburiyash is himself in good health, and he hopes that Amenophis and his wives and children are also in good health, and that his country and army and government are in a prosperous condition. He goes on to remind the King of Egypt that in days gone by their respective fathers were agreed in friendship, and periodically presented each other with substantial tokens of mutual regard, and proceeds to refer to a gift recently received from the King of Egypt of two manehs of gold. He bluntly complains of its insufficiency, as much beneath the quantity his father, Amenophis III., was wont to send. He entreats him to forward at least half the quantity his father usually sent, and enforces his request by reminding the King of Egypt of certain obligations both he and his father were under for past friendly actions. On the occasion of the Canaanites sending a messenger to Babylonia inviting him to join in an invasion of Egyptian territory, he not only declined to make any league with them or have anything to do with it, but told the ambassador that if they induced any other king to join them in an attack upon the possessions of "his brother," the King of Egypt, he himself would go forth against them in battle. Further, he tells the King of Egypt that if the Canaanites had actually invaded Egyptian territory it was no fault of his, as by the hand of a trusty Babylonian messenger he had sent the King of Egypt notice of recent suspicious proceedings on the part of the Canaanites. He reminds Amenophis that as long as there is an offensive and defensive alliance between them the Canaanites are powerless to do much harm, and may be easily driven off. As a present (evidently with a lively sense of favours to come), he sends the King of Egypt three manehs of lapis-lazuli and five pairs of horses.

A letter from Amenophis III. to Kallima Sin, King of Northern Babylonia, is earlier in point of time, and scarcely less interesting. It is the only known letter of Amenophis III. in the Babylonian language and writing. No such King of Babylon as Kallima Sin was known until the discovery of these tablets. The letter commences:— "To Kallima Sin, King of Karaduniyash, my brother, thus saith Amenophis, the Great King, the King of Egypt, thy brother; I am well, may it be well with thee, with thy government, with thy wives, with thy children, with thy

nobles, with thy horses, and with thy chariots, and may there be great peace in thy land; and with me may it be well, with my government, with my wives, with my children, with my nobles, with my horses, and with my chariots, and with my troops, and may there be great peace in my land." In a previous letter, it would seem Amenophis had requested of Kallima Sin the hand of his youngest daughter, Sukharti, in marriage. Kallima Sin had replied:—"Thou wishest for my daughter to wife; but from the time when my father gave thee my sister to wife no man hath seen her, and none knoweth whether she be alive or dead."

Kallima Sin, in his despatch, had stated that "it was his custom to give his daughters in marriage to the Kings of Assyria, and that the messengers who took them to their future homes were treated with generous hospitality, and handsome gifts were sent in return by the husband's relatives." A fairly broad hint, and apparently producing the desired result, as in this letter Amenophis III. replies "that whatever the great kings and nobles of Babylon may possess, and are willing to give to Kallima Sin as dowries for his daughters, he not only possesses, but is willing to give far more than they all." It further appears that during the reign of his father, Thothmes IV., a similar application for an Egyptian princess in marriage, from a potentate of Babylon, had been received at the Egyptian court most ungraciously. Thothmes had replied—"The daughter of the King of the land of Egypt hath never been given to a nobody." Kallima Sin, in his letter, had quoted this unfortunate remark. Amenophis III. "declines to discuss" the words spoken by his father, and asks that they may be forgotten, as he wishes for "brotherhood." "Now let us two be brethren," he says, and proceeds to sketch out the main features of a commercial treaty between the two countries, but concluding with the renewed request that Kallima Sin would send him his youngest daughter, Sukharti, to wife.

In the end, the correspondence between the two kings resolves itself mainly into a question of dowry. From one of the tablets at Gizeh we find Kallima Sin writing to Amenophis as follows:—"With reference to thy request that my daughter Sukharti be given to thee to wife, my daughter Sukharti hath now come to the age of puberty and may be married; if thou wilt write unto me she shall be brought unto thee." The letter of Amenophis III. is probably a copy of the original sent to the King of Babylon.

Those interested in seeing the tablets in question will find seven specimens in the fourth Egyptian Room at the British Museum, placed in a glass case, and with descriptive notes in English attached.

RIVAL ALKALI MANUFACTURES.

By C. F. TOWNSEND, F.C.S.

THE manufacture of alkali is the most extensive chemical industry we possess. Alkali, in one form or another, is used in the production of nearly every article of commerce, and, owing to its vast importance, competition amongst rival makers is unusually keen. The struggle for commercial supremacy between our own and Continental countries has raged very fiercely round this particular trade during the last few years, and the contest promises to become still more acute. The quantity of salt decomposed in the manufacture of hydrate, carbonate, and bicarbonate of sodium, which are all included under the term "alkali,"

amounted in 1891 to more than eight hundred and forty thousand tons. Anything that gave a preponderating advantage to our Continental rivals would be little short of a national disaster, and it may prove interesting to take a glance at the existing state of affairs.

At present, there are two processes chiefly employed for turning out the different soda compounds, and a third is just beginning to enter the field. The oldest, the Leblanc system, may be described as indigenous and peculiar to these islands. In this process salt is heated with sulphuric acid, and the sulphate thus produced, after admixture with chalk and coal dust, is carried to a high temperature in a revolving furnace. By the last operation, technically known as the "black-ash process," carbonate of soda is formed (Na_2CO_3), together with calcium sulphide (CaS). This last body, after all the soda has been dissolved out of the mass, constitutes "alkali waste." It contains all the sulphur originally present in the sulphuric acid, and, until recently, was deposited on the waste ground adjoining the works. Here it has gone on accumulating until hundreds of acres are covered to a depth of more than ten feet with evil-smelling sludge. In spite of all precautions, a disgusting yellow liquid oozes from the mass. Getting into the drains, it meets with acids and gives out sulphuretted hydrogen, the disgusting odour of rotten eggs. Great expense is incurred in keeping it out of the rivers, and it has even been known to percolate into quarries and coal workings.

Not only is the waste an intolerable nuisance, but it contains millions of tons of sulphur, which are now lost. After years of research and a large expenditure of capital, a means has been discovered for recovering the sulphur in the calcium sulphide, and removing the trouble completely. The invention, due to Messrs. Chance of Oldbury, who are justly rewarded for their skill in overcoming great mechanical difficulties, is so successful that the alkali inspectors have enforced its adoption in all Leblanc soda works. Carbonic acid, obtained from the lime-kilns, is the active agent in the process. The gas is driven through the finely-ground waste by powerful compressors, and replaces the sulphuretted hydrogen, which passes on to a kiln invented by Mr. C. F. Claus. Here it is mixed with just enough air to burn the hydrogen without oxidizing the sulphur. The heat given out is sufficient to keep the kiln red-hot, and the sulphur is deposited in either the liquid or the solid state, according to its distance from the kiln. The system is not an expensive one to work, and it is expected that in a short time 100,000 tons of sulphur, valued at about £100,000, will be added to our national wealth every year.

The Leblanc process has a hard fight to maintain its very existence in the face of competing methods. Every year witnesses fresh prophecies as to its speedy demise; but it dies very hard, and contests every inch of the way. Sulphur recovery will lend it a further prop, and may serve to avert for a considerable period the dislocation which would ensue if the large capital sunk in the old industry had to be abandoned.

The Solvay, or ammonia-soda process, works on entirely different lines to that just described. The whole reaction is carried out with materials in a state of solution, brine being used instead of crystallized salt. In this wet method, ammonia and carbonic acid gases are blown through hot brine together. Chemically, it is equivalent to using ammonium bicarbonate; sodium bicarbonate (NaHCO_3) being formed in the solution, together with ammonium chloride. The crystals of bicarbonate are converted into the ordinary carbonate (Na_2CO_3) by heating, and are much cleaner than Leblanc soda. As the market value of all

chemicals depends entirely on their state of purity, this gives the ammonia-soda process a distinct advantage.

The history of the up-hill struggle made by the wet process before attaining to its present position would form an interesting narrative in itself. Engineering difficulties of every imaginable kind had to be overcome; in fact, the leakage of ammonia at one time was so unaccountable that the chemists in charge were almost reduced to despair, and began to formulate new theories of chemical action to account for the missing molecules. Technical skill of the highest order, applied to every detail, and dogged perseverance in the face of heart-breaking obstacles, at last succeeded, and, for the last ten years, the ammonia-soda process has been gaining ground rapidly.

In both cases, alkali has not been the only product of the chemical reactions involved in the manufacture. Salt consists of chlorine as well as sodium, and its profitable utilization is the key of the disputed position. The Leblanc soda makers can turn a large proportion of their chlorine into bleaching powder and similar compounds, but the ammonia-soda makers have found no satisfactory means at present of utilizing theirs. Comparatively recently, all the hydrochloric acid, formed by the action of sulphuric acid on salt in the first part of the operations, used to pass into the air unchecked, to the great injury of every form of life. Now, the gases from the decomposing pots are passed through coke towers, down which a stream of water trickles, and less than five per cent. is allowed to escape. Chlorine, indeed, has become very valuable. It is the active principle of nearly all bleaching compounds, and an important constituent of chlorate of potash, largely used in fireworks. All the different ways of converting hydrochloric acid into chlorine are the same in principle—the hydrogen is burnt and the chlorine set free. In the venerable Weldon process, the necessary oxygen is supplied by a high oxide of manganese; in Deacon and Hurter's method the acid is mixed with air and passed over clay impregnated with a copper salt which acts as a go-between; and in yet another, nitric acid is the carrier of oxygen. The chlorine of the salt used in the ammonia-soda process goes to form ammonium chloride, as previously mentioned. When this is heated with lime to get back the ammonia the chlorine is converted into calcium chloride, from which it does not pay to recover it at present, although attention has been concentrated on the subject for a long while. In 1888 Messrs. Weldon and Pechiney invented a system for recovering chlorine from chloride of magnesium. This caused the greatest alarm for a time amongst our home manufacturers, for at the salt mines of Stassfurt 200,000 tons of magnesium chloride, containing 50,000 tons of chlorine, are thrown away every year. They feared that, if this could be worked up by the new method, the whole chlorine industry would be diverted to Germany. The high temperature (1000 C.) required in the Weldon-Pechiney process, however, played havoc with the plant, and the anticipations of its promoters have not been realized. Similar methods are being tried for utilizing the chlorine of the ammonia-soda process, but so far unsuccessfully.

The third process for the production of alkali is by means of electricity. When a current of electricity is passed through a solution of salt, sodium hydrate (NaOH) and free chlorine are produced. Electricity is, therefore, the ideal weapon for breaking up the salt, in theory. In practice, unfortunately, many difficulties arise. If the current passes through the solution without a diaphragm between the poles, the separated atoms re-combine to a large extent. If, on the other hand, a wall is introduced to keep the products apart, the resistance is increased

enormously. The possibility of making soda and chlorine by electricity turns on the invention of a diaphragm, which, whilst separating the newly formed atoms, will not add largely to the resistance of the circuit. Messrs. Cross and Bevan, in their recent paper at the Society of Chemical Industry, describe a very ingenious diaphragm, by the help of which they claim that the electrical method can be worked successfully. They state that in America it is already in operation on a large scale, the chlorine produced being used for bleaching paper.

The successful method must ultimately be the one requiring the smallest expenditure of chemical energy, and which can make use of the cheapest available form. In the electrical process, for instance, the loss in converting the energy of the coal first into heat, then into electricity, and finally into chemical energy, may prove greater than in the Leblanc process, where the energy is used directly in the form of heat. In addition, every constituent of the raw materials must be recovered, or in other words, there must be no waste products.

Letters.

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

HABITS OF THE PICHICAGO.

To the Editor of KNOWLEDGE.

Sir,—I regret to find that in my article in the December number I was misled by the artist as to the habits of the Pichicago. The creature does not, as depicted on page 222, creep under rocks, but always inhabits sandy districts; and it has been suggested that the use of the shield at the hinder extremity is to act as a rammer in securely closing the entrance to its burrow with sand. It should also have been stated that the tail protrudes through a notch in the lower border of this shield, and not through a hole in the centre.

R. LYDEKKEK.

THEORY OF THE SUN.

To the Editor of KNOWLEDGE.

SIR,—As in the last number of your magazine you have kindly obliged me with the enumeration of some objections to my explanation of the prominences as merely *cruescent illuminations caused by the propagation of chemical action in comparatively tranquil matter*, I hope you will allow me to state briefly what are the most important facts seeming to me in contradiction with the hypothesis of actual motion in prominences, and fully agreeing with my quite different explanation.

1°. We have the *undisturbed stratification of the solar atmosphere*, which, though continually crossed by the prominences, retains its heavier gaseous components firmly at its bottom. Now, we know that movements a thousand times slower than those of the supposed solar storms are already quite sufficient to impede the least trace of stratification in our terrestrial atmosphere.

2°. We have the *stratification of the prominences themselves*, never carrying the heavier metallic vapours they often contain at their bases to those greater heights where they consist almost only of hydrogen, helium, and some lighter metals as Na, Mg, and Ca.

3°. We have the *dissolving-view-character of many prominences*, almost instantaneously arising, continually altering their forms and, though big as some dozens of earths, sometimes vanishing in the space of a few minutes.

4°. We have the capricious and frequently abrupted forms of the prominences, which, especially when showing often-changing entirely discordant directions, do not convey any idea of possible actual motion.

5°. We have the velocities of the supposed movements, which, though corresponding sometimes (as in the case you have discussed in the Monthly Notices of December, 1880) with the velocities of projectiles shot upward under the influence of solar gravity, are often so irregularly altering their rate and direction that it is impossible to make them agree with any law or any hypothesis, either of eruption or explosion. The velocities, far from diminishing always with the height, very often rapidly increase or show very irregular alterations at different heights in the same prominence (Fenyi, "Publ. d Haynald Obs.," vi., 1892, p. 19; Memoire degli Spetr. Italiani, xviii., Deux "Eruptions Solaires, 5 et 6 Sept.," xxi. "Rapport sur les mouvements, &c., de la protubérance du 17 Juin"; Compt. Rendus, cxi., p. 562). M. Fenyi has also recorded instances of wonderful long-lasting local velocities in the line of sight, which could not be explained by the running of matter flowing from elsewhere (Memoire xx., "Prot. sol. extr. obs. à l'obs. Haynald"; xxi. *loc. cit.*). We know, moreover, that velocities of 1019 kilom. a second have been observed, velocities which, if really possessed by ejected matter, would cause it to leave the sun for ever. But such velocities being so stupendous that they are almost inconceivable, strengthen our doubts whether they may be really due to any actual motion of matter. I know very well that the movements of heavenly bodies show still greater velocities, but such movements cannot be compared with movements due to some local disturbance on the surface of such a body.

6°. We have the impossibility of imagining what a gaseous sun can be, and its photospheric clouds the resisting walls and the eruptive forces working together to produce such terrible explosions (Young: "The Sun," p. 210).

7°. We have the perfect calmness so often observed (a) in quiescent prominences and in small flames floating in the close neighbourhood of prominences in tremendous motion (Memoire xxi., "Sur une protub. d'une hauteur énorme obs. le 5 Mai, 1892"); (b) in the solar atmosphere at the very place where a few minutes before the terrible perturbation should have occurred (Mem. xviii., *loc. cit.*); (c) in the (sometimes even spotless) photosphere at the very places where above enormous prominences are showing their most extravagant velocities (Mem. xviii., *loc. cit.*; xxi., *loc. cit.*).

8° (last, not least). We have the certainty that a great many prominences form and grow larger without any visible connection with the lower chromosphere. And not only the quiescent cloud-like prominences do so, but also suddenly appearing short-lived prominences with enormous velocities—as, for instance, 485 kilom. a second upwards and 890 kilom. in our line of sight! Such a prominence I alluded to in my last letter as observed June 17th, 1891, in Kalocsa, the sun's limb having been continually watched before and having shown no alteration whatever and not the least connection with the stupendous prominence above. Such local outbreaks of luminosity suddenly appearing in the higher layers of the solar atmosphere, and running in different directions with fabulous and nevertheless speedily increasing velocities, cannot be caused by eruptions or explosions.

Whilst the numerous facts here enumerated are either in perfect contradiction with the hypothesis of actual motion or can only be made to agree with it with great difficulty, they correspond, on the contrary, as fully as possible with my hypothesis. Their explanation affords no difficulty at all if we consider the prominences as merely evanescent illuminations caused by the propagation of

chemical action in comparatively tranquil matter. This hypothesis has, moreover, above all, the great advantage of explaining the origin of the prominences. That origin is the "chemical luminescence" in those places of the solar atmosphere where the loss of heat by irradiation causes dissociated matter to combine. The extension and fortuitous forms of these luminous places will depend (1) on small inequalities in the chemical composition and heat-emitting power of neighbouring places in the solar atmosphere; and (2) on the state of the lower photosphere. Spots, for instance, and pores emit less heat than the surrounding clouds, and therefore the atmospheric layers in their vicinity will be less protected against loss of heat than the layers elsewhere. Now, as loss of heat induces chemical combination and luminescence, it is plain that spots must be attended by powerful prominences, crossing there the atmosphere from the bottom to the top, and thus having an eruptive appearance. The rate of the propagation of chemical action, being dependent on the different circumstances indicated above, can be very slow as well as immensely rapid. My theory, thus forecasting the most different velocities, is also in that respect perfectly concordant with the observed facts.

I shall not enter here upon further particulars, which are fully discussed in my book; but I cannot finish without a brief refutation of the ordinary interpretation of the displacement of the prominence-lines. That displacement (never thoroughly or mathematically explained, moreover) is commonly considered as a proof of actual motion. But that interpretation is not infallibly sure. It must be granted, of course, that actual motion causes line-displacement; but there is no reason why a similar displacement should not be caused by the displacement of the luminous condition in tranquil matter.

I finish with the expression of my most sincere gratitude for the welcome opportunity, so kindly given to me, to submit some points of my theory to the judgment of your numerous readers.

Yours faithfully,

DR. A. BRESTER JZ.

Delft (Holland), January 18th, 1893.

[Without entering upon a discussion of the many interesting topics suggested by Dr. Brester's letter, two apparently fatal objections to his "chemical luminescence theory" of prominences may be indicated. The first is, that while the prominence-spectrum is composed fundamentally of the entire series of hydrogen-lines, visible and invisible, without admixture of continuous light, the spectrum of hydrogen burning in oxygen, long and carefully observed by Professor Liveing, is purely continuous, and contains no bright rays (*Philosophical Magazine*, October, 1892, p. 371). The second objection is that the rate of propagation of chemical action is, so far as terrestrial experience goes, exceedingly slow as compared with the enormous velocities testified to by line displacements in prominences. Moreover, the rapid translation towards or from the eye of the luminous condition in gases should give rise to greatly widened lines, unless the kindling action was instantaneously followed by extinction. But this is almost inconceivable. It may be added that the tattered condition of many prominences, and the spiral forms of others, can scarcely be accounted for otherwise than by real physical movements.—A. M. CLERKE.]

[Dr. Brester would be a better and more interesting theorist if he were more critical in collecting his facts. I gather that he is not speaking from his own experience as a solar observer, and must warn readers of KNOWLEDGE that in printing Dr. Brester's letter I do not endorse all his statements of fact. But in watching solar pro-

minences I have myself seen many changes take place which it was difficult to explain on the theory of the upward projection of matter, combined with the assumption that I was looking at the same mass of cooling matter throughout the whole of the observation. In looking at the sun's limb the line of sight passes through a very great thickness of chromospheric matter, and one, no doubt, sees several prominence regions superposed on one another, as well as cool masses of gas which absorb the light of hotter gas behind. The very rapid motions Dr. Brester speaks of, if they exist in the chromosphere, are very rare, though motions of over 200 miles a second are not infrequent. An upward velocity of about 383 miles a second at the level of the sun's photosphere would, if there were no resisting medium round the sun, carry matter projected upward from the level of the photosphere away from the sun never to return; but with a resisting medium like the corona surrounding the sun it is possible that masses of gas may be shot upward with a much greater velocity, and yet never get away from the sun. The forms of the prominences seem to my mind clearly to indicate motion of matter in a resisting medium; and if there were nothing else to go upon, I think that I should have adopted a theory involving motion and projection into a resisting medium to account for them.

The even spherical surface of the solar photosphere does not seem to me to point to an "undisturbed stratification of the solar atmosphere in which the heavier gaseous components sink to the bottom," but rather to a rapid fall in temperature as we proceed upward from the sun, causing the well-churned and evenly mixed matter around the sun to emit different spectra at different levels, the matter in the lower regions being more highly heated than matter above, which can radiate more freely into space.—A. C. RANYARD.]

A BRILLIANT METEOR.

To the Editor of KNOWLEDGE.

DEAR SIR,—You may like to know that I with two other members of my family observed a brilliant meteor here on the evening of the 4th of January, at about 6.30 P.M. It passed near the pole star and left a trail about 10' long. It appeared to be going south. I see by the papers that a bright meteor was observed at about the same time in many parts of England and Wales, and that a meteoric stone seems to have fallen the same evening close to the drill ground at Freiburg, in Baden. I should like to know whether you think it possible that the meteor we saw can have travelled so far, and over what area a meteor can be seen. Yours, &c.,
Folkestone. W. H. WATSON.

Brilliant meteors are seldom, if ever, seen at a height much above 100 miles. A meteor at a height of 100 miles could be seen on the horizon, if its light were not lost by absorption, at a distance of a little more than 900 miles from the place over which it was vertically situated. But the meteor observed by Mr. Watson does not seem to have been moving in the direction of Freiburg. I notice that the account telegraphed from Berlin, and published in the *Standard* of the 12th January, does not say that the meteor was observed to fall at Freiburg; but that fragments of a meteor had been found near to the drill ground, which were blue-green in colour, and contained quartz crystals. If the stones found contain quartz crystals they are in all probability not meteoric, for no quartz has up to the present time been found in bodies known to have a meteoric origin.—A. C. RANYARD.]

Science Notes.

In our last issue we referred to the arrangements now being made for an ethnographical survey of the United Kingdom. It is gradually being recognized that so far from being Anglo-Saxons, with a mere infusion of other races, we are really a very mixed people of diverse origin, and it is expected that the survey in question will dissipate many popular errors. Readers interested in the subject will find a mine of wealth in Canon Isaac Taylor's valuable book, "Words and Places."

The project of establishing a meteorological and astronomical observatory on the summit of Mont Blanc made considerable progress during the summer months of last year. The building will rest on the snow, and this, it is said, can be done with security. An astronomical dome, which is to complete the observatory, will also be taken in hand this year.

Mr. E. T. Newton has communicated to the Royal Society an important paper on some New Reptiles from the Elgin Sandstone (of triassic age). During the last few years a number of reptilian remains have been obtained from the Elgin sandstone at Cuttie's Hillock, near Elgin, which are now in the possession of the Elgin Museum and of the Geological Survey. These specimens represent at least eight distinct skeletons, seven of which undoubtedly belong to the Dicynodontia, and one is a singular horned reptile new to science. All the remains yet found in this quarry are in the condition of hollow moulds, the bones themselves having entirely disappeared; but gutta-percha casts have been taken of them. The casts thus obtained indicate the former presence of several species of *Gordonia*—one of the Dicynodonts—and reveal the nature of the skull, and, to some slight extent, of other parts of the skeleton. *Elginia mirabilis* is the name proposed for the skull of a reptile which, on account of the extreme development of horns and spines, reminds one of the living lizards, *Moloch* and *Phrynosoma*. The skull of this ancient saurian seems to show affinities with both Labyrinthodonts and Lacertilians, and is unlike any living or fossil form. Prof. Seeley's strange *Pariasaurus*, from South Africa (Karoo beds), may be a distant ally.

We hear a great deal nowadays about bacteria, and the science of bacteriology is making great strides. Although some bacteria are so deadly, others are of the greatest possible service to mankind. It has recently been discovered that these minute organisms play an important part in determining the quality of tobacco! The leaves of the tobacco plant, before they are worked up into cigars and finally handed over to the public, undergo certain fermentative changes. It was formerly supposed that the alteration in their condition thus brought about was due to purely chemical changes, but some interesting experiments recently made go to show that these important results are brought about by special micro-organisms. In a paper read before the German Botanical Society, Suchland gives an account of his recent investigations on the bacteria found in different kinds of tobacco. He has examined fermented tobaccos from all parts of the world and found that they contain plenty of micro-organisms, although but few varieties, mostly only two or three different species in any particular brand, and but rarely micrococci forms. He finds that pure cultures of bacteria obtained from one kind of tobacco and inoculated on to another kind generated in the latter a taste and aroma recalling the taste and aroma of the original tobacco from which the bacteria had been in the first instance obtained. This discovery suggests great possibilities. Thus, it is

hinted that in the future it may be possible to raise the quality of German tobacco, not so much by careful culture and judicious selection of varieties, which has so far proved unsuccessful, as by inoculating with pure cultures of bacteria found in some of the fine foreign tobaccos, whereby similar fermentative changes may be induced in the German raw material, and the quality correspondingly improved. It will be highly interesting to watch the future results of this transplanting of bacteria.

The following are the lecture arrangements at the Royal Institution before Easter:—Sir Robert S. Ball, six lectures (for young people) on Astronomy; Professor Victor Horsley, ten lectures on the Brain; the Rev. Canon Ainger, three lectures on Tennyson; Professor Patrick Geddes, four lectures on the Factors of Organic Evolution; the Rev. Augustus Jessopp, three lectures on The Great Revival—a study in Mediæval History; Professor C. Hubert H. Parry, four lectures on Expression and Design in Music (with musical illustrations); the Right Hon. Lord Rayleigh, six lectures on Sound and Vibrations. The Friday evening meetings began on January 20th, when a discourse was given by Professor Dewar on Liquid Atmospheric Air, followed on January 27th by Francis Galton, F.R.S., on The Just-Perceptible Difference. The other lectures will be as follows:—February 3rd, Alexander Siemens, Theory and Practice in Electrical Science (with experimental illustrations); February 10th, Professor Charles Stewart, Some Associated Organisms; February 17th, Professor A. H. Church, F.R.S., Turacin, a remarkable Animal Pigment containing Copper; February 24th, Edward Hopkinson, Electrical Railways; March 3rd, George Simonds, Sculpture considered apart from Archaeology; March 10th, Sir Herbert Maxwell, Early Myth and Late Romance; March 17th, William James Russell, F.R.S., Ancient Egyptian Pigments; March 24th, Discourse by Lord Rayleigh.

Fifty years ago the introduction of iron as a building material created a revolution in the science and art of shipbuilding, and of late years steel has largely taken the place of iron. But it now seems highly probable that a still greater change is coming. In the near future we may expect to see aluminium replacing steel to some extent. There are at present in existence five small craft constructed of this metal. There are three petroleum yachts, which were built last year at Zurich. One is a Swedish lifeboat. The fifth is a yacht which is now completing for sea in Germany. Aluminium has lately become cheaper, and to the shipbuilder it offers so many striking advantages that, even at its present price, it is sure of more general adoption. In strength and toughness it rivals steel, in non-liability to corrosion it is almost as good as gold, and in lightness it stands altogether alone.

Sir John Lubbock, in a recent lecture on the Habits of Ants, suggested the question whether ants were moral and accountable beings. Their communities were no mere collection of independent individuals, but organized communities, labouring with the utmost harmony for the common good. Various observers had recorded instances of attachment and affection. He himself had never noticed a quarrel between two ants belonging to the same nest. All seemed to be in harmony within the limits of the community. But ants not belonging to the same nest were always enemies, even if they belonged to the same species.

A valuable forthcoming work is that of Mr. Flinders Petrie, on "Meidoun." The author has visited the temple of the pyramid of Senefra, still quite perfect. One of the inscriptions he found must be quite 5000 years old.

The tunnel at Niagara Falls is finished, and the plant for obtaining power will be in operation by next March. It is expected that a current of 15,000 electric horse-power will be transmitted from there to Buffalo, and 30,000 to other points.

Geologists will be glad to hear that the plans of the long-promised Sedgwick Geological Museum were under discussion at Cambridge last month, and there now seems to be a prospect of the early realization of the scheme for a Memorial Museum. The staff of the geological department of the university is also to be increased by the addition of a demonstrator in palæontology.

Good illustrations of the geological features of the earth's surface are still much wanted. We therefore welcome the publication of the first part of a large illustrated work on "The Volcanoes of Japan," by Professors John Milne and W. K. Burton, with photographs by K. Ogawa. The present part contains ten plates, and is devoted to the illustration of the most famous and beautiful of all the Japanese volcanoes—Fujisan (or Fuji Yama, as we still find it in our atlas). The photographs are reproduced as permanent collotypes 11 by 8 inches, and are in every way admirable. Last year we called attention to a similarly illustrated work on "The Great Earthquake in Japan, 1891." We hope soon to see the second part. The book may be obtained of Messrs. Kelly and Walsh. Professor Milne gives in his text some interesting particulars about this great volcano.

Mr. Preece's wire to wire communication, mentioned in our January issue, is not a new idea. The late Mr. Willoughby Smith made similar tests some years ago. Before the Indian Mutiny in 1857, Sir Wm. O'Shaughnessy, Director-General of Electric Telegraphs in India, made fairly successful experiments in that direction, which, but for the mutiny, would, no doubt, have been continued and improved.

The great American pneumatic gun is described by a visitor to Shoeburyness as capable of throwing a shell having a charge of 600 lbs. of dynamite. It resembles a huge telescope, pointing upward at an angle of 30 degrees, and is 70 feet long. The missile is discharged by compressed air, and yet its discharge produces a report and a cloud of smoke, just as if gunpowder had been exploded. The shots were carried a mile and a half.

THE LUNAR APENNINES.

By A. C. RANYARD.

THE range of lunar mountains which runs diagonally across our plate is described by the Rev. T. W. Webb, in his *Celestial Objects for Common Telescopes*, as being "more like the mountains of the earth than is usually the case." This range of mountains is known as the lunar Apennines. It rises gradually on its south-west flank, but is comparatively precipitous on the other side, as though it was a mountain range composed of strata tilted or tipped up towards the north-east. But the greater steepness on one side of a mountain range must not, without further evidence, be taken as proving that the mountains are built up of stratified rocks which have been laid down beneath a lunar ocean; for there are many terrestrial volcanic ridges which are steep on one side and slope away gently on the other, ridges which exhibit a stratified structure being built up of beds of volcanic ash, sometimes alternated with

lava. Thus the Monte Summa, which partly surrounds Vesuvius, is steep on the inside towards the present cone, and it slopes away gently on the outside. On the moon we have many such volcanic rings. The lunar crater Archimedes (shown on the lower right hand side of our plate) is surrounded by an elliptical ring which is steeper on the inside than on the outside.

The question whether the lunar Apennines are similar in character to terrestrial mountain chains, or whether they form a part of a vast ring of volcanic origin which once surrounded the Mare Imbrium, is one which has very important bearings on the theory we are led to adopt with regard to the early history of the moon, and also with regard to the early history of the earth.

If the Mare Imbrium is not an ancient sea bed, but is the floor of an immense volcanic crater, the lunar Apennines must be very old, probably far older than any terrestrial landmarks, for they must have been raised at a time when the moon was hot enough to pour forth a sea of lava which covered a seventieth of the entire lunar surface—a sea which must have glowed with a red heat, when the lava was liquid enough to flow evenly over the entire area of this titanic crater, forming a spherical bed. For the floor of the Mare Imbrium, as well as the floors of the other great lunar plains, are all curved, and they appear to correspond with the spherical curvature of the lunar surface.

The even curvature of the floor of the Mare Imbrium will be recognized in our plate. The sun has risen high upon the western side of the Mare, but the eastern side of the floor is only just emerging gradually from darkness. Many of the large lunar craters have similar flat sea-like areas within them. Thus Archimedes, the crater referred to above, has a level floor some fifty miles in diameter, and some seven hundred feet above the level of the surrounding Mare Imbrium. Other lunar craters have a flat floor and a central peak or mountain, but the Mare Imbrium has no central elevation, nor have any other of the lunar maria, though they are all more or less circular or elliptical in outline. The circular walls of the lunar craters are very frequently terraced on their inner and steeper side as if there had been a tendency for the crater edge to slip down in parallel ridges, or as if there had been many ebbings and flowings of the lava sea within, leaving terraces at different levels. But the precipitous south-eastern declivity of the lunar Apennines does not exhibit such terraces, and it is much more irregular in outline than the rings which surround the majority of lunar craters. In order to realize the uneven character of the steep south-east front of the lunar Apennines the reader should compare the curving white projections shown in the plate published with this number with the beautiful pictures of the same region taken by the Brothers Henry, which were published in the December number of KNOWLEDGE for 1890, and with the lunar photographs taken at the Lick Observatory, published in KNOWLEDGE for October, 1889. It will be seen that the north-eastern side of this mountain range is much notched and broken into projecting promontories capped by peaks of very unequal altitude. The loftiest of these summits is known as *Huygens*. It rises, according to Neison, to a height of 18,000 feet, and according to Madler to a height of 20,900 feet above the plain below. Its long straight edged shadow may be seen in our plate stretching to a distance of rather more than fifty miles across the Mare Imbrium. At the summit of this lofty peak is a minute crater, not discernible in the photograph, but easily seen under favourable circumstances with the telescope. To the north-west is another lofty peak known as Bradley, which reaches a height of 13,600 feet.

Along the south-eastern flank of the lunar Apennines is a somewhat broken range of lower hills such as would be called foot-hills in the Rocky Mountain region of North America. A little further to the south-east, and just catching the rays of the rising sun, is a narrow wall, parallel to the general backbone of the Apennine range. This is one of the narrow walls or ridges on the moon which has been referred to as being possibly an immense terminal moraine built up of rocks brought down during a glacial epoch. If such a theory could be supported, it would prove that the moon must have possessed, since the raising of the Apennine range, an extensive atmosphere as well as a considerable supply of water. But this ridge does not seem to me to have the characteristics of a glacial moraine which, in terrestrial mountain regions, generally stretch across a valley in a curve that is concave towards the hills from which the glacier that built the moraine descended. With a higher sun, this curious ridge takes the appearance of a very narrow bright line joining two small craters. Whether some of the smaller ridges across lunar valleys, which were pointed out by Prof. Frankland as due to glacial action, are terminal moraines, I am not prepared to say. The lunar Apennines appear so much more rugged than the formations which are apparently more recent, that one would be inclined to believe that time brings about a change in the form of lunar mountains. But the change need not necessarily have been brought about by the carving action of ice and water. The volcanic vents that one sees in various parts of the lunar Apennines, must have done something to increase the irregularities by the addition of matter ejected from below; and the earthquakes which accompany such eruptions would no doubt tend to shake down the softer and weaker portions of the range. As we learn more of the history of our own mountain ranges, we may learn how to interpret with greater certainty the forms of the valleys and the peaks into which this ancient range of lunar mountains is broken up.

It seems to me that we have some evidence of drainage action upon the moon, in the curious dark patches on the plains at the base of mountain slopes—see for example the delta-like patch in the bay within the foot hills between Archimedes and the lunar Apennines—a dark form which is visible when the sun is at all altitudes, showing that it cannot be due to shadows cast by irregularities in the surface. In order to make sure of what I refer to, I would ask the reader to compare our plate with the Henry photographs (KNOWLEDGE, December, 1890), and with the Lick photographs (KNOWLEDGE, October, 1889). There are also some dark spots, which I believe to have a similar origin, on the other side of the lunar Apennines, in a line between Archimedes and Manilius, a crater about 25 miles in diameter, to the south west of the Apennine range. These dark markings, as well as the similar dark patches to the south-west of the Palus Nebularum, are seen as dark when the sun is at all altitudes; and they are generally found near to the base of mountain slopes in the equatorial regions of the moon. It is hardly conceivable that these darker patches can be due to a difference in the nature of the surface rocks—which crop out always towards the base of mountain slopes—and the form of the patches seem to indicate a flow of matter down a slope. They can hardly be lava streams, for they are not associated with adjacent craters, and the radiating narrower forms which have been usually assumed to be lava flows from craters are generally whiter than the surrounding surface.

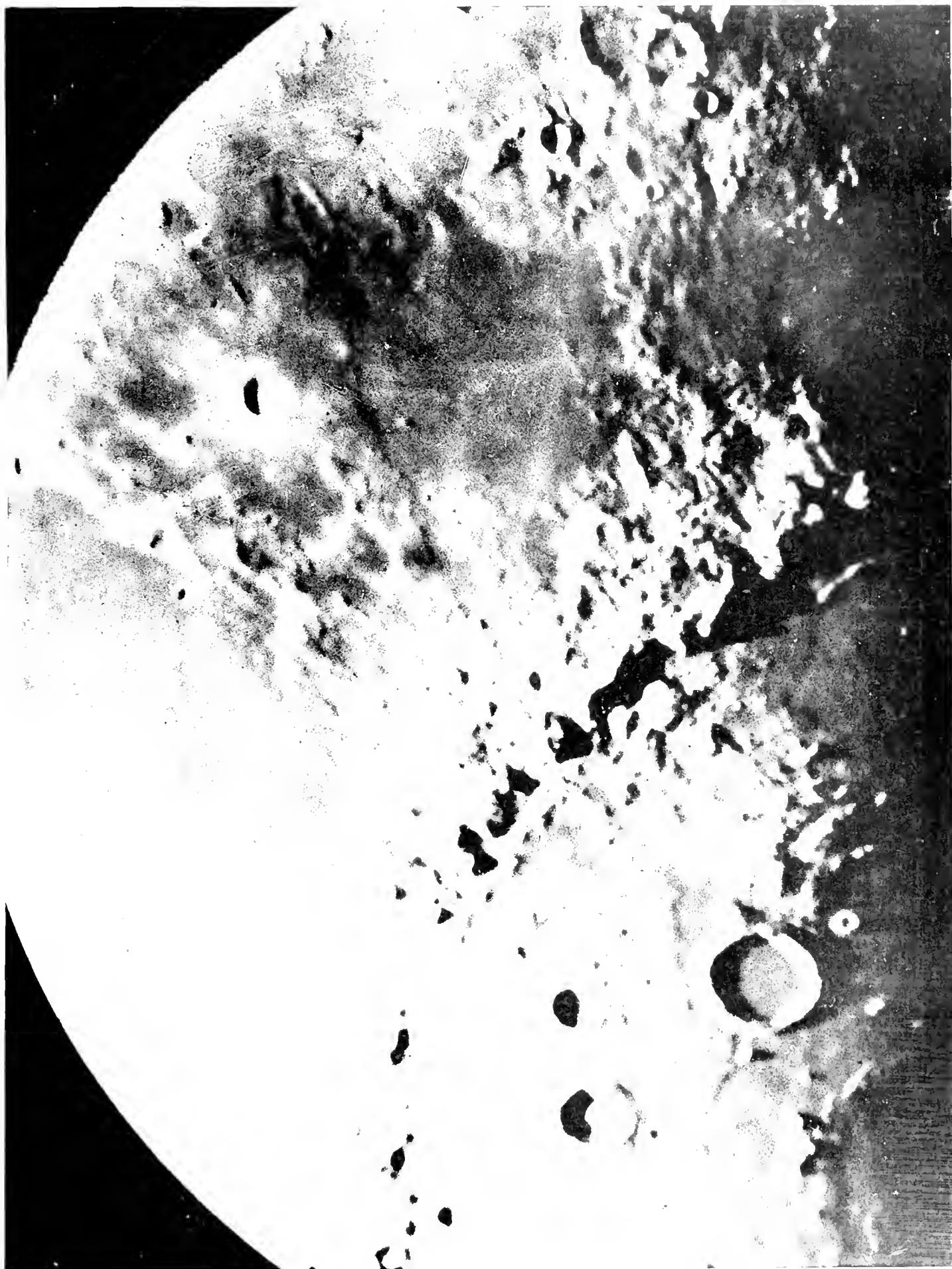
* The Palus Nebularum is the smaller plain to the east of Manilius, and to the south-west of the lunar Apennines.

SOUTH

WEST

EAST.

Archimedes



THE LUNAR APENNINES AND SURROUNDING REGION.

From a photograph taken by Mr. H. C. ROSSITT, Government Astronomer at the Observatory, Sydney, New South Wales.

CATERPILLARS.—IV.

By E. A. BUTLER.

(Continued from page 7.)

THE frequent handling of a hairy caterpillar naturally causes some of the hairs to become detached, thereby often occasioning much annoyance to the operator, and the finer the hairs the more disagreeable the results. These slender little appendages, partly by reason of their barbed structure, and partly in consequence of the minuteness of their points, cling to or penetrate the skin, and are difficult to get rid of; rubbing generally makes matters worse, only causing the hairs to cling all the more tightly. They thus act as mechanical irritants, producing a tickling and worrying sensation, especially when they become attached to the skin between the fingers. The caterpillars of the drinker and oak egger moths (Fig. 11) are perhaps the greatest sinners in this respect. They are closely covered with a short thick pile, which not even the most careful and tender handling can keep from coming off; the little hairs enter the skin, sticking in it upright, but the fragments are so short that it is not easy to see them, and they are usually too fine to be seized between the finger nails or to be extracted by means of tweezers. But there are a few insects whose power of annoyance is far greater than this, so great indeed as to suggest the presence of some poisonous principle in the hairs.



FIG. 11.—Hairs of larvae of (A) Drinker Moth; (B) Oak Egger; very greatly magnified.

Amongst British insects there are two which have attained this undesirable notoriety, and which, when handled, produce exceedingly irritating and painful swellings. They are closely allied species called the gold tail and brown tail moths (*Porthesia auriflua* and *chrysothaa*). The moths may be very easily recognized, as they are like no other British insects; they are of a satiny or creamy white colour, the former having the hinder parts of its body clothed with bright golden silky hairs, and the latter having the same parts covered with soft down of a deep brown colour. They are often very abundant, and then the caterpillars do a great deal of damage to hawthorn hedges, sometimes absolutely stripping them of their bright spring foliage.

The caterpillar of the gold tail is the handsomer of the two, as well as the more virulent. Its black body is adorned with vermilion stripes and little warts, from which spring clusters of white (Fig. 12) and black hairs in pretty contrast. It has also on its back two orange, cup-shaped, wax-like bodies, which are glands for the secretion of an odoriferous and easily vaporizable liquid. These caterpillars are common in the early summer, and may easily be reared, but they should on no account be touched. If they are handled, and the hands are then brought into contact with the face or neck, large oval wales are produced on these parts in a few minutes, and these quickly become highly inflamed and itch intolerably; rubbing, of course, only aggravates the discomfort. After a while the swellings subside and the irritation is allayed, so that the inconvenience is merely temporary; still it is an extremely undesirable experience while it lasts. Sometimes merely holding the head over the cage while the food is being



FIG. 12 Cluster of white hairs from larva of Gold Tail Moth

changed is sufficient to cause the symptoms to appear. No doubt small fragments of the hairs are wafted about in the air, and any little disturbance like that caused by putting fresh food in brings them into contact with the skin. The hairs retain their disagreeable power for a long time. Many of them are woven up with the silk of the slight cocoon the caterpillar makes when it becomes a chrysalis, and if such a cocoon be pulled to pieces even long afterwards, the operator not infrequently suffers in consequence. This seems to throw doubt upon the suspicion that the hairs are poisonous, since it might be expected that a poisonous secretion would be operative only when freshly formed and still moist. The fluid above mentioned as secreted by the glands on the back does not appear to be used to supply the hairs, and indeed it is itself not of an acid character, and hence is less likely to be able to produce irritation. The brown tail caterpillar, which is rather like the gold tail, but not so brilliant, produces similar results, but not in so marked a degree, at least in the experience of some people; but it must be admitted that the testimony of entomologists varies on this point, and some denounce the brown tail as the greater delinquent of the two. Possibly the difference may be a matter of individual temperament. In any case, collectors of caterpillars should beware of these two species, and on no account handle them; indeed, it is safe to lay down the rule that, for their own sakes quite as much as for the collector's, caterpillars of whatever kind should be handled as little as possible.

Other species in tropical countries produce results which are even more disagreeable. Mr. Poulton once exhibited to the Entomological Society of London a large hairy caterpillar from the island of Celebes. It was described by the natives as causing a complaint something like erysipelas in those who touched it. The bristle-like hairs, which were hollow and barbed, easily penetrated the skin and then broke off. Of course, as the hairs were hollow, it is probable that they contained a poison during the lifetime of the insect, but as the specimen had been preserved in spirit, that point could not be determined. The caterpillars of the processionary moths of the Continent, so called from the wedge-shaped phalanx they form when they go out to feed, produce great irritation, accompanied by inflammation and eruptions of the skin, and their hairs are not only barbed, but have been found to contain formic acid, facts quite sufficient to account for the effects produced.

Glands for the secretion of protective liquids are frequently found on caterpillars, and are probably of much commoner occurrence than has hitherto been suspected. Almost all the members of the family *Liparidae*, to which the gold tail and brown tail, as well as the "tussocks" and "vapourers" belong, have been found by Mr. Poulton to possess them. The caterpillar of the puss moth, again (Fig. 13), has a large gland just beneath its mouth, from which it can shoot forth strong formic acid with considerable force, the expulsion being caused in this case as in others by the partial eversion of the gland, which consists of a sort of pocket in the skin. The caterpillars of certain saw-flies, which are much like those of moths, also have the power of squirting fluids with

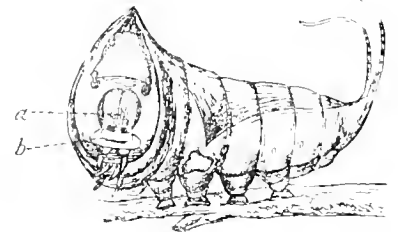


FIG. 13 Caterpillar of Puss Moth, in torturing attitude (after Poulton). a, head; b, position of formic acid gland.

great force from small glands distributed over the body. These liquids are very volatile, and therefore, though the jet itself may not reach the assailant, the atmosphere around becomes charged with the vapour and is thus rendered repulsive, warning off the enemy.

As caterpillars constitute the staple food of many vertebrate animals, especially certain species of birds and reptiles, it becomes an interesting enquiry whether, amongst the great multitude of species, all are equally palatable to each insectivorous vertebrate, and would therefore be taken indifferently; or whether, on the other hand, any choice is exercised, and there are any kinds of caterpillars for which a decided preference is manifested, or whether any are absolutely repugnant to the taste, and if so, how the distasteful ones are recognized so as to be avoided. Observations and experiments made in connection with various kinds of birds and reptiles in confinement have clearly demonstrated that all caterpillars are not regarded by them as alike suitable for food, and there are many indications that, when any are rejected or only reluctantly taken, it is because of something unpleasant in the taste that they are thus treated. The more refined taste of modern civilized society is prejudiced against the use of caterpillars as an article of diet; nevertheless, it is a well-known fact that some species are sufficiently palatable to have been used with relish as food by human beings: and though it would be unsafe to argue at once from human partialities to those of the lower animals, there is probably enough in common between the palate of man and that of bird or reptile to permit of our forming some notion as to what might be unpalatable to these lower animals. For example, we know enough of the effects of acrid or foetid liquids to render it a safe assumption that caterpillars which secrete such fluids will for that reason prove to be unpalatable to birds and reptiles; and the same might be expected to be the case with such as feed upon plants possessing strong and disagreeable tastes or poisonous properties. At the same time, just as to us a little acidity is by no means a drawback in an article of diet, but on the contrary imparts a stimulating and refreshing flavour, so caterpillars that secrete acid juices might be expected not to become thereby unpalatable unless the secretion were excessive. This supposition is borne out by the instance of the puss moth caterpillar above referred to. Notwithstanding its secretion of formic acid, it is eagerly devoured by lizards, and that too in defiance of its somewhat alarming aspect and the whisking movement of its whip-like tails, so that it must evidently be regarded in the reptilian world as a savoury morsel whose acquisition is worth some risk.

At a meeting of the Entomological Society of London in 1867, Mr. A. R. Wallace, the apostle of natural selection, ventured to predict that caterpillars which were very brightly coloured and conspicuous would be found to be distasteful to some at least of their bird enemies, the suggestion being that the caterpillars had acquired the intensity of their colour by a process of natural selection, their conspicuous appearance serving as a danger signal or warning to their vertebrate foes that they were inedible; thus the warning became the more perfect and the protection afforded therefore the more complete in proportion to the intensity of the coloration. Acting upon this hint, several competent observers made repeated trials of the behaviour of various birds and reptiles towards about a hundred species of caterpillars. Mr. J. Jenner Weir, experimenting with such birds as robins, yellow hammers, chaffinches, thrushes, &c., showed that green caterpillars were always eaten with relish, as were also those that were dull coloured, with fleshy bodies and smooth skins; brown

or green geometric larvæ also were invariably eaten. Very conspicuous larvæ, on the other hand, such as those of the magpie moth (*Abraeus grossulariata*) (Fig. 14), which is distinctly marked with black and orange on a cream-coloured ground, the figure-of-eight moth (*Diloba caruleocephala*), which is greenish or bluish white, with distinct black and yellow spots and stripes, and the mullein moth (*Cucullia verbasci*), which is also greenish white with black and yellow markings, were not molested by the birds.



FIG. 14.—Caterpillar of Magpie Moth.

Miss Lilian Gould has recently made further experiments with the two last-named insects, which seem to indicate that these caterpillars are really disagreeable to the avian taste. The bird employed as judge was a tame jackdaw of about a twelvemonth old. As it had been captured while still unfledged, it certainly could have had no personal experience of caterpillars in a state of nature; and during the twelvemonth of its captivity, its only chance of gaining any knowledge of them and their edibility would be the possible fall into its cage of casual specimens dropping from the beech tree under which it was kept, and this was evidently a rather remote contingency. It would thus appear that it was to all intents and purposes a novice in the art of discriminating caterpillars. The jackdaw having been fed in the morning, at mid-day Miss Gould offered him a larva of the figure-of-eight moth, and she thus reports of his behaviour: "The bird looked at the larva suspiciously for a long time, and would not take it. Then he seized it, and, on tasting it, shook his head violently, evidently disliking it. He then dropped it, but picked it up and tried it again, shook his head as before, and finally put it down on the floor of the cage and refused to eat it." That the hesitation did not arise from any objection to caterpillars *per se*, was shown by the fact that when a smooth green larva was offered, the bird snapped it up at once and ate it with avidity. On another occasion, with the view of testing whether the pangs of hunger would be a sufficient inducement to overcome this reluctance, and thus to determine whether there was a limit to the degree of protection afforded to the caterpillar by its coloration, the jackdaw had been purposely left unfed, so that he was very hungry, and begged for food by carrying his empty food vessel and placing it against the bars of his cage. A large larva of the mullein moth was then given him. "At first he refused it, then took it, but dropped it instantly, shaking his head, and never touched it again. He appeared quite subdued for a time, and sat shaking his head and swallowing. Nor would he take anything else offered him at all for a little while, but finally ate a gooseberry with relish." Two points seem to be substantiated by these experiments: first, that brilliant and conspicuous colouring in a caterpillar is itself deterrent, at least to a jackdaw, and secondly, that this conspicuous coloration is accompanied by a disagreeable taste. Of course, neither of these two means of protection ultimately availed the caterpillar in these particular instances, since it perished from the injuries received by the tasting as surely as if it had been eaten. But though that might be the case in a bird's first experiences of caterpillar diet, a few trials would teach the novice to avoid such caterpillars for the future, and therefore the sacrifice of the life of a few individuals would contribute towards the salvation of the majority, and would thus ultimately tend to the advantage of the

caterpillars as a race. But just as "what is one man's meat is another man's poison," so it seems that there are some birds that are prepared to eat even the caterpillar of the mullein moth, notwithstanding its taste, for Mr. H. D'Orville records that, according to his own observations, some birds in a state of nature do eat this larva, picking it off from its food-plant, the black mullein, on which it feeds exposed and conspicuous.

A very curious instance has been recorded by Weismann. The caterpillar of the cinnabar moth (*Euclyptus jacobae*) is of a deep orange colour, banded with black, and is apparently distasteful, as might be expected of an insect feeding upon ragwort. At any rate, Weismann found that it was invariably rejected by lizards. Now it so happens that there is another caterpillar which, when young, is also orange banded with black, but which, as befits a creature feeding upon heather, does not appear to be unpalatable. This is the larva of the fox moth (*Lasiocampa rubi*), which, in its more advanced stages, when it is plain reddish-brown, we have already mentioned as having on one occasion, notwithstanding its hairiness, formed the staple food of a particular bee-cater. This caterpillar, in its juvenile clothing of orange and black, Weismann also offered to a lizard. The reptile at first seemed doubtful about it, applying its tongue to it, but not venturing to do more. After retiring for a short time, however, it returned to the attack and swallowed the caterpillar. This was a piece of education to its reptilian mind, apparently teaching it that there might be caterpillars banded with black and yellow which were palatable, as well as distasteful ones. After this experience, therefore, it sometimes went so far as to taste the cinnabar caterpillars, as if to assure itself that they were really disagreeable, and that it was not losing the enjoyment of a tit-bit through prejudice. In such cases, however, it invariably rejected the morsel after tasting, thus plainly showing that while the coloration served as a warning, there was underlying that a real inedibility which justified the avoidance of the caterpillar.

We have already seen that hairy caterpillars are very commonly though not universally rejected by insectivorous vertebrates. Mr. Jenner Weir, experimenting with the same birds as before upon the caterpillars of the tiger moth (*Arctia cija*), the small egger (*Eriogaster lanestris*), the gold tail (*Porthesia auriflora*), and the vapourer (*Orgyia antiqua*), found that they were all rejected, and were not even casually examined, the merest glance seeming to be sufficient to settle the matter. That the objection depended not simply upon the hairs, unless they themselves, as in the case of the gold tail, produced irritation, seems evident from the facts that some hairy larvæ are eaten by birds, and that young and comparatively hairless larvæ of species which become densely hairy when older were tasted by certain birds, but were found disagreeable, and so finally left alone. Hence, there seems to be some justification for the idea that these larvæ are actually disagreeable to the taste, and that the hairs serve as a warning just as do the bright colours mentioned above. It must be confessed, however, that much more evidence is desirable before the exact relations between edibility, brilliant coloration, and hairiness in larvæ, and the influence of these upon insectivorous vertebrates, can be stated with the comprehensiveness of a general law. If any of our readers have opportunities of making such observations, they would materially contribute towards the solution of the problem by preserving minute and accurate records of the facts observed, and of all circumstances that appear to have any bearing, however remote, upon them.

(To be continued.)

THE ASTRONOMY OF SHAKSPEARE.

By Lieut. Col. E. E. MARKWICK, F.R.A.S.

IN the enormous amount of literature which has come forth in connection with Shakspeare, most probably every special science or profession touched on in his writings has been taken up by someone or other, and all the passages bearing on the subject brought together and collated, thus giving an idea how far the great master was acquainted with it.

Without pretending to any special knowledge of what has been written to elucidate the plays of Shakspeare, I thought it would be interesting to note all passages in the dramas touching on astronomy or the heavenly bodies. Before entering upon a discussion of these, it will be well to note the state of popular astronomy in Shakspeare's time.

Taking 1608 as about the date when he was in the full enjoyment of his splendid powers as a dramatist, it will be remembered that Copernicus had then been dead some sixty-five years, but his ideas had gained but few adherents. Tycho Brahe died at the beginning of the seventeenth century, and possibly Shakspeare may have heard of him in connection with that wonderful star which appeared in 1572, and which is sometimes called Tycho's star. Galileo, born in 1564, was in 1610 making discoveries of planetary wonders with the newly-invented telescope. Kepler, born in 1571, was at the period of our poet's zenith commencing his researches into the motions of the planets, which ultimately resulted in the announcement of his celebrated three laws. We know that Kepler particularly directed his attention to the planet Mars, which as it were became the criterion for the other planets. Now in *Henry VI.*, Part I., Act I., Scene II., we find Charles observing—

"Mars his true moving, even as in the heavens,
So in the earth, to this day is not known."

Is it possible that Shakspeare, through his mouthpiece, may here be alluding to Kepler's studies in connection with the planet? or has the passage only reference to the then generally incomplete knowledge of the cause of the movements of the planets?

Public or national observatories had not yet been established, unless, perhaps, we except the magnificent building called Uraniburg, in which Tycho was installed on the island of Huenna, in the Baltic. It was here that James the First of England paid a visit of eight days to Tycho, "when he went to Denmark to complete his marriage with a Danish princess." Monarchs of the present day would be few and far between who would be sufficiently smitten with the charms of Urania to sojourn for a week with a professional astronomer; neither would the means of the latter be sumptuous enough to enable him to entertain royalty.

The general knowledge of astronomy in those days was probably confined to an acquaintance with a few of the constellations, and being able to detect the planet or planets of the season. What was known was simply the result of naked eye observation. It was not yet the day of the modern "amateur astronomer." In fact, at the time of which we are speaking, astronomy proper was merely a handmaid to astrology. The former simply gave the necessary data for ascertaining the positions of the heavenly bodies at any time, to enable a nativity or horoscope to be cast. Astrology, at least in the popular eye, was the profession, and no doubt a lucrative one to anyone who had made a name at this sort of work. Every person of any importance, rank, or position had his or her horoscope cast, and the belief in the influence of the planets

on men and mundane affairs was deeply rooted in the popular mind. Consequently we find frequent allusions to this celestial influence, and the power of the planets to "strike." Yet in two places the master is bold enough to avow, through his characters, his dis-belief in astrology. Cassius in *Julius Cæsar* observes—

"The fault, dear Brutus, is not in our stars,
But in ourselves, that we are underlings."

Again, in *King Lear*, we have the following thoroughly Shakspearean bit of dialogue—

Geo. "These late eclipses in the sun and moon portend no good to us, though the wisdom of nature can reason it thus and thus, yet nature finds itself scourged by the sequent effects," etc.

Edmund: "This is the excellent foppery of the world! that, when we are sick in fortune (often the surfeit of our own behaviour), we make guilty of our disasters the sun, the moon, and stars, as if we were villains on necessity; fools by heavenly compulsion; knaves, thieves, and breakers by spherical predominance; drunkards, liars, and adulterers, by an enforced obedience of planetary influence; and all that we are evil in, by a divine thrusting on."

The rest of the passage is not quite suitable for quotation, but is nevertheless soundly true.

What strikes one in looking over the passages noted is the frequent reference to the "spheres" in which the sun, moon, planets and stars were supposed to move. The doctrine of *crystalline spheres* seems to have been "first taught by Eudoxus, who lived about three hundred and seventy years before Christ. According to this system, the heavenly bodies are set like gems in hollow orbs, composed of crystal so transparent that no inner orb obstructs in the least the view of any of the orbs that lie behind it. The sun and the planets have each its separate orb, but the fixed stars are all set in the same grand orb; and beyond this is another still, the *primum mobile*, which revolves daily, from east to west, and carries along with it all the other orbs. Above the whole spreads the *grand ætherean*, or third heavens, the abode of perpetual serenity." (Mitchell, "Orbs of Heaven," p. 287, fourth edition.) This idea seems to have been thoroughly ingrained into Shakspeare's mind. Of course it in no way interfered with the systems either of Ptolemy, Tycho Brahe, or Copernicus. A transparent sphere was provided for each planet, and the difficulty was to prove that it did not exist.

In *The Tempest*, Gonzalo says—

"You are gentlemen of brave metal; you would lift the moon out her sphere, if she would continue in it five weeks without changing."

In *Midsommer Night's Dream*, Fairy says—

"I do wander everywhere
Swifter than the moon's sphere"

In *A You Like It* we find—

"And thou, three-crowned queen of night, survey
With thy chaste eye from thy pale sphere above, . . ."

And in *A Winter's Tale*—

"Though you would seek to unsphere the stars with oaths."

In *King John*, Bastard observes—

"Now, now, ye stars, that move in your right spheres,
Where be your powers?"

Again, the principle of each star being alone in its sphere is enounced in the well-known line—

"Two stars keep not their motion in one sphere."

Then we have "the music of the spheres," and "discord in the spheres"; these and other passages showing that the doctrine was a familiar one at the beginning of the seventeenth century.

The connection of the moon with the tides is clearly indicated, as in *The Tempest* Prospero says—

"His mistress was a witch, and on so strong
That could control the moon, make flows and ebbs,
And deal in her command, without her power."

In *Measure for Measure* the moon is styled the "governess of floods."

In *A Winter's Tale* we read—

"By all their influences, you may as well
Forbid the sea for to obey the moon."

Also Prince Henry, in *Henry IV.*, observes jocosely—

"For the fortunes of us that are the moon's men doth ebb and flow like the sea: being governed as the sea is, by the moon."

Nothing could be more correct in its way than these references to the power of the moon, although the force of gravity had not then been discovered by the great Newton.

Calendars or almanacs must have been in use at the time. Thus, in *Julius Cæsar*, Brutus asks Lucius his servant—

"Is not to-morrow, boy, the ides of March?"

and on receiving the reply that he knew not, tells him to "look in the calendar," and then observes that "the exhalations, whizzing in the air," gave so much light that he could see to read by them. By "exhalations," meteors would here seem to be meant.

In *Midsommer Night's Dream* occurs a curious passage, where Hermia says—

"I'll believe as soon
This whole earth may be bored; and that the moon
May through the centre creep, and so displease
Her brother's noontide with the Antipodes."

The poetic image here seems to be that the earth might be bored by a cylindrical passage which would just let the moon through. Full moon, too, is evidently referred to, with the moon on the meridian, so that it will be near midnight, and the sun consequently on the meridian at the Antipodes.

Astronomical expressions occur occasionally in the plays. For example, the Zodiac is employed to denominate the year. Speaking of laws or punishments which have long been in abeyance, Shakspeare says—

"Which have, like unscour'd armour, hung by the wall
So long, that nineteen Zodiaes have gone round."

Again, we read in *Titus Andronicus*, "Gallops the Zodiac in his glistering coach."

The word "meridian" is brought into the following beautiful passage with very happy effect. Wolsey, in predicting his own downfall, says—

"I have touch'd the highest point of all my greatness
And from that full meridian of my glory,
I haste now to my setting. I shall fall
Like a bright exhalation in the evening,
And no man see me more."

Most have probably witnessed, on some country walk at night, the flash of a meteor across the sky and its almost instantaneous disappearance. Exactly with such suddenness and completion did Wolsey foresee his own fall. Meteors are frequently referred to—not always under this name, however.

In *King John*, Lewis says he was more amazed

"Than had I seen the vaulty top of heaven
Figured quite o'er with burning meteors."

Again, in *Richard II.*—

"And meteors fright the fixed stars of heaven;
The pale-faced moon looks bloody on the earth," &c.

In the same play, Salisbury, anticipating the downfall of Richard, says—

"Ah, Richard! with the eyes of heavy mind
I see thy glory, like a shooting star,
Fall to the base earth from the firmament!
Thy sun sets weeping in the lowly west," &c.

The sentiment here is very similar to that in Wolsey's speech just quoted.

Venus seems to be the only planet mentioned other than in an astrological sense. In *Midsummer Night's Dream* occurs the following

"Yet you, the murderer, look as bright as dear
As yonder Venus in her gimmered spheres."

Stars and constellations are pretty frequently brought in, or referred to. The north star is held up as an example of fixedness and constancy. Caesar says of himself—

"But I am constant as the northern star,
Of whose trim-fixed and resting quality
There is no fellow in the firmament;
The skies are painted with unnumbered stars,
They are all fire, and every one doth shine;
But there's but one in all doth hold his place."

In another play we note the comparison "Strong as the axle-tree on which the heavens ride." A tempest at sea is described in the following graphic words—

"The wind-shake'd surge, with high and mounting main,
Seems to cast water on the burning bear,
And quench the guards of the ever-fixed pole."

Ursa major is mentioned in the following, and it is evident that country people used to note the stars sometimes, to give them an idea of the hour. A carrier, on the early morning before departing from Rochester on the journey when they were attacked by Falstaff and his bogus highwaymen, says—

"Heigh ho! An't he not four by the day, I'll be hang'd!
Charles' wain is over the new chimney, and yet our horse not pecked!
What, oster!"

Here is another constellation mentioned. The expression seems to be another form of our modern proverb, "Carry coals to Newcastle." In *Troilus and Cressida* Ulysses observes—

"And add more coals to Cancer, when he burns
With entertaining great Hyperion."

The reference is evidently to the sun, when in Cancer. The "seven stars" are occasionally referred to, by which expression I presume we may include the sun, moon and planets, unless it means the Pleiades. Falstaff says—

"Indeed, you come near me now, Hal, for we that take purses, . . .
by the moon and seven stars, and not by Phoebus."

The same expression occurs in a comic dialogue between Lear and Fool.

Comets are pretty often mentioned, almost always as objects of dread and foreboding tearful disasters. Probably no celestial object was so much stared at in the old days as a comet—see the well-known picture from the Bayeux tapestry of men gazing upwards in wonder at one of these strange visitors. Petruccio, in *aming of the Shrew*, says—

"And therefore gaze this golly company,
As if they saw some wondrous monument,
Some comet, or natural prodigy."

Then we have the well-known introduction to *Henry VI.*—

"Hung be the heavens with black, yield day to night,
Comets, importing change of times and states,
Brandish your crystal tresses in the sky,
And with them scourge the bad revolting stars
That have consented unto Henry's death."

In *Pericles* we read: "But have been gazed on like a comet." And again in another play, a clown, speaking of the rarity of good women, says—

"One in ten, quoth a'! and we might have a good woman born, but
one every blazing star, or of an earthquake, 'twould mend the Lottery
well."

Blazing star would here probably refer to a comet, as meaning a rare event. We have the expression "blaze star" in modern astronomy to denote one of those temporary stars which from time to time—but at very long intervals—burst out from the heavens and astonish mankind. It is doubtful if the expression bears this meaning in the passage quoted; comet would be more probable.

In another place, we find Bacon, in a speech the drift of which is to promote the advantages of study, observing—
"First, to study the motions of heaven's lights,
That you may know the very fixed star,
Have a commandment of the rising and the setting,
Learn those that are, and yet not what they are."

It is a curious expression in the first line, and might now-a-days be well applied to those who have introduced their names and the names of their contemporaries into the geography of Mars.

Sometimes we find what may be called miraculous or wonderful meteorological signs described, as in *Henry VI.*, Part III., where Richard and Edward see what seem to have been mock suns on either side of the true sun.

"These glow-worms, as it were, are perfect suns
Not separated with the smoking clouds,
But save of time, pale near-shining sky,
So, see! they burn, endure, and seem to kiss,
As if they would some league be made,
Now are they but one lamp, one light, one sun;
In this the heaven, it gives some event."

Shortly afterwards Edward observes—

"Whatever it be, let her forward with I bear
Upon my target three fair-shining suns."

In *Romeo and Juliet* we have what has been supposed to be an allusion to the Zodiacal light. Juliet says—

"You light is not daylight, I know it, I
It is some meteor that the sun exhal'd."

At the same time Romeo seems to be pretty certain that the day is coming on, or perhaps that it may be moonlight, for he says—

"I'll say, you gray is not the morning eye,
'Tis but the pale reflex of Cynthia's brow."

The powerful influence supposed to be exerted by the moon on mortal men is expressed by Othello—

"It is the very error of the moon,
She comes in measure, ere with that, she was wont,
And makes me mad."

Her influence on the vegetable world is also mentioned—

"As true as steel, as plantage to the moon," &c.

The word "astronomer," which is rare, comes in, spoken by Imogen—

"O, how I would were that astronomer
That knew the stars as I his characters;
He'd try the nature open."

We now come to the astrological passages. A glance over them will show how deeply the idea of the influence of the heavenly bodies on men was ingrained in the popular mind, as it comes out in so many different ways. Even now, many astrological expressions survive and are in daily use: such as "disaster," "in the ascendant," "mercurial," "jovial," &c. But three hundred years ago the "skies influences," it was generally thought, were invincible and fatal, hanging over men and women in such a way that nothing could change them. Hence, the stars and planets are referred to in two senses, favourable and unfavourable. In the former sense we have "truer stars," "good stars," and "constellation right apt"; while in the latter we have "some ill planet," "planets of mishap," "adverse planets," "malignant and ill-boding stars," "thwarting stars," &c. Two planets are actually mentioned in the astrological sense. In *Macbeth*, Don John observes—

"I wear the crown of Saturn, as thou say'st thou art born under
Saturn, 'twere best to apply a moral medicine to a mortifying
mischief."

Autolyus in *A Midsummer Night's Dream* describes himself as "littered under Mercury," and "a snapper up of unconsidered trifles."

In *A's Well* Helena soliloquizes—

"Our souls' bodies out of ourselves do lie,
Which we ascribe to Heaven, the fate of sky,
Gives us free scope, only doth but keep pull
Our slow designs, when we ourselves are dull."

Comets, of course, were considered as special messengers, foreboding changes and disturbances on the earth at large. But they had nothing to do with ordinary folk—

"When beggars die, there are no comets seen;
The heavens themselves blaze forth the death of princes."

Then we hear elsewhere of a "comet of revenge."

A quaint tradition, that about Christmas time the planets could exert no baneful influence, is embodied in the following passage from *Hamlet*—

"Some say, that ever 'gainst that season comes
Wherein our Saviour's birth is celebrated,
The bird of dawn singeth all night long;
And then, they say, no spirit can walk abroad;
The nights are wholesome; then no planets strike,
No fairy takes, nor witch hath power to charm,
So hallowed and so gracious is the time."

Lastly, we may refer to the "man in the moon." Stephano tells Caliban he is the man in the moon, and Caliban then says—

"I have seen thee in her, and I do a lore thee; my mistress showed thee me, and thy dog and thy bush."

And Moonshine, in the interlude of *Midsummer Night's Dream*, says—

"All that I have to say is, to tell you, that the lantern is the moon; I, the man in the moon; this thorn-bush, my thorn-bush; and this dog, my dog."

If Shakspeare's astronomy is largely clouded by astrology, in that very respect does he hold the mirror up to Nature and reflect the prevailing ideas of his time. Yet these scattered allusions are, as it were, mere drops in the ocean of his works, which are not for an age, but for all time.

THE FACE OF THE SKY FOR FEBRUARY.

By HERBERT SADLER, F.R.A.S.

SUNSPOTS show little diminution in size and number. Conveniently observable minima of Argol occur on February 3rd, 5h. 55m. p.m.; February 20th, 10h. 48m. p.m.; February 23rd, 7h. 37m. p.m.; February 26th, 4h. 26m. p.m.

Mercury is invisible during the first half of February, being too near the Sun. He is in superior conjunction on the 16th. On the 25th he sets at 6h. 10m. p.m., or 10m. after the Sun, with a southern declination of $7^{\circ} 3'$, and an apparent diameter of $5\frac{1}{2}''$, $\frac{1}{100}$ ths of the disc being illuminated. On the 28th he sets at 6h. 32m. p.m., or 56m. after the Sun, with a southern declination of $4^{\circ} 31'$, and an apparent diameter of $5\frac{1}{2}''$, $\frac{1}{100}$ ths of the disc being illuminated. During the last four days of the month he describes a direct path through part of Aquarius to the borders of Pisces.

Venus is too near the Sun to be observed after the first part of February. On the 1st she rises at 6h. 39m. a.m., or 1h. 2m. before the Sun, with a southern declination of $24^{\circ} 51'$, and an apparent diameter of $10\frac{1}{4}''$, $\frac{1}{100}$ ths of the disc being illuminated. On the 11th she rises at 6h. 10m. a.m., or $\frac{1}{2}$ h. before the Sun, with a southern declination of $19^{\circ} 46'$, and an apparent diameter of $10\frac{1}{2}''$, about $\frac{1}{100}$ ths of the disc being illuminated. After this she is too near the Sun to be observed. While visible she pursues a rapid direct path through Capricornus.

Mars is an evening star, but is rapidly getting fainter and smaller in size. On the 1st he sets at 11h. 30m. p.m., with a northern declination of $9^{\circ} 33'$, and an apparent diameter of $7\cdot6''$. On the 19th he sets at the same time, with a northern declination of $11^{\circ} 0'$, and an apparent diameter of $6\frac{1}{4}''$, about $\frac{1}{100}$ ths of the disc being illuminated. On the 28th he sets at the same time, with a northern

declination of $16^{\circ} 0'$, and an apparent diameter of $6\frac{1}{2}''$. During the month he describes a direct path from the borders of Pisces through a great part of Aries. He is occulted by the Moon on the afternoon of the 21st, but the phenomenon is not visible in these latitudes.

The minor planet Juno comes into opposition on the 14th, when she is distant from the earth about 141,400,000 miles, and appears as bright as an $8\frac{1}{2}$ magnitude star. She sinks on the 24th at 11h. 14m. p.m., with a northern declination of $5^{\circ} 54'$. During February she describes a retrograde path through part of Sextans on to the confines of Hydra and Leo, but without approaching any naked eye star.

Jupiter is still the most conspicuous object in the evening sky, but as he is rapidly approaching the west he should be looked for as soon after sunset as possible. He sets on the 1st at 11h. 3m. p.m., with a northern declination of $6^{\circ} 36'$, and an apparent equatorial diameter of $37''$. On the 20th he sets at 10h. 8m. p.m., with a northern declination of $7^{\circ} 55'$, and an apparent equatorial diameter of $35\frac{1}{4}''$. On the 28th he sets at 9h. 46m. p.m., with a northern declination of $3^{\circ} 32'$, and an apparent equatorial diameter of $31\cdot6''$. During the month he describes a direct path in Pisces. At 8 p.m. on the 14th he is $10s.$ and $5\frac{3}{4}'$ north of the 6th magnitude star $\text{Ll } 2677$. At 8h. 15m. p.m. on the 22nd a 9th magnitude star will be $52'$ north of the planet. Jupiter is occulted by the Moon in broad daylight on the 20th. The disappearance takes place at 2h. 16m. p.m., at an angle of 15° from the northern point of the lunar disc, and reappears at 3h. 24m. p.m., at an angle of 263° . The planet will be just on the meridian at the time of re-appearance. The following phenomena of the satellites occur while Jupiter is more than 8° above and the Sun 8° below the horizon. On the 1st a transit egress of the shadow of the second satellite at 7h. 3m. p.m. On the 3rd an occultation disappearance of the first satellite at 8h. 42m. p.m. On the 4th a transit ingress of the first satellite at 5h. 50m. p.m., of its shadow at 7h. 4m. p.m.; a transit egress of the satellite at 8h. 5m. p.m., and of its shadow at 9h. 17m. p.m. On the 5th an eclipse reappearance of the first satellite at 6h. 35m. 1s. p.m. On the 6th an occultation disappearance of the second satellite at 9h. 35m. p.m. On the 7th a transit egress of the third satellite at 7h. 57m. p.m. On the 8th a transit ingress of the shadow of the second satellite at 7h. 14m. p.m.; a transit egress of the satellite at 7h. 22m. p.m., and of its shadow at 9h. 40m. p.m. On the 11th a transit ingress of the first satellite at 7h. 50m. p.m., and of its shadow at 9h. p.m. On the 12th an eclipse reappearance of the first satellite at 8h. 30m. 33s. p.m. On the 15th a transit ingress of the second satellite at 7h. 34m. p.m. On the 17th an eclipse reappearance of the second satellite at 6h. 22m. 51s. p.m. On the 18th an eclipse reappearance of the third satellite at 6h. 19m. 3s. p.m. On the 19th an occultation disappearance of the first satellite at 7h. 12m. p.m. On the 20th a transit egress of the first satellite at 6h. 35m. p.m., and of its shadow at 7h. 37m. p.m. On the 21st an eclipse reappearance of the second satellite at 9h. 0m. 31s. p.m. On the 25th an occultation reappearance of the third satellite at 6h. 41m. p.m., and its eclipse disappearance at 8h. 39m. 18s. p.m. On the 27th a transit ingress of the first satellite at 6h. 22m. p.m., a transit ingress of its shadow at 7h. 20m. p.m., and a transit egress of the satellite at 8h. 36m. p.m. On the 28th an eclipse reappearance of the first satellite at 6h. 50m. 11s. p.m. The following are the times of superior and inferior conjunctions of the fourth satellite:—Superior, February 12th, 6h. 31m. a.m. Inferior, February 3rd, 10h. 28m. p.m.; February 20th, 6h. 22m. p.m.

Saturn is an evening star, rising on the 1st at 10h. 10m. P.M., with a southern declination of 2° 40', and an apparent equatorial diameter of 17.4" (the major axis of the ring system being 41½" in diameter, and the minor 6½"). On the 28th he rises at 8h. 16m. P.M., with a northern declination of 2° 8', and an apparent equatorial diameter of 17.9 (the major axis of the ring system being 43" in diameter, and the minor 6½"). Titan is at his greatest eastern elongation at 2.3h. P.M. on the 6th, and at 0.7h. P.M. on the 22nd. Iapetus is at superior conjunction at 1.5h. A.M. on the 11th. The accompanying map (based upon Cottam's smaller star charts, with a few minor alterations) shows the path of the planet in the constellation Virgo (and the principal stars and nebulae near) from February 1st to September 1st, the position of the planet on the first day of each month being marked with a cross. The magnitude of the principal stars are: γ Virginis (binary), 3.1; β Virginis, 3.5; η Virginis, 4.0; 16 Virginis, 5.5; 13, 14 P. xii., 38, 44, and 46 Virginis, 6.0. All the other stars are below the 6th magnitude. The numbers attached to the nebulae are from Dreyer's new General Catalogue. On the evening of the 3rd a 9.3 magnitude star will be occulted by the planet, the central occultation taking place at about 8h. 50m. P.M. On the evening of the 23rd the planet will be about ½° north of 38 Virginis.

As Uranus does not rise till after 11h. P.M. on the last day of the month, we defer an ephemeris of him till March.

Neptune is still well situated for observation. He rises on the 1st at 11h. 4m. A.M., with a northern declination of 20° 12', and an apparent diameter of 2.6". On the 28th he rises at 9h. 58m. A.M., with a northern declination of 20° 13'. He is almost stationary in Taurus, to the W.N.W. of the 5¼ magnitude star, Weisse's Bessel, iv. 650. A map of the small stars near his path will be found in the *English Mechanic* for October 28th, 1892.

There are no well-marked showers of shooting stars in February. The zodiacal light should be looked for in the west shortly after sunset on the nights from the 3rd to the 21st, when the Moon will not interfere with observation.

The Moon is full at 2h. 14m. A.M. on the 1st; enters her last quarter at 8h. 12m. P.M. on the 8th; is new at 4h. 17m. P.M. on the 16th; and enters her first quarter at 2h. 14m. P.M. on the 23rd. She is in apogee at 4h. A.M. on the 9th (distance from the earth 251,230 miles), and in perigee at 8h. P.M. on the 21st (distance from the earth 229,710 miles).

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

Solution of January Problem (by J. N. Babson) :—

Key-move: 1. Q to R8.

If 1. . . . K to K1, 2. Q to KRsq, &c.

If 1. . . . K to B6, 2. Q to QR2, &c.

CORRECT SOLUTIONS received from Alpha, W. T. Hurley, and H. S. Brandreth. The latter gives only the minor variation.

E. Reginald Blakely.—(1) After 1. Kt to Q5, K to K4; 2. Q to Kt3ch, K x P, there is no mate. (2) *The Chess-Monthly*, edited by L. Hoffer; published by Horace Cox, Brems Buildings, Chancery Lane, E.C. Annual subscription, 11s., post free.

* The map is not ready in time for this month's issue.—A. C. R.

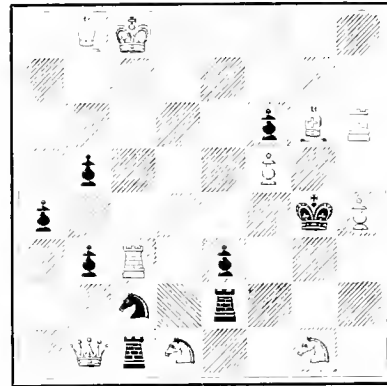
W. T. Hurley.—The idea of another Solution Tourney does not find favour with the proprietors. We hope to make arrangements this month for a Problem Tourney instead, probably for three movers.

PROBLEM.

By A. F. MACKENZIE, Jamaica.

First Prize in *Pittsburg Dispatch* Tourney.

BLACK.



WHITE.

White to play, and mate in three moves.

Mr. S. Loyd, one of the judges, describes the above as "a remarkably difficult, original and well-constructed position, commencing with an excellent key, followed by fine strategy." The other judges were even more enthusiastic.

The following game was played in the telephone match on December 17th.

RYE LOPEZ.

WHITE (Liverpool C. C.)

BLACK (British C. C.)

- | | |
|-----------------|-------------------|
| 1. P to K4 | 1. P to K4 |
| 2. Kt to KB3 | 2. Kt to QB3 |
| 3. B to Kt5 | 3. Kt to B3 |
| 4. P to Q3 | 4. P to Q3 |
| 5. P to B3 | 5. P to KKt3 |
| 6. QKt to Q2 | 6. B to Kt2 |
| 7. Kt to Bs4 | 7. Castles |
| 8. Kt to K3 (a) | 8. P to Q4 |
| 9. Q to B2 (b) | 9. P to Q5 (c) |
| 10. Kt to B1 | 10. Kt to Q2 |
| 11. Castles | 11. Kt to Kt3 |
| 12. B x Kt | 12. Kt x Kt |
| 13. P x P (d) | 13. Kt to Kt3 |
| 14. B to R4 | 14. Kt x B |
| 15. Q x Kt | 15. P x P |
| 16. B to B4 | 16. B to Kt5 (e) |
| 17. Kt to K5 | 17. B x Kt (f) |
| 18. B x B | 18. B to K7 |
| 19. KR to Ksq | 19. B x P |
| 20. B x QP | 20. Q to K2 (g) |
| 21. Q to Kt3! | 21. B to R3 |
| 22. Q to QB3 | 22. P to Kt3 (h) |
| 23. B to B6 | 23. Q to B4 |
| 24. Q to Q2 | 24. KR to Ksq (i) |
| 25. QR to Bs4 | 25. Q to Q3 |
| 26. Q to Kt5 | 26. P to B4 |
| 27. P to K5 | 27. Q to Bs4 |
| 28. R to K4 | 28. R to K3 (j) |
| 29. R to B3 | 29. QR to Ksq |
| 30. R to KR3 | 30. B to Bs4 |
| 31. R x P | Resigns. |

NOTES.

(a) 8. Kt to Kt3 instead would have prevented Black from freeing their game by P to Q1.

(b) Probably best. Evidently 9. B x Kt leads to nothing.

(c) This move, always so tempting, is not generally good, the Pawns being liable to be broken up ultimately by P to Kt4. In the present instance, however, Black gain time by attacking the Knight, and follow up the move very ingeniously.

(d) If 13. B x P, B x B; 11. P x Kt, P to Q6, &c. The course adopted gives Black the advantage of two Bishops, White's compensation, if any, lying in the open QB file.

(e) 16. . . . P to Qb1 would not be good, for Black would break up the Pawns by R to Qb5q and P to Qk4.

(f) A fatal mistake. 17. . . . B to K3 was the correct reply. 17. . . . B to K7 (perhaps their original intention) was not good, e.g., 17. . . . B to K7; 18. KR to Ksq, B x Kt; 19. B x B, B x P; 20. B x QP with the same advantage as in the actual game. In taking the Knight, the London players relied too much on the assumption that Bishops of opposite colours always lead to a draw. Some remarks of ours on "Chess Fallacies," in the June number of KNOWLEDGE, are so appropriate to the present instance that they may be quoted here: "*Fallacy VIII. That Bishops of opposite colours always tend to a draw.*—The contrary is often the case. Imagine that Black has castled on the King's side, and weakened his position by the move P to Kk3. It is now to White's advantage that each player should lose his King's Bishop, leaving the Bishops of opposite colours. The White Queen's Bishop, in conjunction with the Queen and a Knight or Rook, will then probably be irresistible on the King's side, White's Bishop commanding the holes at Kk6 and Kk6, while the Black Queen's Bishop is practically useless for defence. The general rule may be stated as follows: If your opponent has all, or nearly all, his Pawns on one colour, get rid, if possible, of his Bishop of the *other colour*. The remaining Bishop may guard some of the Pawns, but he cannot guard what is more important—the *diagonals among the Pawns*." The above remarks exactly describe the present position after the exchange of pieces.

(g) This makes matters worse, as now White cleverly gain time by threatening to win the exchange. 20. . . . Q to Ksq and 20. . . . P to Kt4 have been suggested as alternatives, the latter for choice. We should prefer, however, 20. . . . Q to R5, for if White in reply advance one of their Pawns on the King's side their Rooks are thereby prevented from coming into play on that wing.

(h) 22. . . . KR to Ksq was probably better. The move must be made soon.

(i) 24. . . . Q to Kk4 would be met by 25. QR to Qb5q and 26. R to B3, &c. 21. . . . Q to Q3 would lose a Pawn on account of 25. Q to Kt5, P to R3, 26. Q to R4.

(j) If 28. . . . P to R3, 29. R to Kk4, K to R2; 30. R to B3 (threatening mate in 3), B to Bsq; 31. R (B3) to B4 and wins. 28. . . . P to R1 would also lose by 29. P to Kk4! (not 29. R to Kk4, K to R2, threatening Q to R3). The Liverpool players conducted the latter half of the game with great skill and ability.

CHESS INTELLIGENCE.

Herr Walbrodt, of Berlin, who was so successful in the late Dresden International Tournament, is now fulfilling an engagement with the Havana Chess Club. Mr. Lasker has also been invited, on the condition that he will play a match with Herr Walbrodt.

After his successes with the Manhattan players, Mr. Lasker's progress received a slight check at the hands of Mr. J. W. Showalter. They played a short match, and after each player had won one game the match was rather tamely abandoned as drawn.

The North v. South match at Birmingham, on January 28th, is exciting the greatest interest. The Southern Committee found themselves with no less than 180 names to select their team of 100 from; probably some 60 or 70 of the team will be representatives of London and its suburbs.

The proposed Winter Tournament for amateurs has been postponed till Easter, when it is expected to take place at Cambridge.

Modern Chess Brilliances is the title of a collection of seventy-five games edited and arranged by Mr. G. H. D. Gossip. Most of the games are briefly annotated, but there is nothing in the notes to alarm the least advanced student. Whether all the games in the selection deserve their place, or not, may perhaps be open to question. Game No. 55 has certainly no pretensions to be classed as one of the two "most brilliant games on record," and postal brilliances might perhaps have been omitted in favour of such a game as Mason v. Winawer, in the last Vienna Tournament. In most respects, however, it is an interesting collection, and quite worth the shilling asked for it. Messrs. Ward and Downey are the publishers.

We have received from Mr. J. E. Whineop, of 23, West Hillary Street, Leeds, a very useful pocket chess-board on the diagram principle. The principle is not new, but has been greatly improved. The board is on solid leather, the chess-men being of ivory or bone. The whole is enclosed in a strong leather case. The price, 3s. 2d. (post free), seems very moderate.

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CATERPILLARS.—V.

By E. A. BUTLER.

(Continued from page 35.)

THAT the colours of caterpillars have some sort of relation to their surroundings is a conclusion at which one would be able to arrive after even a limited experience in the woods and fields. Thus it would soon be discovered that those larvæ that feed in the stems of plants or the trunks of trees, or in roots, or between the skins of leaves, are mostly pale whitish or yellowish, and that those that dwell in the seclusion of a coiled-up leaf are chiefly of a dirty greenish or yellowish white without distinct markings. On the other hand, it would be found that those that feed in the open are much less uniform in tint, and are often brightly variegated, or at least decidedly coloured, and marked not unfrequently with distinct and intricate patterns of exquisite hues, in sharpest contrast with one another—patterns, indeed, which might often be worth the attention of students in a school of art, for the suggestion and elaboration of artistic designs. Moreover, speaking again only of those caterpillars that feed exposed, one of the earliest generalizations the practical naturalist feels himself in a position to make is, that the two colours to which, out of all the variety of Nature's extensive *répertoire*, the preference has been given in the vegetable world, viz.,

green and brown, are also those that prevail in the caterpillar world, while some others, such as blue, for example, are very rarely to be met with. And, as such caterpillars spend their life amongst vegetation, some on the leaves, others in closer proximity to the stems and branches, it is not unreasonable to conclude that the prevalence of green and brown in their skins is due in some measure to the state of affairs found in the vegetable world; for the assimilation of the insect to the aspect of its surroundings would render it less conspicuous, and would probably, therefore, to some extent protect it from foes which might otherwise jeopardize its existence.

But after all, such a conclusion only pushes the enquiry a stage farther back, for, if we accept it, we then need to enquire why these two particular colours are also the dominant ones in the vegetable world; it cannot here be a case of the imitation of environment, but some other and perhaps more obscure reason would seem to underlie the fact. And here, whatever may have been the case before, we get most distinctly into the regions of chemistry and physiology, for the green colour of plants is due to the presence in their tissues of a particular substance called chlorophyll, and the presence of this is again due to physiological changes in the plant brought about through the influence of the sun's rays, so that again the enquiry would be pushed back a stage, for we should need to ask why chlorophyll is green. While, therefore, it will be a distinct advance in knowledge if it can be shown that the colours of certain living beings are to any extent determined by those of the inanimate objects around them, we must not lose sight of the fact that this is by no means the end of the matter, that we have advanced but one step along the path of truth, and that many more may be necessary before it is possible to establish in all their completeness the connections that exist between the forces of Nature and the present conditions of the various animate and inanimate organic bodies we see around us.

Bearing these cautions in mind, then, we may proceed to consider in a little more detailed way, some of the chief facts connected with the colours and markings of caterpillars. If the colours of caterpillars are affected by their surroundings, it would appear that the result would be produced in one or other of two ways, either by the colour of the food itself affecting that of the tissues of the body and the blood, and this colour then appearing through the transparent skin, or, on the other hand, by the presence of some sensitiveness in the individual, which enables it unconsciously to respond to the nature of the light falling upon it from surrounding objects, and produce pigments of one colour under the influence of light of one kind, and of another colour with a preponderance of light of a different kind. Caterpillars feeding upon green leaves, and having thin transparent skins, might thus, on the first hypothesis, be expected to show a tendency towards a green colour, and this has been proved in some cases to account for the greenness of larvæ. Indeed, when such larvæ are not green, it is not necessarily through the absence of that colour in their tissues, but often merely because it is concealed by other pigments deposited in the skin. These facts have been established by Mr. Poulton, by means of a series of very elaborate experiments, which lead also to the second hypothesis mentioned above.

To determine this latter point, namely, the influence which the surroundings exercise by their mere presence, he experimented with several kinds of larvæ, but especially with those of the pepper moth (*Amphidasis betularia*), as this proved to be by far the most susceptible to external influences, and therefore the best for experimentation. The food uniformly supplied being the leaves of the black

poplar, a large number of the larvæ were separated into groups, which were placed in different receptacles. Of course in all it was inevitable that there should be a certain amount of green surroundings, because of the leaves of the food plant: but the circumstances were varied by the introduction of other objects. For example, to give a preponderance of dark surroundings there were introduced a number of very dark twigs from a kind of oak tree, together with stems of other kinds, all dark but of different tints in the different cases. Spills made of dark-coloured paper, and artificial leaves, or natural dead leaves, were also used, being stuck about amongst the food plant. In the case of the light surroundings, there were, besides the leaves of the food plant, green twigs, and spills of white or light-coloured paper. The caterpillars were introduced into these special surroundings when about half-grown, as that was found to be, on the whole, the most susceptible age. The general results of a large series of experiments (Fig. 15) were that the majority of those amongst the dark



FIG. 15.—Larvæ of Pepper Moth (*Amphispiza icularia*). A. Green specimen on green twig; B. Brown specimen on brown twig. (After Poulton.)

surroundings tended to become darker than when introduced, developing some shade or other of brown—such, namely, as best harmonized with the exact tint of the dark objects used, while in the experiments with light surroundings the reverse was the case, and the larvæ became pale green or other light colour, some of the most remarkable results being produced where the white spills were used. It thus seems to be established that, in the case of some insects at least, the colour of their environment has an important influence in determining their own colour. But it must also be admitted that there are many species amongst those experimented upon, which show very little of such susceptibility, so that the final determination of colour in many instances is probably a somewhat intricate matter, and dependent upon many different conditions.

Recognizing, however, as we seem bound to do, that the surroundings

do constitute a possible factor in determining the colour of the caterpillar, we may even take one step farther and suggest that the general pattern, as well as the mere colour of the surroundings, may also be reproduced in the skin of the caterpillar. It is not difficult to call to mind many curious facts illustrating such connection between the pattern of the caterpillar's ornamentation and the prevalent features of its environment. For example, the larvæ of the butterflies of the family *Satyridae*, such as the familiar meadow browns and heath butterflies, which feed on grasses, are striped longitudinally with dark and pale lines. Now it is obvious that in a spot where a quantity of tall grass is growing, longitudinal lines of shading and colouring, caused by the ribs and veins, stems and leaves of the grasses, and the shadows they produce, will be artistically the predominant feature; and then we find that the caterpillars which live in such spots partake of the prevailing style of colour-arrangement too; while, to put the converse fact, those caterpillars that feed upon broad-leaved plants, in which such longitudinal effects of light and shade will be much less conspicuous, if present at all, are usually found, though still possessing some pale

longitudinal lines, not to have them so prominent or occupying so much of the surface. These can hardly be mere coincidences.

When oblique stripes are present it is in species which feed on broad-leaved plants; and as the venation of leaves of this kind is of a different type from that of grasses, the chief veins branching from the midrib at an angle, instead of running more or less parallel to the edge of the leaf, the oblique stripes on the caterpillars have been supposed to be a sort of reflection of the obliquity of the veins of the leaf, especially as there is often present on the caterpillars a longitudinal line as well, just beneath or running through the oblique stripes, suggestive of the midrib of the leaf. However, as it is only in a small proportion of cases amongst those that feed upon plants whose leaves are veined in this way that such ornamentation holds, and by far the greater number show no trace of diagonal lines, the case for imitation is a far less strong one than that of the longitudinal striping. The most remarkable instances of oblique striping are to be found amongst the caterpillars of the hawk moths, many of which exhibit it in the highest degree, thereby greatly enhancing their beauty. Nothing can be more harmonious, for instance, than the coloration of the larvæ of the privet hawk moth, one of the commonest of the group; in this insect the ground colour is a beautiful tint of green, and the stripes, which are seven in number on each side, are white edged with a band of the purest lilac on the upper margin. The huge caterpillar of the death's head moth is another very remarkable instance; its stripes are pale blue on the back, but farther down they deepen into black and are edged with yellow.

But the greatest interest attaches to that peculiar style of ornamentation called "eye-spots." These are large circular patches of concentric rings of colour, which occur only in a very few caterpillars, and irresistibly suggest the eyes of some vertebrate animal. The true eyes of the caterpillar, it will be remembered, are practically invisible except on a close inspection, and there is nothing, therefore, to compete with these spots or neutralize their effect. By far the best illustration of this type of ornamentation that we meet with in this country is to be seen in the larva of the elephant hawk moth (*Charocampa elpenor*) (Fig. 16). It feeds on the common hairy willow-herb of damp ditches and riversides, a plant which, from its gay clusters of large pink flowers and its habit of growing

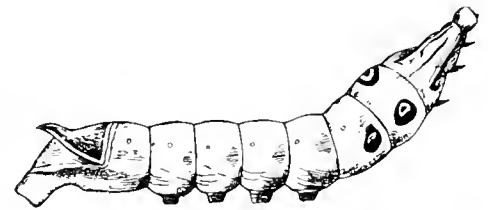


FIG. 16.—Larva of Elephant Moth (*Charocampa elpenor*) in its last stage, slightly reduced.

in dense clumps to the height of four or five feet, is one of the first of summer wild plants to attract attention, and must be well known to everybody. The caterpillars may also sometimes be found in gardens feeding on fuchsias.

These larvæ are interesting in many respects. They are of the type known as dimorphic, *i.e.*, like those of the pepper moth they have two varieties when fully grown, a green one and a brown one, a circumstance which, according to Mr. Poulton, betokens a ready adaptability in the insect to colour changes in its surroundings. At first, however, they are all green, and during the early part of their life they remain amongst the leaves of their food plant when not eating, thereby availing themselves of the concealment afforded by the harmonizing of their colour with that of the foliage around them. But when

they reach their fifth stage, a great change comes over them. The casting of the skin on this occasion leaves them, not green as heretofore, but with a coat of brown instead; this at least is what happens to the majority, though some few erratic individuals still retain their juvenile greenness, which, indeed, they never lose. Concurrently with this change in colour there is an alteration of habit; they now no longer rest amongst the fresh foliage of the food plant, but descend to the ground when not feeding, where their changed colour is as efficacious in concealing them amongst the dead leaves, stems, and brown soil, as it would have been in exposing them had they remained embosomed in green.

But this is not the only peculiarity. When first hatched they have no markings of any kind, but after the first change of skin, which takes place when they are five or six days old, they appear with two longitudinal white lines stretching the whole length of the body. At this time they are utterly unlike what they will ultimately become. After a few days, the upper line, in the region of the fourth and fifth segments behind the head, begins to show signs of irregularity, a slight swelling appearing in each of these segments. These are the commencements of the eye-spots, though from their present appearance it would be quite impossible to predict what they might become; indeed, they are most inconspicuous, and only to be noticed at all by a careful inspection. By another moult they pass into their third stage, when it is observed that the lower line has disappeared, and the two white swellings have become larger, and are now recognizable as distinct spots. After the next moult, the most noticeable change is that the incipient eye-spots are larger and are now surrounded by a black line. Again in the next stage, the fifth, and last but one, the spots are much larger, the black margins being spread out into a broad patch, and the white reduced to a ring by the appearance of a violet spot in its centre, so that it now begins to look something like an eye. At the same time, the longitudinal lines become almost obliterated and *diagonal* ones take their place. In the final stage all these points are still more emphasized, and at the same time, the third and fourth segments, which at first were no larger than the rest, have become considerably swollen, while the head looks disproportionately small, having grown hardly so much as might have been expected. Hence the caterpillar suddenly bulges out in the third and fourth segments, and this becomes all the more marked when the head is drawn back. By this movement the eye-spots on the fourth segment are brought into great prominence, and the whole of the front of the insect acquires a slight resemblance to a snake's head, with staring, stony eyes. The effect, even upon those who are familiar with the insect, is really quite startling, and it is difficult to persuade oneself that those glaring orbs are not really eyes with the most cruel and penetrating glance.

Now these eye-spots are unquestionably of considerable use to the insect; for, suggesting as they do a dangerous animal which it will be as well not to molest, they warn off any but the hungriest or most knowing of enemies, and save their possessor's life. And well the poor creature needs such a defence, for it appears to be a decidedly palatable morsel to insectivorous vertebrates. There is direct evidence, too, that the above suggestion of the function of the eyespots is not mere imagination. Dr. Weismann, who has made a particular study of the colour and markings of the *Sphinxidae* in general, was especially interested in this species. He had an enclosure for fowls which was open above, so that wild birds could easily fly in, and this they were often accustomed to do whenever

the fowls were not there. On one occasion Weismann put a large brown larva of the elephant moth in the food trough, after having removed the fowls. Flocks of sparrows and chaffinches soon flew down as usual, and alighted near the trough in the hope of picking up grain or other stray food. One bird soon flew on to the edge of the trough, and was about to hop into it, when it caught sight of the caterpillar. This deterred it, and it stood jerking its head enquiringly from side to side, but did not venture to go any nearer. One after another, about a dozen of the birds acted in the same way; when, however, the caterpillar was removed, they hopped into the trough briskly enough. The fowls themselves behaved somewhat similarly. When a specimen was placed in their midst, they at first ran hastily towards it, evidently in expectation of a feast, but as soon as they came near to it, they stopped and ran round it irresolutely, and it was not till after something like a score of half-hearted attempts to seize it, in each of which courage had failed at the last moment, that one more courageous than the rest at last reached the insect, and finding that nothing serious happened, pecked away at it till it was demolished. Caterpillars of ordinary appearance were, of course, swallowed at once without any difficulty. A domesticated jay was much more plucky, and swallowed the elephant caterpillar as soon as it was offered; but as domestication has the effect of taking off much of the shyness of birds in other respects, it is possible that this boldness may have had a similar origin, and that the bird would not have acted thus in the wild state.

We have not space to pursue this subject further, but can only indicate the general conclusions which seem to follow from the experiments and observations mentioned in this paper. These are, that the colours and patterns of caterpillars are not accidental, but have an intimate relation to their circumstances; that they can, at least in some cases, be modified by their environment, and that many have thus become useful to their possessors, whereby again they tend to be perpetuated; and finally, that the order in which the changes of colour and pattern appear in the life of the individual specimen is also that in which they have been acquired in the life of the species, so that the progressive changes observable in the present-day caterpillar's individual experience reveal something of the facts which constitute the past history of the generations which have preceded it.

DEEP SEA DEPOSITS.

By REV. H. N. HUTCHINSON, B.A., F.G.S., *Author of*
"Extinct Monsters."

[FIRST PAPER.]

THE wish to know something of what goes on "at the bottom of the deep blue sea" is a very natural one, but until late years the bed of the ocean has been a *terra incognita*. Popular imagination, however, fastens itself more on the sunken treasures and dead men's bones than on the natural phenomena and life of the deep sea. We propose, however, to consider only the scientific aspects of the subject, and to endeavour to lay before the reader a brief account of the deposits now in process of formation on the bed of the sea. Recent deep sea dredging expeditions have opened out a new world to the naturalist, the geologist, and the geographer. Of this new world we will endeavour to give a few glimpses, though the light at present thrown on it is only as moonlight to sunlight. Within the last thirty or forty years many ships belonging to different nations have, by means

of dredgings and soundings, made a large number of observations bearing upon the depths of the oceans in different places, the deposits forming, the forms of life flourishing there, and many other interesting questions. But of all such expeditions that of H.M.S. *Challenger* has been the most fruitful. The *Challenger*, with its able staff of naturalists, chemists, and others, under the direction of the late Sir C. Wyville Thomson, left England in 1872. The cruise lasted three and a half years, and since she returned a large number of most valuable and exhaustive reports have been issued. The last of these, published in 1892, deals with deep sea deposits, and is the first attempt ever made to deal with such deposits systematically. It treats of the geology of the sea bed throughout the whole extent of ocean. The authors are Mr. John Murray, naturalist of the *Challenger* expedition, and the Rev. A. F. Renard, Professor of Geology in the University of Ghent. Our remarks will be chiefly based upon this most excellent report. But, before forming their conclusions, the authors have studied samples obtained by other expeditions, so that the results arrived at are all the more firmly established. Since the return of H.M.S. *Challenger* very many samples of marine deposits have been collected from nearly all regions of the ocean basins by various ships. The great majority of these have been examined by them, so that altogether they obtained a very large amount of material.

Of pelagic or true ocean deposits, as distinguished from the coarser terrigenous materials laid down nearer to the shores, more than 2000 samples (from depths exceeding 1000 fathoms) have passed through their hands. Indeed, so great is the experience of ocean deposits they have thus gained, that they can even guess with a good deal of certainty the

region from which a sample submitted to them came, as well as state approximately the depth and distance from land at which it was procured. To test this, they frequently asked their assistants to select a sample for them (without giving any clue as to where it came from), and they found that, in nine cases out of ten, they could state the position within a few hundred miles, and the depth to within a few hundred fathoms!

In all parts of the ocean where the slope of the sea bed is not precipitous, and where no strong currents sweep over it, the rocky bed (supposed to be the original cooled crust of the earth—in some of the deepest parts) is covered with a mantle of deposits of various thickness, to which the gently-rounded contour of the ocean beds is largely due. Readers of KNOWLEDGE will scarcely need to be reminded that, broadly speaking, these deposits consist of (1) sands, gravels and muds (mostly formed near shore); (2) finer muds (further out to sea) passing gradually, as the depth becomes greater, into (3) various organic oozes, such as the well-known "globigerina ooze," which takes its name from a very abundant little foraminiferal shell known as globigerina (on account of its globular shape); and lastly (4) the equally well-known "red clay," found in all the deepest depressions of the oceans. And now arises the question of classification, which is not a very easy one. Messrs. Murray and Renard, however, point out that these ocean deposits may be classified either as regards geographical position, or as regards composition, as well as position and depth. In the first case we have the following scheme:—(1) Deep sea deposits; (2) Shallow water deposits between the 100-fathom line and low water mark; (3) Littoral deposits, formed between high and low

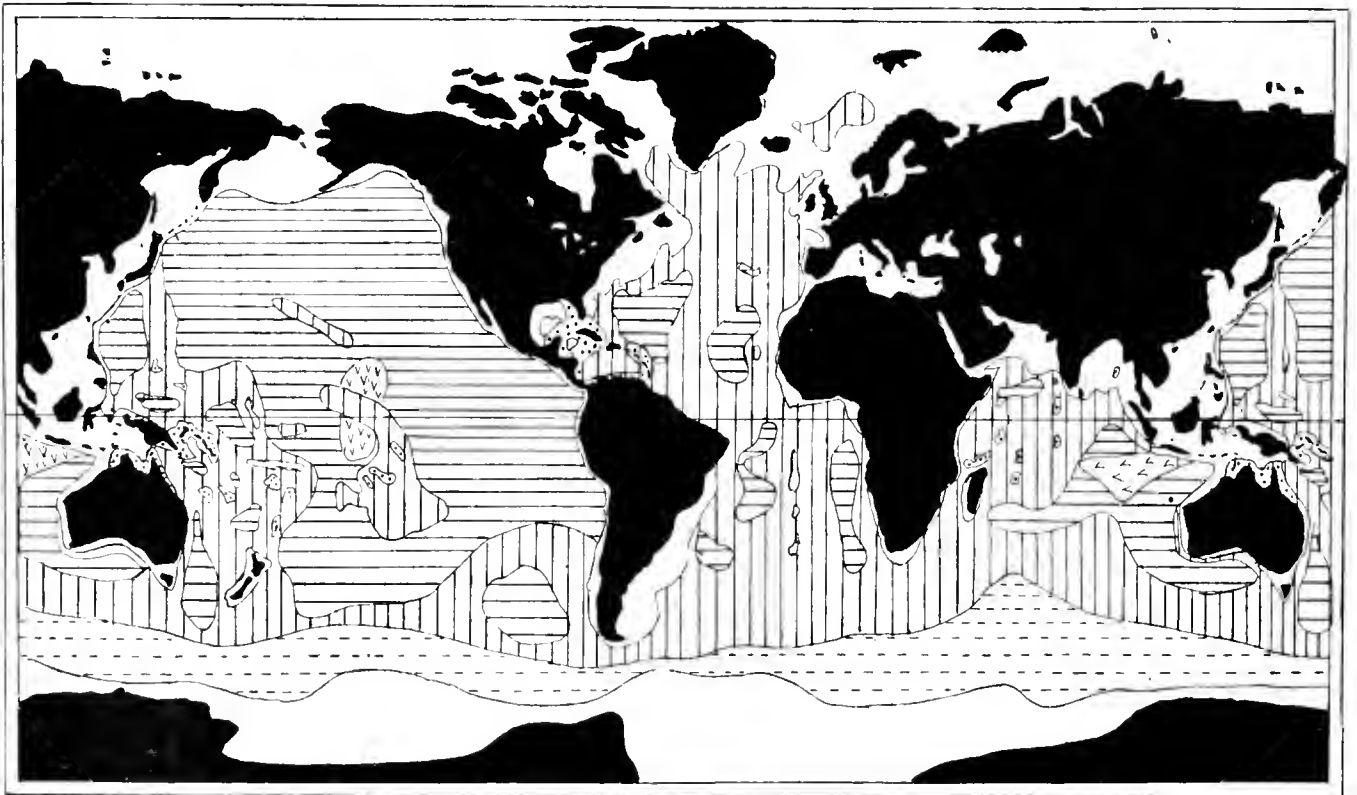


CHART I. OCEAN DEPOSITS.—*Explanation.*—The white space bordering lands marks the region of Terrigenous Deposits; vertical lines mark Globigerina Ooze; horizontal lines mark Red Clay; broken horizontal lines mark Diatom Ooze; two areas marked thus $\nabla\nabla$ mark Radiolarian Ooze; dotted spaces mark Coral Sands and Muds; a few small white spaces mark Pteropod Ooze.

water mark. In the second the arrangement would be as follows:—(1) Pelagic deposits—those formed towards the centres of the great oceans, and chiefly made up of the remains of pelagic organisms (foraminifera, radiolaria, pteropod shells, diatom frustules), along with the ultimate products arising from the decomposition of volcanic rocks and minerals, viz., the red clay; (2) Terrigenous, or land-derived, deposits—those formed close to continents and islands, and largely made up of transported materials—gravels, sand, muds, &c. The relations of these two groups to each other, and their subdivisions, are shown in the following scheme which the authors have put forward as the first attempt at a systematic classification, and which combines the two methods above mentioned.

<p>1. Deep sea deposits, beyond 100 fathoms.</p>	<p>Red Clay. Radiolarian Ooze. Diatom Ooze. Globigerina Ooze. Pteropod Ooze.</p>	<p>I. Pelagic deposits, formed in deep water removed from land.</p>
<p>2. Shallow water deposits, between low water mark and 100 fathoms.</p>	<p>Blue Mud. Red Mud. Green Mud. Volcanic Mud. Coral Mud.</p>	<p>II. Terrigenous deposits, formed in deep and shallow water close to land masses.</p>
<p>3. Littoral deposits between high and low water mark.</p>	<p>Sands, gravels, muds, &c.</p>	

As we are dealing with deep sea deposits, it will not be necessary to dwell upon those formed in shallower waters (2 and 3). Their characters are well known to all students of geology. They are chiefly due to the action of rivers

transporting debris worn off the land; but they pass at their lower limits into deep sea deposits, and all through show the results of mechanical action. Vegetable and animal life abounds. They occupy about 10,000,000 square miles of the earth's surface out of a total of 196,940,700.

Passing on to No. 1, it should be pointed out at once that, for various reasons, Messrs. Murray and Renard include in the term deep sea deposits all deposits formed at depths beyond 100 fathoms. This may seem at first a little extreme, for the 100-fathom line, as geographers know, runs very near all the coasts. But this line is one that is well known on our charts, and, secondly, this submarine contour line appears to mark the depth at which (on the average) most of the fine amorphous land-derived particles begin to settle down, so that beyond this line are found chiefly fine muds, or organic oozes. Also, at about this depth deposits become more uniform, and signs of mechanical action are much less evident. Between this line and the coasts the deposits are much coarser and more variable.

Referring to the scheme given here, it will be observed that even deep sea deposits are, some of them, terrigenous or land-derived, and not all organic oozes or red clays. But by choosing a lower limit of depth, it would be easy to make a scheme in which all deep sea deposits were either the one or the other. However, by taking the 100-fathom line, the authors have been able to include in their survey many interesting deposits, the study of which throws light on some important geological problems.

As a rule, all land-derived material falls on to the bed of the ocean within 100 or 200 miles of the shore; but in some exceptional cases it may float on to 300 miles or more from the coast. A line drawn 250 miles from all our coasts

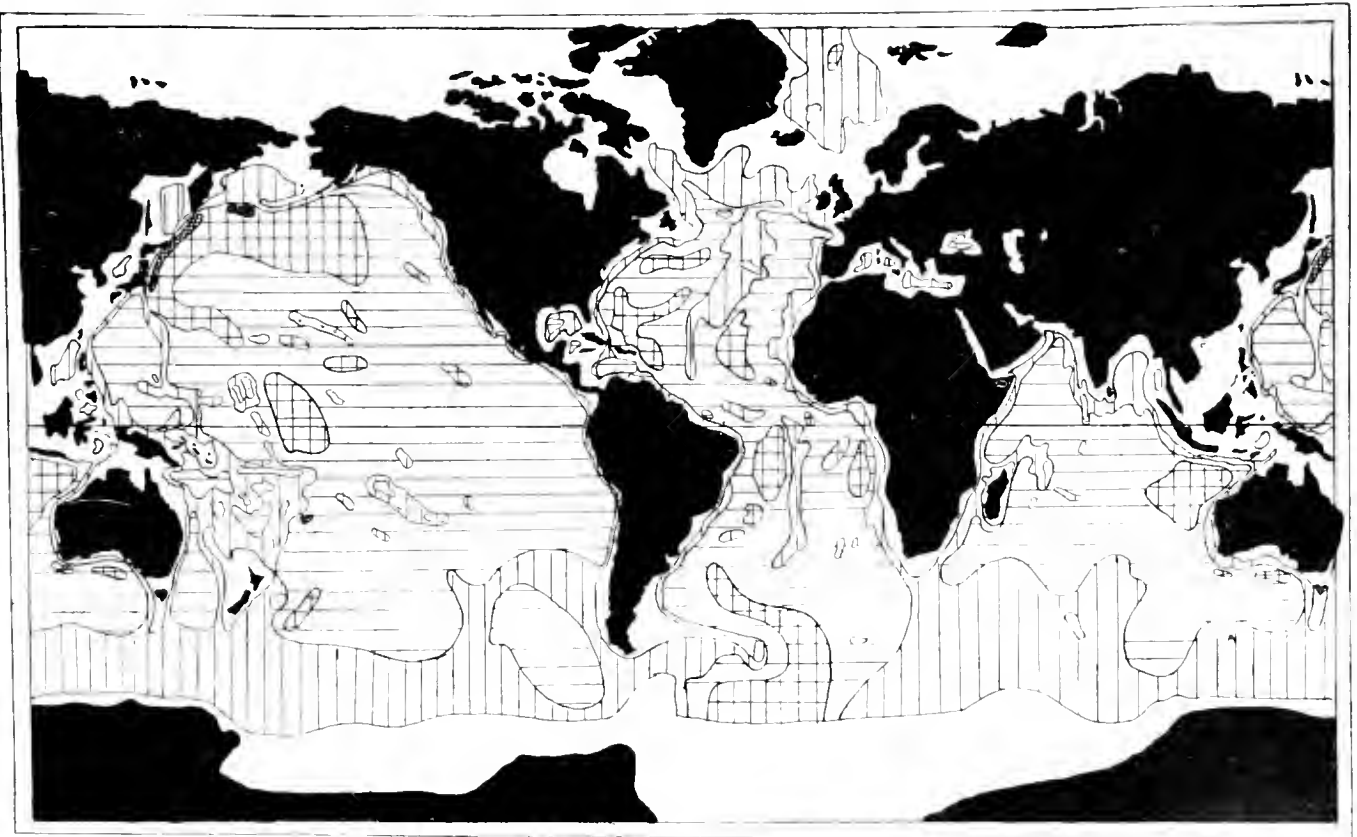


CHART II OCEAN CONTOURS.—Explanation.—The white space bordering lands marks the shallow waters up to 1000 fathoms—the 100 fathom line (not shown) runs near this; vertical lines mark 1000 to 2000 fathoms; horizontal lines 2000 to 3000 fathoms; squares 3000 to 4000 fathoms; fine cross over 4000 fathoms.

would practically mark the boundary between terrigenous and pelagic deposits. Very large and swift muddy rivers, like the Congo and the Amazon, however, cause the former to travel to even greater distances. The work of icebergs makes another exception to this rule; for they drop stones and mud all along the path of the ocean currents which drift them into warm seas, thus tending to some extent to confuse the limits of terrigenous and pelagic deposits. Winds also blow desert sand and fine volcanic ashes for hundreds of miles out to sea. Still, the broad distinction remains.

Before passing on to consider somewhat in detail the nature and origin of some of the deposits mentioned in the above scheme, let us look for a moment at their geographical distribution, as well as the depths at which they occur. It is estimated that terrigenous deposits cover one-fifth of the area of the oceans (or one-seventh of the earth's surface); so that the pelagic deposits occupy four-fifths of the ocean bed (or four-sevenths of the earth's surface—the land occupying two-sevenths).

Charts I. and II. have been reduced by photography from two larger drawings made by the author. No. I. is a generalized form of the map in the report of Murray and Renard, and No. II. is based on a map by J. Bartholomew. The first shows at a glance the distribution of the principal marine deposits, the second shows the depth of the ocean, as far as known at present; and it is instructive to compare the two charts in order to see how far depth is a factor in determining the character of the deposits lying on the sea floor. It will be apparent at once that, broadly speaking, depth is the chief factor, although other causes (such as latitude and temperature) have their influence. Take, for example, the distribution of the globigerina ooze* (shown by vertical lines) and you will see how it occupies the shallower parts of the Atlantic Ocean between 1000 and 2000 fathoms and between 2000 and 3000 fathoms, and parts of the Pacific and Southern Oceans between 1000 and 2000 fathoms. As we shall see in the next paper, it is most typically developed at depths between 2000 and 3000 fathoms, but its average depth is just about 2000 fathoms. Over part of the great Southern Ocean its place is taken by diatom ooze. Still, even that ooze will contain a very fair proportion of foraminifera. Look again at the large area surrounding the east of Australia and the many groups of islands to the north and east, and you will see this same ooze, &c., occupying most of this region within the depth range of 1000 to 2000 fathoms.

But the red clay brings out the importance of depth as a factor in this matter of distribution much more plainly. Take the Atlantic Ocean, and you will find four large patches of this deposit, lying in four or more hollows where the depth (shown by cross lines) is 3000 to 4000 fathoms—two on each side of the well-known ridge that runs straight down the Atlantic. Taking the Pacific, we find red clay in a depression off the south-west coast of South America, with globigerina ooze surrounding it where the depth is less. The greater part of the Pacific we see has red clay, the globigerina ooze confining itself to the shallower waters (1000 to 2000 fathoms) nearer land, or groups of islands. The long and rather wide strip of diatom ooze in the southern hemisphere is peculiar, and its presence there must be explained by other causes. So with the two patches of radiolarian ooze—one in the Indian Ocean, and the other in the centre of the Pacific (marked in Chart I. by little marks like a v). The dotted spaces mark coral mud, derived from the wear and tear of coral reefs, and their positions can easily be

accounted for; but even these are partly limited by depth. The three little plain spaces on the ridge of the South Atlantic denote pteropod ooze, and there is another one between New Zealand and the Equator.

The areas around the continents and islands in which terrigenous deposits are being laid down is marked in Chart I. by a plain white area, and it need hardly be pointed out that depth is the chief factor in determining the areas over which they spread.

But it must not be supposed that the boundaries of the various deposits are as accurately known as might be implied by the definite bounding lines shown in Chart I. In reality, these deposits shade off one into the other in a gradual manner, such as should be indicated by shading rather than by sharp lines. It is necessary also to add that some of these bounding lines are more or less hypothetical in places, and have been got by filling in outlines suggested by mapping down the results of sounding and dredging operations. So with regard to the ocean contours; they are not yet fully mapped out, as our knowledge of certain areas is limited. If future soundings modify some of the contour lines shown in Chart II., it is pretty certain that changes on the other Chart will be required; for, as we have shown above, depth is the chief factor in determining the distribution of deep sea deposits.

ON CERTAIN LOW-LYING METEORS.

By CHARLES TOMLINSON, F.R.S., F.C.S., &c.

I.—THE IGNIS FATUUS.

THE term "low-lying meteors" involves something like a contradiction, since the word "meteor" (*μετεωρος*, "high") originally referred to appearances in the upper regions of the atmosphere, such as the *Aurora Borealis*. As science advanced, the word was extended to all the varied phenomena that are connected with the weather and embodied in the term "meteorology." Our present purpose, however, is to give some details on a subject that seems to have fallen into hopeless confusion—namely, the phenomena to which the term *ignis fatui* has been applied by the English, *feu follets* by the French, and *Irrlichter* by the Germans.

Some old pupils of mine were seeking for information on the subject of the *ignis fatuus*, or "will-o'-the-wisp," also known as "jack-o'-lantern," and turned to one of those popular books grandly styled "Guides to Knowledge," and read as follows:—

"This luminous appearance (which haunts meadows, bogs, and marshes) arises from gas of putrefying animal and vegetable substances, especially from decaying fish. These luminous phantoms are so seldom seen because phosphoric hydrogen is so very volatile that it generally escapes into the air in a thinly diffused state. They fly from us when we run to meet it, because we produce a current of air in front of ourselves (when we run towards the *ignis fatuus*) which drives the light gas forwards. It runs after us when we flee from it, because we produce a current of air in the way we run, which attracts the light gas in the same course, drawing it after us as we run away from it. The Welsh "corpse candles" are the same thing as the *ignis fatuus*. Swarms of luminous insects passing over a meadow sometimes produce an appearance similar to the *ignis fatuus*."

This passage contains nearly as many blunders as lines. The *ignis fatuus* is not seen in meadows; it is not due to putrefying animal matter; there is no such gas as phosphoric hydrogen—the gas really meant is one of a series of inflammable compounds, in naming which the Latin word *uret* ("it will burn") is introduced, such as phosphuretted hydrogen, carburetted hydrogen, &c., but now known by the shorter terms "phosphide," "carbide," &c. As a specimen of English composition may be noted the

* See KNOWLEDGE, Vol. XV., p. 161.

sentence, "They fly from us when we run to meet it." The Welsh corpse candles and the luminous insects wind up appropriately a series of mistakes.

On turning to so respectable a publication as the *English Cyclopædia* (Arts and Sciences Division), 1860, the *ignis fatuus* is described as a meteor resembling a flame, which is vaguely said to do a number of things, and may be seen over marshes and burial grounds; and the case is related in which a weak blue flame came up from the sea, and burnt some ricks of hay. It is also stated that "such meteors are most usually witnessed during a fall of rain or snow." After referring to some other cases, the writer remarks, "Little confidence can be placed in the descriptions given of them, as few persons have been able to examine them with due attention; and commonly they have been observed under the influence of an ill-regulated imagination rather than a philosophical spirit." That such meteors are due to phosphuretted or carburetted gas is termed "a plausible hypothesis," but "there is a great dearth of satisfactory observations on moving lights seen in Nature, and the entire subject is at present in obscurity."

In the ninth edition of the *Cyclopædia Britannica* the subject is treated, oddly enough, under *Phosphorescence*, which is said to be a name "given to various phenomena due to different causes, but all consisting in the emission of a pale, more or less ill-defined light, not obviously due to combustion." It is stated that the *ignis fatuus*, as seen in marshy districts, has given rise to much difference of opinion. Kirby and Spence suggested that it might be due to luminous insects, "but it is more reasonable to believe that the phenomenon is caused by the slow (?) combustion of marsh-gas."

In *Chambers's Cyclopædia* (a Dictionary of Universal Knowledge), new edition, Vol. VI., 1890, the article *Ignis Fatuus* seems to have been entirely derived from the article *Irrlichter* in the *Konversations-Lexicon*. In this there is the same uncertainty in the treatment of the subject, and the same confusion as in the earlier writers, arising from the application of the same term to meteors of very different origin. The article begins by stating that the *ignis fatuus* "is a luminous appearance of uncertain nature, which is occasionally seen in marshy places and churchyards. The phenomenon has been frequently described, but it has been observed so rarely in favourable circumstances by scientific men, that there is no satisfactory explanation." The theory that the meteor is due to ignited marsh-gas is dismissed as untenable, because the gas does not ignite spontaneously. The more plausible suggestion, that it is due to phosphuretted hydrogen, which ignites on contact with oxygen, is also rejected, on the ground that a German observer "passed his hand through the luminous appearance, and felt no warmth"; while another German "held the metal tip of a walking stick in the flame of a fixed *ignis fatuus* . . . for a quarter of an hour, but the metal was not warmed." The luminous appearances here referred to were evidently electrical, not gaseous, as was also the meteor, which was seen to "bound over the country like a ball of fire for half an hour at a time."

It is sufficiently evident that the compilers of the articles just quoted were not scientific chemists, nor had ever had any experience in laboratory practice. They seem to have derived their information from some of the older books of science, in which certain natural phenomena are attempted to be explained before the science of the subject had been discovered. Thus, previous to Franklin's great discovery of the identity of lightning with common or frictional electricity, that brilliant meteor was supposed to be due to the oil of plants evaporated during the heat of the day,

and set on fire in the sky. Ignorant, too, of gases, they could not explain phenomena due to that source. What they wrote up to the science of their time they generally wrote well, but they had the unfortunate habit of explaining within the terms of their own knowledge what lay far beyond it, and which it was the function of future men of science to discover. Such a writer was Dr. Van Musschenbroek, Professor of Mathematics and Philosophy in the University of Leyden. His Latin treatise on Natural Philosophy was translated by John Colson, M.A., F.R.S., Lucasian Professor of Mathematics in the University of Cambridge, and was printed for J. Nourse at the "Lamb," without Temple Bar, 1714. The following paragraph is copied from Vol. II., p. 291:—

"§ 1329. *Wandering fires, or ignis fatuus*, are of a round figure, in bigness like the flame of a candle, but sometimes broader, and like bundles of twigs set on fire. They sometimes give a brighter light than that of a wax candle, at other times more obscure, and of a purple colour. When viewed near at hand they shine less than at a distance. They wander about in the air, not far from the surface of the earth, and are more frequent in places that are unctuous, muddy, marshy, and abounding with reeds. They haunt burying places, places of execution, dunghills. They commonly appear in summer, and at the beginning of autumn. But in the country about Bononia they are seen throughout the whole year in a dark night. For there in a cold winter, and when the ground is covered with snow, they are in greater plenty than in the hottest summer. Those, also, are observed in winter which Gassendus says are seen at Rogon, a town of Provence. They appear more frequently in hot than in cold countries. In Italy, near Bononia, are the greatest, and in the greatest plenty. Sometimes they vanish on a sudden, and presently shine out in another place. They are generally at the height of about six feet from the ground. Now they dilate themselves, and now contract. Now they go on like waves, and rain, as it were, sparks of fire, but they burn nothing. They follow those that run away, and fly from those that follow them. Some that have been caught were observed to consist of a shining, viscous, and gelatinous matter, like the spawn of frogs, not hot or burning, but only shining, so that the matter seems to be phosphorous, prepared and raised from putrefied plants or carcasses by the heat of the sun, which is condensed by the cold of the evening, and then shines. Yet I do not think that the matter of all is the same, for without doubt those of Bononia differ from those of Holland. It is a mere fiction that these fires are evil spirits, or wandering ghosts, misleading travellers out of mere spite, to plunge them into ditches and bogs, as some trifling philosophers have told us."

In the above passage there are some good descriptions of low-lying meteors, but the writer cannot reconcile the phenomena as due to one source, for he does not suppose that "the matter of all is the same." With our present knowledge it is easy to recognize, in his description, three varieties of low-lying meteors, namely, the gaseous of two kinds, and the electrical. On the present occasion we will trace the history of the *ignis fatuus* properly so-called, reserving for another article the consideration of the other two meteors.

The first step towards a true explanation of the *ignis fatuus* was taken by Priestley, who in 1767 commenced his "Experiments and Observations on different kinds of Air," and thus laid the foundation of pneumatic chemistry. Among his experiments are a considerable number on the inflammable air produced during the decomposition of various kinds of vegetable matter, and he says: "The air from marshes also, which, with Sig. Volta, I doubt not comes from putrefying vegetable substances, I have also found to be equally permanent," that is, not absorbed by water as in the case of fixed air. Volta distinctly stated that the gas from marshes is the cause of the *ignis fatuus*, and that the gas is kindled by lightning or by an electric spark.

The next step was taken by the Abbé Bertholon, Professor of Experimental Physics at Languedoc, and member of various scientific societies. In 1787 he published a work on meteors, containing a chapter on the

ignis fatuus. Taking advantage, apparently, of Priestley's discoveries—for, as he appropriately remarks, it was impossible to explain the *ignis fatuus* before gases were discovered—he proceeds to describe the following capital experiment, which we must let him relate in his own language:—

“ Il est bien prouvé, par l'expérience et l'observation, que dans les marais, et les terrains marécageux, il y a de l'air inflammable; il suffit, pour en obtenir, de remuer avec une canne la vase de ces endroits, aussitôt on verra s'en échapper, à travers de l'eau qui en couvre plus ou moins la surface, une quantité assez considérable. Si dans cet instant on approche la lumière d'une bougie on verra aussitôt l'air inflammable s'allumer, et la flamme s'étendre au loin.”

The gas thus formed has been collected in bottles full of water inverted in the water of the marsh with a funnel in the neck of the bottle. On stirring the mud below, the gas enters the funnel in bubbles, and, rising up, displaces the water in the bottle. It was found by Sir Humphry Davy and others to contain carbonic acid and a small quantity of nitrogen, the proportion of either or both of which would, of course, influence the character of the flame. Davy found the pure gas to consist of four parts of hydrogen in chemical union with one part of carbon, identical in composition with the fire-damp of the coal mine. It is known as marsh-gas, or light carburetted hydrogen. It is the only source of the *ignis fatuus*, properly so called. It is ignited either by lightning or by an accidental flame. I knew it in one case to be ignited by a labourer passing by a marsh lighting his pipe and throwing the match away. Another case has recently come under my notice. An old pupil of mine informed me that four or five years ago he was rowing in a boat with some friends on a pool of some three acres in extent. A stream of water flowed through it, but the pool was stagnant, or nearly so, in the rear of an island in the pool. At this spot he noticed large bubbles of gas rising and bursting, and at once surmised that they contained marsh-gas. To test this he applied a lighted match, but not taking heed as to the direction of the wind, the flame from a large bubble instead of being blown away from him was blown towards him, and burnt all the hair from off the back of his hand. Many trees grew near the spot, and leaves fell abundantly into the water, so that in the course of years the decaying matter had produced a considerable deposit of mud, which necessitated the emptying and cleansing of the pool, after which the production of marsh-gas ceased.

The *ignis fatuus* is now seldom or never seen, and the reason is that the places which produced it have been drained and brought under cultivation. Some years ago, however, Major Blesson of Berlin made a number of capital experiments on the subject in a valley in the forest of Gubitz, in the Neumarek, where the meteor had been often seen. The valley cuts deeply into compact loam, and is marshy at its lower part. The water of the marsh contains iron, and is covered with a shining crust. During the day bubbles of gas were seen rising from it, and at night bluish-purple flames were observed playing over the surface. On visiting the spot by night, the sensitive flames retired as the major advanced; but on standing quite still, they returned, and he tried to light a piece of paper at them, but the current of air produced by his breath kept them at too great a distance. On turning away his head, and screening his breath, he succeeded in setting fire to the paper. He was also able to extinguish the flame by driving it before him to a part of the ground where no gas was produced; then applying a flame to the place whence the gas bubbles issued, a kind of explosion was heard over eight or nine square feet of the marsh; a red light was seen, which faded to a blue flame about three feet high, and this continued to burn with an unsteady

motion. As the morning dawned the flames became pale, and seemed to approach nearer and nearer to the earth, until at last they faded from sight. The same observer also made experiments in other places. At Malapane, in Upper Silesia, he passed several nights in a forest where the meteor was to be seen. In the Komski forest, in Poland, the flame appeared of a darker hue than usual, and on attempting to ignite paper and shavings of wood they became covered with a viscous kind of moisture, as in Musschenbroek's observation, when an *ignis fatuus* was “ caught.” On another occasion he succeeded in lighting up the meteor by standing at a distance and hurling ignited fireworks into the marshy ground. He visited by night the summit of the Porte Westphalia, near Minden; the meteor was not visible, but on firing a rocket into the marsh a number of small red flames were observed, which soon went out, but appeared again on firing another rocket.

Hence, it will be seen that the *ignis fatuus*, or “ will-o'-the-wisp” or “ jack-o'-lantern,” is due to the ignition of a gas arising from the decay of vegetable matter, and known as marsh-gas, or light carburetted hydrogen. Low-lying meteors due to phosphorus and electricity will be treated of in another article.

Letters.

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

To the Editor of KNOWLEDGE.

DEAR SIR,—May I suggest to the writer of “ The Astronomy of Shakspeare ” in KNOWLEDGE, that the seven stars referred to when Falstaff says, “ Indeed, you come near me now, Hal: for we that take purses, go by the moon and seven stars, and not by Phœbus,” are the seven stars forming Charles' Wain?—for this constellation, after the moon, forms the most conspicuous object of the night sky. Believe me, yours sincerely,

HAROLD M. COLLISON.

Hillsboro', Wallington, February 2nd, 1893.

[Mr. Collison is probably right, for in Shakspeare's time it was necessary to count in the sun and moon to make up the seven planets. Falstaff probably did not refer to the seven stars of the Pleiades, but to the better known seven conspicuous stars of the Great Bear, which pointed out the north and indicated the time to the intelligent traveller. A friend reminds me that the Latin and French word for north, *septentrionale*, is derived from these seven stars, and that the Great Bear is still commonly referred to in Italy as the seven stars.—A. C. RANFORD.]

THEORY OF THE SUN.

To the Editor of KNOWLEDGE.

SIR,—I hope you will allow me to answer briefly the objections enumerated in the last number of your magazine against my explanation of the prominences as *merely evanescent illuminations caused by the propagation of chemical action in comparatively tranquil matter*.

Miss Clerke states “ that the rate of propagation of chemical action is, so far as terrestrial experience goes, exceedingly slow as compared with the enormous velocities testified to by line-displacements in prominences.” That objection would be fatal if even the least analogy could be expected between the propagation of chemical action in the hot solar atmosphere and such a propagation in the ignited

explosive mixtures tested in our laboratories. But there is here no necessary analogy. In the explosive mixtures of our laboratories the propagation of chemical action is relatively slow, because each successive part of the mixture must needs be ignited and exploded by the heat evolved before the action can pass onward. In the explosive mixtures of the solar atmosphere such a heating cannot take place. *Chemical action is not caused there by a considerable heating, but by an almost infinitesimal cooling.* The cooling required is almost infinitesimal because the rate of dissociation of solar matter necessarily corresponds with the temperature. The cooling required will occur, and cross the solar atmosphere from the bottom to the top with the velocity of radiant heat, when the heat radiated by the photosphere is suddenly diminished by the forming of a spot or pore. If that sudden cause of cooling is not immediately attended by chemical action propagated also with the velocity of radiant heat, it is because the dissociated matter is not always ready to combine on the least loss of heat.

Another objection is "that the rapid translation towards or from the eye of the luminous condition in gases should give rise to greatly widened lines, unless the kindling action was instantaneously followed by extinction." Here I must remark that the prominence lines are sometimes greatly widened, and that in the cases where displacement is observed without widening there is no great difficulty in conceiving that the kindling is instantaneously followed by extinction.

The last objection of Miss Clerke is that *the forms of many prominences* seem to indicate real movements of matter; but I think that such indications must be accepted with caution. The cirri-clouds of our own atmosphere, for instance, seem also very often to be formed by real movements of their cloudy constituents. *But that appearance is surely misleading* when it is shown by cirri suddenly appearing, and then covering *almost instantaneously* a great part of the heavens with their straight or elegantly curved, parallel or divergent filaments. Many prominences have, moreover, very capricious and frequently broken forms, which show often-changing entirely discordant directions when suddenly appearing in the higher layers of the solar atmosphere, running in different directions with irregularly varying and *speedily increasing* velocities. They do not, to my mind, convey any idea of actual motion in a *resisting* medium. If the prominences, as we see them, consist of several prominences superposed on one another, the difficulty of explaining their sudden outbreaks in the higher layers of the solar atmosphere by the hypothesis of upward projection increases: for if it is difficult to assume that one prominence should have its connecting stem with the underlying photosphere hidden by some cool mass, the difficulty is increased when there are several co-existing prominences.

Your last objection is that solar observations "do not seem to point to an undisturbed stratification of the solar atmosphere in which the heavier gaseous compounds sink to the bottom." According to you the matter in the solar atmosphere is well churned and evenly mixed, and its different spectra at different levels are caused by differences of temperature. Your explanation, however, does not explain why the matter indicated by the spectroscopy in the lower regions is generally much *heavier* than the matter above. There is no reason why metals should require a higher temperature to show lines than hydrogen. It seems also to me very difficult to comprehend that in the close neighbourhood of the *immense* photosphere the temperature should be so low that iron vapour would not show its lines, for we know that even in the Bessemer flame those lines

are easily detected, and that they have also been observed in the immensely rarefied matter of comets when heated in the proximity of the sun.

Yours faithfully,

Dr. A. BRESTER, Jz.

Delft, Holland, February 16th, 1893.

[I have printed the parts of Dr. Brester's reply which seemed to me most cogent. His first point seems to amount to the statement that we know nothing about the chemistry of hot bodies, and therefore explosions on the sun *may* be propagated with the velocities which his theory requires. They are certainly not propagated in the sun with the velocity of radiant heat, and if it were possible that a spot or pore in the photosphere could throw a shadow, as Dr. Brester suggests, the cooling effect would be produced in radial lines from the sun, and not in the curiously contorted forms which the prominences present. On the one hand we have vague guesses at what the velocity of explosions with an unknown chemistry might be, and on the other we have the fact that the observed upward velocity of several of the great projection prominences has been shown to correspond with the velocity of matter projected upwards under the influence of solar gravity in a thin resisting medium.

How Dr. Brester reconciles his theory of explosions with a quiescent solar atmosphere I do not understand, for explosions seem to me to imply disturbance and the actual displacement of matter, so that if there were no such thing as gaseous diffusion the vaporous material of the sun would be speedily mixed. The spectra of terrestrial elements which can be recognized in the sun are not arranged vertically in the order of their vapour density, and we know that in the spectra of metals in the electric arc some lines are longer than others, that is, some of the lines are only visible in the hot central region of the arc, while others extend into the cooler outer region.—A. C. RANFORD.]

THE LIFE OF STARS.

To the Editor of KNOWLEDGE.

SIR,—I am not aware that the theorists who have written on the evolution of stars have hitherto attempted to trace out the effects of the supposed changes on the stellar spectra. I venture to offer a few suggestions on this topic.

Starting with the nebular theory, some form of which seems to be generally accepted, we would have a bright-line spectrum to commence with. If the nebula was distant and had shrunk to small dimensions it might be otherwise undistinguishable from a star. The continuous spectrum would not appear until condensation (probably into the liquid form) had commenced. But this might commence in two ways—the formation of a central solid (or rather liquid) nucleus and the formation of luminous clouds. The sun's photosphere probably is of the latter character. The solar spots seem to be breaks in the clouds, revealing glimpses either of a solid nucleus or of a second cloud-bank below. But these breaks are caused by disturbances which somewhat complicate the phenomena.

The light of a central nucleus would reach us through a great depth of absorbing gases. The dark lines would therefore in all probability be numerous and strongly marked; but bright lines might, I think, also be expected to appear. The hemisphere of the star turned towards us would consist of a solid portion seen through the gases, and another portion (and at early stages a much larger one) purely gaseous. The gas-light would thus come to

us from a much greater surface than the continuous light, and might make up in quantity what it wanted in intensity. Such a star would not, I think, be variable in the ordinary sense, but as time rolled on the continuous spectrum would become more powerful, the bright gas-lines would die out, and the dark absorption lines would become less numerous and less marked. The radius of the nucleus would become more nearly equal to that of the star, and the depth of the absorbing atmosphere would slowly diminish.

Cloud formations would produce different phenomena, for clouds could not be expected to remain constant, but to form, dissipate, and reform, though slowly increasing on the whole. They would probably not form at the outer surface of the nebula (since only the lighter and finer gases, such as hydrogen, would be found there), but at some depth below. Absorption-lines, particularly of the lighter gases, might therefore be expected, though not so numerous or so well marked as when the light came from a central nucleus. Bright lines would probably appear at the earlier stages also, for the clouds would not cover the entire surface. The rotation of the star on its axis would probably produce variations of a periodic kind, for it is not likely that the clouds would be equally developed on both hemispheres of the star until they had formed to such an extent as to cover almost the entire surface. Gradually the variations would cease and bright lines die out, the entire surface becoming clouded over.

These deductions partly agree with and partly differ from the results of observation. Stars presenting the phenomena indicative of a central nucleus seem more inclined to variation than those whose phenomena are suggestive of clouds. Perhaps, instead of a central nucleus, clouds are formed at a great depth in such cases. Again, in the cloud-stars the bright lines should be most conspicuous when there is least cloud, *i. e.*, at the minimum, but they seem to be most conspicuous at the maximum. Of this I see no satisfactory explanation. An outburst of highly-heated gases through a break in the cloud might perhaps produce this effect, but if sunspots are of this character they are always darker than the surrounding portion of the surface. Messrs. Carrington and Hodgson, however, observed a phenomenon of a different kind on one well-known occasion.

Truly yours,

W. H. S. MONCK.

THE γ ARGÛS REGION OF THE MILKY WAY.

By A. C. RANYARD.

WE are indebted to Mr. H. C. Russell, Director of the Sydney Observatory, New South Wales, for the two photographs given in this month's number of KNOWLEDGE. They represent, on different scales, the remarkable region of the southern Milky Way around the variable star γ ArgÛs. At first sight it is not easy to compare them or to recognize what part of the one picture is represented on a larger scale in the other.

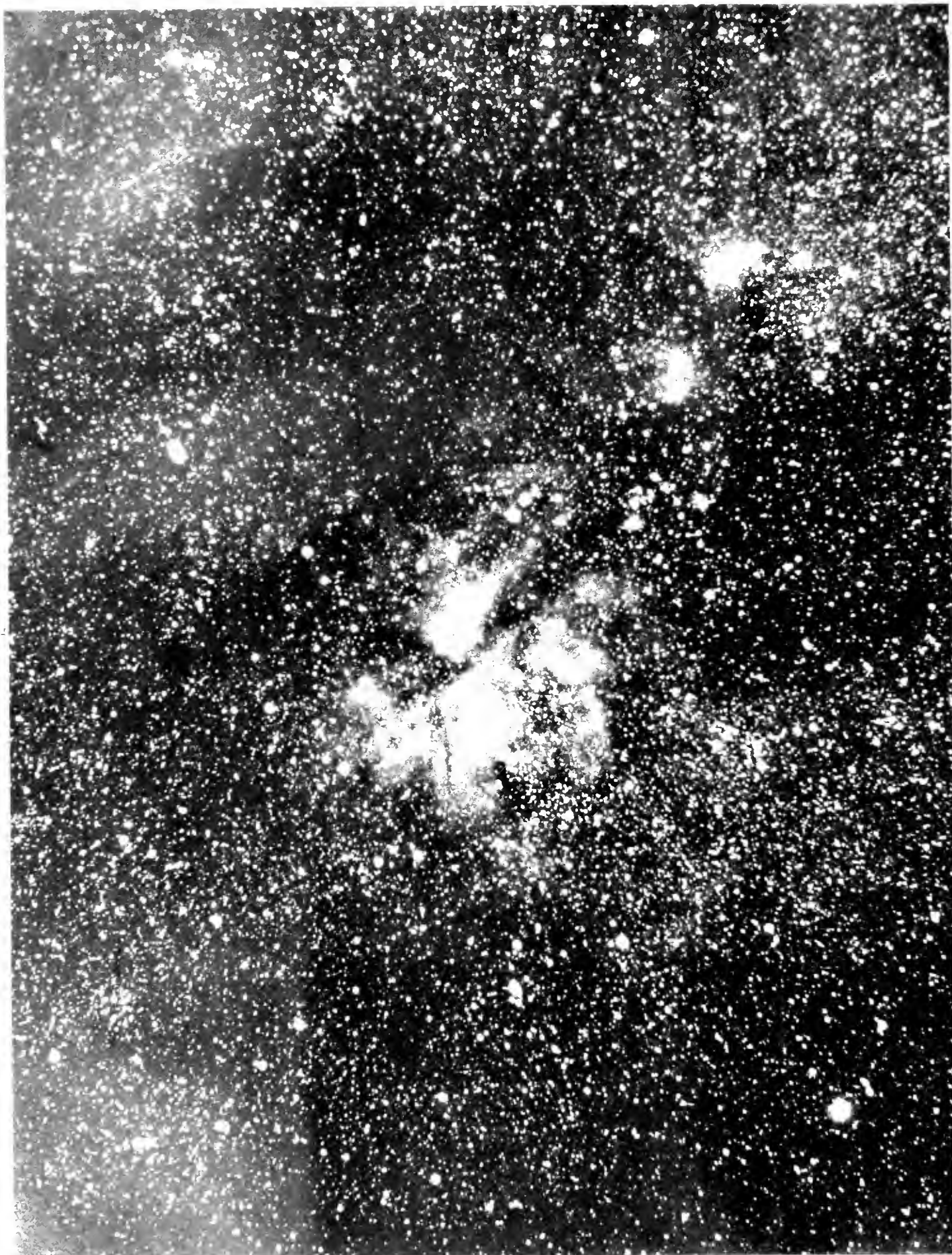
The left-hand picture was taken with a short focused instrument, which threw an intensely bright but small image on the plate, while the right-hand picture was taken with a 13-inch refracting telescope of about eleven feet focal length, used at the Sydney Observatory for the international photographic survey of the heavens. The image thrown by it upon the sensitive plate was larger and fainter, but more sharply defined, than the image thrown by the smaller instrument, consequently the right-hand picture does not show the fainter outlying parts of the nebula, which are shown in the other picture, but it shows

the nebulous structure on a larger scale. In fact the whole region shown in the right-hand picture is comprised within an area of about two inches by three, near to the centre of the left-hand plate.

This region of the Milky Way shows some dark channels and dark structures, which are such striking features when seen in the telescope that they attracted the attention of Sir John Herschel, and are minutely described by him in the "Cape Observations." He also recognized the connection between the dark regions and the lines of stars which border them. The facts disclosed point to such important conclusions that I propose to reproduce Sir John Herschel's drawing in another number of KNOWLEDGE, together with an additional large photograph of this region, and will postpone any remarks with regard to the dark structures till all the photographs are before my readers for comparison.

In the meantime those who are interested in the subject will find a photograph on a small scale of the γ ArgÛs region and surrounding clusters in the June number of KNOWLEDGE for 1891. It shows the exceptional character of this region of the Milky Way. As Herschel remarked, it is coarser grained than other parts of the galaxy, and is rich in loosely-packed clusters of stars. The γ ArgÛs nebula is a star cluster as well as a nebula, and the question, What is a nebula? seems to be intimately associated with the equally difficult question, What is a star cluster?

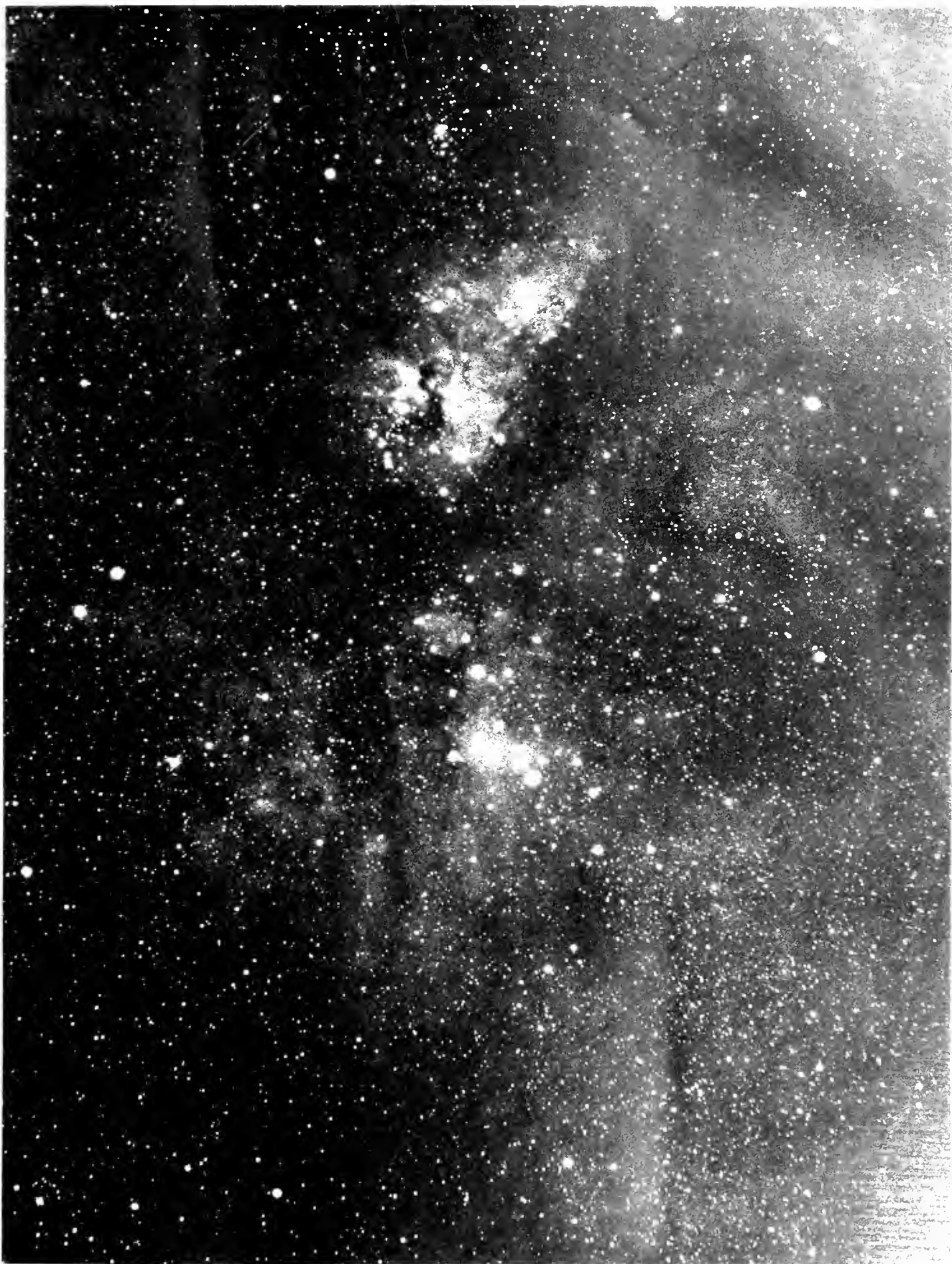
The variable star γ ArgÛs, which gives its name to this nebulous cluster, is a reddish star now too small to be visible to the naked eye. It is immersed in the nebulosity on the following side of the dark structure, or hole in the nebula, which Herschel named the "key-hole," though it looks very little like a key-hole in these photographs. γ ArgÛs is in the upper or northern nebulous mass surrounded by a number of smaller stars. It was first observed by Halley, at St. Helena, in 1677, and was rated by him as of the 4th magnitude. According to Winnecke, it was next seen by Père Noël, a Jesuit missionary, in China, about ten years later, who rated it as a 2nd magnitude star, as it also appeared to Lacaille sixty-four years later, in 1751. Sir John Herschel mentions that in the subsequent catalogues of Fallows (1822), Brisbane (1826), Johnson (1832), and Taylor, it was ranked as a star of the 2nd magnitude, but that it was observed in February, 1827, by Mr. W. J. Burchell, at San Paulo, in Brazil, to be as brilliant as α Crucis. Another vigorous outburst of its light was observed by Sir John Herschel at the Cape, on the 16th December, 1837. It suddenly increased from the 2nd magnitude and became as bright as Rigel. It continued to increase in brightness till the 2nd of January, 1838, when it was as bright as α Centauri. It then declined in brightness and again increased, then decreased and increased again, till, in April, 1843, Sirius alone amongst the fixed stars slightly outshone it. This intense brightness was maintained for some ten years, when it was observed by Gilliss at Santiago in 1850 as very little inferior to Canopus in light, and in colour to be more deeply tinged with red than Mars. According to Miss Clerke, who gives a curve representing its changes of brightness (see her *System of the Stars*, p. 118), it was still of the first magnitude in 1856, it fell to the second in 1858, to the third in 1859, and ceased to be visible to the naked eye in 1868. Twenty years later its magnitude was rated by Mr. Finlay at the Cape as 7.6. Since that time it has slightly increased in brightness, and its tint has changed from "dull scarlet" to "bright orange." Evidently changes are still going on; the observations seem to indicate that it is an irregular variable, rather than a star having a regular period of change.



Preceding

THE η ARGUS REGION OF THE MILKY WAY.

FIG. 1. Photographed by the Sargoy Observatory, with a perfect lens by Dallmeyer of 6 inch aperture and 5 inch focal length. $\theta = 10^{\circ} 30'$. $\lambda = 4$. The scale of this enlargement is approximately 48 in. = 1".



PHOTOGRAPH OF THE η ARGUS NEBULA.

Taken by Mr. H. C. Russell, with the Astro-Photo telescope of 13 inches aperture used for the International Survey of the Heavens, at the Lick Observatory, California, U. S. A. Enlargement $6\frac{1}{2}$ times. Total Exposure 5 hours.

Notices of Books.

Familiar Studies in Homer. By Agnes E. Clerke (Longmans, Green & Co.). Miss Clerke, who is well known to our readers by her astronomical writings, treats in this delightful book of many details of life and civilization during Homeric times. The volume is a collection of essays or articles, many of which have been already published in the pages of *Nature*, *Macmillan*, and the *British Quarterly Review*. In discussing the Homeric knowledge of astronomy Miss Clerke points out that none of the planets are referred to in either the Iliad or the Odyssey, though many of the fixed stars and constellations are described and named, a fact which points to the high antiquity of the Homeric poems. Hesiod, she remarks, appears equally unconscious, with Homer, of the distinction between the "fixed" and "wandering" stars. In another chapter Miss Clerke deals with "Homeric Horses," "The Dog in Homer," "The Metals in Homer." A very interesting chapter is that on Homeric meals. The Homeric bill of fare was concise and admitted of slight diversification. Day after day, says Miss Clerke, and at meal after meal, roast meat, bread, and wine were set before perennially eager guests, in whose esteem any fundamental change in the materials of the banquet would certainly have been for the worse. Variety, in fact, was in the inverse ratio of abundance; butcher's meat (as we call it) was the staple food of Greek heroes. Oxen, however, were not recklessly slaughtered; "great meals of beef" usually honoured great occasions. The fat beasts, reckoned to be in their prime at five years old, met their fate for the most part in connection with some expiatory ceremony, as that employed to stay the pestilence in the First Iliad. The gods were served first with tit-bits wrapped in fat and reduced by fire to ashes with steamy odours, supposed to be peculiarly grateful to immortal nostrils. Vegetables figured very scantily, if at all, at Achaean feasts; one species only is expressly apportioned for heroic consumption. Nestor and Machaon were guilty of eating onions as a relish with wine. Wine was also mixed with goat's cheese and honey, and esteemed the most refreshing and delightful of drinks. The book is interesting from beginning to end, and can be heartily recommended.

Astronomy for Every-day Readers. By B. J. Hopkins (London: Geo. Philip and Son, 1893). This well-illustrated little book explains in a simple and very elementary manner the phenomena of the tides, the seasons, eclipses and occultations, meteors, shooting stars, and comets. The chapter on the phenomena of meteors is especially interesting, as Mr. Hopkins is himself a practical observer of meteors. At page 78 he gives a good picture of the corona visible in Egypt during the eclipse of 1882, but it is turned the wrong way up, and the comet which was shown on the eclipse photographs at a distance of about a radius from the sun's limb has been tampered with by the artist and turned round so that its tail, in the neighbourhood of the nucleus, is directed nearly radially towards the sun's centre, as is usually the case with comets, but in this instance it was inclined at a considerable angle to the radius vector. As this cannot be an effect due to perspective, it probably indicates that the comet, when near to perihelion, was moving very rapidly compared with the velocity with which the matter of its tail was being driven backward from its nucleus.

Remarkable Comets. By William Thynne Lynn (Edward Stanford, 1893). Mr. Lynn's gift for historical research is already well known. In this little book of forty pages he brings together a mass of historical information with respect to the more remarkable periodical comets, which will be found generally interesting as well as valuable to

the student. Mr. Lynn barely attempts to deal with the physical constitution of comets, but some of his remarks are original and bold. Speaking of the observed connection between some comets and meteor streams, he says "It is quite possible that the observed identity of orbits, instead of showing community of composition, simply arises from the comet having been caught and kept in duration by the meteors. The small mass of comets is evidenced by the absolutely imperceptible effect produced in altering the motions of the planets and their satellites when comets have approached them." Thus Lexell's comet is instanced as having passed nearer to Jupiter than its most distant satellite, without having produced any recognizable change in the orbit of the planet or its satellites, though the orbit of the comet was entirely changed by the *rencontre*.

Science Notes.

Prof. C. A. Young, in a recent letter, states that he sees the fifth satellite of Jupiter with the Princeton 23-inch achromatic whenever circumstances are favourable at the time of elongation. He makes the period 11h. 57m. 1s.

Two parties are leaving England to make observations during the solar eclipse of April 15th—16th. One will be stationed at Para Cura, in Brazil; the other, about sixty miles from Bathurst, on the West Coast of Africa. The sun will be totally eclipsed for 1 min. 43 secs. at the former station, and 4 min. 12 secs. at the latter.

An electric locomotive of about 2000 horse power, or more than the power of the largest steam locomotive, is reported as finished at Baden Zurich.

In the January number of the *American Journal of Science*, Mr. Clarence King has a paper on "The Age of the Earth," in which he has applied some recent work in geological physics to Lord Kelvin's reasoning as to the probable rate at which the earth has cooled, and by this means he arrives at the value of twenty-four million years for the earth's age.

It has recently been decided in the American Supreme Court that a meteorite, though a stone fallen from heaven, belongs to the owner of the freehold interest in the land on which it falls, and not to the tenant.

Wiedemann's Annalen contains an account of a number of experiments made by Mr. Wesendonck to determine whether electricity is produced by the friction of gases. The results show that no electrification is produced by the friction of pure gases, or of air freed from dust and moisture, but only when solid or liquid particles are suspended in them.

It has recently been shown in Germany that light exercises a deleterious action upon certain micro-organisms, so that the natural purification of sewage matter in rivers during their flow must be partly due to sunlight. Another investigator has found that red rays favoured the growth of certain bacteria, whilst violet rays acted prejudicially—although less so than the white rays.

It is well known that extreme cold paralyzes every vital function, but Prof. Pictet has discovered that at a temperature of -150° C. no chemical action takes place between nitric or sulphuric acid and potash, or between oxygen and potassium, though, under ordinary circumstances, so great is the affinity of the latter metal for oxygen that it will burn if thrown into water, owing to its combination with the oxygen in that fluid.

Prof. Crookes and others have for some years been making experiments which go to prove that the so-called elements have not the absolutely fixed atomic weights generally assigned to them, or that there exist a great number of unrecognized substances shading off by almost imperceptible differences from one element towards another. The latest experiment is that of Lord Rayleigh, who has prepared nitrogen by two different methods, and finds the atomic weight of one specimen to be one-thousandth part less than that of the other.

By the reflecting power of a surface is meant the ratio of the amount of light reflected by it to the total amount of light incident upon it. Zollner and others have determined this ratio for various substances, and also for the planets and some of their satellites. Dr. Sumpner has recently made a number of similar measures of the reflecting powers of common materials. He finds that white blotting paper reflects 82 per cent. of the incident light; white cartridge paper, 80 per cent.; tracing cloth, 35 per cent.; ordinary foolscap, 70 per cent.; deep chocolate paper, 4 per cent.; and black velvet, only 0.4 per cent.

We are glad to notice (says *Natural Science*) that the New Zealand Government is actively engaged in preventing the total extinction of the rarer plants and animals of the colony. Acting on the advice of Mr. Henry Wright, the Government has arranged for the purchase of Little Barrier, or Huturu Island, near Auckland, which will be kept as a national preserve. This island measures $4\frac{1}{2}$ miles in length by $3\frac{1}{2}$ miles in breadth, and rises in the centre to an elevation of 2000 feet. It is generally rugged, but there is comparatively flat land at the northern and southern extremities. Even now its flora and fauna are particularly rich and varied, and no more suitable area could have been secured.

The illustration of scientific lectures or papers by means of lantern slides is becoming fairly general, and it certainly tends to render the meetings of learned societies more instructive as well as more interesting. In this way the physical features of a country, or the microscopic structure of a rock, the organisms of sewage, or the "extinct monsters" of many geological periods, may be reproduced on the screen from photographs or original drawings. The Astronomical Society, the Royal Society, the Linnean Society, the Royal and the London Institutions, the Geologists' Association, and probably other bodies in London, have introduced the lantern into their meeting rooms with marked success; the Geological Society, however, has hitherto held aloof.

It has been asserted that anomalous disturbances of magnetic needles have occurred when brilliant faculae were visible near the middle of the sun's disc; and the conclusion jumped at was that the two phenomena were intimately connected. In the *Comptes Rendus* of February 6th, Prof. George Hale deals with this theory. Photographs of the sun have been taken with the spectro-heliograph of Kenwood Observatory since the beginning of last year. Of the 112 pictures obtained, 132 show one or more groups of faculae on or near the central meridian of the solar disc. It would therefore have been difficult to find an unusual movement of the magnetic needle which did not coincide with the appearance of faculae near to the middle of the sun's disc.

The engineer of the Channel Tunnel Company makes the following statement in his recent report of the trial boring for coal—"The coal boring has now reached a depth of 2228 feet, including 1071 feet of coal measures in which nine workable seams have been found, containing altogether 20 feet in thickness of good bituminous coal. This coal is suitable for gas making and household purposes. The deepest seam, 4 feet in thickness, was met with at 2222 feet from the surface."

A series of very interesting photographs has been made illustrating the movements of the growing parts of such climbing plants as the convolvulus and the hop plant. It is said that the "movement of the young stems consists of a succession of irregular circular or elliptical curves which vary every moment, even in their direction." This successive series of photographic records reveals some interesting facts. For instance, it is found that, even when they are asleep, plants move continuously, and not intermittently, as was formerly supposed.

Mr. Edmund G. Gardner, of Cambridge, contributes to *Nature* (Jan. 26th) a most interesting article on Dante's "Inquiry concerning Water and Land." The treatise is little known in comparison with the other writings of the poet, but its genuineness and importance are now almost universally admitted. It seems to have been his last work, and has not yet been translated into English. According to this work, a good deal of so-called modern science was anticipated by the great Italian poet. Mr. Gardner concludes by giving a list of nine scientific truths about the earth known to Dante, amongst which are (1) the moon, the principal cause of tides; (2) equality of the sea's level; (3) "centripetal force"; (4) sphericity of the earth; (5) northern grouping of the continents; (6) universal attraction; (7) elasticity of vapours as a motive power. The reader is referred to Signor A. Stopani ("La questione dell'Acqua e della Terra di Dante Alighieri," in "Opp. Lat. di Dante," ed. Gniliari, Vol. II.).

A large audience assembled at the Royal Institution on February 21st, to hear Prof. Dewar lecture on "Liquid Air." Until recently, liquid oxygen was a curiosity, only produced in very small quantities—too small and too evanescent to admit of any exact examination of its properties. Prof. Dewar produces it by the pint, and demonstrated its more obvious physical properties—its beautiful blue colour, somewhat like the blue of the sky, its high magnetic quality, and its characteristic spectrum—with as much facility as if he had been dealing with water. He surrounds the vessel containing the liquid with a high vacuum, in order to reduce the flow of heat, by convection, not by radiation, as was suggested in the *Times*. Liquid air behaves in the magnetic field and in the spectro-scope simply as diluted oxygen. When the liquid is allowed to boil, the nitrogen distils off first (having a lower boiling point), and the oxygen follows.

Dr. Gilbert, of the U.S. Geological Survey, communicated a quaint paper on the origin of lunar craters to the National Academy of Science, in November, 1892. His theory is based upon the phenomena of the planet Saturn and its ring. "Assume," says Dr. Gilbert, "that a similar ring of minute satellites once encircled the earth, and that these gradually became aggregated into a smaller number of larger satellites, and eventually into a single satellite—the moon. The craters mark the spots where the last of the small bodies collided with the surface,

when they finally lost their independence and joined the larger body." According to Dr. Gilbert's theory the moon would have been most bombarded in its equatorial regions. But there are very numerous craters in the neighbourhood of the lunar poles; indeed, the polar regions seem to have been more disturbed by what is usually spoken of as volcanic action than the lunar equatorial regions. On the side of the moon turned towards us the planes seem to be aggregated towards a zone which is not greatly inclined to the plane of the lunar orbit.

A novel idea was brought out by Mr. Francis Galton in a lecture delivered at the Royal Institution on January 17th. It consists in expressing outline drawings by means of letters or numbers. Anyone can understand that sketches of a face, or an outline map, can be reproduced by arranging a number of small discs or counters so as to imitate the alignment of figures and that any figure could be constructed, step by step, if the bearing of each disc, with respect to the one before it, is known. Suppose each of the sixteen principal points of the compass is represented by a separate letter of the alphabet, and it were desired to translate a map of England into a formula on Mr. Galton's plan. The outline would be imitated by laying down a series of small discs on a flat surface. Then, beginning, say from Land's End, the bearing of such disc with respect to the preceding one would be observed, and the letter which distinguishes the bearing, would be written down. When this has been done for the entire map, a string of letters is obtained as its formula. The map could afterwards be reconstructed from this formula at any place by laying down discs or points in the manner indicated by the letters. The utility of translating a drawing into a formula, and then reconstructing the same drawing from it, is not obvious at first sight; but when it is remembered that such a formula could be transmitted by telegraph, the importance of the plan becomes apparent. The site of a battle, the plan of a newly-explored region, a design, or even a portrait, could be wired as easily as any other information, and the cost need not be great. Mr. Galton exhibited a map of England at the lecture made with 248 dots, and its cost of transmission from the United States would only be about £5, which is small in comparison with the amounts spent by newspapers on telegraphic information. It seems very probable, therefore, that pictorial telegraphy "may have a future."

THE CONSTITUTION OF GASES.

By J. J. STEWART, of Emmanuel College, Cambridge.

WITHIN comparatively recent years, it was generally taught that the pressure exerted by a gas on the sides of the vessel which contained it was due to a mutual repulsion of the particles of the gas. Now, the beautiful kinetic theory of gases furnishes us with a much more satisfactory and withal more simple explanation of the behaviour of gases. While this hypothesis, in its main features, is simple, and easily understood, to advance any distance into its method and results requires considerable mathematical knowledge. Still, as the statement of the principal laws of matter in the gaseous state, in accordance with the kinetic theory, can be readily made and grasped. I propose to endeavour shortly to give the results hitherto arrived at by scientific men working in this department of physics, together perhaps with some of their methods of investigation, so far as the latter can be done without the aid of mathematical symbols.

The anticipations of modern discovery which were made by some of the keener intellects, among the ancient Greeks especially, is most remarkable. The idea that many of the observed properties of bodies around us, which are apparently at rest, are due to the particles composing these bodies being in reality in a state of rapid motion amongst themselves, is to be found distinctly stated by the Roman writer Lucretius. His conception of atoms "strong in solid singleness" comes surprisingly near to some modern hypotheses as to the constitution of matter.

The atomic theory of matter was expounded by Democritus of Abdera, in Thrace, and the interest felt at that time, *i.e.*, about 450 B.C., in such questions is shown by the fact that the lecturer realized a handsome sum in talents of gold.

Anaxagoras, known as the teacher of Socrates, stated a theory which was diametrically opposed to that of Democritus. According to his speculations, matter is infinitely divisible; the smallest divided portions can again be divided, and this without end. Thus he considered matter to be homogeneous, to have the same structure throughout, and that there was no limit to the smallness of the possible particles.

On the other hand, Democritus taught that matter is not infinitely divisible, but that if we could continually divide up portions of matter we would at length reach particles which could no further be divided, *i.e.* atoms—things which cannot be cut. In this belief Democritus was followed by Epicurus and Lucretius, and it is to a very similar idea that modern research has been led. But the present views of physicists are founded on the method of questioning Nature by experiment, and reasoning on the results found in answer to their enquiries. These ancient philosophers spun their more or less ingenious theories out of *a priori* notions in their own minds.

Daniel Bernoulli, the mathematician, born in 1700, was probably the originator of the thought that the pressure exerted by a gas on the walls of its containing vessel is caused by the bombardment of these walls by the minute particles of matter making up the gas. For long after his time no further step was made in discovery, and his remark seems to have remained comparatively unnoticed.

Roughly stated, the kinetic theory of gases may be said to be this: A gas consists of separate particles or molecules of matter at a distance from each other, and of excessive smallness; these are continually flying about in all directions, and in their passage they strike against each other, and also against surrounding bodies. Imagine a volume of gas shut into a glass vessel, then the sides of this vessel are exposed to a continual bombardment from the particles of the gas dashing against them. This bombardment of molecules is so continuous and rapid, and the number of particles which strike against a given portion of the containing walls is so large, that the result is a pressure outwards on the vessel caused by the gas, and this being resisted by the rigidity of the glass, an equal and opposite pressure inwards balances the pressure outwards exerted by the gas. Though we can never hope to capture or to see a single molecule, yet many experiments and considerations, converging from different starting-points, prove that something of this sort goes on in all gaseous bodies. Of course the assumption of a hard solid atom is entirely arbitrary, and can only be considered a first approximation to the actual truth; yet many of the properties of matter can be explained on the hypothesis that it is made up of such hard spheres, and thus this conception is a valuable aid to fixing and making definite our views as to the constitution of matter. It also serves to express concisely the results arrived at by experimental

research; though it must be insisted on that the actual constitution of matter is a yet unpenetrated mystery, and one which some able physicists consider to be quite beyond the powers of man to solve. After Bernoulli's time, Lesage, of Geneva, and Prevost applied the theory to explain various phenomena. Herapath also worked in the same field.

In the year 1848, Dr. Joule, of world-wide fame from his researches on the dynamical theory of heat, explained the pressure of gases as being due to the impact of their molecules, and not only this, but he also calculated the velocity which these particles must have in order to produce the observed pressure. It is, however, to Clausius in Germany, and to Clerk Maxwell in our own country, that we chiefly owe the mathematical development of this subject. These physicists, starting from the mathematical theory of probability, and using a statistical method of investigation, which they applied to companies of molecules, arrived at results which agreed with the test of experiment, and which could be applied to whole aggregates of molecules existing under certain conditions, though the behaviour of a single molecule, considered by itself, might be unknown and untraceable.

All portions of matter, whether in the solid, liquid, or gaseous state, consist of a finite number of very minute parts or molecules. This particle or molecule is not necessarily homogeneous throughout, but from chemical considerations we must suppose it to consist of two or more atoms. These atoms, which together make up the molecule of a substance, may consist of matter of the same kind, or of a different kind. A molecule made up of similar atoms forms a particle of an element, *i.e.*, a body which cannot be split up into two different sorts of matter. A molecule made up of differing atoms forms the smallest portion of a *compound*. A molecule may be defined as the smallest conceivable portion of a substance which can move about freely by itself without its constituent atoms parting company.

In solids the molecules can move with reference to each other, but only with difficulty, and they are never outside the influence of neighbouring molecules. Their excursions from one spot are probably of the nature of vibrations. In the case of liquids the constituent molecules are much more free to move about amongst themselves. The particles of the liquid can slide past each other, and the liquid exhibits mobility—it takes the form of the vessel which contains it. A molecule in a liquid can, in course of time, penetrate to any part of the liquid mass, but its course must be a slow one, as it will continually run against other molecules, and have its path changed.

When we come to consider gases, it is seen that here each molecule leads a more independent existence. In a gas at ordinary temperature and pressure, during the greater part of the path of a molecule it is not in direct contact with its fellows.

As during this "free path" of the molecule it is not acted on by any sensible force, it tends to move onwards in a straight line. Soon, however, it encounters another molecule, and from the collision between the two both the velocity and direction of the moving molecules are altered. Each starts off again in a new and different direction, again in course of time to come into contact with other molecules. The free motion of a molecule takes up considerably more time than the duration of an encounter; but as the density of the gas increases there are more and more gas molecules in a given space, and thus they strike each other more frequently, the length of their undisturbed path diminishes, and at length, if the gas is still further condensed, it becomes a liquid in which no portion of a

molecule's course can be called its free path; it never gets beyond the influence of its neighbours.

In an encounter between two molecules, since the force of the impact acts between the two masses, the motion of the common centre of gravity of the two molecules must be the same after the collision as it was before. Also it follows from the principle of the conservation of energy, that the velocity of each molecule relatively to their common centre of gravity continues the same in magnitude but may be changed in direction.

It necessarily follows that the velocities must vary as we pass from molecule to molecule. For even if we could imagine all the molecules to be moving with the same velocity at a given instant this velocity would soon be changed by the successive encounters between the molecules. Some of the constituent particles may have a relatively very high velocity, others may be moving comparatively slowly, while most of them will have various velocities intermediate between the highest and lowest.

If the systems of moving molecules be divided into groups according to the velocity which they may have at the instant considered, a regular progression is observed as to the number of molecules which fall into each separate group. At the same time the motion of a simple molecule, if it were possible to follow it, would be found to be exceedingly changeable and irregular. The behaviour of the groups may be stable but the individual molecules making up these groups are continually changing; a molecule belonging to one group or another, according to its velocity at a given instant, and of course belonging to different groups at different parts of its career. This statistical method of investigation resembles somewhat the method of obtaining average characteristics of classes of the community, these being made up of individuals differing amongst themselves; and the results attained are only true when considered as giving broad characteristic outlines of masses of people. The distribution of the molecules according to the speeds with which they are moving is calculated by the theory of probability, and this distribution is found to be of the same mathematical form as that of the marks made on a target when these are arranged according to their distances from the centre aimed at, always supposing that the shots fired are numerous, and that the riflemen have the same degree of skill.

To compare such systems of moving molecules together, it is desirable to take the mean of the *squares* of all the velocities, for the effect of a blow struck by a projectile depends upon the square of its velocity. This is referred to as the *mean square* of the velocity, and the square root of this mean square is called the "velocity of mean square."

Clerk Maxwell has shown that if two sets of molecules whose mass is different are in motion in the same vessel they will, by continually striking against each other, exchange energy until the average kinetic energy of one molecule of either set is the same.

Let M_1 represent the mass of one molecule of the first kind, and M_2 the mass of a molecule of the second sort, while V_1 and V_2 are equal to their respective velocities, then ultimately we shall have $M_1 V_1^2 = M_2 V_2^2$.

In the case of any mass M , with a velocity V , the *kinetic energy* is equal to $\frac{1}{2} M V^2$. So if we call M the mass of a single molecule, and V its velocity of translation, its average kinetic energy is expressed by $\frac{1}{2} M V^2$. But this is not the only energy which the molecule may possess, for any given molecule (with perhaps one or two exceptions, as that of mercury vapour) is made up of constituent parts, it contains two or more atoms, and these may have relative motions amongst themselves, and besides, the molecule as

a whole may have a motion of rotation. All these secondary kinds of motion, which do not consist of motion of the molecule as a whole from place to place, are considered separately and called the internal energy of the molecule. The determination of its nature and amount is a problem of extreme difficulty, and is yet unsolved, though the ratio of the energy of translation or agitation to the internal energy is in some cases known or guessed at.

(To be continued.)

LIVING FOSSILS.

By R. LYDERKER, B.A.

IN an article entitled "The Oldest Fishes and their Fins,"* it was pointed out how that through the discovery of the Australian lung-fish † (*Plecrotodus*), the ancient mesozoic fauna of Europe was brought into much closer connection with that of the present day than had hitherto been supposed to be the case. This, however, is by no means a solitary instance of the discovery in a living condition of forms of life which have been regarded as long extinct; and since the subject of the survival of ancient types in remote corners of the earth or the abysses of the ocean is one of wide interest, we propose to consider it in some detail in the present article. For such survivors from a distant past we venture to suggest the title of "living fossils," seeing that for the most part they have but little in common with the dominant fauna of the greater part of the world; while their alliance with extinct types is of the most intimate kind. It is of course difficult to know where to draw the line in the use of such an arbitrary designation; but we shall endeavour to restrict the term either to types which, although still more or less abundantly represented at the present day, are of extreme antiquity, or to such as are now represented by comparatively few forms, living either in distant parts of the world, or in the ocean depths, but which were abundant in past epochs. Of those coming under the latter category, the majority, as might have been expected, were first made known to science from the evidence of their petrified remains, while their existing relatives were not discovered till later. Whether, however, the extinct or the living types were the first to be discovered, the progress of research has been gradually tending to connect the past more intimately with the present than was originally supposed to have been the case.

Our first examples of "living fossils" will be taken from the mollusca, among which the gastropods, described under the name of *Pleurotomaria*, afford the most striking instance. The shells of this genus, which are frequently very elaborately sculptured, have a general external resemblance to a *Turbo* or a *Trochus*, but are readily distinguished by a deep horizontal slit in the middle of the outer wall of the mouth, from which the genus takes its name. The genus *Pleurotomaria* was originally established in the year 1826 on the evidence of a species from the English lias;



FIG. 1. — Shell of *Pleurotomaria*. (After Dr. H. Woodward.)

and a host of other extinct kinds were subsequently described, ranging from the silurian to the chalk. Till 1855, no one, however, had the least idea that the genus was

still existing, but in that year a living specimen was obtained off Mariagalante, which was subsequently sold in London in 1875 for £25. The species to which this first recent specimen belonged was named *P. quoyana*; and three examples of the same form have subsequently been obtained. The next discovery of a *Pleurotomaria* occurred in 1861, when an imperfect specimen of another species (*P. alansonia*) was obtained. A second example of this same species was taken in 1852 near Guadaloupe, and three others are in existence, while a seventh was purchased in 1890 at Tobago by Mr. R. J. S. Guppy. The latter example was a very large shell, measuring just under six inches in height; and it was also distinguished by its striking coloration, being marked by a number of oblique splashes of reddish-orange on a pale flesh-coloured ground. A third species of the genus (*P. boydii*), represented of the natural size in our figure, was first obtained from Japanese waters in 1877; and three examples have been subsequently secured. Finally, the fourth and largest living species is only known by a single example, which was recognized in 1879 among a collection of shells at Rotterdam, and is believed to have come from the Moluccas. The height of this fine shell is six and three-quarter inches.

It will thus be apparent that only fourteen specimens of living *Pleurotomaria*, referable to four distinct species, are at present known to zoologists. These molluscs, which are known to inhabit deep water on rocky bottoms, must therefore be extremely rare; although from the nature of their habitat it is probable that not so many specimens are obtained as might otherwise be the case. In the tertiary period, according to Dr. H. Woodward, only eleven species are known, of which two are from the pleistocene, two from the miocene, and seven from the eocene. Directly, however, we reach the cretaceous, the number of species suddenly leaps up to 208, while the total number of secondary and palaeozoic species is upwards of 1115. Accordingly, out of a total of 1160 representatives of the genus, only fifteen are of post-cretaceous age, of which only four now exist, and these apparently poorly represented in individuals. Here, then, we have indeed a striking instance of a "living fossil."

The well-known bivalve shells named *Trigonia* afford a scarcely less well-marked case of the persistence of early types. This genus was originally named in 1791, on the evidence of an extinct species, but when fully described by Lamarek in 1801 some few recent living examples had also been obtained. For the benefit of those of our readers who may not be familiar with these molluscs, it may be mentioned that the living *Trigonia* are rather small shells, of about an inch and a half in diameter, characterized by their somewhat triangular shape, and the strongly marked transverse ribs, marked with rough tubercles on the outer surface. Internally the shell has a polychroic pearly lustre; while the peculiarly-shaped and striated interlocking hinge, when once seen, can never be mistaken. At the present day the *Trigonia* are represented only by some five closely allied species, confined to the Australian seas; while in the tertiary, although more widely distributed, they were likewise rare. In the secondary period, where they range down to the lias, these shells were, however, extremely abundant, and attained far larger dimensions than their existing relatives. Indeed, in the oolites *Trigonia* were some of the most common molluscs, whole slabs of rock being sometimes found paved with their handsomely sculptured shells, while all who have visited the Isle of Portland must be familiar with the countless swarms in which casts of their shells occur in the so-called "roach-

* KNOWLEDGE, September, 1892.

† The writer is indebted to Mr. Davidson for pointing out in the January number of this serial, p. 13, that the name "barramunda" is not applicable to the lung-fish alone, but denotes all the big fish of the Australian rivers.

bed" of the quarrymen. The survival of *Trigonia* in the Australian seas alone affords a curious parallel to the persistence of pouched mammals and monotremes on that island-continent, and of the lung-fish in its rivers.

The pearly nautilus, of which there are some three or four species from the warmer seas, is likewise entitled to occupy a place among "living fossils," since this group of cephalopods has existed continuously to the present day, from the epoch of the lower silurian, with a progressive diminution in the number of species. It was long considered that the palæozoic nautili were congeneric with the existing ones, but although this is probably not the case, the whole are so closely allied as to show a most remarkable persistence of type throughout untold ages. Nautili have, indeed, witnessed the incoming and the decline of the whole group of ammonites, so characteristic of the secondary rocks; but the reason of the persistence of the one type and the total extinction of the other type appears entirely beyond our ken.

The most remarkable instance of the persistence of type is, however, afforded by the genus *Lingula* among the brachiopods, or so-called lamp-shells. *Lingulas* have oblong, flattened, and somewhat nail-like shells, composed partly of horny and partly of calcareous matter, and are attached to foreign substances by a long muscular pedicle passing out between the beaks of the two valves, which are generally of a greenish hue. These molluscs range from the Cambrian—at the very base of the palæozoics—to the present day, without any trace of generic modification, and indeed, with no perceptible change. Moreover, the group seems to be now as well represented in species as ever it was, the total number of living forms being given in the second edition of Woodward's "Mollusca" as sixteen while the total of fossil species at that date was but ninety-one. The *lingulas* are, therefore, the very oldest animals at present in existence. They are, however, run somewhat close by two other genera of brachiopods respectively known as *Discina* and *Crania*, both of which range from the lower silurian or ordovician epoch to the present day. The parallelism in this respect is not, however, so close as it might at first sight appear, since the lower palæozoic representatives of both the latter genera are subgenerically distinct from their living analogues. While the first of these two genera has some ten living species, the latter possesses but five, and both had a large number of palæozoic representatives.

It is, perhaps, almost superfluous to add that the whole of the brachiopods are a waning group, although the types known as *rhynchonellas* and *terebratulas* have been ascertained, of recent years, to be more numerous represented, both as regards species and individuals, than was formerly considered to be the case.

The so-called stone-lilies, or crinoids—near relatives of the familiar star-fish, but attached, in the young condition at least, to the sea-bottom by a jointed stem—likewise constitute a group in which by far the greater number of types are totally extinct, although a few survive to merit the title heading the present article. The stone-lilies are divided into two primary groups, of which one is totally extinct, while the other, which does not extend backwards beyond the secondary period, comprises the few existing representatives of the class. The genus which may be selected as especially worthy of the designation "living fossil," is *Pentacrinus*, so named from the pentagonal form of the discs of the stalk—so familiar to all who have studied the fossils of the British secondary rocks. The pentaeriniids were originally named on the evidence of certain species from the British lias, which attained a height of several feet, and flourished in extraordinary

profusion on the old sea-bottom, as the reader who cares to pay a visit to the fossil galleries of the Natural History Museum may see for himself. For some time the genus was only known from the secondary rocks, but eventually a minute species (*P. Europæus*) was found living in deep

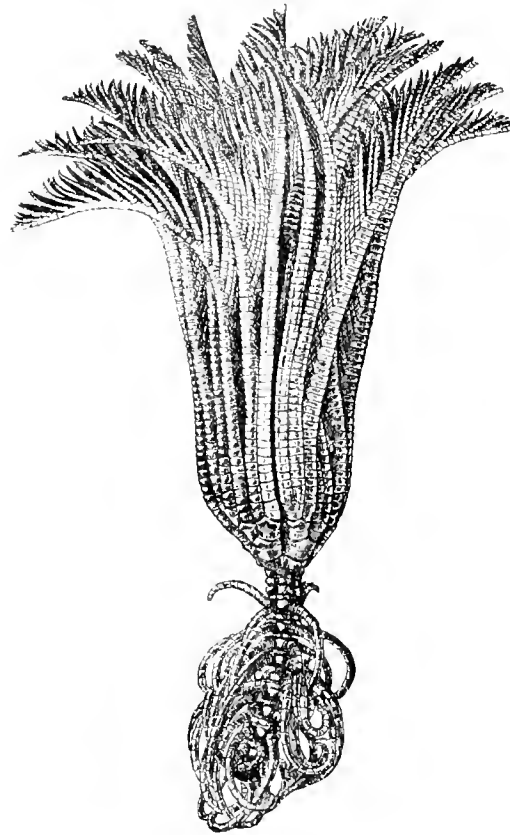


FIG. 2.—A Living Pentacrinid.

water off the Irish coast; while in 1755 a much larger form (*P. caput-medusæ*) was discovered in the West Indian seas. For a long period these living crinoids were supposed to be of extreme rarity, only a few examples being from time to time procured. With the development of deep-sea dredging it was, however, found that pentaeriniids were really abundant in certain localities, and several new species (one of which is represented in the accompanying figure) have been named of late years. Thus in the summer of 1870 the late Dr. Gwyn Jeffreys dredged up quantities in the Atlantic; while in the neighbourhood of the Aru Islands the late Professor Moseley tells us that during the voyage of the *Challenger* more than thirty specimens of *Pentacrinus* were taken at a single haul of the dredge in 500 fathoms of water. Although their pyritized remains, which are so common on the slabs of lias, would have indicated that these crinoids must have been creatures of extreme beauty, no adequate idea of their gracefulness would ever have been obtained had the group not been represented in the living state.

Pentaeriniids are, however, by no means the only "living fossils" belonging to this class of animals. For instance, the smaller and simpler *Ithycrinus* of the Atlantic is a survivor from the eocene; while both this genus and the allied *Bathycrinus*, from depths reaching to 2400 fathoms in the Atlantic, are near relatives of the extinct *Bourqueti-crinus* of the chalk. Moreover, all these forms are related to the so-called Pear-crinites (*Apiocrinus*), so common in the middle jurassic rocks of Europe; while these, again,

lead on to the still earlier lily-enerinites (*Encrinurus*) of the trias.

If space permitted there are several other groups of invertebrates which might claim our attention, but we must pass on to the vertebrates. Among the fishes the one which has the greatest claim to the title of a "living fossil" is the aforesaid Australian lung-fish of the rivers of Queensland. As we have mentioned in the article referred to, teeth of fishes allied to the Australian lung-fish have long been known from the secondary rocks, ranging downwards to the trias, and occurring in Europe, India, Africa, and North America. These teeth were, indeed, first described by Agassiz as far back as the year 1838; and the group was believed to be extinct till 1870, when one of the two living forms was discovered. At first, as stated in the same article, it was believed that the latter were generically identical with the fossil, *Ceratodus*, but it has been ascertained recently that there are certain slight differences which justify the separation of the living species as a distinct genus. At present we have no decisive evidence of the existence of these fishes between the upper jurassic of the United States and the pleistocene of Queensland, so that there is a long gap in their history to be filled up, it may be hoped, by future discoveries.

The Australian lung-fish is, however, but one of three nearly allied genera, of which the other two (*Lepidosiren* and *Protopterus*) are each represented by a single species, severally inhabiting the Amazons and the rivers of West Africa. These three widely separated types are, then, the sole living representatives of an extensive order which was once widely distributed over the globe, and has been slowly waning ever since the palaeozoic period. The group is one of especial interest, since from some of its extinct representatives it is probable that amphibians, and hence the higher vertebrates, have all been derived.

Of nearly equal interest with the lung-fishes are the bony pikes (*Lepidosteus*) of the rivers of North America and the bichir (*Polypterus*)^{*} of the Upper Nile and the rivers of Western Africa; which, together with another West African form (*Cabonnoichthys*), are the sole existing representatives of the mail-clad ganoid fishes so abundant during the secondary period. The African forms are at present unknown in the fossil state, but the bony pikes date from the lower eocene, and thus indicate continuity with the extinct secondary types.

Another living fossil among fishes is the well-known Port Jackson shark (*Cestracion*), the last survivor of a genus ranging in the secondary rocks of Europe down to the Kimmeridge clay; and also the sole living member of a vast group of sharks characterized by the pavement of crushing teeth with which the mouth is covered. As remarked long since by Dean Buckland, cestraciont sharks lived side by side with trigonias in the old jurassic seas of Europe; and it is not a little remarkable to find the same comradeship still kept up on the distant coasts of Australia.

Quite recently another link connecting the present fauna of Australia with that of secondary Europe has been discovered. For a considerable time a peculiar group of herrings (*Diplomystus*), characterized by having a row of scutes on the back resembling those found in other types on the opposite aspect of the body, have been known from cretaceous and early tertiary rocks, their range including Brazil, Wyoming, the Isle of Wight, and the Lebanon. Till the other day, these doubly-armoured herrings were considered to be totally extinct, but now, lo and behold! they have turned up alive in certain rivers of New South Wales.

Among amphibians, the creature which seems best entitled to be called a "living fossil" is the giant salamander (*Cryptobranchus*) of Japan, since, together with a smaller North American kind, it is the representative of a genus once common in Europe during the middle portion of the tertiary period. Indeed, our first knowledge of the group was derived from a fossil specimen of one of these salamanders from the Continent, described in the year 1726 under the title of *homo diluvii testis*, in the belief that it was a human skeleton!

Passing on to the reptilian class, we have to notice that in the year 1842 the late Sir R. Owen described from the triassic rocks of Shropshire the remains of a small lizard-like reptile (*Rhynchosaurus*), differing from all living forms in the structure of its skull, of which the jaws terminated in a peculiar beak. Eleven years previously the late Dr. Gray had, however, applied the name *Sphenodon* to a then very imperfectly known living reptile from New Zealand; which when fully described by Dr. Günther in 1867 turned out to be very closely related to the triassic *Rhynchosaurus*. Although externally somewhat like a lizard, but with a different kind of skin, the tuatara, as the New Zealand reptile is called, differs entirely in the structure of its shell and skeleton in general from the true lizards, and comes much closer in these respects to crocodiles and tortoises. Subsequent researches have brought to light the existence of the remains of a large number of more or less nearly allied reptiles in the secondary rocks of Europe and other parts of the world. Accordingly the tuatara, although not generically identical with any one of these extinct forms, has every right to be regarded as a "living fossil"; while it enjoys the further distinction of being, with the exception of the lancelet, the only vertebrate animal which can be definitely regarded as the sole living representative of a distinct order.

Since birds have no species with any very great claim to be mentioned here, we pass on to mammals, of which our notice must necessarily be brief. In a previous article,[†] it has been stated that certain remarkable secondary European and American mammals appear to be related to the egg-laying mammals of Australia and New Guinea; and we may, therefore, assume that the latter, as their structure indicates, are very ancient types, although their direct ancestors have not yet been discovered. The banded anteater (*Myrmecobius*) and the bandicoots (*Perameles*) of Australia seem to be the nearest relatives of another great group of secondary mammals, and are therefore probably some of the oldest types with which we are yet acquainted, although here again their exact genealogy is at present unknown. No other groups of living mammals are yet definitely known to have existed before the tertiary period, and the pedigree of the class in general is consequently brief as compared with that of many of the animals discussed above. The opossums (*Didelphys*) are, however, perhaps those mammals best entitled among the tertiary groups to the appellation of "living fossils," as they have existed without generic modification since the period of the eocene, and have now entirely vanished from their old European haunts to maintain an existence in America, where they are mainly characteristic of the southern half of the continent. Although the insectivores and the lemurs (as mentioned in our article in the January number of KNOWLEDGE) are evidently primitive types, but few of their existing genera date far back in the tertiary period, while in the latter group, not a single existing genus is known before

* Figured in KNOWLEDGE for September, 1892, p. 173.

† KNOWLEDGE, November, 1892, pp. 214, 215.

the present epoch. None of these mammals properly come, therefore, within the scope of the present article. On the other hand, tapirs and rhinoceroses, as dating from the lower part of the miocene or the upper portion of the eocene period, might be considered to claim notice in our survey, while the same remark would apply to the civets of the genus *Viverra*. Since, however, these mammalian types are comparatively well represented at the present day, they scarcely come under the designation of "living fossils." There is, however, one mammal to which this title is strictly applicable, namely, the water-chevrotain of Western Africa. This genus of mammals was originally made known to science upon the evidence of fossil remains from the pliocene rocks of Darmstadt described under the name of *Dorcatherium* in 1836. Four years later, a living ungulate from West Africa was described as a species of musk-deer (*Moschus*), and the same creature was in 1845 made the type of a new genus, *Hymoschus*. Subsequently other extinct species of *Dorcatherium* were described from the miocene rocks of Europe and the pliocene of India, and it was eventually proved that the African water-chevrotain belonged to the same genus as these reputedly extinct forms. Hence, the animal in question, as being the sole existing representative of a genus which had formerly a comparatively wide distribution and which was originally described as extinct, has the most indisputable claim to rank as a "living fossil."

THE FACE OF THE SKY FOR MARCH.

By HERBERT SADLER, F.R.A.S.

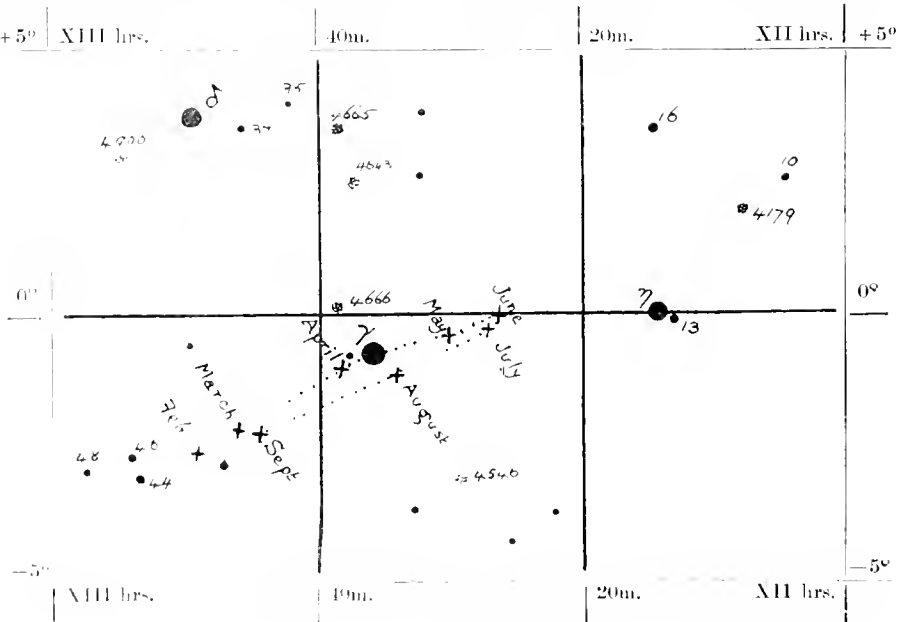
SEVERAL fine groups of spots have recently appeared on the solar surface. Conveniently observable minima of Algol occur at 0h. 30m. A.M., on the 13th, and at 9h. 19m. P.M., on the 16th. A maximum of the beautiful variable Omicron Ceti will take place about the 11th.

Mercury is an evening star, and is well situated for observation during the greater part of the month, setting on the 1st at 6h. 10m. P.M., or 1h. 2m. after sunset, with a southern declination of $3^{\circ} 37'$, and an apparent diameter of $5\frac{1}{2}''$, $\frac{100}{1000}$ ths of the disc being illuminated. On the 7th he sets at 7h. 21m. P.M., or 1h. 33m. after the Sun, with a northern declination of $1^{\circ} 43'$, and an apparent diameter of $6''$, $\frac{73}{1000}$ ths of the disc being illuminated, and the planet being then at its brightest. On the 12th he sets at 7h. 47m. P.M., with a northern declination of $5^{\circ} 37'$, and an apparent diameter of $6\frac{3}{4}''$, $\frac{51}{1000}$ ths of the disc being illuminated. On the 17th he sets at 7h. 56m. P.M., or 1h. 50m. after sunset, with a northern declination of $8^{\circ} 23'$, and an apparent diameter of $8''$, $\frac{32}{1000}$ ths of the disc being illuminated. On the 22nd he sets at 7h. 48m. P.M., or 1h. 31m. after sunset, with a northern declination of $9^{\circ} 33'$, and an apparent diameter of $9\frac{1}{2}''$, $\frac{11}{1000}$ ths of the disc being illuminated. After this he gets too faint and too near the Sun for observation. He is at his greatest eastern elongation ($18\frac{1}{2}^{\circ}$)

on the 14th. While visible he describes a direct path in Pisces, without approaching any bright star. Venus is invisible.

Mars is still visible, but is a very uninteresting object for the amateur. He sets on the 1st at 11h. 29m. P.M., with a northern declination of $16^{\circ} 10'$, and an apparent diameter of $6\frac{1}{2}''$. On the 31st he sets at 11h. 24m. P.M., with a northern declination of $21^{\circ} 30'$, and an apparent diameter of $5\frac{1}{2}''$. During the month he passes through part of Aries into Taurus, being south of the Pleiades on the 25th.

Jupiter is still an evening star, but should be looked for immediately after sunset. On the 1st he sets at 9h. 43m. P.M., with a northern declination of $8^{\circ} 36'$, and an apparent equatorial diameter of $31.6''$. On the 31st he sets at 8h. 23m. P.M., or 1h. 53m. after sunset, with a northern declination of $11^{\circ} 2'$, and an apparent equatorial diameter of $32''$. He is occulted by the Moon on the morning of the 20th, the disappearance taking place as the planet is rising, at 7h. 1m. A.M., at an angle of 68° from the northern point of the lunar disc, and the reappearance at 7h. 52m. A.M., at an angle of 237° from the northern point. During the month he describes a direct path through Pisces into Aries. On the evening of the 19th a 7th magnitude star will be very closely north of the planet. The following phenomena of the satellites occur while Jupiter is more than $8'$ above and the Sun 8° below the horizon. On the 3rd an occultation disappearance of the second satellite at 7h. 23m. P.M. On the 5th a transit egress of the shadow of the second satellite at 6h. 50m. P.M. On the 6th a transit ingress of the first satellite at 5h. 23m. P.M. On the 12th a transit ingress of the shadow of the second satellite at 7h. 1m. P.M.; and a transit egress of the satellite at 7h. 55m. P.M. On the 14th an occultation disappearance of the first satellite at 7h. 46m. P.M. On the 15th a transit egress of the first satellite at 7h. 9m. P.M., and of its shadow at 7h. 52m. P.M. On the 22nd a transit ingress of the shadow of the first satellite. On the 23rd an eclipse disappearance of the first satellite at 7h. 4m. 27s. P.M. The following are the times of superior and inferior conjunctions of the fourth



Path of the Planet Saturn in the Constellation Virgo, from February 1st to September 1st, 1893. The map is based on Cottam's Star Chart. γ Virginis (binary) 3.1 magnitude, δ Virginis 3.5, η Virginis 4.0, 16 Virginis 5.5.

satellite:—Superior, March 17th, 11h. 22m. P.M. Inferior, March 9th. 2h. 45m. P.M.; March 26th, 11h. 30m. A.M.

Saturn is well situated for observation, coming into opposition on the 29th at a distance of about 797½ millions of miles. He rises on the 1st at 8h. 12m. P.M., with a southern declination of 2° 7', and an apparent equatorial diameter of 18·3" (the major axis of the ring system being 43" in diameter, and the minor 6½"). On the 31st he rises at 6h. 2m. P.M., with an apparent equatorial diameter of 19" (the major axis of the ring system being 43½" in diameter, and the minor 5½"). Saturn will be occulted by the Moon on the 4th, but the phenomenon will only be visible in the southern hemisphere. He will also occult a 9½ magnitude star on March 12th. central occultation taking place at 9h. 32m. P.M. This will, of course, be visible in England. Dione is in inferior conjunction at 8·2h P.M. on the 2nd; Rhea in superior conjunction at midnight on the 4th; Dione is in inferior conjunction at 1·1h. A.M. on the 11th; Rhea is in superior conjunction at 0·7h. A.M. on the 13th; in inferior conjunction at 7·2h. P.M. on the 20th; in superior conjunction at 1·4h. A.M. on the 23rd; Iapetus is in inferior conjunction at 8·5h. P.M. on the 24th; Rhea is in inferior conjunction at 7·8 P.M. on the 29th. During March, Saturn describes a retrograde path from 38 to the east of γ Virginis.

Uranus is an evening star, rising on the 1st at 11h. 5m. P.M., with a southern declination of 14° 35', and an apparent diameter of 3·7". On the 31st he rises at 9h. 2m. P.M., with a southern declination of 14° 20'. During the month he describes a retrograde path in Libra, through a region barren of naked eye stars.

Neptune is still visible, and sets on the 1st at 1h. 44m. A.M., with a northern declination of 20° 13', and an apparent diameter of 2·6". On the 31st he sets at 11h. 18m. P.M., with a northern declination of 20° 19'. During the month he describes a short direct path in Taurus to the west of the 5¾ magnitude star, Weisse's Bessel², iv. h. 650. A map of the small stars near his path will be found in the *English Mechanic* for October 28th, 1892.

There are no very well marked shooting stars in March. The zodiacal light should be looked for in the west on every moonless evening.

The Moon is full at 4h. 3m. P.M. on the 2nd; enters her last quarter at 5h. 13m. P.M. on the 10th; is new at 4h. 33m. A.M. on the 18th; and enters her first quarter at 9h. 34m. P.M. on the 24th. She is in apogee at midnight on the 8th (distance from the earth 251,330 miles), and in perigee at 7h. P.M. on the 20th (distance from the earth 226,620 miles).

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

Solution of February Problem (by A. F. Mackenzie):—

Key-move: 1. B to KR7.

- If 1. . . . R × Q, 2. R to B7, &c.
- If 1. . . . R × Kt, 2. Q × R, &c.
- If 1. . . . R to Q7, 2. Kt × Pch, &c.
- If 1. . . . R to B7, 2. Kt × Rch, &c.
- If 1. . . . R to K8, 2. Kt to B2ch, &c.
- If 1. . . . P to Kt7, 2. Q to R2, &c.
- If 1. . . . P to R6, 2. Q × P, &c.
- If 1. . . . P to Kt5, 2. R to B4ch.
- If 1. . . . Kt moves, 2. Q to K4 mate.

CORRECT SOLUTIONS received from Alpha, A. G. Fellows, R. A. B., W. T. Hurley, and A. Rutherford. Additional correct solution of January Problem from S. V. Mott.

C. T. Blanshard.—Apart from duals in the 1. . . . P to B4 variation (e.g., 3. Kt to R1, and 2. P to QKt4), your problem may be solved simply by 1. Q to B5.

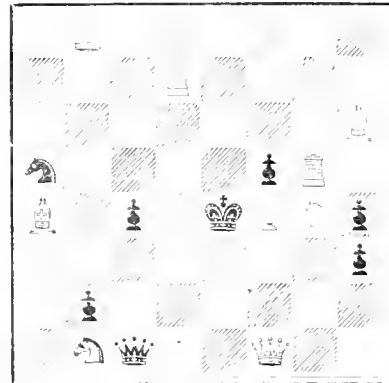
A. G. Fellows.—Thanks for the problem, which we reserve for next month, a two-mover being now due.

PROBLEM.

By W. A. CLARK, East Molesey.

First Prize in Liverpool *Woolly Mace* Tourney

BLACK.



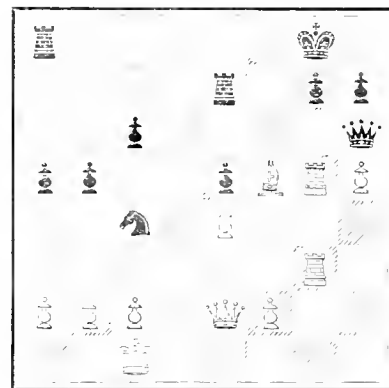
WHITE.

White to play, and mate in two moves.

The following game was played in the North v. South match at Birmingham. To save space, the opening moves are omitted:—

Position after Black's 27th move.

BLACK.



WHITE.

WHITE
(Rev. W. E. Bolland).

- 28. P to Kt3
- 29. Q to K3!
- 30. Q × Kt
- 31. Q to K3 (b)
- 32. K to Ktsq
- 33. Q to Bsq (d)
- 34. P to R3 (c)
- 35. R to Q3
- 36. P × R
- 37. P to Kt4 (f)
- 38. Q to B2

BLACK
(W. H. Pullinger).

- 28. Kt to Kt3?
- 29. Q to Q3 (a)
- 30. P to R5
- 31. Q to R6ch (c)
- 32. R to Qsq
- 33. Q to Kt5
- 34. Q to B4
- 35. R × R
- 36. Q × P
- 37. Q to B6
- 38. Q to K6

- 39. R to Kt2
- 40. B to K6ch
- 41. R to B2 (*h*)
- 42. R to B8ch
- 43. B to B5ch? (*i*)
- 44. P × Pch (*j*)
- 45. R to B7ch
- 46. P × R
- 47. B to Q7
- 48. B × P (*k*)
- 49. B × P
- 50. Q to KR2 (*l*)
- 51. K to B2
- 52. Q × KP
- 53. K to B3

Adjudicated a win for White (*o*).

NOTES.

(*a*) It was better to move the Knight, giving up the Queen and probably two Pawns for the two Rooks, *e.g.*, 29. . . . Kt to Q2; 30. R × Pch, Q × R; 31. Q to R6, Q × R; 32. P × Q, Kt to KBsq, &c., with better prospects than in the actual game.

(*b*) Much better than 31. R to Q3, which Black could answer either by 31. . . . Q to R3; 32. P to KB4? P × P; or by 31. . . . Q to R6ch, which, however, is probably not so good. The text move prevents 32. . . . P × P.

(*c*) This and his next move are mistakes. He should play 31. . . . P × P.

(*d*) Not so forcible as 33. R × Pch, K to Rsq; 34. Q to Q2!—a resource which not only saves the game but wins it on the move, for the Queen goes next to R6, forcing mate.

(*e*) R × Pch was again quite feasible; so also on the next move. White's line of play not only loses a Pawn, but by exposing his King's position increases the chances of a draw.

(*f*) 37. Q × P was safe enough and more vigorous. White probably feared the reply . . . P × P, which would lose the Queen by 38. Q to B8ch, K to B2; 39. B to K6ch, &c.

(*g*) In order to advance the QBP; but he has no time, and should therefore withdraw the Queen to KR3.

(*h*) Not nearly so strong as 41. Q to Q2, Q to Q5; 42. P to R6! P to Kt3; 43. Q to Kt5, and wins.

(*i*) Strangely overlooking the mate in three moves.

(*j*) A safer line of play would be B × Pch followed by R to Q8. The exchange of Rooks and subsequent gain of Pawns was no doubt tempting, but it leaves Black with a dangerous passed Pawn.

(*k*) 48. Q to Qsq is an alternative here.

(*l*) It is difficult to say whether 50. Q to B7ch, K to B3; 51. Q to Q8ch! is better or not than the course adopted. Probably both are good enough.

(*m*) Threatening 52. . . . Q to Kt7ch. White's reply is forced.

(*n*) 52. . . . Q to Kt7ch; 53. K to B3, P to R7 loses the Queen by 54. B to B4ch, K to Kt3 (or mate in two); 55. Q to K8ch! K to B3 (best); 55. Q to K6ch, &c.

(*o*) For if 53. . . . P to R7; 54. B to B4ch, K to Bsq (otherwise White changes Queens, followed by B to Q5); 55. Q to R8ch, K to K2; 56. Q to Kt7ch, K to Qsq (if the King play to Q3 instead, White forces the game by checking with the two Pawns, followed by Q to Kt6ch); 57. B to K6 (or A), K to Ksq (best); 58. B to Q7ch! K to Qsq;

59. B to B5! K to Ksq; 60. Q to Kt8ch, K to K2; 61. Q to K6ch, K to Bsq; 62. Q to B6ch, and wins.

(A) 57. B to Kt5, Q to K8ch? (or 57. . . . K to Bsq! 58. Q to Q7ch, K to Ktsq; 59. Q to Q6ch, K to Kt2 (best); 60. B to B6ch! K to R3; 61. B to Q5 dis ch, Q to Kt3; 62. P to K5 and wins); 58. K to B4, Q to B8ch; 59. K to Q5, Q to Bsq; 60. Q to B8ch, K to B2; 61. Q to Q6ch, and wins.

CHess INTELLIGENCE.

The long-expected match between the North and South of England was decided at Birmingham on January 28th. There were 106 players on each side, those reserve men who were not required in their special capacity being paired against one another. After a most exciting match the Southern team scored a hard-earned victory with a score of 53½ to 52½. It is remarkable that if there had been only 100 players a side the result would have been a tie; so also before the adjudication of unfinished games the score was exactly even; and if one of these latter had been adjudicated in accordance with the subsequently expressed views of some experts the result would also have been a tie. In spite, however, of the closeness of the result it would appear that the South is really the stronger side. On the first 20 boards, which should furnish a sufficient test, they did not lose a single game, except at board No. 11, where two reserve men were opponents. That the North should have done so well at the other boards may be perhaps accounted for by the fact that the Southern team was not quite representative. Arrangements are in progress for a return match to be played in London next autumn.

The honorary secretary of the West London Chess Club informs us that the club now meets on Monday and Thursday evenings at the Holland Park Club, 3, Norland Place, W.

A new chess club has been started at Clapton under the title of the Lonsbury Chess Club. The club meets on Wednesday evenings at Lonsbury College, Nightingale Road.

Mr. Lasker is now at Havana, where he has defeated the two leading players of the Havana Chess Club, Señor Golmayo and Señor Vasquez, in short matches. Mr. Lasker did not lose a game in either match. The great event of his visit will be the match with Herr Walbrodt, of Berlin.

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CATERPILLARS' DWELLINGS.—I.

By E. A. BUTLER.

AMONGST the caterpillars of butterflies and moths, the architectural instinct is developed chiefly in two directions. Some live in communities and construct a common dwelling-place: others, which are solitary in habits, either rear amongst the foliage of their food-plant some sort of tent or covering to serve as a snug and safe place of retreat and shelter, or else construct a portable receptacle into which the greater part of the defenceless body is thrust while the insect travels in search of food. In the formation of a common dwelling-place, no such wonderful ingenuity is displayed as characterizes the workmanship of bees, ants, or wasps, and for this several reasons may be assigned. In the first place, the architects are not perfect insects, but only immature creatures which live a very vegetative sort of life. Their communities, again, do not reach that high degree of organization which is implied in the term "social": they form what were called by Kirby and Spence "imperfect societies," *i.e.*, the individuals of the tribe, though sharing in the construction of the abode which serves as a common means of defence, do not contribute to the common support, nor supply one another's needs in the way of food, but each looks after its own interests, and recks not what may befall the rest. And again, though they are larval forms, each is able to provide for itself from the moment of hatching; thus there are no helpless young to be tended, and this at one stroke removes the necessity for the multi-

farious duties that occupy so much of the time of truly social insects, and at the same time renders any elaborate structure unnecessary. Indeed, there is little more than their common descent from one batch of eggs, and the presence of the common food in their vicinity, to induce them to form any bond of association at all. Hence they are more appropriately styled gregarious than social. The common domicile, moreover, is not made by the heaping up of particles of foreign matter, nor by the excavation of galleries in earth or wood, so that no toilsome journeys in search of building materials, nor hard labour in the excavation of tenacious matter are requisite. The caterpillars' lives are much too fully occupied with eating to leave time or energy for such undertakings. The material made use of is simply silk spun from their own bodies, and the supply keeps pace with the increasing necessities of the case, till at last an extensive web is formed, whose dimensions are such that it lodges the whole community and still leaves plenty of room to spare.

There are not many British species that adopt this practice: those that do fall chiefly into three groups. One of these occurs amongst that interesting division, the rather large-sized and heavy-bodied moths called Bombyces, some of the densely hairy larvæ of which we have already discussed; the second, amongst a set of small moths called "knot-horns"; and the third is a genus called *Hyponomacuta*, which belongs to the division containing the smallest Lepidoptera in the world, and known as the Tineæ. To take these latter first. Most owners of gardens sooner or later come into collision with representatives of the genus *Hyponomacuta*. They are called "small ermine moths" (Fig. 1), and the different species are all very similar, having narrow, whitish or slate-coloured fore-wings with rows of black dots, and lead-coloured hind-wings with long fringes, and a clear transparent space at the base of the wing. The expanse of wings is generally under three-quarters of an inch; but when the moth is at rest, with its wings closed, it becomes a narrow cylindrical object, showing nothing more than the spotted, ermine-like fore-wings.



FIG. 1.—Small Ermine Moth (*Hyponomacuta padella*).

Hedges of hawthorn, apple trees, and euonymus shrubs are the particular kinds of vegetation most attacked by these elegant but destructive little pests. The young, fresh shoots of the shrubs are found span together in early summer by a quantity of silken threads like a cobweb, and in the midst of the mass are to be seen a number of small black-spotted caterpillars, which are of a smoky or yellowish colour, according to the species. On being disturbed they wriggle violently, and either crowd together side by side in the centre of the web, or drop out of it, descending to the ground at the end of an improvised thread. Under the shelter of the web, they devour the surface of the foliage of the shrubs, thereby causing the remainder of the leaves to wither and shrivel up and turn brown. Apparently the caterpillars do not suffer from the assaults of birds, for the sticky and clinging threads would greatly incommode and annoy any bird that ventured to tamper with them; and as pretty good proof that they are amongst Nature's favourites may be cited their extreme abundance, which is often far greater on the Continent than even in this country, so that their ravages become sometimes a source of serious loss to the agriculturist. It is thus clear that they have found web-making an exceedingly paying transaction.

The early history of these little creatures is rather peculiar. The eggs are laid on the stems of the food-plant at the end

of summer, and are covered over by the mother with a layer of varnish. Towards autumn they hatch, but the young larvæ remain throughout the winter crowded together under the waterproof skin so thoughtfully provided for them. When the leaves appear in spring the little creatures, which throughout their life seem to have a wonderful faculty of looking after their own safety, come out from their shelter, and begin to burrow into the young leaves, devouring the soft matter underlying the cuticle, and thus exchanging the protection of their dome of animal varnish for shelter by a flat vegetable roof, which the leaf-skin now constitutes over their heads. When they have grown sufficiently, and their jaws have become strong enough to attack the leaf from the outside, they come out of their burrows and then begin to provide for their further safety by spinning a web, under which they continue to carry on the work of destruction. This will be their condition about midsummer. This is the period of their life when they are most annoying to the gardener, because when they have finished the leaves enclosed in one web they migrate to another spot and spin another, which they continue to inhabit till their rapacity has again brought about a dearth of food, when a further migration takes place. Thus, during the course of their life, several webs may be formed by the same batch, and the larger the colonies the more frequent will be the moves, so that the trees soon become covered with masses of sticky threads, which, quite apart from the actual damage done to the trees, are annoying as presenting an exceedingly untidy appearance. Sometimes there will be from one hundred to two hundred caterpillars in a single brood, and it is obvious that the daily provisions required for such an army will be considerable. The threads of the web, though apparently arranged quite indiscriminately, run pretty much in the same direction, and each caterpillar, forming its own line, seems to use that as a kind of climbing ladder, in preference to those of its neighbours. Hence results the parallelism of their position when they crowd together in the centre of the web. They run up and down their threads like sailors in the rigging of a ship, and can go almost as rapidly backwards as forwards.

When they are full fed each caterpillar spins a close-fitting cocoon of its own inside the general web, and within this it changes to a shining chestnut-coloured chrysalis. As all the members of one colony belong to the same batch, they all reach maturity about the same time, and form a cluster of cocoons in the midst of the web. This change is very rapidly made, the cocoon taking no more than a day to construct, so that the result is rather striking—one day we may see the wriggling caterpillars twisting about in the web, full of life and energy; the next, all is as still as death, and in place of the active grubs there is only a closely packed bundle of oval objects, reminding one of a cluster of "ants' eggs" done up in cobwebs. Thus even in their chrysalis condition they preserve their gregarious habits, while their customary faculty of self-preservation is again strongly asserted, for they are doubly protected, first by their own cocoons, and secondly by the web outside. But when they reach their perfect condition, an event which occurs in July, all these artificial aids to security are discarded, and the little moths sit about on the tree trunks and on blades of grass, as well as the leaves of their food-plant, in the most prominent positions without any attempt at concealment, their white satiny wings rendering them indeed doubly conspicuous against the darker background of their surroundings. They are, moreover, sluggish in the daytime, and if disturbed do not fly far. If they once gain a footing in a garden they are difficult to eradicate, and it is not easy to discover remedies that may be entirely relied

upon. Of course, the surest remedy is to cut off the shoots on which the webs are found and burn them, but in bad attacks this involves a great waste of material as well as expenditure of time.

Turning now to the more or less hairy caterpillars of the Bombyceæ, we find one of the most noteworthy instances of web-forming amongst British species in the small egger moth (*Eriogaster lanestris*). This is in many respects a remarkable insect. It feeds on hawthorn, and occurs commonly on hedges in June and July, the chrysalis being formed in August. The moth appears, strangely enough, not in the summer time, as most of the related species do, but in February, sometimes in the next year to that of its larvalhood, but frequently not till another twelvemonth has elapsed. In some cases a much longer time than this intervenes before its final change, as much as five years of pupahood having been recorded. This is a truly marvellous instance of suspended vitality, since of course no food is taken during all that period, and the moth is probably fully formed within the chrysalis at the end of its first winter. It is also remarkable that the insect should be able to pass through the heat of the summer without emerging, although that very heat is the necessary condition for the emergence of most Lepidoptera, and the factor instrumental in producing that emergence. It is only fair to note, however, that these long delays occur in confinement, when the external circumstances are not altogether natural, and of course it is impossible to say whether a similar course is followed by the insect in the wild condition with its natural surroundings.

The eggs are laid in spiral coils round the twigs of hawthorn while they are still bare of leaves (Fig. 2), and



FIG. 2.—Egg-Coil of Small Egger Moth, on hawthorn twig.

when laid they are wrapped round with dark grey wool, derived from the end of the mother's abdomen, whereby they are preserved from all the mischances that might otherwise befall them during the three or four months that must elapse before they are hatched. The ground colour of the caterpillars is black, and they are ornamented with a few bright yellowish spots and streaks; they remain very much of this appearance during all the first portion of their life. Then comes a sudden change. At the last moult they assume a reddish-orange coating, like velvet pile, on the upper surface of each segment, and become very handsome objects, so different from what they were before that they might easily be taken for a different species. Soon after hatching, the young caterpillars begin to surround themselves with a web, spinning the threads from twig to twig around their birthplace, on which the remains of the down-covered coil of egg-shells are still visible. As they grow, and gradually devour the foliage immediately around, the web is extended so as to enclose the twigs that are stripped, the caterpillars dispersing in the neighbourhood to feed at night, and returning to the nest by day. The web (Fig. 3) is very different from that of the small ermine moths, the threads being spun so close together and in such dense masses that nothing can be seen of its internal structure. When fully formed, it appears as a compact angular mass, often as much as eight or ten inches in diameter, and composed of white silk, usually more or less

discoloured by the traffic that goes on amongst it. Externally it appears to be one continuous mass of interwoven threads, but there are plenty of passages inside, into which the insects retreat on being alarmed. When undisturbed,



FIG. 3.—Nest of Small Egger Moth Caterpillar (*Eriogaster lanestris*). (About half natural size.)

they delight to rest on the outer surface, where they lie at full length, basking in the sun; and it is astonishing to see the rapidity with which, when danger threatens, even a large batch of them will move off and completely disappear into the depths of the nest, leaving no hint outside of their presence within. The nest is something like a whitened sepulchre, for though it often looks clean enough outside, especially just after new outworks have been made, it is extremely untidy within, through the accumulation of cast skins, excrement, fragments of leaves, &c., which lie about entangled in dirty silk. Thus these web-forming caterpillars contrast in their habits most unfavourably with the scrupulous cleanliness of the truly social insects. In the size and opacity of the nest, as well as in its fixity of position, and in the greater freedom of the caterpillars, which not only lie habitually *outside* the nest and leave it to feed, but also, when full grown, abandon it altogether, the small egger moth differs entirely from the small ermines. A further difference appears in the act of pupation, for whereas the ermines form a cluster of cocoons inside the nest, the small egger caterpillars leave the nest and form their cocoons amongst the surrounding herbage, generally near the ground, and in doing so do not cluster together, but each follows its own taste in the selection of a locality in which to construct its strong, egg-shaped, pale brown case.

Several other insects, not distantly related to the small egger, construct and inhabit similar nests, especially while young. The best known of these is probably the lackey moth (*C'lesiocampa neustria*), the flabby caterpillar of which, with its pale blue head marked with two black spots like

eyes, and its body gaudily striped with red, blue, and orange, is often seen on apple trees and hawthorn hedges, to the former of which it has sometimes done irretrievable damage. The eggs of this moth are glued to the young twigs in the form of a tight-fitting bracelet, encircling the twig, but not covered with down. The gold-tail and brown-tail moths, again, whose stinging caterpillars we mentioned some time ago, construct elaborate nests with partitions and cells, to which in their youth they retire when not feeding, and in which also they hibernate. The processionary caterpillars of the Continent (*C'uthocampa*) form another excellent example of web-forming insects belonging to this group. The nest has but one opening, and this fact seems to be in some way connected with their habits of marching forth in long processions in the most regular order; for all must pass out at the same spot and in the same direction, and hence necessarily form a definite line of march—in one species, feeding on fir, going in single file, and in the other, feeding on oak, in a wedge-shaped body. Some tropical species, also belonging to the same group, vary the proceedings by forming, when they have come to the end of their larval life, a common nest in which to pass into the *chrysalis* condition. For example, the caterpillars of a moth found in Natal, and called *Anopha panda*, a cream-coloured insect with rusty red streaks on its wings, construct a large spherical chamber on a branch of their food-plant, some eight or ten inches in diameter, making its walls of several layers of rough brown silk of different degrees of consistency. This will accommodate from two hundred to three hundred caterpillars, each of which makes its own slight cocoon of light yellowish silk. These are placed side by side, all pointing towards one or other of the two places of exit, until the whole space is closely packed; thus the whole structure forms a kind of compound cocoon.

The "knot-horns" are a group of small moths not much larger than the small ermines, and amongst them are a number of insects belonging to the genus *Eplastia*, which feed upon dried fruits and other stored vegetable produce, and hence are commonly found in warehouses. They are gregarious and possessed of wonderful powers of multiplication, and these facts, coupled with their small size, often render their eradication an almost hopeless task, except by the sacrifice of the greater part of the stored goods. One species, *E. elutella*, is the pest of chocolate warehouses. The fragmentary and easily shifting nature of their food, the chocolate nibs, would cause them considerable inconvenience, and possibly even danger, as they climb about over the pile; therefore, to obviate this, they carry their silken threads with them wherever they go, and ultimately spin a large silken sheet entirely covering the stores, while the individual nibs are fastened together in all directions by silken threads; and thus in course of time the whole store is ruined, becoming an inextricable and loathsome mass of web, cocoa fragments, cast skins, and excrement. Another species, *E. Kühniella*, which has lately been introduced, and, notwithstanding great precautions, succeeded in establishing itself in London warehouses, more insidious still in its operations, and more disastrous in its results, similarly attacks flour, spinning its filthy webs over the sacks and amongst the grains of flour, till the whole is rendered utterly unfit for human food. Thus the damage wrought by these insignificant insects is by no means to be measured merely by the amount devoured; in their attempts to secure themselves amidst the treacherous piles of their easily disturbed food, they spoil with their penetrating webs and their disgusting remains far more than they actually consume.

(To be continued.)

WOODPECKERS.

By HARRY F. WITHERBY.

THE woodpeckers (*Picida*) may be distinguished by the formation of the tail and head. The tail would, perhaps, strike the ordinary observer as the most curious part of the bird. It is composed of stiff but elastic feathers, and is used as a support for the body when climbing. The usefulness of the tail is seen to best advantage when the bird is pecking, for it then uses the tail as a prop to lean upon. This support enables the bird to throw its head right back, and then strike or hammer the tree with great force, and without losing its balance. The woodpecker's head, which is described later on, is even more remarkable than the tail.

Another peculiarity in the anatomy of the woodpecker is the small size of the keel of the breastbone. This dwarfing of the keel permits the bird to keep its body close to the tree while climbing.

Comparing the breastbone of a green woodpecker with that of a stockdove, a bird of about the same size, a remarkable difference is seen. The stockdove is endowed with great powers of flight, and thus requires large pectoral muscles, and it possesses a deep keel to the breastbone; while the woodpecker, being endowed with but moderate powers of flight, does not possess these large pectoral muscles, and as it is a climber it has the peculiarity of breastbone mentioned above.

The green woodpecker (*Picus viridis*), figured in our illustration, is the most common bird of the genus found in England. It may easily be known from other members of the family by its plumage, which is of a lovely olive green on the back, shading to a bright yellow on the tail coverts. The top of the head is of a rich crimson.

The male differs from the female in having a crimson "moustache," whilst the female has a black one. The peculiar marking, which has earned the name of moustache, is a line of feathers running from the base of the lower mandible under the eye to the end of the skull.

In common with all others of its genus, the green woodpecker is possessed of an immensely strong head and beak, admirably suited to the work of hammering trees in search of insects, and boring holes in them for nesting purposes.

When the bird is climbing a tree it grasps the bark with its feet, and, aided by the tail, proceeds by a series of jerks, always in an upward direction. Every now and then it will be seen to give the tree a tap with its beak, so as to ascertain by the sound given out where the tree is rotten. If the bird finds a decaying part in the tree, it continues its blows

in order to disturb the insects under the bark, and as these try to escape they are secured with the tongue. Sometimes the bird will tear off a piece of bark while searching for food.

The tongue is very curiously formed; it is long and tapers to a hard sharp point like that of a needle, and is furnished at the tip with several hair-like barbs. By means of a very simple contrivance of the muscles of the head, the bird is enabled to project its tongue a great distance beyond the point of the beak. When the bird sees an insect in a crevice of the bark or in a hole into which it cannot put its beak, it thrusts its flexible tongue into the crevice and impales the insect, the barbs preventing it from escaping. Insects captured in this manner form the staple food of the green woodpecker. It occasionally feeds on ants and their eggs, obtained by scraping with its feet at their nests.

These birds have no song, but they utter a harsh mocking noise like a laugh, which may be heard from a good distance, and sounds very uncanny to the unaccustomed ear. The laugh is made, as a rule, in the bird's flight, which is heavy and undulating.

Very early in the year a decayed or decaying tree is chosen for the nest, and tree after tree is attacked until a suitable one is found. Small holes in trees, formed in this way, may always be found in localities frequented by woodpeckers. The bird, once satisfied with the tree of its selection (frequently an old beech), bores a hole some eighteen inches deep into it. The chips are carried away with the beak, while some of the wood-dust, similar to the saw-dust of carpenters, is left at the bottom of the hole. The eggs are laid and the young hatched upon the wood-dust, which takes the place of a nest. Both birds take their turn at sitting. The hole is usually made at about twenty feet from the ground, but I have seen one in a ash tree, containing eggs, not more than five feet from the



Green Woodpeckers; with entrance to nest in an old beech tree.

ground. The hole is generally bored into the trunk, but it is occasionally found in one of the larger branches. The eggs are generally five or six in number, and are of a dull ivory white.

The young of the green woodpecker, during the first year, may be distinguished from the adult birds by the back being speckled. The whole of the plumage of the young birds is duller than that of the adults.

Three of the genus *Picus* are inhabitants of England—the spotted woodpecker (*Picus major*), the lesser spotted woodpecker (*Picus minor*), and the green woodpecker (*Picus viridis*). The habits of the first two are very much the same as those of the green woodpecker described above.

The black woodpecker (*Picus martius*) and the three-toed woodpecker (*Picus trydactylus*) have been occasionally observed in Great Britain.

DEEP SEA DEPOSITS.

By REV. H. N. HUTCHINSON, B.A., F.G.S., *Author of*
"Extinct Monsters."

[SECOND PAPER.]

HAVING, in our previous paper, given a general idea of the classification and geographical distribution of deep sea deposits, we now pass on to consider the different kinds somewhat in detail. In the scheme given on page 45 it was shown that, classifying them by their composition, they may be arranged in two groups. (1) Pelagic, (2) Terrigenous. Those of the first group are all organically-formed oozes, except one, the red clay; and may therefore rightly be called pelagic, since they are all born of the sea. Those of the second group are derived from land, or in other words, are products of denudation: hence the term "terrigenuous" (earthborn). We will begin with the pelagic deposits. These are generally to be found in situations far from land, and one of them (the red clay) always in the deepest hollows of the ocean bed. Their characteristic mineral particles either have a volcanic origin, or are of secondary origin, *i.e.*, have been formed by some of the wonderful and little known chemical actions taking place on the floor of the deep ocean. Classifications are useful in their way, but are sometimes apt to be misleading, and the reader must be warned against supposing that *no* land-derived material ever finds its way into a pelagic deposit, or *vice versa*, that *no* pelagic organisms (such as make up most of the oozes) ever enter into the composition of the terrigenous deposits. It is really a question of percentages; and just as a town where the majority vote Liberal may be called a "Liberal" constituency, so a deposit of which the majority (or even a fair percentage) of its myriad individual units or particles are of pelagic origin may be called "pelagic." It is important to bear this in mind, otherwise the scheme of classification alluded to will convey a wrong idea. With the exception of the red clay, all the pelagic deposits are organic oozes *principally* composed of the remains of "pelagic"* organisms that have slowly fallen

from the ocean surface, together with some that live on the sea floor. These have received different names, according to the nature of the different organisms of which they are largely composed. Sometimes they are principally composed of the shells of foraminifera, sometimes of the frustules of diatoms, sometimes of radiolaria; and so we have globigerina ooze (taking its name from one of the foraminifera, *globigerina bulloides*, which so largely predominates), diatom ooze, radiolarian ooze, and so on.

Red Clay is the most widely distributed and the most characteristic of all the deep sea deposits (see Chart I., page 44). It covers more than a quarter of the globe's surface. In the Atlantic there are only four patches of it of any great size, but more than half the floor of the Pacific is covered by it. On looking at Chart II. the reader will see that it is spread over the greater depths of the ocean remote from land. In the *Challenger* report seventy samples are described. These ranged in depth from 2225 to 3950 fathoms; average depth, 2730 fathoms. Ever since the red clay was first discovered by the *Challenger* naturalists in depths over 2500 fathoms there has been much discussion and speculation on the subject. Before the present, and perhaps true, theory of its origin was formed, two other views were put forward. As the reader is probably aware, the present theory, due to Mr. John Murray, is that this clay is chiefly derived from the decomposition of volcanic products. Its red colour is due to the formation of ferric oxide and peroxide of manganese from decomposing volcanic material. The rate at which it grows is very much slower than that at which the organic oozes form, and microscopic examination has revealed the interesting fact that cosmic dust from meteorites is one of its constituents. The first theory of the red clay was this: that it is the ultimate product produced by the disintegration of the land—the most finely divided material—which, held in suspension in sea-water, was distributed to great distances by ocean currents. Though this theory has been abandoned there seems to be some truth in it after all; for even Messrs. Murray and Renard admit that some small part of the red clay may be land-derived, or terrigenous. Prof. J. W. Judd, whom we recently consulted on the subject, thinks that this view may be partly true, and that at present it is impossible to determine how much of the deposit comes from the chemical alteration of fine volcanic dust, &c. It may be, after all, that the land-derived debris plays an important part, and that the authors of the report attribute too much importance to the volcanic material.

The second theory may be thus stated: in 1874 Wyville Thomson expressed the opinion that the red clay was primarily of organic origin, being essentially the insoluble residue of calcareous organisms forming the globigerina ooze. But this explanation had to be abandoned because there is no evidence that pure and clean foraminiferal shells contain any appreciable proportion of such mineral matter. It is well known that the surface waters over those deeper parts of the ocean where red clay is found contain an abundance of foraminifera; but these, as we shall see later on, are dissolved in sinking through the deeper waters where there is more carbonic acid in the water. This is clearly proved, because the globigerina oozes gradually pass, as the depth becomes greater, into red clay; and

transition or intermediate group for it? It is by no means free from organic remains, and in some cases 20 per cent. of it is composed of foraminifera, while radiolaria often form so much of it that it passes into a "radiolarian ooze." Sharks' teeth, ear-bones of whales, fragments of echinoderms, mollusca, &c., are often met with in considerable abundance; still the mineral, as distinguished from organic particles, are its chief feature.

* Here we are using the word in the sense used by naturalists. Under the designation "pelagic" may be included those forms of life which habitually pass their existence on the free expanse of the ocean, and which only on accidental occasions, if at all, visit the continental borders, or descend (while alive) to the floor of the sea. Messrs. Murray and Renard use the word in a geological or geographical sense by applying it to those deep sea deposits which are for the most part formed either of "pelagic" organisms, or of minute mineral particles, such as floating pumice and fine volcanic dust, which, inasmuch as they are universally distributed over the surface waters of the ocean, may in one sense be also called pelagic. We would, however, point out that it is open to question how far it is wise to confuse the clear and obvious distinction between what is derived from the land and what is derived from the sea. Would it not have been better to place the red clay with terrigenous deposits? They admit that its mineral particles have for the most part a volcanic origin, but M. Renard is inclined to believe that they are due more to submarine eruptions than to the eruptions of land volcanoes. That is a question not yet settled; but surely the word "terrigenuous" still applies in either case. If the volcano happens to be a submarine one, that is an accident, but it still belongs to the earth rather than to the sea. We should prefer to see the word "pelagic" reserved entirely for the organic oozes which are truly born of the sea. Particles of volcanic dust and crystals of volcanic minerals, however long they may have been floating about in the sea, are hardly entitled to the term "pelagic." *The sea does not produce them*; so we prefer to consider them terrigenous. The dead body of a sailor floating on the sea, or lying on the ocean bed, could hardly be considered a "pelagic organism," even if it had been shot out of a submarine volcano! Moreover, it is admitted by the authors that "colloid clayey matter from land may play some part in the formation of red clay." This is rather an important question, on which we shall say more presently, but the admission tends to confirm our criticism. Or if, for some reasons, this deposit should appear out of place in the terrigenous group, why not form a

it is easy to trace the gradual rotting away of these shells with increase of depth. Fragments of volcanic minerals are always associated with the globigerina ooze, and, as this fact was ignored or unperceived, it was not unnatural to regard the red clay as something belonging to the ooze itself.

Messrs. Murray and Renard speak of the red clay as a purely chemical deposit, universally distributed in the ocean basins, but often obliterated by admixture with organic oozes, or with mechanical deposits such as mud and sand. It undoubtedly has undergone much chemical change, and in view of this fact, perhaps it would not be a bad plan to class this curious substance by itself as a chemical deposit. We should then have three groups as follows: (1) *Chemical deposit* (the red clay, with its manganese nodules and secondary products); (2) *Pelagic deposits* (all the organic oozes); and (3) *Terrigenous deposits* (muds, sands, gravels, all mechanically formed). By this arrangement we should avoid the difficulty above pointed out, viz., the question how far it has a truly terrigenous origin, like the various muds.

The colour varies greatly in different samples, but red is the prevailing colour, and hydrated silicate of alumina is always present. Sometimes it is brick red, at other times of a chocolate colour, from the presence in great abundance of minute grains of manganese peroxide; and sometimes of a bluish tinge, from the presence of organic matter and sulphide of iron (but only near a continent with large rivers flowing into the sea). The average percentage of carbonate of lime is 6.7, and the amount of lime gets less as the depth increases. Foraminifera may make up as much as twenty per cent. of it; of these some live at the bottom, but the majority are pelagic, and come from the ocean surface. Together with thousands of sharks' teeth (preserved on account of their enamel), and ear-bones of cetaceans, are found numerous large and small fragments of pumice and other volcanic materials; also an abundance, in some places, of manganese nodules. How the latter have been formed we cannot stay to consider now. Remains of pelagic organisms, with siliceous shells or skeletons, are widely distributed in the red clay. When radiolarian remains increase so as to form a considerable part (as in some tropical areas of the Pacific and Indian Oceans), the deposit passes into a radiolarian ooze. When diatom remains (frustules) similarly increase (as in the Southern Ocean) it passes into a diatom ooze; and in other regions, according to the depth, into a globigerina ooze, or even a blue mud. The siliceous spicules of sponges were also found in nearly all the samples.

According to the *Challenger* researches, living organisms appear to be universally distributed over the floor of the ocean; but they are much less abundant on the red clay areas than on any of the other kinds of marine deposits. In the greatest depths, far from land, there is a relative scarcity of life; but even there it cannot be said that nothing lives, as was thought at one time. Star-fishes, echinoderms, foraminifera, &c., have been dredged up from great depths. Fragments of pumice are very widely distributed throughout the ocean floor, varying in size from masses larger than a man's head down to the minutest particles, and they are met with in all states of disintegration—some little altered, others surrounded by zones of chemical alteration; they are often coated with peroxide of manganese. What the authors call "fine washings" (amorphous clayey matter) make up by far the greater part of the red clay and the greater the depth the greater the proportion of the mysterious clayey material. This is an important fact, evidently pointing to long-continued chemical action. The mean percentage of fine washings in the seventy samples reported on was 85.3. The

mineral particles are mostly very small—the majority of them ranging from 0.1 to 0.85 millimetre in diameter. In some cases wind-borne particles from neighbouring land have been traced and in other cases ice-borne fragments—for example, portions of ancient continental rocks, such as granite, mica-schist, &c. In the western North Atlantic they were abundantly found as far south as the latitude of the Azores, and must have been brought down by Arctic icebergs which melted as they reached warmer waters. Lastly, the red clay in some localities is found to contain crystals of the class of minerals known as "zeolites," which are the result of certain chemical changes in the material of the clay.

Radiolarian Ooze.—Silica is not nearly so soluble in sea-water as carbonate of lime, and therefore, when the depth is greater than 2500 fathoms (when the foraminifera are mostly dissolved and the red clay begins to be found) and radiolaria abound on the surface, their siliceous skeletons form a large proportion of the material reaching the bottom. So we get a radiolarian ooze. These oozes are confined to the greater depths of the ocean. They resemble red clay in most respects, but differ from it chiefly in containing a much larger number of radiolarian shells, skeletons, and spicules. When a red clay contains twenty per cent. of these beautiful little organisms, so much admired by microscopists, it is classed as a radiolarian ooze. In one sample, from a depth of 4475 fathoms, they formed eighty per cent. Radiolaria seem to be slowly dissolved after the death of the organisms that secrete them from the silica contained in sea-water, for the skeletons and spicules are often seen to be reduced to the merest threads. Siliceous organisms average 54.4 per cent. The average depth at which the deposit occurs is 2894 fathoms.

Readers who live in London should pay a visit to the splendid Natural History Museum, and inspect the beautiful models in glass of the radiolaria, near the corallines. How they have been made is a puzzle to the writer, so exquisitely fine are their long threads.

Diatom Ooze.—Diatoms are also well known to microscopists. These organisms, which belong to the vegetable kingdom, abound in cold seas and estuaries. Their cases, or frustules, show structures of great beauty. The ooze that takes its name from them is found at all depths in the Southern Ocean. When dried it is nearly pure white. [A huge lump, obtained from the bed of a lake, may be seen in the Botanical Gallery of the Natural History Museum.] Marine diatom oozes contain about fifty per cent. of diatom frustules, mixed with radiolaria, sponge spicules, together with ten or twenty per cent. of carbonate of lime. A great zone of this ooze, of varying width, surrounds the south polar regions, and covers over 10,800,000 square miles. The low temperature of this region accounts for the small proportion of foraminifera, &c. it contains, for the lime is only ten to twenty per cent. The presence of a good deal of terrigenous matter in this ooze proves the existence of an unknown ice-covered continent round the South Pole.

(To be continued.)

THE DISTRIBUTION OF THE STARS.

By MISS A. M. CLERKE, *Authoress of "The System of the Stars" and "A Popular History of Astronomy during the Nineteenth Century," &c., &c.*

THE fundamental difficulty of stellar astronomy is that of rightly inferring the real from the projected places of the stars. Prolonged study is needed to show that they are not scattered at random over the sky. They shine down upon us as if flung loosely over the surface of a sphere, and indeed owe their

name of "fixed" stars to the crude early notion of their being rivetted—*infixa*—to the "palace-roof" they very effectually serve to adorn. Yet in reality this starry vault integrates, so to speak, immeasurable abysses of star-strewn space. There, as elsewhere, "things are not what they seem," and we are confronted with the inevitable question as to the relation between the thing that is and the thing that seems. From the aspect of the Milky Way came the first suggestion of an answer. The thought could not but present itself to intelligent inquirers that the dimly-shining girdle of the sphere might exercise a governing influence over its contents. Varied investigations of this obvious possibility were accordingly carried out, and the fact was established of a general increase of stellar density, gaining intensity with descent in magnitude, towards the galactic plane. The combination into a system was thus rendered probable of the sprinkled stars of the constellations and the streaming stars of the nebulous zone running through them; but no hint could be gathered as to the nature of the combination. Only the bare existence of some principle of arrangement was perceived by unsatisfactory glimpses.

Until lately the only practically available means of searching out the plan of stellar structure was by instituting comparisons between the numbers and the magnitudes of the stars. Average brightness, it was reasonably supposed, gave a measure of average relative distance, and from distance relative abundance per unit of space could be inferred by simply counting the successive photometric ranks. But the value of this method has been impaired by an advance of knowledge in two directions. In the first place it became evident, on a wider acquaintance with stellar proper motions, that their assorted amounts afforded a much surer test of distance than could be derived from the consideration of magnitude alone. Next, it came to be recognized that the intrinsic brilliancy of stars is very different for different spectral types, so that stars of the Vega type must be nearly three times more remote than stars like Capella or the sun, equally massive, and possessing the same visual brilliancy. Diversity of stellar type implies then, diversity in laws of distribution—diversity, not only of the photometrical, but also of the physical kind, and hence constituting an essential feature of sidereal organization. The preponderance of Sirian stars in the Milky Way, simultaneously ascertained during the progress of Prof. Pickering's spectrophotographic survey and of Dr. Gill's photographic Durchmusterung, appears to be a combined result. In part, it must depend, as pointed out by Mr. Monck, upon the crowding in of Sirian stars lying far beyond the limiting distance of the included solar stars; but there is reason to believe that it is also in part produced by a genuine relationship. What is certain is that it fits in with much that was already known, and provides a fresh platform for further inquiry.

It was in great measure through the labours of Prof. J. C. Kapteyn, of Groningen, in measuring and reducing the Cape Durchmusterung plates, that the systematic difference in question was detected; and their conclusion has allowed him leisure to follow up the clue thus placed in his hands. He has done so by a research into the distribution of the stars, with special reference to their spectral types, communicated to the Amsterdam Academy of Sciences in two important papers, read April 29th, 1892, and January 28th, 1893, respectively. The first, indeed, gave only preliminary inferences, but they were ratified and extended in the second by the discussion of a greatly enlarged stock of data. These related to 2357 stars, of which 1189 are classed in the Draper Catalogue of Stellar Spectra as of the first, 1106 as of the second, and 62 as of the third type. The proper motions of 476 of them were taken from

the list prepared by Herr Stumpe for his determination of the solar translation; those of the rest from the Bradley-Auwers catalogue. The treatment of this material was on the principle that stars are, on a fairly wide average, distant from us in the inverse ratio of their apparent movements. So far as concerns the perspective element contained in them, this is of course strictly true, allowance being made for differences of angular position with regard to the apex of the sun's way. That is to say, the line traversed in a given time by the sun, if seen *square* from any star, would be of a length proportionate to that star's remoteness; and the transferred displacement of the star, as viewed from the sun, would be equal and opposite to the proper displacement of the sun as viewed from the star. Thus, assuming the direction of the solar translation known, and the "peculiar" movements of the stars to be so irregular as to give a zero effect when numerously thrown together, a secure measure is afforded of comparative stellar distance. Prof. Kapteyn accordingly resolved his proper motions into two components, one directed along a great circle passing through an apex in R.A. 276°, Dec. + 34°, the other at right angles to it. The first, reduced to a position 90° from the apex, was treated as of wholly perspective origin; the second could not but be wholly original. And it was reassuring to find that their values (abstraction being made of a few exceptionally swift objects) varied in groups of stars arranged according to proper motion, pretty nearly in the same proportion. Either component, then, of stellar motion—the parallactic, or the peculiar—appears to supply a valuable criterion of stellar distance.

The initial difficulty connected with space-sounding operations being thus removed, a number of interesting conclusions lay, comparatively speaking, close at hand. Some of these had been anticipated by Mr. Monck, and their independent deduction, through a far more elaborate investigation, shows them to be deserving of no small credit. To begin with, the remarkable circumstance seems fully established that stars with well-accentuated proper motions show predominantly spectra of the solar description.* Nor can we hesitate to agree that these objects owe their mobile character to their relative vicinity. They constitute, accordingly, a group which surrounds and includes the sun. It is most likely roughly spherical in shape, and is so strongly condensed interiorly that a volume of space near its centre contains 98 times as many stars as an equal volume near its circumference. The maximum compression appears to be round a point† lying away from the sun, towards the north-western section of Andromeda, supposed by Prof. Kapteyn to coincide with the centre of the Milky Way. But this identity is highly questionable. It depends—since the centre found for the cluster has a southern galactic latitude of about 20°—upon the truth of Sir John Herschel's and Struve's respective inferences of a position for the sun, eccentric as regards the round of the Galaxy, and to the north of its medial plane. The brilliancy of the Milky Way, however, in the southern hemisphere affords in reality not the slightest presumption of nearness; and Gould was unable, from a much more complete inquiry than Struve's could possibly be, to assign to the sun either north or south galactic latitude. His situation, for anything that can be proved to the contrary, may be perfectly symmetrical within the great cosmical annulus. It cannot then be admitted, at least on the present showing, that the latter is concentric with the newly-constituted solar star-

* See Ranyard, KNOWLEDGE, Vol. XIV., p. 50; "Old and New Astronomy," p. 798.

† The co-ordinates of which are R.A. Oh. Om., Dec. + 12

‡ Sutton, KNOWLEDGE, Vol. XIV., page 12.

group, which, it may be remarked, has little or nothing in common with "Gould's cluster." This is projected in the form of a belt, and is largely made up of Sirian stars with slight or inappreciable proper motions: while Prof. Kapteyn's collection shows no preference for the galactic, or any other plane, and includes only a slight sprinkling of "white stars," such as Vega, Sirius, Altair, and Regulus, admitted because of the vicinity implied by their motions.

Beyond a certain limit of distance (estimated by proper motion), both Sirian and solar stars exhibit marked condensation towards the plane of the Milky Way. The former, indeed, much more than the latter; yet even solar stars, when remote enough to be sensibly stationary, obey the law of galactic attraction to an equal extent with the whole body of stars down to the ninth magnitude. The distribution, accordingly, of second type stars is apparently regulated by two distinct principles; and the first, that of globular aggregation about the sun, acts altogether independently of the second, that of galactic thronging. But how the sphere and the stratum resulting severally from the two kinds of influence are related, whether they are contiguous or widely separated, we have no means of determining.

Stars of the first type are more equably distributed. They are at least exempt from the tendency of their correlatives to concentration in the neighbourhood of the sun. On the other hand, they are drawn more strongly towards the Milky Way. They accumulate mainly into a disc, or possibly into a series of rings. The proportion of their numbers to those of second type objects grows rapidly with increase of distance. Outside a sphere, of which the radius corresponds to an annual proper motion of $0.07''$, they are in a minority smaller and smaller as its centre is approached; outside of that sphere they claim about a two-fold numerical superiority. But is the superiority real or fictitious? We seem obliged to adopt the latter alternative. The disparity can, at any rate, be amply accounted for by the systematic difference in real brightness between the two great stellar orders.

Prof. Kapteyn holds that there is no satisfactory evidence of their differing systematically in real swiftness. He has investigated the matter with a negative upshot. At equal distances, he finds Sirian and solar stars to be pretty equally displaced. The balance, that is to say, does not so far incline decisively either way. But at equal distances Sirian stars appear brighter by more than two magnitudes than solar stars of similar mass. To send us the same quantity of light, they must then be 2.7 times more remote. Hence, obviously, an indiscriminate collection of stars exceeding a given magnitude represents the contents of a far larger volume of space as regards the first than as regards the second stellar order.* If the latter be included in a sphere of mean radius=1, the former must be diffused through a sphere of radius=2.7. The true proportion of their numbers, as compared with solar stars, would accordingly be increased in such a collection not far from twenty times! And the chief part of these adventitious stars, if they may be called so, would naturally fall into the ranks of immobile objects. To their presence, then, the excess of first type spectra among the Bradley-Draper stars with evanescent proper motions may safely be attributed.

The leading results of Prof. Kapteyn's able and exhaustive discussion may be recapitulated in the two following propositions:—

1. Stars with appreciable proper motions belong mainly to the solar spectral class, and gather round a point adjacent to the sun, in total disregard to the position of the Milky Way.

2. Stars sensibly fixed, Sirian and solar alike, although not to the same extent, collect towards the galactic plane. Both types can hence be inferred to obey the same organic laws, and to be united into a coherent whole.

An unexpected peculiarity of distribution, indicated by this investigation, if not convincingly proved by it, is that stars of determinate magnitude of either type are on the whole more remote when situated in or near the Milky Way. It can only be explained as due to a greater prevalence of larger or more luminous bodies in that region than in other parts of the sky.

The general shape of the stellar universe is compared by Prof. Kapteyn to that of the Andromeda nebula, as depicted in Mr. Roberts's photographs. The globular nucleus represents the solar cluster, the far-spreading rings or whorls the compressed layers of stars enclosed by the ring of the remote Galaxy.

[Prof. Kapteyn's conclusion that Sirian stars appear brighter by more than two magnitudes than solar stars of similar mass is very interesting in connection with the evidence we already possess as to the relative density of Sirian and solar binary stars. The tables given on pages 796-7 of "The Old and New Astronomy" give 0.3094 as the mean density of the binary stars of known period whose spectrum is of the solar type, and 0.021 as the mean density of the binaries of known period whose spectrum is of the Sirian type—that is, solar binaries are on the average about fifteen times as dense as Sirian binaries.]

So that, if Sirian stars and solar stars have photospheres of equal brightness, the Sirian stars will have on the average a diameter nearly two and a half (2.466) times as great as the diameter of solar stars of the same mass, and they would appear equally bright to us if situated at 2.466 times the distance of similar solar stars. In other words, the evidence derived from binary stars shows that Sirian stars appear to us nearly two magnitudes brighter than solar stars of similar mass.

Prof. Kapteyn's general result seems to me to be involved in his assumption that proper motions are to be taken as the criterion of distance. This seems to me to involve the assumption that all types of stars are moving with the same average velocity, an assumption which is not self-evident, but which seems, on the contrary, improbable in view of what we know as to certain types of stars being associated in clusters. Such clusters evidently form systems, and the individual stars cannot therefore have large proper motions relatively to one another, for such motions could not be controlled by the mutual gravity of the stars forming the system.

A solar cluster of swift-moving stars, such as Prof. Kapteyn supposes, could not form a permanent system. The vast velocity which we know that our sun and other stars having large proper motions are endowed with would carry them away from the centre of gravity of such a system, if it was composed only of the swift-moving bright stars we see. Their swift motions cannot be controlled by one or more dark stars of enormous mass, for the places of such dark attracting masses would be indicated by the symmetry of the motion of the bright bodies about them; and it is evident that such a solar cluster could not be held together by the attraction of rings of matter outside it.—A. C. RANFORD.]

* With proper motion, that is to say, smaller than $0.07''$.

† This mode of reasoning has been anticipated by Mr. Monck

NORTH



Proceeding.

SIR JOHN HERSCHEL'S DRAWING OF THE GREAT NEBULA ABOUT η ARGUS
as seen with his 24 feet Reflector at Feldhausen, Cape of Good Hope, in the years 1834 to 1837.

This drawing was derived from the plate in the "Cape Observations." It has been reduced so as to correspond with the photograph of Messrs. Russell and De Groot's photograph of the same object. Her own having observed the nebula in 1834, she became acquainted with his drawing by it, and left it to us to make it correspond with the photograph. The drawing is the work of the artist, Ross, on the R. to the original photograph.

THE ARGUS NEBULA.

By A. C. RANFORD.

WE are indebted to Dr. Gill for the very beautiful photograph of this nebula, which we are enabled to present this month to our readers, for comparison with the photographs of Mr. Russell published in last month's number of KNOWLEDGE, and with the drawing of the nebula laboriously made by Sir John Herschel during his visit to the Cape in 1834-38.

On first comparing the drawing with the photographs, probably most of our readers will fail to recognize much similarity; but, on closer inspection, many of the striking features of the nebula as shown in the photographs will be recognized as having certainly been seen by Sir John Herschel. For example, the dark oval space, shaped like a "kidney bean," shown in the lower part of Sir John Herschel's drawing, to the right of the centre, is distinctly recognizable on Dr. Gill's photograph. It is to be found in the horizontal rows of squares marked out by the reticule which have been numbered 5 and 6, and in the vertical column of squares marked 26. That this is the dark patch which was noted and attempted to be drawn by Sir John Herschel is evident from the stars which surround the dark region. The positions of these stars were carefully measured, and their magnitudes were noted and repeatedly compared by Sir John Herschel. Two of the brightest of them are on the south following side of the dark patch, and lie just upon the edge of the nebulosity. There is also a line of stars which lie upon the preceding side of the dark patch, and seem to coincide with and mark out the limit of nebulosity. The brightest of the stars on the preceding side of the dark area is at its northern end, and lies just within the nebulosity.

It will be noticed that these stars, though they agree satisfactorily in position with the stars given in Sir John Herschel's drawings, differ so materially in their relative magnitudes that we are forced to conclude either that many of the stars are variables, or that the photographic magnitudes (which agree on comparing Dr. Gill's photograph with Mr. Russell's) do not at all correspond with the visual magnitudes. A similar remark applies to the four stars shown in Sir John Herschel's drawing on the following side of the pair of stars bordering the south following edge of the dark oval area.

Another feature of Sir John Herschel's drawing of the nebula, which is distinctly recognizable in the photographs, is a narrow dark channel which runs north and south near to the centre of the lower (or southern) part of Sir John Herschel's drawing. This will be found in Dr. Gill's photograph on the preceding side of the vertical column of squares numbered 23, and extending from the horizontal row numbered 7 to horizontal row 5. The stars at the southern end of this dark channel on the Herschel drawing can, with difficulty, be recognized on the photograph, but a group of stars forming two closed curves on the north following side of the dark channel can be distinctly recognized on the photograph, in columns 22 and 23, row 8. In this region the nebulosity, as drawn by Sir John Herschel, entirely differs from the photographs.

One of the most striking features of Sir John Herschel's drawings, which is not shown in the photographs, is a curious trident-shaped structure on the following side of the centre of the Herschel drawing. The upper part of this structure has been compared by Dr. Gill to the figure of a swan, but although it is one of the brightest structures in the lower half of Sir John Herschel's drawing, there seems to be no nebulosity corresponding with it in position

on the photographs which, on the hypothesis that there has been no change in the nebula since 1834, could have been represented by Sir John Herschel by this swan-shaped structure. Its place on Dr. Gill's and Mr. Russell's large photograph is nearly free from all nebulosity—and even on Mr. Russell's very dense photograph taken with his Dalmeyer 6-inch lens, which was reproduced in the last number of KNOWLEDGE; though there is a general faint nebulosity in the corresponding region, there is no trace of the curving form drawn by Sir John Herschel.

The question whether we are warranted in assuming that a change of such magnitude has taken place in the nebula in a period of less than sixty years is one of great interest. The structure we are considering measures about seven minutes across its smaller diameter, and even if we assume that the nebula is not at a greater distance from us than our nearest neighbour amongst the stars (α Centauri), the diameter of the structure would be equivalent to 280 times the diameter of the earth's orbit, or to more than nine times the diameter of the orbit of Neptune; consequently, the disappearance of such a structure would involve either a change of brightness of the matter distributed over an enormous space, or a very rapid motion of the nebulous matter. The swiftest-moving star we know (1830 Groombridge) would only move across a space equal to the diameter of the missing structure in sixty years.

A series of observers have examined the nebula since Sir John Herschel's drawing was published, and have noted changes which they believed could not be explained by inaccurate draughtsmanship, but it seems to me that their drawings differ as much amongst themselves as Sir John Herschel's drawing differs from the photographs. The difficulty of accurately drawing an object like a nebula, which cannot be sketched with definite outlines, can only be realized by those who have made an attempt to represent a nebula or a corona or other object where the likeness or want of similarity depends upon the due graduation of tints, and where an alteration in the intensity of the brightness of any area frequently involves a corresponding alteration in the tints representing the brightness of surrounding areas. In a question of such importance I prefer to wait until we have the unbiassed evidence of photographic plates taken at long intervals, before admitting that there is undoubted evidence of changes rapidly taking place on so gigantic a scale.

The following list of papers on this nebula may interest those who desire to examine more closely the evidence we already possess with regard to changes which most of the observers who have given their attention to the nebula believe are rapidly taking place within it. I am indebted to my friend Mr. Sadler for several of these references.

- 1834-1838.—Sir John Herschel, "Cape Observations," pp. 32-47.
 1861-1864.—Mr. F. Abbott, of Hobart Town, Tasmania, *Monthly Notices*, xxiv., pp. 2-5.
 1863-1868.—Mr. F. Abbott, *Monthly Notices*, xxviii., pp. 200-202.
 1870-1871.—Mr. F. Abbott, *Monthly Notices*, xxix., pp. 225-234.
 1871.—Captain J. F. W. Herschel, *Monthly Notices*, xxix., p. 235.
 1854-1870.—Mr. J. Tebbutt, *Monthly Notices*, xxiv., p. 211.
 1871.—Mr. H. C. Russell, "Transactions of the Royal Society of New South Wales for 1871," pp. 15-24.
 1869-1871. Mr. F. Macgeorge, "Transactions of the Royal Society of Victoria," vol. x., pp. 106-113. [This paper contains drawings by Mr. Le Sacur, as well as by Mr. Macgeorge.]
 1882. Mr. C. E. Peck, "Rensdon Observatory Observations for 1882-5." Contains a drawing of the nebula, made by Mr. Peck at Jimbour, Queensland.
 1891. Mr. H. C. Russell, *Monthly Notices*, li., pp. 494-497.

Most of these observers have given special attention to the region in the northern nebulous mass around the dark opening which, in Sir John Herschel's drawing, looks like a keyhole. He refers to it in the "Cape Observations,"

p. 38, as "a singular lemniscate-oval vacuity," and says that a thin nebulous veil extends over a part of its area on the preceding side. In the photographs it appears much narrower, and with a form which reminds one of a solar prominence. This is no doubt the blackest and densest part of the dark area drawn by Sir John Herschel. That there still exists a wider dark area with an outline somewhat similar to that drawn by Sir John Herschel is evidenced by the drawing of Mr. Peek made in 1882, as well as by the drawing of Mr. Le Sueur made in 1862, given in Mr. Macgeorge's paper.

In the photographs several narrow, somewhat similar curved structures will be noticed extending into the northern nebulous mass. They should, in the first instance, be looked for on Dr. Gill's photograph, and should then be examined on the less dense photograph of Mr. Russell published in the March number of KNOWLEDGE. The largest lies a little to the north of Herschel's lemniscate structure, and is situated in column 24 and row 14. It seems to extend downwards from an area about two bright stars, and it has a spreading and branching head like the largest of the structures which has attracted the attention of all observers. A third of these curving structures is cut by the line of the reticule between rows 13 and 14, on the south preceding side of the great nebulous mass. It, too, seems to have a branching head and a curving stem, which is broadest and darkest near its base. A similar but rather smaller dark branching structure will be found in row 14, column 26, and another in row 15, column 26, entering the great nebulous mass from its north following side, and again another on the south preceding side of the great nebulous mass in row 12, column 25.

The appearance of many of these smaller dark structures is somewhat similar to the appearance which the largest lemniscate structure of Herschel assumes on the dense photograph taken with Mr. Russell's camera, which was reproduced in the March number and faces his larger photograph. In the camera photograph it will be noticed that the great lemniscate structure is reduced to a very narrow, dark, almost linear structure; this may possibly be due to the irradiation and encroachment of the brighter parts caused by the want of sharpness in the image thrown by the short-focussed camera lenses, or it may be due to the partial transparency of the edges of the dark structures. That the dark structures are partially transparent is, I think, rendered evident by a comparison of them as shown upon Dr. Gill's photograph and Mr. Russell's less dense large photograph published in the March number. In the latter photograph they appear broader and far less sharply defined at their edges than in Dr. Gill's photograph.

The connection between the dark areas in this nebula and alineations of stars along their borders was noticed by Sir John Herschel. Such bordering lines of stars are noticeable about the dark area that lies in rows 5 and 6, column 26, which has been referred to as being shaped like a "kidney bean." A similar bordering of a dark area by lines of stars is noticeable about the dark structure which lies in row 13, columns 28 and 29, and there are also very evident lines of stars along the borders of the broad dark channel on the south preceding side of the northern nebulous mass.

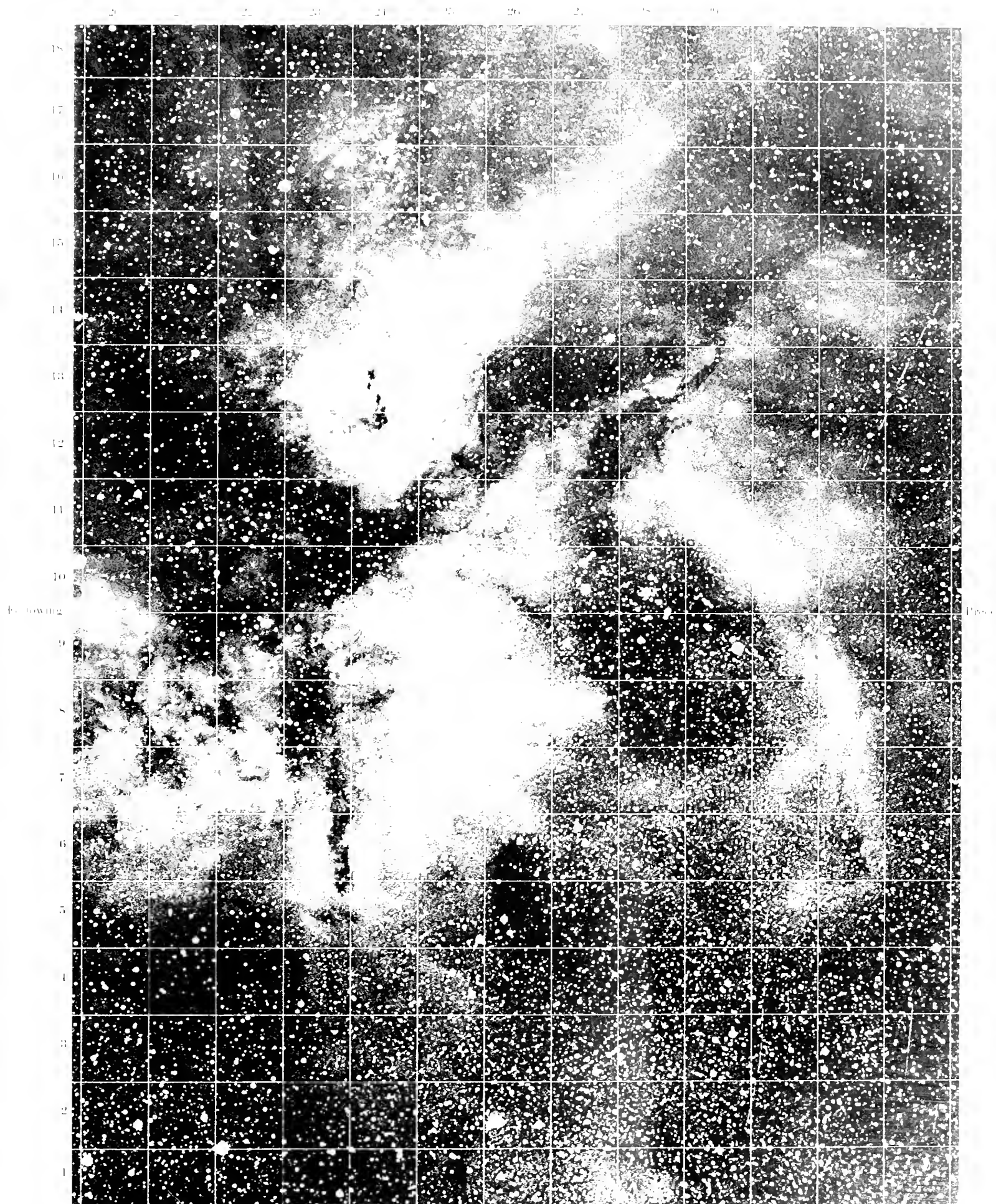
Some light may be thrown on the nature of the dark structures in the Milky Way by the forms they assume in this nebula. The prominence-like dark forms all appear to spring from the outside of the bright masses, and to be projected into the brighter matter. In the nebular mass to the north of the trifold nebula (a photograph of which was published in the January number, 1893) three dark

prominence forms seem to spring from two central dark patches within a bright nebulous cloud. Similarly, in the photograph of the Sagittarius region, published in the December number of KNOWLEDGE for 1891, three dark branching structures appear to spring from a dark area surrounded by bright stars and star clusters at the lower right-hand corner of the picture. In the region about α Cygni, a photograph of which was published in the October number of KNOWLEDGE for 1891, the dark branching structures (with the exception of the tree-like structure to the north of α Cygni) seem to spring from the dark region on the following side of α Cygni, and the tree-like structure to the north of α Cygni is connected with a long dark channel running east and west upon the plate, and associated with lines of stars. In all these cases the dark structures seem to represent matter projected into a resisting medium.

There are many ways of accounting for an opaque or partially opaque cloud in space. We have, in the chromosphere of our own sun, dark prominence forms, which are occasionally seen, and have been photographed by Prof. Hale. These, we have reason to believe, are due to cool masses of gas cutting out the light derived from similar incandescent gas behind them. But in the case of the Milky Way it seems more probable that we have to deal with matter at a lower temperature than that in the solar chromosphere, and it seems reasonable to suppose that such moving streams of gas would be derived from a heated source, and would be hotter than the medium surrounding them. We have, therefore, to account for an opaque condition of matter when it is comparatively hot, and a luminous condition as it cools.

A mass of mixed gases and vapours, on expanding and radiating into space, would no doubt, in the first instance, be precipitated into very fine particles surrounded by gaseous matter corresponding to the materials which only condense at a still lower temperature. The transparency of such a cloud would depend upon the size of the particles into which the less volatile constituents were precipitated, and on the distance between such particles. The amount of matter in a unit of volume remaining unchanged, the smaller the particles into which the matter condensed the more opaque would be the cloud; thus, if the earth were broken into cubical masses an inch in diameter, which were distributed uniformly throughout a sphere with a diameter as large as the diameter of the earth's orbit, and the sun were situated at the centre of such a spherical cluster of stones, it may be shown that only about half his light would emerge from the cluster. If the fragments were very irregular in shape, though of the same average weight as before, a larger proportion of the sun's light would be intercepted; and if the stones were broken into fragments as large as sea sand, a planet outside such a cluster would revolve in practical darkness. It is evident that a cloud or fog of precipitated particles would become more and more transparent as condensation and aggregation of the particles went on.

The microscopic structure of meteors seems to indicate that they originally consisted of minute separate particles, which have become aggregated and cemented together. As such aggregation went on, a cloud of meteoric matter would become more and more transparent, and the uncondensed gaseous residue would tend, as it cooled to a low temperature, to collect around such meteoric bodies in loosely packed atmospheres. I assume that the incandescence must be caused by occasional impacts between such atmospheres, which, if the meteors are moving, must come into collision much more frequently than the meteoric bodies themselves.

PHOTOGRAPH OF THE ϵ ARGUS NEBULA.

Taken by Dr. Gill at the Royal Observatory, Cape of Good Hope with the Astro-Photoduck, of 43 inch aperture, used by the International Survey of the Heavens. Enlargement $6\frac{1}{2} \times 48$. Exposure, 72 hours, 72 negatives on four days, March 20th to March 20th, 1892. The squares are produced by the Reticule used for the International Survey photographs.

Science Notes.

In the *Astronomical Journal* (Nos. 285-86), Prof. Barnard gives the results of a series of observations of Jupiter's fifth satellite. The period of revolution is found to be 11h. 57m. 23.06s. "The hourly motion of the satellite is $30^{\circ} 11'$, and the velocity in its orbit about 16.4 miles a second, which is some twelve times as rapid as the motion of Phobos, the inner satellite of Mars. The horizontal equatorial parallax of the new satellite is $21' 61''$. The distance from the surface of Jupiter is about 67,000 miles. The satellite seems equally bright at the eastern and western elongation. No amount of magnifying power has shown it other than as a stellar point. Its shadow cannot be seen in transit." From new determinations the following values were adopted for the Jovian diameters:—

Equatorial diameter 89,790 \pm 65 miles.
Polar " 84,300 \pm 80 miles.

The values given in Young's "General Astronomy" are 88,200 and 83,000 miles respectively.

The determination of the period of the new satellite by Prof. C. A. Young, given in our last number, was by mistake printed 11h. 57m. 4s.; it should have been 11h. 57.4m., the 4 being a decimal and equivalent to 24s., which corresponds very exactly with Prof. Barnard's determination.

According to Mr. Harold Jacoby, "the Rutherford photographic measures of the stars about β Cygni, contained in the sixth volume of the *Annals of the New York Academy of Sciences*, exhibit certain discordances which can be explained on the hypothesis of a large parallax for β Cygni, amounting to nearly a whole second of arc. The evidence cannot be regarded as conclusive, but Mr. Jacoby thinks that it is sufficiently strong to make this star an object of especial interest and promise to parallax-observers." Measures taken from six negatives give $0.97''$ as the parallax of the star. The parallaxes of μ and δ Cassiopeia, also deduced from Rutherford's photographic measures, are $0.275''$ and $0.232''$ respectively.

Our knowledge of the solar corona would no doubt advance more rapidly if a means could be devised of photographing it in ordinary daylight. Recently the matter has been taken up again by M. Deslandres, of the Paris Observatory, and Prof. George E. Hale. The former observer passes sunlight through two prisms having their faces parallel, but with the base of one opposite the refracting edge of the other. If the whole spectrum formed by the first prism pass through the second the sunlight is recomposed into white light; but by placing the prisms some distance apart only a portion of the first spectrum traverses the second prism, and a coloured image of the sun is obtained. The colour of this image can be changed by rotating the first prism; but at present no region of the spectrum has been found in which the light of the corona is so much greater than diffused daylight as to permit the corona to be seen or its image to be registered upon a photographic plate under ordinary circumstances. Prof. Hale thinks that the best results will be obtained by using ultra-violet rays in future photographic experiments, for there is some reason to suspect that the brightness of the corona with respect to the surrounding sky is inversely proportional to the wavelength of the light employed for the observation. Prof. Hale will shortly try an instrument, similar to the spectroheliograph, which has been constructed for the express purpose of photographing the corona.

The Actoman prize of one hundred guineas, which is awarded by the Committee of Managers of the Royal Institution every seventh year, has been given this year to Miss Agnes M. Clerke for her works on Astronomy. The recipient in 1886 was Sir George Stokes for his little book on "Light."

A society has recently been formed for the purpose of furthering the study of the Mollusca and Brachiopoda. It is to be called the Malacological Society of London, and its meetings are to be held monthly, at eight o'clock in the evening of the second Friday in the month, at 67, Chancery Lane. Dr. H. Woodward is to be the first President.

Dr. Scott, in his latest experiments on the proportion in which hydrogen combines with oxygen to form water, finds that the ratio of hydrogen to oxygen is not 2 to 1, but more than 2 volumes of hydrogen to 1 of oxygen. The exact ratio is 2.00246 hydrogen to 1 oxygen. This result has an important bearing on the determination of the atomic weights of the elements, the exact value for the atomic weight of hydrogen not being known with reference to other elements, such as oxygen.

Mr. Boys with his radio-micrometer can observe a deflection of the instrument, which is due to a temperature difference of less than one two-millionth ($\frac{1}{2,000,000}$) of a degree Centigrade. In one particular case the surface receiving the radiant heat is a disc only 2 millimetres in diameter, and when the scale is 30 inches from the mirror, the hand held about a yard from the instrument produces at once a deflection of 16 centimetres, shown by the spot of light thrown by the mirror on the scale. Mr. Boys also calculates that the heat received by a halfpenny at 1500 feet from a candle flame would, if concentrated on the sensitive surface, produce a readable deflection.

Mr. J. W. Salter, writing to the *Zoologist* from University College, Aberystwith, says that on January 1th last he obtained a polecat about six miles south of Aberystwith. He thinks that there is reason to believe the species is by no means extinct in Cardiganshire.

In *Nature* for February 23rd Dr. Ball gave an interesting account of lion-tiger hybrids. In the next number Mr. S. F. Harmer, of Cambridge, draws attention to the fact that his university possesses the skeleton and stuffed skin of an *adult* hybrid between a lion and a tigress. It was about six years old, and although inferior in size to either of its parents, the animal appeared to have attained its full dimensions. The shape of the head resembled that of the father (the lion), whilst the form of the body was more similar to that of the tigress. The body was faintly striped. It was a female and had neither a mane nor a tuft at the end of its tail.

The *Times* recently gave an account of a process by which anthracite coal bricks are now being manufactured. Grains of anthracite dust are forced together, partly by means of a cementing compound and partly by great pressure. The coal dust is mixed with the binding material in the proportion of ninety-six per cent. of the former to four per cent. of the latter. These coal bricks are said to make an excellent fuel, and to possess a very high efficiency for steam-raising purposes. Should this fuel be largely used for household purposes, it is to be hoped that the atmosphere of our towns will be less smoky.

The idea that water on freezing gets rid of its impurities turns out to be another instance of a popular fallacy. Recent careful experiments show that the average amount of impurity retained by ice is 34.3 per cent. of organic matter and 21.2 per cent. of inorganic matter. In view of these results it behoves those who supply ice to shops to exercise some care as to the source from which it comes.

A translation of Prof. Weisman's "Das Keimplasma" (the Germ Plasm) has been issued in "The Contemporary Science Series" (Walter Scott). The translators are Prof. W. N. Parker and Harriet Rönnfeldt, who have done their work carefully. Prof. Parker has had the great advantage of being able to consult Prof. Weisman personally with regard to many of the more difficult passages.

An important paper on "Fossil Mammals of the Wahsatch and Wind River Beds," by H. F. Osborn and J. L. Wortman, has been issued as a bulletin by the American Museum of Natural History, and has also been published separately. It is principally devoted to a description of a collection made by Dr. Wortman during the summer of 1891. The authors claim that many new facts of great interest are brought out by the material in the collection.

M. Moissan, the eminent French chemist, who succeeded a few weeks ago in producing diamonds artificially, contributes to the *Comptes Rendus* of March 6th some further observations on the chemical properties of the diamond. He finds that the temperature of combustion of diamonds in oxygen varies with different specimens from 760° C. to 875° C. In general, the harder the diamond the higher is its temperature of combustion. Dry chlorine and hydrofluoric acid vapour are incapable of acting upon the diamond until a temperature of about 1200 C. is reached. At this temperature, however, fused carbonates of potassium and sodium easily dissolve it, carbonic oxide being evolved by the reaction.

Dr. Bashford Dean, who was sent by the United States Fish Commission in 1891 to study the cultivation of the oyster in Europe and America, has just issued two reports (*Bulletin U.S. Fish Comm., 1890*), one dealing with "Oyster Culture in France," the other with the "Natural Oyster Grounds of South Carolina." The first report shows the very high state of perfection to which the cultivation of the oyster has been brought in France. The second report deals in the fullest manner with the natural conditions affecting the growth, the nature of the bottom, the food, enemies, &c., of the South Carolina oyster, and is illustrated by reproductions of photographs.

The *Geological Magazine* for February contains an instructive sketch of the life and work of the late Sir Richard Owen from the facile pen of the editor, Dr. Henry Woodward, who was his official colleague during a quarter of a century. We will only quote the following paragraph:—"The success that attended him in his long life resulted from a combination of circumstances. Everybody will readily admit the fact of Professor Owen's extraordinary genius, his sagacity in interpretation, and his remarkable ability as a lecturer: but behind these he owed very much to his indomitable energy and power of sustained work, to his marvellous flow of language, to his vigorous bodily health, and, in controversy, not a little to his cleverness both in defence and attack. His courteous manners, when dealing with the general public, were proverbial, and also the marked attention which he paid to the rank of the individual."

The Rev. F. J. Smith, Millard Lecturer at Trinity College, Oxford, points out in *Nature* of March 9th that an efficient screen from the magnetic influence of a large dynamo is obtained by building two brick walls a short distance apart and filling the interspace with scrap iron. A screen of this character has been constructed to protect the physical instruments of the Millard Laboratory from the intense magnetic field of the transformer of the Oxford Electric Lighting Company, and it answers the purpose extremely well.

The Commission appointed to investigate the subject of electrical communication with lighthouses and lightships has recently finally considered an *ad interim* report. This report deals with that portion of the evidence relating to the necessity of establishing telegraphic communication with lightships and lighthouses on the British coast. It is understood that the Commissioners recommend experiments being made in the matter of direct communication between lightships, &c., and the shore upon some of the most dangerous shoals and sands.

For some time M. Mascart has used, under the name of a *gravity-barometer*, an instrument by means of which the variation of gravity between different places can be determined. The instrument has recently been employed in determining whether there are temporary variations of gravity in one and the same place, and M. Mascart finds anomalous disturbance, which he is unable to attribute to changes of temperature or other physical changes affecting the instrument. He is inclined to treat them as evidence of variation in the force of gravity, and it is pointed out that observations of this kind will no doubt present a peculiar interest in volcanic districts if the changes are due to displacement of masses in the interior. (*Philosophical Magazine*, March, 1893.)

Two important papers upon the ready preparation of large quantities of the more refractory metals, by means of the electric furnace, are contributed by M. Moissan to the *Comptes Rendus*. The electric furnace is simply a small furnace constructed of lime, so arranged that it can be intensely heated by a very powerful electric arc. A quantity of magnesia, which M. Moissan finds to be perfectly stable, even at this high temperature, is first placed in the cavity of the furnace, and upon this the crucible of retort-carbon, containing a mixture of powdered carbon and the metallic oxide to be reduced. In this way M. Moissan has succeeded in rapidly preparing considerable quantities of the metals of the alkaline earths, calcium, strontium, and barium.

There is little doubt that exaggerated statements are frequently made with regard to the speed of flight of birds. A writer in *Science* records a case in which a couple of wild ducks started off at full speed in front of a train which had disturbed them; and, though the train was running at the rate of only thirty-seven miles per hour, the birds were overtaken. In a letter to *Nature* on the same subject, Mr. H. Withington gives an instance of a pair of turtle-doves flying at a speed rather less than a train travelling about forty miles per hour. But the turtle-dove is probably below the average pigeon in point of flying capacity. As Mr. Withington remarks, "it certainly cannot be compared with the passenger pigeon of America, which has frequently been killed in the neighbourhood of New York with Carolina rice still undigested in its crop, having probably accomplished a journey of between 300 or 400 miles in about six hours, giving the high record of sixty miles an hour for six hours in succession."

Dr. Robert Munro, in the *Fortnightly Review*, in an article on "Prehistoric Trepanning," says: "The first person to call attention to the fact that trepanning had been practised in prehistoric ages was Dr. Prunières, of the town of Marvejol, who found a perforated skull in his researches among the dolmens in his neighbourhood, some twenty years ago. Dr. Paul Broca subsequently devoted much time and study to the subject, and added greatly to the facts already known by his researches in the artificial caves newly brought to light in the Valley of Petit Morin. He discovered that the polished portions round the margin of some of the perforations were due to cicatricial deposits, and concluded that during the neolithic period a surgical operation was practised, which consisted in making an opening through the skull for the treatment of certain internal maladies."

There seem to be serious prospects of a failure of our india-rubber supply, and consequently the price of gutta-percha has considerably increased. Last year it was 4s. 6d. per pound. Efforts are now being made in the Indies, especially in the neighbourhood of Saigon, to create large plantations, but it will take many years before these young plantations can yield. In the meantime it is suggested that a more rational method of extracting the gum or gutta-percha should be adopted, so that existing trees may not be altogether destroyed. Some day, probably, Africa will send us a good deal of this most valuable substance, new applications of which are continually arising. Prof. Tilden, F.R.S., of Birmingham, has recently succeeded in making a chemical compound with somewhat similar properties. If chemists can make a substance equally good, they will confer a great benefit on the community.

Letters.

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

To the Editor of KNOWLEDGE.

SIR,—I see that I have made it appear in my last article as though the crinoid originally described as *Pentacrinus europæus* really belonged to that genus; whereas, of course, it is the larva of the common feather-star (*Antedon*, or *Comatula*). I had intended to refer to it merely as the first-discovered living erinoid in a *general*, and not in a *generic* sense.

R. LYDEKKER.

THE IGNIS FATUUS.

To the Editor of KNOWLEDGE.

DEAR SIR,—In his interesting article "On Certain Low-lying Meteors," in your March number, Mr. Tomlinson asserts that "the *ignis fatuus* is now seldom or never seen." Perhaps I may be permitted to instance a very fine example of it in this neighbourhood. Three miles north of here there is a small deep dam, which serves as a reservoir to supply the railway company with water for their locomotives, and on which I, with a few friends, have skated, whenever it has been sufficiently strongly covered with ice, for many winters past. It has been our custom to take a borer with us and make a small hole in the centre of the ice, through which a stream of CH_4 issues, and which we ignite by applying a lighted match, when a pale blue flame, rising occasionally to a height of three feet, appears; in bright sunshine this becomes practically invisible, but it is undeniably very hot. The feeding stream runs through fields and along hedges, bearing vegetation derived from these into the pond.

Would not Major Blesson's *ignes fatui* in the Gubitz forest consist rather of PH_3 , seeing they were self-igniting, than of CH_4 ?

Hartlepool,

18th March, 1893.

Yours truly,

CHARLES NIELSEN.

Mr. Nielsen is mistaken in assuming that the gas in the Gubitz forest was self-igniting. He will know from his own experiment that the flame of CH_4 is often so faint by day as to be invisible, but it becomes visible by night.—C. TOMLINSON.]

ASTRONOMY AND SHAKSPEARE.

To the Editor of KNOWLEDGE.

SIR,—The suggestion put forward by Mr. H. M. Collison, as to the "seven stars" mentioned by Shakspeare being "Charles' Wain," seems probable. I have on two or three occasions heard the "Great Bear" spoken of by people ignorant of astronomy as the "seven stars"; and only recently on pointing out to a person the Pleiades as the "seven stars," he asked me if "they were a guide to the pole star, as he had always understood that the 'seven stars' enabled one to find it." The persons to whom I have referred were each of provincial birth and upbringing, and probably came from parts of England where the old name still survives. In America the commonplace name for "Charles' Wain" is "the Dipper," but the most curious name I have heard applied to it is "the Butcher's Cleaver." The same individual asked me whereabouts in the sky he could look for the "Yard Measure." I assumed at the time that he meant the three stars in the belt of Orion.

Yours faithfully,

Forest Gate, E.

B. J. HOPKINS.

THE STRUCTURE OF THE GALAXY.

To the Editor of KNOWLEDGE.

SIR,—According to Professor Pickering, the stars in the Galaxy are rated about one-fifth of a magnitude too low (on the average) in eye-estimates on the subject. He offers no explanation of this fact, but it seems to me to follow naturally from the brightness of the background on which these stars are projected. According to Professor Kapteyn, a star in the Galaxy is photographically brighter than a star of equal magnitude elsewhere—the difference between the photometric and photographic magnitudes diminishing as we pass outwards from the centre of the Galaxy. This seems to be a different statement of the same fact. If a galactic star, rated at 6.0, is really of magnitude 5.8, we may expect to find it photographically on the 5.8th magnitude.

We have as yet only one-half of Mr. Marth's list of the galactic latitudes and longitudes of stars up to the 6th magnitude. Few of the stars in his list have a galactic latitude of more than 20° or 25° . But as the result of a rough comparison of the stars lying within 20° of the Galaxy on either side, I cannot find either that there is any clustering of these stars round the galactic circle or that there is any material difference in the relative proportion of Sirian, Capellan, and Arcturian stars throughout this region. The inference appears to be that, whatever the structure of the Galaxy may be, almost all the stars brighter than the 6th magnitude lie on this side of it, and as the Draper Catalogue is not to be relied on for stars much below that magnitude, our *data* as to the real structure of the Galaxy are at present altogether inadequate from the spectroscopic point of view.

Truly yours,

March 11, 1893.

W. H. S. MONCK.

[Sirian stars are bluer than solar stars and richer in the

short wave-lengths beyond the violet end of the spectrum, which affect the photographic plate but do not affect the eye; consequently the photographic trace left by Sirian stars is denser than that left by solar stars of the same visual magnitude. Prof. Pickering has shown from an examination of the stars contained in the Draper Catalogue (see *Annals of Harvard Coll. Obs.*, vol. xxvi., p. 152) that stars of the second and third type above the $6\frac{1}{2}$ magnitude are distributed nearly equally over the northern heavens, while stars of the A or Sirian type above the $6\frac{1}{2}$ magnitude are nearly twice as numerous in the region of the Milky Way as in the rest of the sky. Mr. Marth, in his list of galactic stars, does not profess to give all stars down to the 6th magnitude. His stars are chosen so as to give convenient points of reference for drawing the Milky Way.

Mr. Proctor's discession in the *Monthly Notices* twenty years ago, as to the probability of the observed number of stars brighter than the 6th magnitude falling by chance on the area of the Milky Way, seems to me to prove conclusively that the majority of these stars must be actually associated with the Milky Way. But if this class of evidence does not appeal to Mr. Monck's mind, I should have thought that an examination of the recent photographs of the Milky Way could have left no reasonable doubt that many of the brighter stars in the region of the heavens occupied by the Milky Way are intimately associated with the regions of nebulosity on which they are projected, and that, consequently, these stars are at the same distance from us as the nebulosity.—A. C. RANYARD.]

THE INSECT PLAGUES OF URUGUAY

To the Editor of KNOWLEDGE.

DEAR SIR,—The pastoral country of Uruguay depends for its prosperity upon the amount of rainfall. For the last four or five years the drought has been exceptional; occasional slight showers which have fallen seem to do more harm than good, as they merely moisten the surface without penetrating to the roots, and the strong sun immediately cakes the ground again. Since August, 1891, there has not been enough rain to fill the rivers and streams. In consequence, the sheep and cattle have been unable to find any sustenance in the shrivelled grass. But though the higher animals have been reduced in numbers by famine and disease, the unnatural dryness has favoured the increase of insect life.

A little grey beetle named Vaquilla has swept over the land in swarms, devouring every remnant of vegetable life. It seems to be something akin to the well-known Colorado beetle. Amidst the general sterility it seems to flourish.

A more curious, or at any rate less known beetle, is the Isoea. Not content with devouring the surface produce, it begins its work underground. The grub is like a fat white worm, about two inches in length, and half an inch in diameter. It burrows in the ground, cutting off the roots of every vegetable it comes across—wheat, maize, and other cereals, as well as grass. At intervals it throws up mounds of earth on the surface, which are like diminutive mole-hills. Sometimes these so completely cover the ground that it is impossible to step between them.

Yours faithfully

G. E. MITTON.

To the Editor of KNOWLEDGE.

SIR,—The following simple tests of the divisibility of any number by 7, 13, and other primes, seem worthy of record. They are not given in any algebra with which I am acquainted, but of course very possibly they are well known.

Let $a_1, a_2, \&c.$, be the digits taken in order of any number, N, a_1 , being the digit in the units' place. Then (scale r)

N and $a_1 + a_2 + a_3 + \dots$ leave the same remainder when divided by $r-1$; and

N and $a_1 - a_2 + a_3 - \dots$ leave the same remainder when divided by $r+1$

with the proviso in the latter case that, when the sum is negative, the true remainder is found by subtracting the actual remainder from $r+1$. These two statements are proved in most algebras and, when the scale is 10, constitute the usual rules for divisibility by 9 and 11 respectively. We can at once deduce other results by simply observing that the above statements hold when $a_1, a_2, \&c.$, represent, instead of single digits, sets of any the same number of consecutive digits, $r-1$ becoming the same number of digits, each equal to $r-1$; and a similar change being made in the meaning of $r+1$. In fact, the latter expression becomes, whatever the radix, $10 \dots 01$, the number of digits being one more than the number in each of the sets. Thus, in scale of 10:

(1) $99 = 9 \times 11$; $\therefore 9776517$ is divisible by 9 and 11, if $47 + 65 + 77 + 9 = 198$; *i.e.*, if $98 + 1 = 99$ is.

Again, 75132141 is so, if $41 + 21 + 43 + 75 = 180$; *i.e.*, if $80 + 1 = 81$ is so. Hence the latter number is divisible by 9, and leaves remainder 4 when divided by 11. This method seems shorter than the application of the two ordinary rules: $7 + 5 + 4 + 3 + 2 + 1 + 4 + 1 = 27$; $1 + 1 + 3 + 5 = 10$; $4 + 2 + 4 + 7 = 17$; $10 - 17 = -7$; $11 - 7 = 4$.

(2.) $999 = 27 \times 37$; 357202995

$995 + 202 + 357 = 1554$; $554 + 1 = 555$; \therefore the number is divisible by 37; and, when divided by 27, the remainder is 15.

(3.) $9999 = 9 \times 11 \times 101$; and we can proceed as before but with sets of four digits. And so on.

(4.) 88529631 ; $31 - 96 + 52 - 88 = -101$; \therefore the number is divisible by 101.

(5.) $1001 = 7 \times 11 \times 13$; 71420843 ; $843 - 420 + 71 = 494$; \therefore the number is divisible by 13, and leaves remainders 10 and 4, when divided by 11 and 7 respectively.

(6.) $10001 = 73 \times 137$, which gives us easy tests for the primes 73 and 137. And so on.

(7.) If $P = a_1 - a_4 + a_7 - \dots$; $Q = a_2 - a_5 + a_8 - \dots$; and $R = a_3 - a_6 + a_9 - \dots$; then N and $P + 3Q + 2R$ leave the same remainder when divided by 7; and N and $P - 3Q - 4R$ leave the same remainder when divided by 13, with the same proviso, when the sum is negative, as in the ordinary rule for divisibility by 11.

Example, 54269761 . Here $1 - 9 + 4 = -4$; $6 - 6 + 5 = 5$; and $7 - 2 = 5$; $\therefore -4 + 3 \cdot 5 + 2 \cdot 5 = 21$; and $-4 - 3 \cdot 5 - 4 \cdot 5 = -39$. Hence the number is divisible by 7 and 13.

(8.) N and $(a_1 + a_4 + \dots) + 10(a_2 + a_5 + \dots) - 11(a_3 + a_6 + \dots)$ leave the same remainder when divided by 37, with proviso as before in regard to negative sum.

Example: 115989904 ; $1 + 9 + 5 = 15$; $0 + 8 + 4 = 12$; $9 + 9 + 1 = 19$; $15 + 10 \cdot 12 - 11 \cdot 19 = -74$. Hence the number is divisible by 37.

Hereford, March 2nd, 1893.

EDWIN ANTHONY.

To the Editor of KNOWLEDGE.

SIR,—While trying to find a formula for the solution of "figure squares," similar to the one which I give below, I discovered what to me is a new and interesting sequence in the numbers which constitute the answers to squares of successively and uniformly increased dimensions.

I think the matter will interest some of your readers.

PROBLEM.

1	2	3	4	5	6
2	3	1	5	6	7
3	1	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10
6	7	8	9	10	11

In how many different ways may the figures in the square be read from 1 to 11 consecutively? Answer, 252.

The smallest square that can be arranged is one of two dimensions, viz., $\frac{1}{2} \frac{2}{3}$; and it is at once obvious that the figures in it can only be read two different ways.

It is equally obvious that in a square of three dimensions, viz., $\frac{1}{2} \frac{2}{3} \frac{3}{4}$, that the figures can only be read in six different ways.

But in a square of four dimensions they may be read 20 different ways; in one of five dimensions, 70 ways; in one of six, 252 ways; in one of seven, 924; and so on, the numbers forming a series in geometrical progression of which 2 is the first term, and 3 the common ratio, but after the second term each successive term is plus a fraction of the preceding term.

It is this constantly recurring fraction, and the form it takes, which, to me, are the novel features of the series.

Where n is any whole number greater than 2 the n th term of the series always takes the form—

$$n\text{th term} = 3(n-1 \text{ term}) + \frac{n-2}{n}(n-1 \text{ term}).$$

(The n th term answers to a square of $n+1$ dimensions).

The series therefore runs as follows, viz. :—

1st term	...	...	...	...	...	=	2
2nd	..	= (3 × 2)	...	...	...	=	6
3rd	..	= (3 × 6) + $\frac{1}{3}(6)$	...	...	...	=	20
4th	..	= (3 × 20) + $\frac{2}{4}(20)$	...	...	...	=	70
5th	..	= (3 × 70) + $\frac{3}{5}(70)$	...	...	...	=	252
6th	..	= (3 × 252) + $\frac{4}{6}(252)$	...	...	...	=	924

and so on.

It will be seen that while the fraction in each term of the series takes the form of $\frac{n-2}{n}$ that when the numerical value is given to each one, according to the term in which it appears, we have a series of fractions whose numerators and denominators each form a series of numbers in arithmetical progression, the numerators beginning at unity and the denominators at 3, the common difference in each case being 1, viz., $\frac{1}{3}, \frac{2}{4}, \frac{3}{5}, \frac{4}{6}, \frac{5}{7}, \frac{6}{8}, \frac{7}{9}, \dots$ and so on, *ad infinitum*, the successive fractions constantly increasing but never reaching the value of $\frac{1}{2}$.

The numbers carried to the 10th term of the series are 2, 6, 20, 70, 252, 924, 3132, 12,870, 48,620, 184,756, and so on.

Has such a series of numbers any mathematical designation? Faithfully yours, W. STANFORTH.

Upperthorpe, Sheffield, March 13th, 1893.

[I am not aware of any distinguishing name for Mr. Stanforth's series.—A. C. R.]

THE CONSTITUTION OF GASES.

By J. J. STEWART, of Emmanuel College, Cambridge.

(Continued from page 55.)

TO find the pressure on the sides of a vessel due to the contained gas, imagine the containing vessel to have the shape of a cube, and let l be the length of an edge, V the speed of each molecule of gas, and n their number. Now a cube has three pairs of faces, each pair being at right angles to

the other two pairs; and the velocity of a particle may be considered as made up of three velocities at right angles to each other (call these component velocities u, v, w , and V the actual velocity, then the relation between the velocity V and its components is given by the equation $V^2 = u^2 + v^2 + w^2$). Thus we may suppose one-third of all the gas particles to be moving perpendicularly to each pair of faces of the cube, and the number of impacts made per second by any one particle on any one face is $\frac{V}{2l}$, for the particle moves over twice the length of the cube between each of its impacts on the same face. As there are n particles present the total number of impacts on one face is $\frac{nV}{6l}$. Now, as at each impact the speed of each particle is reversed—after an impact the molecule is moving with speed unchanged in magnitude but reversed in direction—and as the mass of each molecule is $\frac{M}{n}$ (the whole mass of gas divided by the number of molecules), the measure of the impact is $\frac{2MV}{6l}$. To get the pressure from these data we must multiply the value of the impacts by their number per second, and to express the pressure in terms of unit area we must also divide by the area of the face, *i.e.*, l^2 . Thus the pressure is $\frac{2MV}{6l} \times \frac{nV}{6l} \times \frac{1}{l^2} = \frac{MNV^2}{3l^3}$. But the quantity $\frac{M}{l^3}$ is the mass of gas divided by its volume, *i.e.*, its density, so that the pressure is $\frac{1}{3}$ rd of the density of the gas multiplied by the square of the velocity of its constituent molecules; or calling the density of the gas D , pressure = $\frac{1}{3} D V^2 = p$. From this expression Joule obtained the velocity of the molecules of the gas, for the mean square of the velocity $V^2 = \frac{3p}{D}$ where p = the pressure of the gas, and D = its density. For example, take the case of hydrogen, whose density expressed in pounds per cubic foot is .0056, at ordinary atmospheric pressure, which is about 2115 pounds weight on the square foot. Let the gas, moreover, be at the freezing point. The pressure in pounds weight per unit of area must be multiplied by the intensity of gravity in feet per second per second (*i.e.*, by 32.2) in order to bring the measurements to the absolute system. Then we have for the square of the velocity $V^2 = \frac{2115 \cdot 32.2}{0.0056} = 36,500,000$ very nearly, and the square root of this = $V = 6040$ feet per second. That is, the molecules of hydrogen gas at the freezing temperature are moving about with a velocity of over a mile per second. This speed is far in excess of that of a bullet when on its path from a gun.

It must not be supposed that most of the molecules have this particular velocity, nor that a single molecule retains this speed for a lengthened period. At ordinary pressures the hydrogen particle which may happen to possess the above average speed after one of its encounters with a neighbour has scarcely well started in its new path before both its direction and velocity are changed by a fresh collision. But the above quantity, 6040 feet per second, is an important and characteristic property of hydrogen, and comes into account whenever we have to consider the average behaviour of masses of the gas as effected by the molecular velocities; for instance, in considering the rate of diffusion of hydrogen through a porous diaphragm or a crack in a glass vessel. Other phenomena (especially chemical ones) cannot be explained without supposing *some* of the particles of hydrogen to have a much higher velocity than this average one. As another example consider the case of oxygen, and let us now calculate the values, using the centimetre as the unit of length, the gramme as the unit of mass, and the second as the unit of time—these units being now almost universally

used by scientific men. Let there be 1 gramme of oxygen at 0° C. and at a pressure of 76 c. m. of mercury. Using the above expression for the pressure $p = \frac{1}{3} D V^2$, or $V = \sqrt{\frac{3p}{D}}$ and considering that the density of oxygen is 1.1 with reference to air, and a cubic centimetre of air weighs .001293 grammes, the mass of unit volume (*i.e.* 1 cubic centimetre) of oxygen is $1.1 \times .001293 = .00142$ grammes. The pressure of the atmosphere being equal to that of a column of mercury 76 c. m. in length, and the density of mercury being 13.596, the pressure of the atmosphere equals 76×13.596 grammes per square c.m. Multiplying this number by 981 (the value of the intensity of gravity in the centimetre—gramme—second system) in order to express the value in absolute units, we have finally for the velocity of oxygen molecules:—

$$V = \sqrt{\frac{3 \times 1033 \times 981}{.00142}} = 46250 \text{ c.m. per second}$$

nearly. As 1 c.m. = 2.34 inches, this velocity is rather over a quarter of a mile per second. The velocity of the hydrogen molecules we saw to be about 6000 feet per second, or more than a mile per second. Thus the particles of hydrogen are four times more rapid than those of the denser gas oxygen. Now it is found experimentally that the rates of diffusion of gases through porous membranes vary inversely as the square roots of their densities. Oxygen is sixteen times as dense as hydrogen, and its particles diffuse four times more slowly. So the rates of diffusion of gases are proportional to the velocities of the particles of the gas. This is just what we would expect if the kinetic hypothesis was a true explanation of what actually takes place.

If a heavy gas, such as carbonic acid, be placed in a vessel, and above it a layer of some lighter gas, such as air or hydrogen, it is well known that after a lapse of time the two gases will be found thoroughly mixed—any cubic inch of the space contains the same relative amounts of the two gases: part of the heavy gas below has risen against gravity and the lighter one has descended. The explanation of this is that the particles of both the gases are in constant motion, and in course of time, after being retarded by a succession of collisions, they spread themselves throughout the whole enclosing space. When the mixture is complete the motion, of course, does not cease, but henceforth it can produce no change on the average constitution of the gaseous mixture. We do not require to go farther than to the case of our atmosphere for a perfect example of a uniform mixture of gases. The almost unvarying ratio of the oxygen to the nitrogen is due to this rapid motion of the gaseous particles from place to place, coupled with the fact of the enormous number of these particles.

The well-known law relating to the pressure and volume of gases, named after its discoverer, Boyle, is readily deduced from the kinetic theory. Suppose a mass of gas to be shut into a cylinder, the top of this cylinder being formed by an air-tight piston. Push in the piston till the gas is compressed and occupies only half its original volume. If we may suppose that the average velocity of the gas particles has not been altered, then the number of impacts per second on the ends of the cylinder has been doubled, for the lengths of the paths of these particles, parallel to the axis of the cylinder, are now only half what they were before, while the speed of the particles has not changed. Moreover, the number of impacts on the curved surface of the cylinder are as frequent and strong as formerly, only they are now spread over only half the former surface. Thus over all the area of the walls

of the cylinder the pressure has doubled, owing to the halving of the volume occupied by the gas. Thus the pressure varies inversely as the volume, which is Boyle's law.

But this law may also be expressed by saying that the pressure and the density of a gas vary in the same proportion. For the density of a body being the quantity of matter m in a unit of volume, when the volume of the gas is halved its density is doubled, and the density varies inversely as the volume. Now we saw above that $p = \frac{1}{3} D v^2$ when p = the pressure, D the density, and v^2 the square of the average velocity of the molecules. This equation shows that when the density D varies the pressure p must vary proportionally. V^2 varies with the temperature, because the temperature of a gas depends on the speed possessed by its particles—whatever the density of the gas the speed of the particles is the same at the same temperature. But as long as we consider the same gas at an unvarying temperature the equation $p = \frac{1}{3} D V^2$ holds good.

Gases expand $\frac{1}{273}$ rd of their volume at 0° C. (freezing point) for every rise of 1° C. in temperature. Thus if a gas is cooled down below freezing point at -273° C., it would have contracted so as to occupy no volume. We cannot imagine this happening, but the volume then occupied by the gas, if we suppose this temperature attainable, must be exceedingly small, probably approaching the space actually occupied by the molecules themselves. We cannot conceive a lower temperature than this to be possible. This point in the Centigrade scale is therefore called the zero of absolute temperature, and the existence of this absolute zero is proved by more strict reasoning from the principles of thermo-dynamics.

The equation above for the pressure may be written:—
 $p = \frac{1}{3} V^2$.

The product $p \times v$ is proportional to the absolute temperature as measured by a thermometer containing the special gas we may be considering. Thus V^2 , or the mean square of the velocity of translation of the gaseous molecules, is proportional to the absolute temperature, *i.e.* to the temperature measured from the point 273° C. below freezing point. On this "absolute" scale the temperature of melting ice will thus be 273.

If M = the mass of a single gas molecule and N = the number of molecules in an enclosure whose volume = unity the mass of the contained gas is $M \times N$. Now $p = \frac{1}{3} D V^2 = \frac{1}{3} M N V^2$.

Neither M nor N need be known, but the product of these two quantities we are acquainted with, for it is the mass in unit volume, *i.e.* the density of the gas. Above we saw that $M_1 V_1^2 = M_2 V_2^2$ when there is no passage of heat from one gas to another, that is, when they are at the same temperature, as in general $p = \frac{1}{3} M N V^2$.

Therefore for each gas this holds true; thus $p_1 = \frac{1}{3} M_1 N_1 V_1^2$ and $p_2 = \frac{1}{3} M_2 N_2 V_2^2$ where p_1 and p_2 represent the respective pressures of the two gases. When the two gases have the same pressure $M_1 N_1 V_1^2 = M_2 N_2 V_2^2$. When they have the same temperature $M_1 V_1^2 = M_2 V_2^2$. Dividing the first of these last two equations by the second, we get $N_1 = N_2$; that is, when there are two gases, each possessing the same pressure and temperature, then the number of molecules in the unit volume of these gases is the same in each case.

This deduction from the kinetic theory has been shown to be true from reasoning based on chemical grounds. It is of great importance, and is known as Avogadro's law. Its deduction independently in this simple way from the mechanical theory of gases, points to this theory being

based on an accurate representation of the constitution of gases.

If D_1 and D_2 represent the densities of the two gases, $D_1 = M_1 N_1$ and $D_2 = M_2 N_2$; as also $N_1 = N_2$, it follows that $D_1 : D_2 :: M_1 : M_2$, or in other words the densities of two gases which have the same pressure and temperature are proportional to the masses of the molecules composing these gases.

This is the expression in the language of the mechanical theory of the law, proved by Gey-Lussac, that the densities of gases are directly proportional to their molecular weights.

It was discovered by Charles that all gases expand equally under the influence of heat. This follows at once from the kinetic theory, for when two gases have the same temperature the kinetic energy of their molecules is the same, there is no tendency for heat (or what comes to the same thing, energy of motion possessed by the gas particles) to pass from one gas to the other.

Then $M_1 V_1^2 = M_2 V_2^2$, and the absolute temperature is proportional to V_1^2 when measured by a gas thermometer containing the first gas, and to V_2^2 when the thermometer contains the second gas. Now as V_1^2 is proportional to V_2^2 , the absolute temperatures, as indicated by those two gas thermometers, must be proportional, and if the readings on the thermometers coincide at any one temperature, say that of melting ice, then they must coincide at every other temperature; in other words, Charles' law holds good.

The length of the mean free path can be deduced from the kinetic theory. Clausius, reasoning from the theory of probability, shows that the ratio of the free path (*i.e.*, the course of the molecule between two collisions) to the diameter of a molecule is the same as the ratio of the whole volume of the gas to $8\frac{1}{2}$ times the volume actually occupied by the molecules themselves. We can find this latter quantity, for the volume taken up by the molecules will not differ much from the volume into which the gas is condensed when it becomes liquid, as we may consider the particles of a liquid to be almost in contact. Thus the volume of steam, at atmospheric pressure, is about 1700 times that of the water from which it is produced, or the ratio of the volume of the gas to the volume occupied by its constituent molecules is, in this case, nearly 1700:1. Knowing, in the case of gases, these two volumes, the size of the particles of gas follows. For example, the number of molecules of hydrogen gas in one cubic inch at standard temperature and pressure is about 300 millions of millions of millions—300,000,000,000,000,000. In the case of oxygen, as stated above, the velocity of the particles is about 1500 feet per second, and in this gas the mean free path is about $\frac{1}{350,000}$ inch. Thus, in one second, each oxygen molecule has about 7600 million encounters with other molecules.

These enormous numbers give us a striking mental picture of the jostling crowds of molecules through which we move, and enable us to realize the little likelihood of finding any marked difference in the relative quantities of the oxygen and nitrogen particles in any given portions of the air around us.

Let us consider what happens in experiments showing the diffusion of gases. Take a cylinder made of porous earthenware, such as is used for tobacco pipes, or in the cells of some voltaic batteries. Close it, except at one point in the end, where a glass tube is to be fitted in airtight. Now put the open end of the glass tube into water, while the porous cylinder remains in the air. The water will rise a short distance up into the tube, owing to the action of capillary forces, and thus things will remain.

Now bring over the cylinder or jar containing hydrogen (ordinary coal gas will do), and the state of affairs is very different. At once air-bubbles are seen rising through the water, they are forced out of the tube before the entering hydrogen, and whenever the jar is removed so that air once more surrounds the outer surface of the cylinder, the water rapidly rises in the glass tube. What has happened is, that first of all, when the apparatus was in air, as many gas particles entered through the pores of the cylinder as made their escape outwards by the same means; the pressure in the tube was the same as outside. When, however, hydrogen gas was made to surround the cylinder, gas entered much faster than the air could escape—about four times as quickly; thus the air was forced down the tube, and up through the water in the trough. When, again, the jar of gas was removed, the hydrogen rapidly escaped through the porous surface, while the more sluggish air entered slowly; hence the pressure fell inside the tube, and the water rose, pushed up by the pressure of the atmosphere. Graham made many experiments in the diffusion of gases, and reached the result mentioned above, that the rates of diffusion are inversely as the square roots of the densities. The above simple experiment is a striking exemplification of the kinetic theory, and gives one some idea of the very rapid movement the gas particles must have, and how independent each one must be of another.

The viscosity of a gas is the name given to that property which causes bodies moving in it to gradually come to rest. It is this viscosity also which affects the flow of gas through a narrow tube. When air passes through a tube the layer next the tube moves slowly, or almost imperceptibly; the succeeding layers increase in velocity till we reach the axis of the tube. The measurement of the viscosity of gases is important, as from a knowledge of the value of this quantity, and with the help of the mechanical theory of gases, the length of the mean free path of the gas particles can be calculated. Measurements of the viscosity of gases have been made by Maxwell, and also by O. Meyer in Germany. The methods employed were first that of observing the rate of flow of gases through tubes of known dimensions under given pressures and hence deducing the gaseous friction; and second, causing a disc to vibrate in its own plane in the gas, and observing the damping of its motion due to viscosity.

Consider a stratum of gas of unit thickness—1 centimetre—extending between two flat surfaces of indefinite extent. Let one of these plane surfaces be moving relatively to the other, with unit velocity—1 c.m. per second—the tangential force on either surface per unit of surface—1 square c. m.—is the measure of the viscosity. Expressed otherwise, we may say that the viscosity is the quantity of momentum which must be supplied per unit area in unit time, in order to keep up the unit rate of change of velocity between layers a unit distance apart.

The viscosity of a gas depends on the transfer of the momentum of its particles exactly as the diffusion of the gas depends on the transfer of the actual masses of the particles themselves. One of the best illustrations of the effect of viscosity is that given by Prof. Balfour Stewart.

Imagine a number of railway trains—*a, b, c, d, e*—on parallel rails; train *a* being at rest, *b* moving slowly, *c* a little faster, and so on, the speed of the trains increasing as we move away from *a*. Suppose passengers are continually passing

e
d
c
b
"

from train to train, leaping from one and alighting in the next, and going backwards and forwards. A passenger passing from train *a* to *e* has his momentum increased. On returning from *e* to *a* he is going from faster to slower moving trains, and he takes away momentum from the trains with the greater speed and gives it up to those possessing less velocity. The increased momentum which a passenger gains by passing from the slower to the quicker-moving train is yielded up again to the slow one when he jumps into it. In this way the tendency of the to and fro motion of the passengers is to bring all the trains to one uniform speed, *i.e.*, to make the momentum of all the trains equal.

Suppose the trains replaced by layers of gas particles, and instead of the leaping passengers consider the back and forward translational movements of the molecules themselves, and we have a correct picture of what is happening in a mass of gas which is extended between a stationary plate and a moving plate (or a layer of the gas itself) at some distance above it. The effect produced is a tendency to stop the motion of the moving plate, or, if the motion of the plate is kept up by an external force, a tendency to drag along the neighbouring stationary plate. Thus, by the observations of Maxwell on his moving disc rotating backwards and forwards in its own plane, he obtained a measurement of the value of the viscosity of air and other gases.

Let η represent the viscosity of the gas, then the length, l , of the mean path of the molecules follows thus:—
 $l = \frac{3\eta}{mnu}$. Where the product mn is simply the mass of a unit of volume (the mass, m , of a single molecule multiplied by the number of molecules in unit volume), and the quantity, u , is the mean velocity of the molecules whose value for hydrogen and oxygen we saw above.

The values obtained by O. E. Meyer for the coefficient of viscosity expressed in centimetre—gramme—second units are:—

	Centimetres.
Oxygen	0.000223
Air	0.000220
Nitrogen	0.000196
Carbon monoxide	0.000194
Carbonic acid	0.000068
Hydrogen	0.000098

From these numbers, by means of the formula given above, the following values for the mean free path are obtained:—

	Centimetres.
Oxygen	0.0000096
Air	0.0000090
Nitrogen	0.0000089
Carbon monoxide	0.0000089
Carbonic acid	0.0000062
Hydrogen	0.0000169

These values of the free path are expressed in centimetres. Reducing the number for that of oxygen to inches, we get four millionths of an inch for its mean free path at ordinary pressures. This number is of the same range of value as that given above from Clausius' formula, and considering the difficulty and the uncertainty necessarily attending the experiments till the methods are further perfected, the correspondence is as good as can be expected. Perhaps all we can at present say is that for air or oxygen the length of the free path is very small, about .00001 centimetre, or $\frac{1}{100,000}$ inch—that is, a length outside the limits of the microscopically visible. A cube, with an edge $\frac{1}{400,000}$ centimetre in length, is the smallest possible area which can be seen with modern microscopes, but the length of the path of a particle of air between its collisions is on the average five times shorter than the edge of this cube.

When the pressure is reduced, as in the vacuum produced by a good mercury-dropping Sprengel pump, in which a pressure of only a millionth of an atmosphere may be readily obtained, the length of the free path is enormously increased. The free path, therefore, in an ordinary electric glow lamp is large. The phenomena of phosphorescence in electric discharges in high *vacua* has been explained by Crookes as due to the bombardment of the glass or yttrium used by gas molecules moving on an uninterrupted free path of a foot or so in length, and striking at their high speed on the surface exposed to them.

The shortness of the free path at ordinary pressures explains how it is that the odour of a strongly smelling gas, as ammonia, does not penetrate almost instantaneously to the end of a room in which a bottle of it is uncorked, as we would expect it to do if its particles are moving at about 1000 feet per second. The rapidly moving molecules are so continually knocked about amongst each other, and by the surrounding air, that their direction is constantly changing, and they are so thickly crowded together that their uninterrupted course is only the small fraction of an inch referred to above, and it is now not surprising that a prolonged period is necessary for the strongly smelling particles to reach an observer across a room.

THE FACE OF THE SKY FOR APRIL.

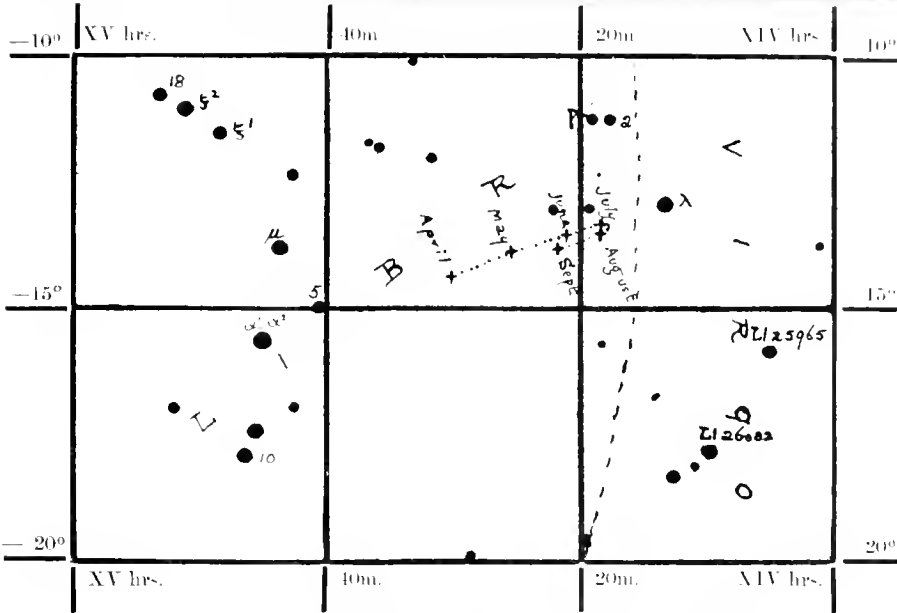
By HERBERT SADLER, F.R.A.S.

SOLAR spots continue to increase in number and magnitude. A total eclipse of the Sun occurs on the 16th, no portion of which will be visible in these islands, though a partial eclipse is visible in southern Europe. The line of central eclipse touches the coast of South America at Chánaral, in Chili, crosses South America, and leaves the continent at about forty miles to the north-west of Ceará, in Brazil. It touches Africa, after crossing the Atlantic, at Joal, in Senegambia, and leaves the earth in the Sahara. The longest duration of the total phase is 4m. 49s. Conveniently observable minima of Algol occur at 11h. 1m. P.M. on the 4th, at 7h. 50m. P.M. on the 7th, and at 9h. 32m. P.M. on the 27th.

Mercury is in inferior conjunction with the Sun on the 1st, and at his greatest western elongation ($26\frac{3}{4}^\circ$) on the 28th, but as he never rises more than forty minutes before the Sun during the whole month, and is therefore quite invisible to the naked eye, an ephemeris of him would be useless. Both Venus and Jupiter are also invisible, the latter being in conjunction with the Sun on the 27th.

Mars is still visible, but is becoming more uninteresting than ever. He sets on the 1st at 11h. 24m. P.M., with a northern declination of $21^\circ 38'$, and an apparent diameter of $5\frac{1}{2}''$. On the 30th he sets at 11h. 10m. P.M., with a northern declination of $24^\circ 17'$, and an apparent diameter of $5''$. He is in conjunction with Neptune on the 12th, Mars being $2^\circ 35'$ north. He describes a direct path in Taurus during the month.

Saturn is an evening star, and is excellently placed for observation. On the 1st he rises at 5h. 58m. P.M., or twenty minutes after sunset, with a southern declination of $1^\circ 11'$, and an apparent equatorial diameter of $19''$ (the major axis of the ring system being $43\frac{1}{2}''$ in diameter, and the minor $5\frac{1}{2}''$). On the 30th he rises at 3h. 52m. P.M., with a southern declination of $0^\circ 24\frac{1}{4}'$, and an apparent equatorial diameter of $18.6''$ (the major axis of the ring



The Path of Uranus from April 1st to September 1st, 1893.

system being 43" in diameter, and the minor 43"). Saturn will be occulted by the Moon on the 1st and 28th, but the phenomena will only be visible in the southern hemisphere. He will be in conjunction with the beautiful double star γ Virginis at 2h. 30m. p.m. on the 8th, the star being only 6.2' north of the planet; and on this and several preceding and following evenings the planet and star will present a charming appearance in the evening sky. This conjunction is, curiously enough, not noticed in the *Nautical Almanac*. Rhea is in superior conjunction at 2.0h. a.m. on the 1st; in inferior conjunction at 8.5h. p.m. on the 7th; in superior conjunction at 2.7h. a.m. on the 10th; in inferior conjunction at 9.2h. p.m. on the 16th; in superior conjunction at 3.3h. a.m. on the 19th; in inferior conjunction at 9.8h. p.m. on the 25th; and in superior conjunction at 4.0h. a.m. on the 28th. Iapetus is at his greatest western elongation on the morning of the 13th. A map of the path of Saturn during April will be found in the "Face of the Sky" for March.

Uranus is well situated for observation, coming into opposition with the Sun on the 28th at a distance from the earth of about 1632½ millions of miles. He rises on the 1st at 8h. 58m. p.m., with a southern declination of 14° 19', and an apparent diameter of 3.8", the apparent star magnitude of the planet being 5.5 in the photometric scale. On the 30th he rises at 6h. 54m. p.m. with a southern declination of 13° 57'. The accompanying map shows the path of the planet in Libra to the confines of Virgo from April 1st to September 1st, all stars down to the 7th magnitude being shown, and the position of the planet on the first day of every month being marked with a cross. The magnitude of the principal stars are: $\alpha^1\alpha^2$ Libræ (pair), 3.1; λ Virginis, 5.0; ν Libræ, 5.5; μ and ξ^2 Libræ, 5.7; ξ^1 Libræ, 6.0. All the remainder are between the 6th and 7th magnitudes.

Neptune is an evening star, but must be looked for as soon as possible after sunset. He sets on the 1st at 11h. 44m. p.m., with a northern declination of 20° 19', and an apparent diameter of 2.6". On the 30th he sets at 9h. 56m. p.m., with a northern declination of 20° 28'. During April the planet describes a direct path in Taurus, being about 4¼' south of the 5¼ magnitude star, Weisse's Bessel², iv. h., 650, on the evening of the 16th. A map of the small

stars near his path will be found in the *English Mechanic* for October 28th, 1892.

Shooting stars are fairly plentiful in April, the best marked shower being that of the Lyrids, with a radiant point in R.A. 18h. 0m. + 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 full at 7h. 18m. a.m. on the 1st; enters her last quarter at 11h. 35m. a.m. on the 9th; is new at 2h. 35m. p.m. on the 16th; enters her first quarter at 5h. 26m. a.m. on the 23rd; and is full at 11h. 23m. p.m. on the 30th. She is in apogee at 7h. p.m. on the 5th (distance from the earth 251,840 miles), and in perigee at 10h. p.m. on the 17th (distance from the earth 223,600 miles).

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

Solution of March Problem (W. A. Clark) :—

1. R to R5, and mates next move.

CORRECT SOLUTIONS received from H. S. Brandreth, A. G. Fellows, L. Bourne, and Delta.

Alpha.—You have overlooked the check with the Black Queen.

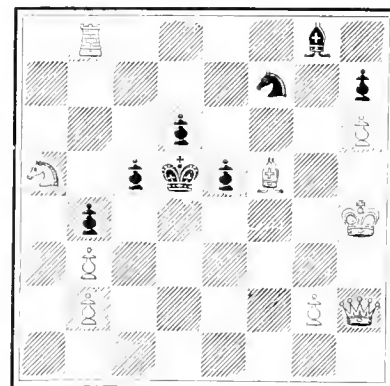
J. C. Knecker.—See answer to Alpha. KNOWLEDGE is published three or four days before the end of the *previous* month. If your local agent cannot supply it at that time, it may be obtained direct from the office (6s. per annum, post free).

A. G. Fellows.—The key is certainly weak, as you say, but the Queen variations are good.

PROBLEM.

By A. G. FELLOWS.

BLACK.



WHITE.

White to play, and mate in three moves.

The following game was played at board No. 8 in the North v. South match:—

WHITE (W. V. Wilson, Brighton).	BLACK (G. W. Wright, Manchester).
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to Kt5	3. P to Q3
4. P to Q4	4. B to Q2
5. Kt to B3	5. P × P
6. Kt × P	6. Q to B3 (a)
7. B to K3	7. KKt to K2
8. Castles	8. Castles QR (b)
9. Kt × Kt (c)	9. Kt × Kt (d)
10. Q to Q2	10. Q to Kt3
11. P to B3	11. K to Ktsq (?)
12. B × Kt!	12. B × B
13. Kt to Q5 (e)	13. B × Kt
14. P × B	14. B to K2
15. Q to Q4	15. P to Kt3
16. Q to QB4	16. B to B3 (f)
17. P to QR1!	17. KR to Ksq (g)
18. P to R5! (h)	18. R × B
19. P × P	19. BP × P
20. R × P (i)	20. R to K2
21. R × R	21. B × R
22. R to Rsq	22. R to Q2 (j)
23. Q to B6	23. R to Kt2 (k)
24. Q to Q8 (ch)	24. K to B2
25. Q × B (ch)	Resigns.

NOTES.

(a) A favourite move in the north of England, but hardly to be commended. The simplest defence here is 6. . . . Kt × Kt; 7. B × Bch, Q × B; 8. Q × Kt, KtB3; 9. B to Kt5, B to K2; but if now White castle on the Queen's side, Black should not play the tempting move 10. . . . Q to Kt5, on account of the reply 11. Q to K3! and Black dare not take the KKtP.

(b) This move and the subsequent exchanges leave the Black King in the cold. Perhaps 8. . . . P to QR3 would be an improvement; at any rate he would learn what the Bishop is going to do.

(c) 9. Q to Q2 at once looks good; but Black could reply 9. . . . Kt to K4, with the idea of getting rid of the White Queen's Bishop by Kt to Kt5 (or Kt to B5 if White exchanges Bishops).

(d) Taking with the Bishop instead might give him the opportunity of freeing his game by P to Q4 later on.

(e) Threatening B × Pch.

(f) There is hardly time for this as it turns out. His proper line of defence against the coming attack lay in bringing the Queen *via* B4 to QBsq.

(g) It was difficult to see that Mr. Wilson would not condescend to move the Bishop, but 17. . . . Q to B4 was again the only correct defence.

(h) A very beautiful sacrifice, absolutely sound in every variation. Black is compelled to take the Bishop lest a worse thing happen to him.

(i) The secondary brilliancy. If Black takes the Rook he is mated in five moves by 21. Q to B7ch, &c. (not 21. R to Rsqch, K to Ktsq; 22. Q to B6; for Black could then delay the mate by R to K8ch and other moves).

(j) Immediately fatal. The best defence, which leads to problem-like possibilities, is 22. . . . R to QBsq; 23. Q to Kt5! K to Kt2 (best, for if 23. . . . B to Qsq, 24. Q to R6, and the King can no longer escape by B2 and Qsq); 24. R to R6! B to Qsq; 25. Q to R1! leaving Black only a selection of various mates to choose from.

(k) 23. . . . R to R2 is equally demolished by Q to Q8ch. Mr. Wilson must be congratulated on having played certainly the most brilliant game in the whole match.

CHESS INTELLIGENCE.

The championship of the City of London Club has been won by Mr. T. Physick, after a tie with Mr. Eckenstein. The previous holders of the title have been Messrs. Loman and Moriau. Messrs. Gibbons and Müller were the other sectional winners.

On February 18th Sussex defeated Kent rather easily by 13 to 3, the losers' score being made up entirely of drawn games. Sussex v. Hants, played two or three weeks later, was left undecided, the score being "6 all," with one unfinished game reserved for adjudication.

An unusually brief Masters' Tournament took place at Simpson's Divan in the week beginning February 27th. The prize fund, amounting to £60, was provided by *Black and White*, in which Mr. Hoffer now edits a chess column. The six players originally selected were Messrs. Bird, Blackburne, Gunsberg, Mason, Tinsley, and Van Vliet. On Mr. Gunsberg's retirement Mr. Teichmann was chosen to take his place. The tournament was limited to one round, the result being—Blackburne, 4; Mason, 3½; Teichmann, 3; Tinsley and Van Vliet, 1½; and Bird, 0. Mr. Bird refused several draws.

The Lasker-Walbrodt match at Havana is not likely to take place after all, Mr. Lasker having excused himself on various grounds. It is rumoured that he even intends to retire from the chess world altogether.

Messrs. I. M. Brown and L. P. Rees, the secretaries of the two teams in the recent North v. South match, propose to issue a book containing a history of the match with all the games played in it. The latter will be annotated. The book will be published at 3s. 9d. post free, its publication depending on the receipt of at least 250 subscriptions before April 1st.

The Handicap Tournament of the St. George's Chess Club was won, after a very close struggle, by Mr. E. M. Jackson (Class 1A). There were about thirty competitors, and the prize winners were neck and neck at the finish, a proof of the excellence of the system of handicapping by half-classes.

Messrs. Veit & Co., of Leipzig, are publishing the *Schach-Jahrbuch* for 1898. The work, which is compiled by J. Berger, the well-known player and composer, is a combination of chess directory and chess history on a most complete scale. The regulations suitable for various kinds of tournaments are fully treated. The book is published at 6s.

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MOLES AND THEIR LIKE.

By R. LYDEKKER, B.A. Cantab.

IT is probably well known to most of our readers that in the evolution of organized nature two great factors have constantly been working against each other—the one being the adherence to a particular type of structure, while the other is the adaptation to a special mode of life. The usual resultant of these two forces has been that, in any assembly of animals specially adapted for a certain peculiar kind of existence, while internally its different members have preserved their essential structural peculiarities more or less intact, externally they have become so much like one another that it often requires the aid of the professed zoologist to point out their essential distinctness. Perhaps in no case is this adaptive similarity in external characters better displayed than among certain of the smaller mammals which have taken to a more or less completely subterranean burrowing existence, of which the common mole is the best known example. In the British Islands we have, indeed, only this one creature which has adopted this particular mode of life; and it is to this animal alone that the name "mole" properly belongs. Other parts of the world possess, however, several more or less closely allied animals to which the same name must clearly be also applied. If, however, we happen to have friends from the Cape, we may hear them applying the name "moles" to certain burrowing mammals from that district, which upon examination would be found to differ essentially in structure both from the ordinary moles and from one another. Then, again, if we

were to travel in Afghanistan or some of the neighbouring regions, we should meet with another mole-like burrowing animal to which we should likewise feel disposed to apply the same name, although it has not the most remote kinship with our English mole. Finally, the deserts of central South Australia are the dwelling-place of the recently discovered "marsupial mole," which, although mole-like in general form, differs from all the animals yet mentioned in belonging to the marsupial order.

We thus arrive at the conclusion that in the popular sense the term "mole" now serves to indicate a number of widely different animals, whose sole or chief bond of union is to be found in their adaptation to a similar mode of life, and their consequent assumption of a more or less similar outward form. Hence, in order to avoid confusion, it will be necessary to prefix the epithet "true" to those species which belong to the same friendly group as the "little gentleman in black velvet," while the remainder must be designated by other distinctive epithets. It might have been thought that such an expanded application of the name "mole" was restricted to popular language. This, however, is not the case, as naturalists have found it convenient to adopt the names "sand mole," "golden mole," "marsupial mole," etc., as the distinctive titles of different members of this purely artificial assemblage of animals; and the reader will accordingly understand that when we speak of "moles and their like," we merely refer to a similarity in habits, and a more or less marked external resemblance between the animals under consideration.

The general bodily form of the common mole is so thoroughly well known and familiar, that the term "mole-like" has been introduced into zoological, if not into popular, literature as a definite descriptive epithet. Since it is perfectly obvious that this peculiar form is the one best adapted for the needs of the creature's subterranean existence, no explanation is necessary why most of the other members of the assemblage have conformed more or less closely to this type. We may especially notice the flat, tapering, and sharp-nosed head, passing backwards without any distinctly defined neck into the long and cylindrical body; the comparative shortness of the limbs and the immense strength of the front pair, which are placed close to the head, and have their feet expanded into broad, shovel-like organs. We shall also not fail to observe the absence of any external conchs to the ears, and the rudimentary condition of the deeply-buried eyes. A long tail would also be useless to a burrowing animal, and we accordingly find this appendage reduced to very small dimensions; while the close velvety hair is most admirably adapted to prevent any adhesion of earthy particles during the mole's subterranean journeys. Equally well-marked adaptive peculiarities would also present themselves were we to undertake an examination of the mole's skeleton. While the majority of the assemblage conform more or less closely to the true moles in appearance, there are others in which such resemblance is but slightly marked, if apparent at all, from which we may probably infer some minor differences in their mode of life.

Proceeding to the consideration of the different groups of mole-like animals, it will be convenient to divide the mixed assemblage into insectivorous moles, rodent moles, and marsupial moles. The term "insectivorous moles," it may be premised, does not primarily indicate carnivorous habits in the species thus designated, but merely refers to the fact that they are members of the order Insectivora. It would of course be impossible, not to say out of place, to attempt a definition of that order; but it may be mentioned that it includes small mammals, like shrews, moles, and hedgehogs, which differ from the rodents in not pos-

sessing a pair of chisel-like teeth in the front of the jaws, and also have their molar teeth surmounted by a number of small sharp cusps.

The insectivorous moles include not only our common

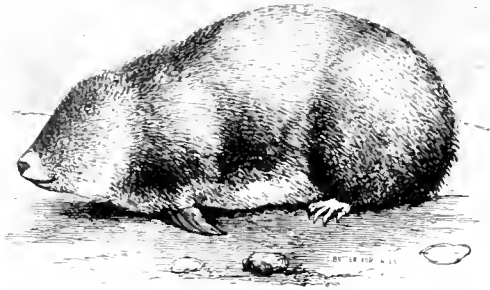


FIG. 1.—The Cape Golden Mole.

mole (*Talpa europæa*), but also many other species belonging to the same genus, as well as certain others which are referred to distinct genera, all of which, for our present purpose, may be collectively spoken of as true moles. Of these, two genera (*Talpa* and *Scaptonyx*) inhabit Europe and Asia, while the other three are North American; Africa having no representatives of the group. It may be well to mention that all the true moles have very broad naked hands, each furnished with five toes carrying long flattened nails, in addition to which there is a sickle-like extra bone internally to the thumb. In burrowing, most of them throw up the well-known molehills at certain intervals from the tunnels driven in search of worms—their chief food.

In addition to these true moles, North America also possesses certain other species known as shrew moles, which, while belonging to the same family (*Talpidae*), are distinguished by the absence of the sickle-like bone in the hand and the less expanded form of the bones of the upper part of the fore-limb. They are thus clearly seen to be less specialized creatures than our own mole, to which they closely approximate in general appearance.

Although belonging to the insectivorous order, the mole-like creature represented in the foregoing figure indicates a totally different family group. If we were to examine the upper molar teeth of a common mole, we should find that they had broad crowns, carrying cusps arranged somewhat after the manner of the letter W. On the other hand, in the Cape golden mole (as the animal represented above is termed) the corresponding teeth have triangular crowns carrying three cusps arranged in a V. Moreover, if we look at the fore-limb, we find instead of the five-fingered hand of the mole that there are but four digits, of which the lateral pair are small, while the two middle ones are enlarged and furnished with triangular claws of great power. As in the true moles, all external traces of ears and eyes are concealed by the fur; this latter, it may be added, having a peculiar golden-green metallic lustre, from which the name of the animal is derived. The golden moles, of which there are several species, are much smaller than our English mole, and are widely distributed in South Africa; in which continent they, in conjunction with the under-mentioned sand mole and its allies, take the place occupied in the northern hemisphere by the true moles. In tunnelling, the golden moles come so close to the surface as to leave a ridge

marking their course. The true moles and the golden moles afford us, therefore, an instance of two entirely distinct groups belonging to the same order having assumed a perfectly similar mode of life, and, consequently, having acquired a superficial general similarity in external appearance.

With the rodent moles, of which there is likewise more than a single group, we come to animals of a totally different order, which have assumed mole-like forms and habits, and are popularly confounded with the true moles. In common with the other members of the order Rodentia, all these rodent moles are characterized by the presence of a pair of powerful chisel-like incisor teeth in the front of each jaw, while their molars have broad and flattened crowns adapted for grinding. Moreover, instead of driving their tunnels in search of worms, these rodent moles burrow for roots and bulbs. All of them have very small or rudimentary ears and eyes, large and powerful claws, and short tails.

One of the best known of these rodent moles is the great mole-rat (*Spalax*), ranging from south-eastern Europe to Persia and Egypt, in which the eyes are completely covered with skin; allied to which are the bamboo-rats (*Rhizomys*) of north-eastern Africa and Asia, distinguished by having minute uncovered eyes and small naked ear-cochles, and thus departing more widely from the mole type. In the sandy soil of Egypt the mole-rat constructs tunnels of great length in search of bulbs. In South Africa these forms are replaced by the huge sand mole (*Bathyergus*), which attains a length of about ten inches; and also by certain smaller animals known as *Georychus* and *Myoscalops*, which differ from the former by the absence of grooves in their incisor teeth. This sand mole is commonly met with in the flats near the shore, while the smaller forms generally frequent land at a higher elevation. Sometimes, however, both are found together, and the country is then covered in all directions with hillocks precisely resembling those made by our English mole. Although the sand mole has uncovered eyes, these are not bigger than the heads of large pins, and can have but little visual power. Still, however, their presence serves to indicate that these animals have not become so completely adapted to a subterranean life as has the common mole; and this is confirmed by the fact that if their burrows are opened, the sand moles after a few minutes usually protrude their noses from the aperture with a view to discover the cause of the disturbance, whereas an ordinary mole would under similar circumstances remain below.



FIG. 2.—The Long-clawed Mole-Vole.

All the foregoing belong to one family of rodents; but in addition to these certain members of the Vole group (a

sub-division of the *Muridae*) have also taken to a subterranean burrowing life, * with the assumption of a mole-like bodily form. These may be termed mole-voles, and range from Russia to central and northern Asia, where they are represented by the two genera *Ellobius* and *Siphneus*. They all have mole-like heads and bodies, short limbs and tails, rudimental external ears, very minute eyes, and powerful fore-paws. In the Russian mole-vole (*Ellobius*) and the allied Quetta mole from Afghanistan the claws of the front paws are short; but, as shown in our figure, they become greatly elongated in the members of the genus *Siphneus*. All of them agree with the ordinary voles in the peculiar structure of their molar teeth, which consist of a number of triangular prisms placed edge to edge. All these animals are described as driving subterranean tunnels and throwing out at intervals heaps of earth precisely after the fashion of the common mole.

The foregoing are the only rodents which have assumed a more or less distinctly marked mole-like external form while retaining all the characteristic structural features of the order to which they belong. There are, however, two other members of the same great order which, while having acquired mole-like habits, have not assumed a distinctly mole-like form. One of these is the tuco-tuco (*Ctenomys*) of South America, belonging to the same great family as the capybara and the coypu. This animal is rather smaller than a rat, with a relatively shorter tail, pale grey fur, and red incisor teeth. Its general form is also not unlike that of a rat, the limbs being of fair length, and the front paws not markedly enlarged, while the eyes are of considerable size. The external conchs of the ears have, however, been greatly diminished in size. The tuco-tuco derives its name from its voice, which resounds day and night from its subterranean dwellings, and is compared by Mr. W. H. Hudson to the blows of a hammer on an anvil. It frequents loose and sandy soil, although occasionally found in moist heavy mould, through which it pierces its way as readily as the mole. Darwin, who states that the tuco-tuco is even more subterranean in its habits than the mole, was told by the Spaniards that blind examples were often captured. This, however, is not the experience of Mr. Hudson, who lays stress on the relatively large size of the creature's eyes. From the soft nature of the soil in which it tunnels, it is not difficult to understand why it has been unnecessary for the tuco-tuco to assume a mole-like bodily form; but the reason for the retention of fully-developed eyes—which we should have thought exceedingly prone to injury—is hard indeed to divine.

The other rodents with mole-like habits are two tiny little creatures from the sandy districts of Somaliland, locally known by the name of *farumfer*, and scientifically as *Heterocephalus*. They are about the size of a mouse, with large hands, moderately long tails, long powerful fore-feet, no external ear-conchs, minute eyes, and the whole skin naked, save for a few sparse bristly hairs. About as ugly a creature as can well be conceived, the *farumfer*, if clothed with a thick coat of fur, would be not very unlike a rather long-tailed, long-limbed, and narrow-handed mole. For tunnelling beneath the hot sand of the Somali desert the naked skin of the *farumfer* is most admirably adapted; and as the creature is allied to the South African *Georchus*, it may be regarded as the member of this group most specially adapted for a subterranean existence. Mr. E. L. Phillips, who was the first to observe these curious rodents in the living state, writes that they threw up in certain districts groups of elevations in the

sand which may be compared to miniature volcanic craters. When the animals are at work the loose sand from their tunnels is brought to the bottom of the crater and sent with considerable force into the air with a succession of rapid jerks, the rodents themselves remaining concealed in the shelter of their burrows, from which they appear never to venture forth.

As we have had occasion to notice in a previous article, the extensive assemblage of pouched or marsupial mammals contains groups corresponding to several of those of the placental or higher mammals. Thus, for instance, the kangaroos in Australia play the same rôle as the deer and ruminants in other parts of the world, while the Tasmanian wolf takes the place of the ordinary wolf, the wombats act the part of the marmots, the phalangers of squirrels, and the bandicoots of the civets and weasels. Till quite recently it was thought that the place of the moles (whether insectivorous or rodent) was unoccupied in the Antipodes, and that no marsupial had adapted itself to a tunnelling subterranean existence. Within the last few years it has, however, been discovered that the sandy deserts of south central Australia are inhabited by a small burrowing creature belonging to the pouched group, which has been fitly termed the marsupial mole (*Notoryctes*);

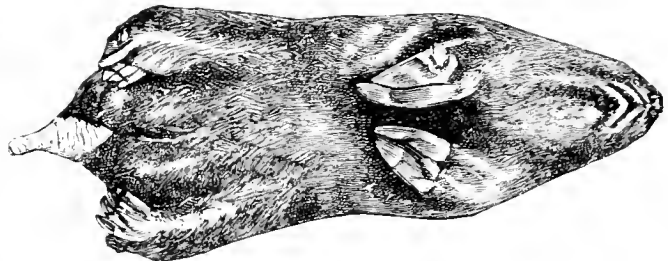


FIG. 3.—Under surface of the Marsupial Mole, two-thirds natural size. (After Stirling.)

and it is not a little remarkable that in general appearance this tiny animal is even more mole-like than are some of the above-mentioned burrowing rodents, thus showing how all powerful is adaptation to environment, and of how little import is internal structure in modifying the external form of an animal. The general mole-like appearance of the Australian burrower will be apparent from the accompanying figure; the most striking mole-like features being the elongated and depressed body passing imperceptibly into the head, the absence of external ear-conchs, the rudimentary pin-like eyes, the small tail, and the short limbs, of which the front pair are armed with claws of great power. The marsupial mole stands alone, however, in having the front of the muzzle protected by a leathery shield; while its short and blunt tail is also covered with a peculiar naked leathery skin. In the fore limbs the structure of the feet recalls the golden moles rather than the true moles, the third and fourth toes being greatly enlarged at the expense of the others, and furnished with huge triangular claws of enormous digging power. In its pale, sandy-coloured hair, with a more or less golden tinge, the marsupial mole departs widely from our sable European friend; but it must be remembered that the difference in this respect is really not so great as it at first sight appears, seeing that cream-coloured varieties of the common mole are far from rare. In the Australian form the pale coloration is doubtless adapted to harmonize with the natural surroundings of its native desert, since it has been ascertained that the creature makes its appearance from time to time above ground. That the resemblance of the marsupial to the golden mole in the structure of

* It should be mentioned that by the term "burrowing" is here meant the construction of tunnels, and not a mere dwelling hole.

the fore-paws is a purely adaptive one, there can be no reasonable doubt; but whether the identical structural conformation of the molar teeth of the two animals indicates any real genetic affinity, or is merely inherited from an old ancestral type which may have been common to many groups, is far less easy to answer.

The marsupial mole, or *ur-quamata*, as it is termed by the aborigines, inhabits a very limited area lying about a thousand miles to the interior of Adelaide; and even there appears to be of extreme rarity. According to observations supplied to its describer, Dr. E. C. Stirling, the creature is generally found buried in the sand under tussocks of the so-called porcupine-grass (*Triodia*), and its food appears to consist of insects and larvæ. The animals appear only to move about during warm, moist weather; and as they are extremely susceptible to cold, it is probable that they lie in a more or less torpid condition during the winter months, when the surface of the ground is often white with frost. When on the move, the marsupial mole is said to enter the sand obliquely, and to travel for a few feet or yards beneath the surface, when it emerges, and after traversing a short distance above ground, once more descends. As it seldom tunnels at a depth of more than two or three inches below the surface, its course may often be detected by a slight cracking or movement of the surface as the tunnel proceeds. Both in this respect, and in the nature of its food, the *ur-quamata* therefore exhibits a further analogy with the golden mole. In burrowing, the leathery shield of the head is said to be brought into play as a borer in the soft sand.

As regards the advantages obtained by the mammals which have taken to a burrowing subterranean existence, it will be manifest that these are twofold. In the first place the creatures are secure from all foes, except those which, like the weasel and the snake, are able to follow them into their underground labyrinths; while, secondly, they tap a food-supply (whether animal or vegetable) which is inaccessible to most other animals. In the case of the mole at least, whose habitations are generally made in comparatively hard ground, the life must be an incessant round of labour; and to our thinking, at any rate, the existence of all these burrowing creatures must be so dull and monotonous as to leave no question as to whether it is worth living.

STELLAR SPECTRA AND STELLAR VELOCITIES.

By MISS A. M. CLERKE, *Authoress of "The System of the Stars" and "A Popular History of Astronomy during the Nineteenth Century,"* &c., &c.

THE first spectroscopic review of the heavens, begun by Father Secchi at Rome in 1863, showed pretty clearly that the geometrical and physical relations of the stars are, to some extent, interdependent; but the establishment of any general connection of the sort was only rendered possible by the publication of the *Draper Catalogue*. Not that the data provided in this repertory—valuable and ample though it be—are well enough assured to serve as the basis of other than preliminary conclusions. For the method by which they were obtained might be called without disparagement a rough-and-ready one; it was applied too extensively to be applied with discrimination. The stars had to be taken in batches as they came, with an unvarying exposure of five minutes,

which was necessarily too long for some, and too short for others. The results should, then, be accepted most thankfully, and with full recognition of the energy, ingenuity, and resourcefulness employed in procuring them; but they should be accepted for what they are worth, and no more.

Again, the absence of settled criteria of classification gives rise to uneasy reflections. It is impossible not to feel some distrust of a system which recognizes no spectroscopic distinction between Capella and Rigel, both being comprised within the sub-class F; and indeed most of the stars designated in the *Draper Catalogue* as of the "Capellan" variety—sub-classes F and G—rank visually, according to Vogel, as of the Sirian type. How then, we cannot but ask ourselves, are differences so numerous and so glaring to be reconciled? To what court of appeal can we turn when eye and camera disagree? Decisions, moreover, presuppose definitions; and no agreement has yet been come to as to what constitutes the essential distinction between a first and a second type star. Perhaps the best available resides in the relative strength of the K-line; and as it lies in the faint violet region of the spectrum, its adoption would devolve the task of their discrimination upon photography. Thus the *Draper Catalogue*, in the construction of which this test has been carefully, though not exclusively, regarded, may turn out to be the best extant authority in the matter. The ratification of its data would be the more welcome as it would tend to fortify the important conclusions drawn from their discussion, some of which have been adverted to in the last number of KNOWLEDGE.

The most fundamental of these relates to the proper motions of the different orders of stars. Members of the solar class, whether of the Capellan or the Arcturian species, traverse the sphere much more rapidly than "white stars" resembling either Vega or Rigel. This seems to be a particularly solid fact. The chances are small that it will be overthrown by the progress of research. It is, then, of great interest to investigate its true meaning. What are we to understand by it? Are the less mobile stars, on the average, more distant, or are they animated by a lower real speed? If proper motion may be taken to be in any way a test of remoteness, the former alternative must be adopted; yet, as Mr. Ranyard truly remarks, "the assumption is by no means self-evident that all types of stars are moving with the same average velocity." Certainly not. The proposition requires to be proved; and if the evidence alleged in its support be inconclusive, all deductions regarding spectral distribution, in which mean proper motion is accepted as a measure of mean distance, must be accounted vitiated by a fundamental uncertainty. It seemed, then, worth while to recur to the subject for the purpose of enabling the readers of KNOWLEDGE to judge for themselves how far Prof. Kapteyn had succeeded in proving a general equality in actual physical speed between the constituents of the two chief stellar orders.

The principle of the inquiry was explained in the April number of KNOWLEDGE. It is that the component of stellar motion directed along a great circle passing through the sun's apex affords, since it is of perspective origin, a safe criterion of the distance from the advancing solar system of the group of stars to which it belongs. Either the remaining portion of their apparent displacements, on the other hand, being that directed across the line of the sun's way (designated τ), or the sum total of their movements (μ), affords an index to their genuine and original rate of transport. Evidently, then, when the perspective element and the original element in the proper motions of two

* Report, British Association, 1868, p. 149.

collections of stars bear somewhat about the same proportion one to the other, it is all but certain that the members of those two collections travel through space with approximately equal average velocities. This test has been applied by Prof. Kapteyn to several groups of Sirian and solar stars, variously selected and discussed, with the result of eliciting no systematic difference between their parallax and their real displacements. That is to say, the small differences that emerged were alternately in opposite senses. Thus, he derived a mean angular value of $0.196''$ for the sun's yearly translation (q) as viewed at right angles from 94 first-type stars common to Stumpe's list of proper motions and the *Draper Catalogue*; while 325 similarly selected second-type stars gave, for the same amount of mean total proper motion (μ), a value of $q=0.166''$. Taken singly, and interpreted strictly, this result would of course imply that the solar stars were, on the whole, more distant, consequently swifter-moving bodies, in the proportion of 196 to 166, than the Sirian stars compared with them. And a similar investigation of 189 Auwers-Bradley stars, with proper motions between $0.08''$ and $0.09''$, brought out a difference of the same character. But a more extensive and more searching inquiry suggested an opposite inference. Here the more stringent method was adopted of comparing the perspective element of proper motion, not with the total movement, but with the exclusively original element directed across the line drawn from each star to the sun's apex; and the stars considered were 230 solar and 338 Sirian, contained both in Auwers's and in Pickering's catalogues. The upshot was to make the Sirian stars this time appear further off and quicker, in the ratio of 37 to 31. It seems, then, difficult to contest, in the present state of knowledge, Prof. Kapteyn's conclusion that stellar rates of travel are independent of spectral distinctions.

CATERPILLARS' DWELLINGS.—II.

By E. A. BUTLER.

(Continued from page 63.)

THE solitary caterpillar, as might be anticipated from the nature of the case, greatly excels the gregarious one in ingenuity. The two great problems of its life are, as usual, the safety of its person amidst the dangers with which the outer world teems, and the assurance of a sufficiency of daily food. Having, in order to secure these ends, to rely entirely upon its own individual exertions, unaided either by parent or companion, and being moreover, so far as British species are concerned, a small and naturally defenceless creature, it endeavours to combine the solution of the two problems by a single device, either constructing its abode in the immediate neighbourhood of its food, or in a truly marvellous way making what is in reality an edible dwelling. In either case it becomes a little hermit, cut off from the world at large, and merely, like Prospero, "master of a full poor cell." In carrying out these designs, one or other of three methods is usually adopted, and these we may roughly distinguish as the method of the "tunnel," the method of the "enclosure" or "coil," and the method of the "portable case." Not that these constitute alternative plans, either of which may be adopted by each species as inclination directs or circumstances demand. On the contrary, each species has its own peculiar method of procedure, which it invariably adopts, thus exhibiting that uniformity of inherited habit to which the name instinct is applied.

The tunnel makers construct a silken tube or run in the midst of their food, within which the proprietor can rest secure from attack, and be at the same time within easy reach of supplies. Amongst the heads of umbelliferous flowers, we sometimes see silken tunnels of this kind, open at both ends, and running between the stalks of the different components of the umbel, other threads acting as cables for mooring the structure, and drawing the flower head together. Several of the smaller species of moths, especially amongst the *Tineæ*, adopt some such plan as this. Considering the immense number of insects of all orders that visit the flowers of the Umbellifera, one can see that these web-and-tunnel-forming caterpillars are much freer from disturbance than they would be if they fed in the open. There may be scores of little creatures of one kind and another crawling about overhead, ransacking the expanded head of flowers, but the caterpillar in its silken home, though close beneath them, is safe from molestation, enjoying a sort of privacy in public. Similarly, the caterpillars of the meal and tabby moths form silken galleries amongst the flour and chaff on which they feed; and so also do some of the clothes moths, the silk in this case being largely mixed with particles of the woollen fabric which they are doing their best to ruin.

Other excellent illustrations of gallery-making are to be found in the honey-comb moths, the chief of which (*Galleria cereella*) is so different in the male and female that Linné made two species out of it. The moths enter beehives in the evening, when the bees are resting, and lay their eggs on the combs. The caterpillar is a pale whitish creature, which feeds on the wax of which the combs are made, and as such depredations would of course be resented by the bees, some thoroughly reliable sting-proof shelter becomes necessary if the marauders are to carry out their enterprises successfully. Hence there is, in this case again, a very good reason for the construction of the silken tube, and the caterpillar, apparently conscious of the risk it would run if exposed, takes good care to spin its tube as far as it travels, and never to thrust out more than just the end of its body, that part being defended by a hard, thick skin, while the rest is soft and unprotected.

In this connection we may briefly notice those caterpillars that excavate minute tunnels or mines between the upper and under skins of leaves. Here the tunnel consists simply of the narrow, linear, zigzag space left by the insect as it devours the soft cellular parts of the leaf that lie between the two surfaces. The greenness of the leaf is not due to any colour in its outer skin, which is almost colourless and transparent, as may be proved by tearing a piece of it off. The green part is contained solely in the cellular tissue that constitutes the central layers of the leaf, and therefore when these are removed, a clear, transparent, or whitish track is left, which, however, usually shows a dark streak down its centre, consisting of the line of excrement left by the caterpillar as it progresses along its life-long course. Thus we

often see the leaves of different trees, shrubs, and her-

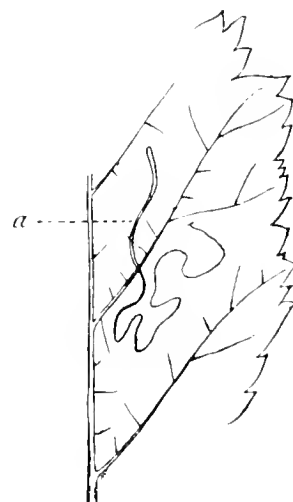


FIG. 4.—Portion of Nut leaf, showing (a) mine of a small Caterpillar (*Nepticula microtheriella*).

baceous plants such as buttercups, marked with curious zigzag lines of most fantastic shapes, very fine at the commencement and increasing in breadth till they abruptly terminate in a club-shaped end (Fig. 4) in the centre of which perhaps a little dark spot and swelling may be seen marking the position of the caterpillar itself. Sometimes, instead of a zigzag line, there is merely a discoloured irregular blotch; sometimes, again, the line follows the outline of the leaf, coasting, as it were, along the various indentations on its margin. But whatever be the precise character of the markings, they are always evidence of the presence, either at the time or shortly before, of a leaf-mining insect of some sort or other. Of course it is only very minute species that can subsist in this way; but almost all the smallest of the Tineæ, amounting to hundreds of species in Britain alone, are habitually leaf-miners. It must not, however, be supposed that all such mines in leaves are caused by the caterpillars of Lepidoptera; other kinds of insects have similar habits, especially some of the smaller flies, a well-known mine in primrose leaves, for example, being caused in this way.

Each mine is the register of the entire larval history of one single insect; its intricacies and windings represent the episodes of the tiny career, and its extent gives an accurate measure of the total amount of food consumed by the insect from its birth till its pupahood, and in fact, one might probably say, till its death, for as a chrysalis it takes no food, and, as a rule, no doubt the same is true of its brief adult life. In each of these mines, then, we have a record, indelible as long as the leaf on which it is traced endures, of the exact amount of work done in the way of the destruction of vegetable produce by a single insect during the whole of its career; and yet, so minute are they, that sometimes half a score of them will be found on a single leaf of no more than moderate dimensions, the great mass of it even then remaining untouched, so that it only seems as if the leaf were adorned here and there with an elegant tracery of filigree work. The little moths whose larvæ are the excavators of these mines are oftentimes some of the gems of the insect world, and were they only larger, would attract universal attention by their splendour. Snowy white or jet black wings, with bars, streaks, or spots of burnished gold or silver, purple or orange, adorn many of them, but they are often too minute for their beauty to be fully recognized and appreciated without the help of a lens.

The second method of home construction is that of folding the edges of a leaf upon one another so as to make an enclosure, or else rolling it up into a coil. There is a large group of small moths that, from the frequency of this habit amongst them are called Tortrices, *i.e.*, "twisters"; they are also known as "leaf-rollers." There is a general similarity of style and shape about them that makes it usually an easy matter to distinguish them from members of other groups. When resting with wings closed, they generally appear as distinctly triangular little moths, with almost straight edges to the fore-wings after a great bend



FIG. 5.—Outline of moths of leaf-rolling Caterpillars (Tortrices), in position of rest.

at the shoulder; but sometimes the outline is more like that of a bell (Fig. 5). Many of them are excessively abundant, not only in woods and hedges, but also in gardens. One of the commonest and best known is the lovely little emerald green moth (*Tortrix viridana*), which is a very familiar object in

woods in June. It infests a number of trees, but especially the oak and hornbeam, and from its association with the former has sprung its popular name of "green oak moth" (Fig. 6). The caterpillars appear in May, while the oak leaves are young and tender. The operation of leaf-rolling is a truly remarkable process, when we consider the size and helplessness of the insect. Taking advantage of some natural curvature in the leaf, the young caterpillar plants itself at the spot, and bending its head from side to side, runs a few short threads from its spinneret tightly across from the extreme point that can be reached on the one side to a corresponding distance on the other—then placing itself at the centre of the little band so constructed, and thereby slightly pressing it down and therefore bending the leaf still more, it runs another set of threads in a slightly different direction, but crossing the others at the centre. So it proceeds till it has made a strong band, which fixes the edge of the leaf in the somewhat curved position into which it has been bent. By similar operations at intervals along the same line, a long roll is produced across the leaf; other little bands of silk, added to the outer surface of this in the same way, cause it to be rolled over still further, thus commencing a second turn of the coil, and so on till ultimately as much as half the leaf may become rolled up. The direction of rolling is not always the same, even with the same species; sometimes it is longitudinal to the leaf (Fig. 7), sometimes transverse, or again diagonally placed. It seems not im-

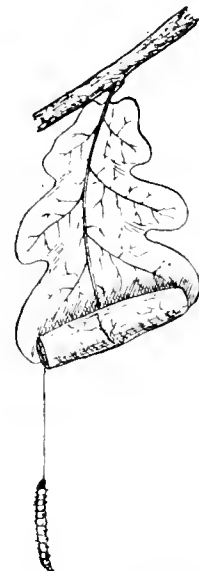


FIG. 6.—Caterpillar of Green Oak Moth, hanging from coiled oak leaf.

probable that the bands of thread, after they are run across, contract somewhat in length so as to increase the curvature of the leaf, by pulling the edges together; otherwise it is difficult to understand whence sufficient power could be obtained by so small and weak a caterpillar, working with a gum which is in a semi-fluid condition as it issues from the spinneret, to overcome the rigidity of so stiff a leaf as that of the oak tree, and coil it up as deftly as human fingers could do it. It is said that if the caterpillar, in the course of coiling the leaf, comes across a vein which is too tough and stubborn to bend as required, it weakens its resistance by biting it partly through, thus manifesting a marvellous degree of intelligence.

The coil so made is open at each end, and the caterpillar then places itself inside and remains there unless dislodged, feeding upon those surfaces of the leaf which line the coil, carefully avoiding, however, causing any damage to the last turn of the coil, which would of course bring about the opening up and destruction of its snug little domicile. When it has devoured so much of its walls as is available and safe, it gives

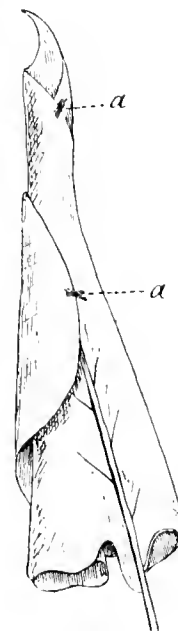


FIG. 7.—Lilac leaf rolled by Caterpillar. a. Silk fastenings.

another turn or two to the coil, thus bringing what

was previously the last turn into an internal position where it may be eaten with impunity. In this sort of life some two or three weeks are spent. If the insect is disturbed in any way, as by jarring the branch, or meddling with the leaf, it usually prefers not to rely on the concealment afforded by its retreat, but to rush out into the open. Wriggling through the outer end of the tunnel, it drops towards the ground, at the same time running out a thread, at the end of which it hangs suspended in mid-air some six or seven feet down. By this thread it can regain its cell when the danger is past. No doubt they often escape from birds in this way, as the thread is almost invisible, and therefore the insect, by suddenly dropping out of the tube at the opposite end to that where the enemy is posted, passes instantaneously out of the range of its hunter's vision and saves its life.

In due time it changes to a reddish-brown chrysalis inside its leafy coil. This, too, is very active, wriggling violently if at all disturbed. The segments of the abdomen of the chrysalis are each furnished with two rows of little hooks (Fig. 8), which are of great importance to the insect when it is ready to become a moth.



FIG. 8.—Body of chrysalis of Leaf Roller, showing hooks.

When the critical moment has arrived the chrysalis works itself along by the help of the hooks to the open end of the tunnel, and thrusts the front half of its body through the aperture. Then the skin splits as usual in the exposed part, and the little moth drags itself out of its case, and prepares to spend the few remaining days of its life in the open air, sitting about on leaves, or fluttering round the bushes in an intermittent and sluggish way.

The green oak moth is sometimes so numerous as to be exceedingly destructive, quite stripping the trees of their first crop of leaves, but at the same time providing a glorious feast for the insectivorous birds which chatter around in exultant chorus, expressive no doubt of supreme delight. Such was the case last year, when, in a certain wood near London, at the end of May, every oak tree over a particular area was black and bare at a time when all the trees of other kinds around were brilliant with the fresh green spring foliage. If the trees were shaken, down fell showers of caterpillars, some precipitated to the earth by the violence of the jerk, others hanging from threads and dangling about in mid-air. A little later in the season, similar shaking would bring down a shower of chrysalids. The leaves of these trees were so completely destroyed that, had it not been for their dried and withered fragments still held together by the little silken cords, one would have imagined that no leaves had yet been produced. Fortunately, they were replaced by a second crop after their destroyers had passed beyond the stage of leaf eating. Many others of the Tortrices carry out their designs in essentially the same way, only varying the details. Some, for example, simply double the two halves of a leaf upon one another; others fasten several leaves together and take up their abode in the midst; others, again, make an incision into a leaf and then turn down or roll up the flap so loosened. In gardens, rose trees are very liable to the attacks of several species, some of which, exceedingly handsome little orange-coloured moths, fold up the leaves, while others establish themselves within the young flower buds and devour them.

(To be continued.)

THE NUTHATCH.

By HARRY F. WILHELMY.

THE nuthatch (*Sitta europæa*) is the only representative of the genus *Sitta* to be found in Great Britain.

It is tolerably abundant in England, especially in wooded districts, and it remains with us all the year round. It is not found either in Scotland or Ireland.

The nuthatch belongs to the same order, or family, of birds as the woodpecker genus, *i.e.*, the scansors, or climbers, and it is a very good type of that order.

The general colouring of the bird is bluish-grey on the back and upper side of the wings, and buff on the breast, shading to a bright chestnut on the under tail-coverts. The upper and under side of the bird thus produce a beautiful contrast in colour. The throat is silvery white. A black line of feathers, very similar to the "moustache" of the woodpecker, runs from the base of the mandible through the eye to the bird's shoulder.

In comparing the nuthatch with the genus *Picus*, or woodpeckers, a great difference in the respective form of each is noticeable, and especially in the shape and texture of the tail feathers. We have already seen that the woodpecker's tail feathers are long and pointed, and that being strong they are very useful to the bird when climbing, whilst the tail of the nuthatch, on the other hand, is short and square, and is composed of soft feathers, which could not be so used. The nuthatch is extremely agile in its movements, and a long tail would no doubt be an inconvenience to it, whereas its short tail never impedes it.

The lack of usefulness in the tail for climbing purposes is amply made up by the construction of the bird's foot. This has three toes pointing to the front and one behind, all of which are armed with strong, sharp claws, curved at the ends. The hind toe and claw are much longer and stouter than the others.

The bird is seldom seen upon the ground, but lives in the trees. With the help of the claws it is enabled to climb with the most extraordinary ease. The bird is remarkable for its agility, and is scarcely ever seen at rest, nor does it seem to be impeded by the law of gravity in the slightest degree when climbing, for it will descend the tree head foremost, a feat which no other bird of its tribe can perform. It creeps along the under side of a branch as frequently as on the upper side. The nuthatch does not climb with a jerky motion like our woodpeckers, but creeps, or rather runs, along as smoothly as a mouse.

The food of this bird is chiefly composed of insects, berries, acorns, and beech-mast, but it is also very fond of the kernels of hazel nuts, which it extracts from the shell in a very clever way. Having obtained a nut from a tree, or from some store hidden by the bird itself, it carries the treasure in the beak to some rough-barked tree hard by, such as an old oak or old birch, and then proceeds to fix the nut securely in a crevice of the bark. The bird then commences to hammer with its beak until it has made a hole in the shell large enough to extract the kernel. Occasionally the bird will place itself over the nut, and attack it head down, probably to give additional force to its blows. Should the nut be dislodged during the operation, the bird is so marvellously quick that it will invariably catch it in its beak before it reaches the ground. From this habit of breaking nuts, it has earned the name of nuthatch, which is probably derived from the French "hacher" to chop, hence our hatchet.

While clinging to the bark to deliver a blow, the bird is greatly supported on the hind part of the leg, which may,

perhaps, be called the heel of the foot, upon which it throws most of its weight, just as the woodpecker throws its weight on the tail, when in a similar posture. When pecking very hard, the bird bends its head right back, and, as it strikes the tree, gives a flap with its wings in order to preserve its balance. If the bird cannot easily dislodge a piece of bark at which it is pecking, it will walk all round it, tapping it with its beak at every possible point, until the object is attained. The beak being broader than high at the base, and very hard, is well suited to give a strong blow.

The nesting habits of this bird are peculiar. It builds in a natural hole in a tree, not boring a hole for itself like the woodpeckers; but if the entrance to the cavity should be too large, or if there be any unevenness in it, the bird will plaster it round with mud to make the hole the required size, and it never seems to be satisfied until the hole is exactly round, and only just large enough for it to enter.

If the mud be examined, the marks of the bird's beak in the form of minute holes are seen all over it, showing with what care the work has been done.

In some parts of the country, in the New Forest for instance, the nuthatch is called the "mud-dabber," from this singular habit of "dabbing" mud round the entrance to its nest.

Nuthatches very often fight with tits of various kinds for the possession of a favourite hole for nesting purposes; and this may be the reason for its habit of making the entrance as small as possible, as a larger aperture would be less easily defended.

The nest itself is composed of moss and leaves, and very often chips of wood are introduced; one which I examined was entirely composed of small flakes of bark from a yew tree. These materials are all broken up into very small fragments, so that the leaves look as if they had been cut in pieces with a pair of scissors. They are carried into the hole apparently without any order, and no attempt is made to weave them together. Upon this nest the bird lays her eggs, which are usually five to seven in number. They are white, spotted over with reddish-brown, and can scarcely be distinguished from the eggs of the cole tit (*Parus ater*).

The eggs are usually laid in the middle of May. During the process of incubation, which lasts some fourteen days, the bird sits very close, and may be even looked at without causing her to leave the nest. A hole quite close to the road is very often chosen for the nest, and I have known one that was situated just over a seat that was in constant use. The bird hides the eggs in the nest before leaving it.

The nuthatch is not a good musician. It has no regular song, but utters several different call notes, the chief of which is very shrill and piercing, and when once heard will not easily be forgotten. It sounds like the syllable "twit" repeated very quickly, usually four or six times in succession. It has also a note sounding like "twe-twit," the last syllable being longer than the first, which is very short. Another note, not so often used, resembles the syllable "tyrrh," repeated quickly twice, and then a third time prolonged.

The flight of the nuthatch is undulating, but very rapid.

Letters.

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

THE η ARGUS NEBULA.

To the Editor of
KNOWLEDGE.

DEAR SIR.—In the very interesting paper comparing Sir John Herschel's drawing with Dr. Gill's photograph, in mentioning the trident-shaped structure, it says: "There seems to be no nebulosity corresponding with it in position on the photograph."

Is there not a faint nebulosity, corresponding to the drawing shown in the photograph, in row 10, column 22 and 23, and lower part of row 11, column 23?

There appears to me a curve, as it were the "Swan's" head, with a star on either side of the line, between rows 10 and 11 in column 23, very similar to Sir John Herschel's drawing.

Yours truly,

VINCENT YARDLEY.
"Ravenscroft,"

Church Hill,
Hoddesdon, Herts.
April 19th, 1893.

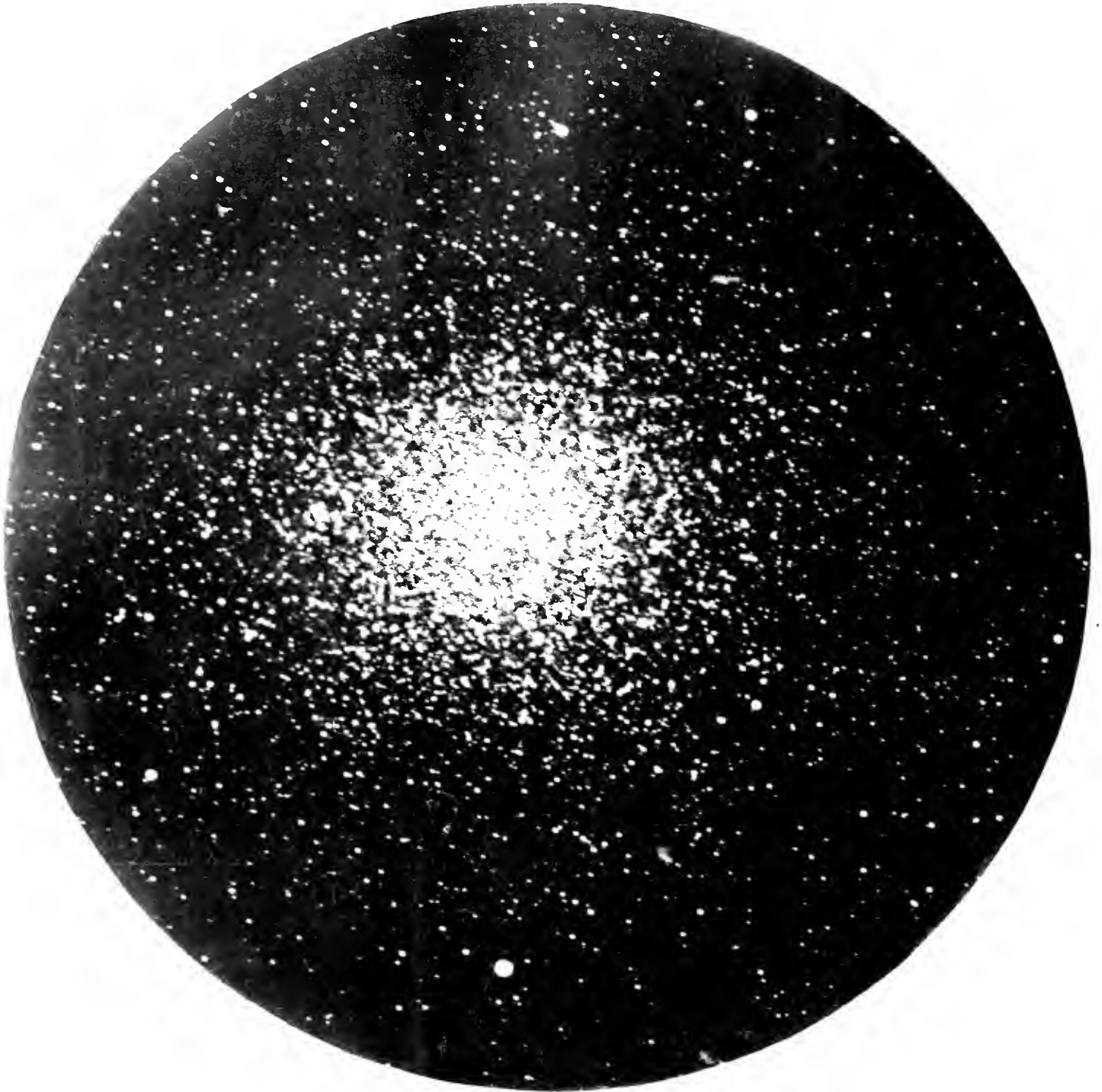
[Mr. Yardley is, I think, correct, but if we assume that the structure he refers to was the one seen and drawn by Sir John Herschel, we must make one of three assumptions—either there has been a great change in the relative brightness of various parts of the nebula since 1837; or Sir John Herschel must have made serious errors in estimating or in representing the relative brightness of different parts of the nebula, and he must have seen with his great Herschelian reflector parts of the nebula which now, by reason of their faintness, are only just traceable in Dr. Gill's photograph, taken with an exposure of over twelve hours; or the brightness of this structure as seen with the eye must be greater than as shown in the photograph—for example, its light might be redder than that of the rest of the nebula.

By a careless mistake I referred to Herschel's great



Nuthatches and Nest, showing entrance plastered with mud.

SOUTH



THE STAR CLUSTER, ω CENTAURI.

1. Photographed by DE GUER at the Royal Observatory, Cape of Good Hope, on 25th May 1892, with the
A. P. L. 100, 100, or B. P. 100, in use for the International Survey of the Heavens.
2. Photographed by DE GUER at the Royal Observatory, Cape of Good Hope, on 25th May 1892, with the
A. P. L. 100, 100, or B. P. 100, in use for the International Survey of the Heavens.
3. Photographed by DE GUER at the Royal Observatory, Cape of Good Hope, on 25th May 1892, with the
A. P. L. 100, 100, or B. P. 100, in use for the International Survey of the Heavens.
4. Photographed by DE GUER at the Royal Observatory, Cape of Good Hope, on 25th May 1892, with the
A. P. L. 100, 100, or B. P. 100, in use for the International Survey of the Heavens.
5. Photographed by DE GUER at the Royal Observatory, Cape of Good Hope, on 25th May 1892, with the
A. P. L. 100, 100, or B. P. 100, in use for the International Survey of the Heavens.

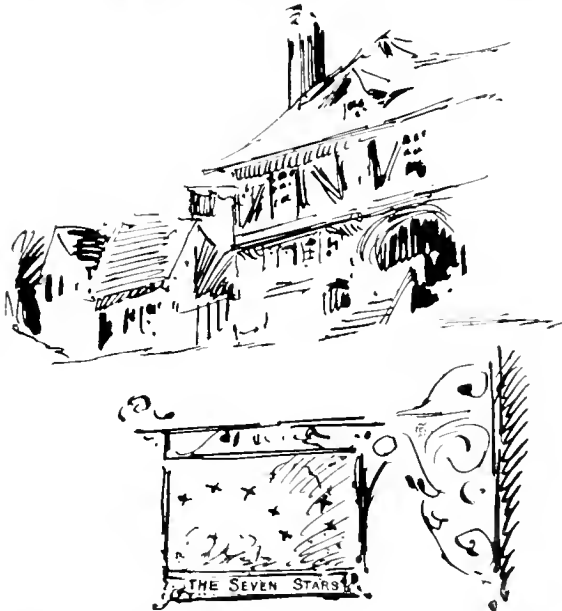
telescope, in the last number, as a Newtonian reflector. It is of course well known that Herschel did not make use of a flat to throw the image to one side of the tube—this would have saved him a little light—but his speculum metal reflector must have behaved remarkably well, as compared with silver on glass reflectors, if it enabled him to see parts of a nebula which are barely traceable on a photograph, such as Dr. Gill's, taken with twelve hours' exposure.

Some may say: If there are variable stars, why should there not be variable nebulae? But I hesitate to assume too lightly that there is reliable evidence of simultaneous changes of brightness taking place over such vast regions as must be occupied by a structure as large as that shown in Sir John Herschel's drawing.—A. C. RANYARD.]

ASTRONOMY AND SHAKSPEARE.

To the Editor of KNOWLEDGE.

DEAR SIR,—I enclose you a rough outline sketch of a very old roadside inn in Warwickshire, called the "Seven Stars of Gurnal." As this is only a few miles from the poet's birthplace, I have no doubt he may have often quaffed his ale beneath this very sign. Yours faithfully,
Hartlepool, March, 1893. H. BECK.



[Messrs. Jacob Larwood and John Camden Hotten, in their "History of Signboards," speak of the Seven Stars as a very common old sign, but does not the iron work of the sign drawn by Mr. Beck point to a later date than Shakspeare's? Messrs. Larwood and Hotten speak of the "Half Moon and Seven Stars" at Aston Clinton, near Tring, and the "Sun, Moon, and Seven Stars" at Blisworth, in Northampton. They say: "These seven stars have always been great favourites: they seem to be the same pleiad which is used as a masonic emblem—a circle of six stars with one in the centre—but to tell to ears profane what this emblem means, would be disclosing the sacred arcana." There was a printing-house with the sign of the seven stars in St. Paul's Churchyard, near to the great north door; but whether they were arranged masonically or Great Bear-wise, I do not know. Here in 1653, J. C. and Richard Moon printed "The first addresses to His Excellency the Lord General, &c., by John Spittlehouse, a late member of the army, and a servant of the Saints of the Most High God."—A. C. RANYARD.]

THE POLECAT IN CARDIGANSHIRE.

To the Editor of KNOWLEDGE.

DEAR SIR,—In the "Science Notes" in the April number of KNOWLEDGE, you quote Mr. J. W. Salter as stating "that there is reason to believe that the polecat is by no means extinct in Cardiganshire." Having passed a good deal of time every year in that county during the last thirty-two years, I can corroborate Mr. Salter's assertion; the animal is very frequently met with. I have seen dozens of skins for sale in the shop of a tradesman in a small town in Cardiganshire—he makes a speciality of collecting them—and I believe the price paid for them is from 1s. to 1s. 6d. per skin, according to quality.

Yours faithfully,

New University Club, THOS. HERBERT MADDY.
St. James's Street, S.W.,
April 17th, 1893.

To the Editor of KNOWLEDGE.

SIR,—The numbers referred to in the "figure squares" problem on page 75 of your April number are the sums of the squares of the co-efficients in the expansion of $(x + y)^n$, the formula for which is $\frac{12n}{10 \cdot 10}$

Yours faithfully,

Technical Schools, Plymouth, J. J. ALEXANDER.
April 15th.

I have received more than one note pointing out that the general term of Mr. Staniforth's series is factorial $(2n)$, divided by the square of factorial n . This will be evident to Mr. Staniforth if he throws his series into the form—

- First term ... $\frac{2}{1}$
- Second term ... $\frac{2}{1} \times \frac{6}{3}$
- Third term ... $\frac{2}{1} \times \frac{6}{3} \times \frac{10}{3}$
- n th term ... $\frac{2}{1} \times \frac{6}{2} \times \frac{10}{3} \times \frac{14}{4} \times \frac{18}{5} \dots \times \frac{2^{(2n-1)}}{n}$

Mr. T. B. Sprague has, in a recent paper published in the "Transactions of the Royal Society of Edinburgh," shown that such figure squares may be used for "A New Algebra," by means of which permutations can be transformed in a variety of ways and their properties investigated.—A. C. R.]

THE IGNI FATUUS.

To the Editor of KNOWLEDGE.

DEAR SIR,—Mr. Marshall Fisher, of Ely, has been so good as to forward me some extracts of a work on New Zealand, published in 1855, by the Rev. Richard Taylor, M.A., F.G.S., formerly curate of Coveney-cum-Manea, in the Isle of Ely.

Mr. Taylor encamped on a rainy night in a forest near the Bay of Islands, when the natives who accompanied him erected a hut, and covered it in with palm leaves, so as to make it water-tight. Fires were kindled and everything made comfortable. No sooner, however, had the men fallen asleep, and the fires began to die away, than a light was observed, like the moon shining through a chink. There was no moon, and the night was very dark. On a closer examination the object appeared as a globe of pale light attached to the point of a palm leaf which hung from the roof. Another ball of light was now seen, attached to the wet sleeve of a shirt hung up to dry. "The air appeared to be charged with these luminous vapours, for while regarding the two in the shed a series of them floated past at an elevation of about a yard from the ground." These and similar phenomena, which are evidently electrical, the author endeavours to trace to the remains of the highly resinous *Kauri* pines which abound in the place.

Should the reader object that these electrical effects would not be likely to occur on a rainy night, he may be reminded that every shower is an electrical phenomenon, and that the rain itself is sometimes luminous. Thus, an officer of the Algerian army states that during a storm on the 25th of September, 1840, the raindrops that fell on the beards and moustachios of the men were luminous.

The author also refers to a luminous appearance which he witnessed one night in the Isle of Ely. It advanced rapidly, and distinctly touched his cheek, when he perceived a sensible glow, but his breath seemed to make it bound away again. This appears to have been a case of marsh gas, but the author thinks that it—namely, the *ignis fatuus*—is simply “a luminous air, a phosphoric light, arising from the oily particles of decomposed aquatic plants . . . or from the gas of the many resinous pine trees which once grew there, and whose remains still lie buried in the peat.”

But the most singular case remains to be told. A brig off New Zealand, having been visited by some electrical brush discharges, the author accounts for them in the following manner:—“These marine lights most probably arise from the decomposed remains of fish, raised to the surface by the violent motion of the water in storms.”

Yours faithfully,

C. TOMLINSON.

WHAT IS A STAR CLUSTER?

By A. C. RANYARD.

IT is hardly possible to conceive that a star cluster such as that shown in our plate can form a permanent system, in which the stars move on from age to age without collision. The facts that we are already in possession of, with regard to the motion of binary stars, seem to render it very probable that the reign of gravity extends to stellar distances, though it must be admitted that we have no indisputable evidence that gravity acts across the interstellar spaces, or even that the apparently elliptic paths, which observation shows that the components of a binary star describe about one another, are swept out under the action of a force varying as the

inverse square of the distance from their common centre of gravity. But in view of the facts with which we are familiar in our solar system, this is the simplest assumption to make, and the observed motions of such binary systems are what gravitation easily accounts for.

More than fifty years ago Sir John Herschel saw the extreme difficulty of imagining the “conditions of conservation of such a system as that of ω Centauri, or 47



FIG. 2.—Untouched block made by a photographic process from a photograph of the Great Cluster in Hercules, taken with the 36-in. refractor of the Lick Observatory, 24th September, 1892.

Toucani, &c., without admitting repulsive forces on the one hand, or an interposed medium on the other to keep the stars asunder.”* But if we put on one side assumptions as to repulsive forces, and endeavour to consider the changes which will probably take place under the action of attractive forces such as we are familiar with in our region of space, we shall be forced to admit that a spherical star cluster cannot be a permanent system, and that the individual stars of the cluster can only escape collisions for a limited period of time. Next let us proceed to consider the results that will probably follow such cataclisms. At every such collision, motion of translation will be turned into heat, and a change in the physical condition of the colliding bodies, or a part of them, may be expected to follow.

Prof. George Darwin has pointed out that if two solid bodies were to collide with planetary velocities, there would be a very rapid development of gas between them at the region of contact, which would cause them to 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 would take place at the region of contact with an explosive development or expansion of gas, that would drive the masses away from one another, causing them to rebound with velocities almost equivalent to their velocities of approach; and it seems probable 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.

Now let us pass to what is actually observed. It has long been remarked that globular clusters frequently present a partially radiated appearance in their outer parts,



FIG. 1.—Untouched block made by a photographic process from a photograph of the Great Cluster in Hercules, taken by the Brothers Henry, 23rd June, 1886.

* “Cape Observations,” p. 439.

and that streams of stars appear to spring from them and to curve away into space. It is difficult to conceive of a stream of stars that is not flowing. The alignment of a

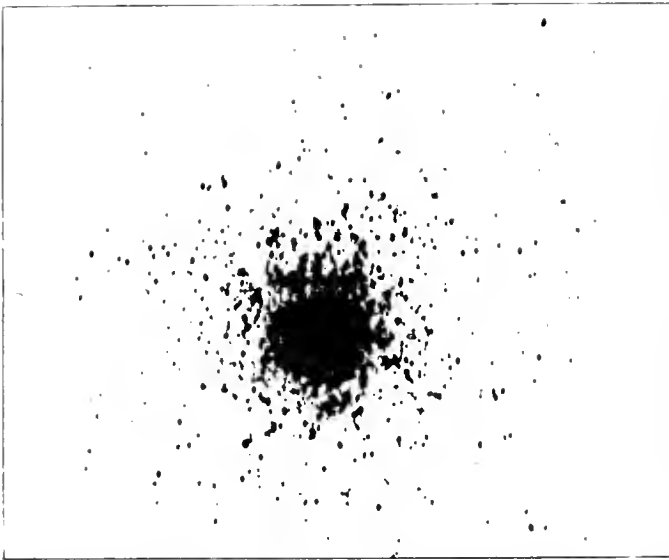


FIG. 3.—Untouched black made from the photograph of the Hercules Cluster, taken at the Lick Observatory, which is reproduced in Fig. 2, but black represents white, and the etching is not carried as far as in Fig. 2.

group of stars suggests their motion with different velocities from a common origin, and that they will be found to be associated with a stream of matter. In the Pleiades cluster we have actual photographic evidence of a narrow nebulous stream of matter linking together an alignment of six stars; and Prof. E. C. Pickering has photographed, in the Orion region, a faint nebulous band of light which actually links together a line or stream of sixteen faint stars,* and many other instances of stars distributed along streams or bands of nebulous matter might be quoted.

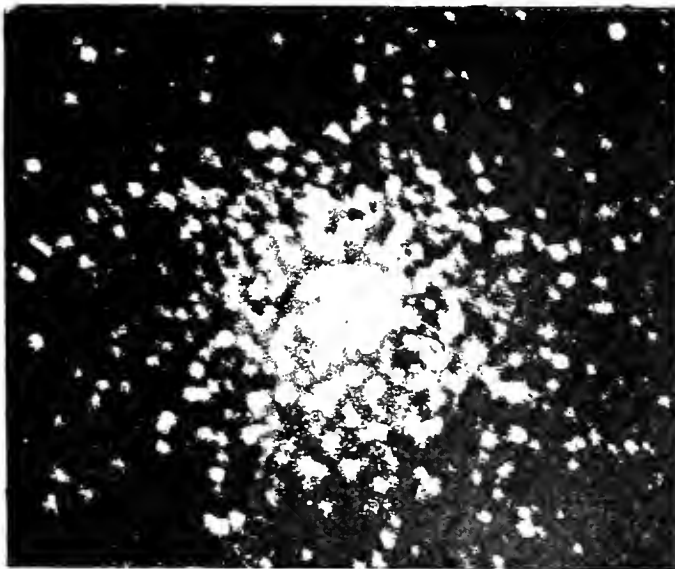


FIG. 4.—Untouched black made from a photograph of the Great Cluster in Hercules, taken by Dr. Isaac Roberts on 22nd May, 1887.

In a space closely crowded with stars like the central region of a star cluster we should expect frequent collisions

* See "Annals of Harvard College Observatory," Vol. XXVII, p. 155.

to take place, and, as the result of such collisions, we should expect to find streams of nebulous matter associated with alignments of stars radiating from the central mass; in fact, we do find that nearly all star clusters show traces of nebulosity, and that the brighter regions of most of the great nebulae coincide in position with clusters of stars which the nebulous matter evidently surrounds. Nebulae and star clusters are divided by no hard and fast line. The larger nebulae may be described as groups of stars surrounded by bright nebulosity, and star clusters may be defined as groups of stars surrounded by a faint nebulosity.

I am indebted to Dr. Gill for the interesting photograph of the ω Centauri cluster; a general nebulosity will be recognized extending through it, especially in the region where the stars are most closely packed, and it will be seen that the nebulous background is interrupted here and there by narrow dark channels—similar to those we have recognized in many nebulae, and in several nebulous regions of the Milky Way.

The blocks are made from several photographs of the great cluster in Hercules—which have all been reduced by means of photography to the same scale—and have been

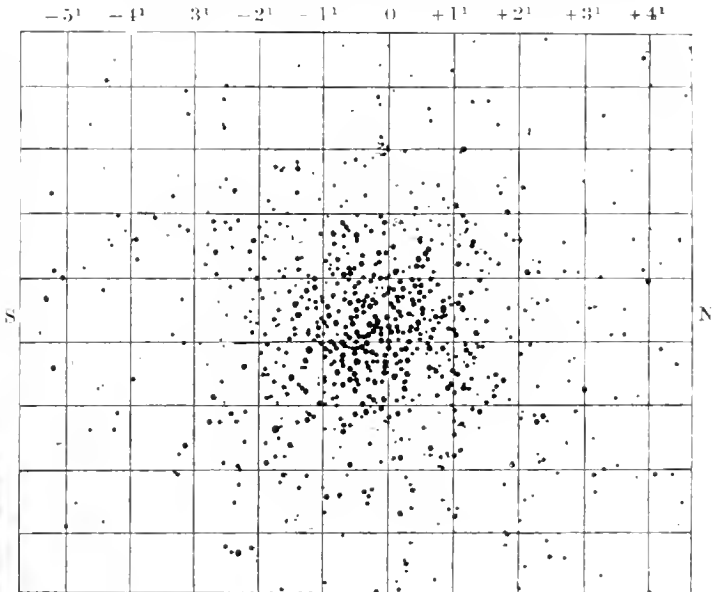


FIG. 5.—Copy of a chart of the Great Cluster in Hercules, made by Dr. J. Scheiner, of the Astro-Physical Observatory at Potsdam, in 1891.

oriented with the same point uppermost, and turned over where they were reversed right and left. The correspondence between Dr. Isaac Roberts' photograph and those taken by the Brothers Henry and at the Lick Observatory will not at first be evident, because the exposure of Dr. Roberts' photograph is considerably greater than the exposure of the photographs taken at Paris and at the Lick Observatory, and consequently the nebulous area shown is larger, and all the stars in Dr. Roberts' photograph are represented by larger patches than in the Paris and Lick photographs. But making these allowances, it will be seen that the photographs correspond, star for star, and that most of the stars shown in Dr. Scheiner's chart can be identified on the photographs.

In the Paris and Lick photographs very curious projecting structures will be seen extending from the central mass of stars and nebulosity. More than one of them has the branching character which reminds one of the forms taken by the streams of heated gas which rush upward from the solar photosphere, but in the case of this

cluster the prominence forms do not appear to be wholly gaseous or nebulous, they are marked out by a series of stellar points.

The scale of the annexed block is not sufficiently large to show the details which are visible in the Lick and



FIG. 6.—The Prominence-like Structure.

Henry photographs, and I will endeavour on some future occasion to give the readers of KNOWLEDGE a tint block showing the details of this remarkable structure on a larger scale. To my mind the form of the structure indicates the existence of a stream of matter on a colossal scale rushing outward from the central region of the cluster, and the broadened summit of the structure seems to me to indicate the passage of the stream through a resisting medium, the density of which is not negligible compared with the density of the out-rushing stream. This would seem to indicate that the density of the stars associated with the out-rushing stream cannot be very considerable, or their motion would not be retarded by the resistance of a nebulous medium. Any assumption involving the existence of an extensive resisting medium, with a density equal to a ten thousand millionth part of the density of our own atmosphere at the sea level, lands us in difficulties similar to those which we pointed out in discussing the density of the Orion nebula; that is, the mass of the nebula would be so great that it would become recognizable to us by reason of the very rapid proper motions of stars in its neighbourhood, whatever were the distance of the nebula. In fact, the greater the distance of the nebula (its angular diameter remaining the same), the greater would be the attracting mass of the nebula, and the apparent motion of stars in its neighbourhood would remain unchanged.

Our own sun—if it were expanded so as to fill a sphere with a diameter equal to the diameter of the orbit of Neptune—would have its average density reduced more than two hundred thousand million times; but since the average density of the sun is 1.444 times that of water, the density of the sun, when expanded so as to fill the orbit of Neptune, would still be considerably greater than a ten thousand millionth of the density of atmospheric air at the sea level. It may easily be shown that a star, similar in density and magnitude to our sun as it now is, would lose an inappreciable fraction of its velocity if it plunged diametrically through the matter of the solar system when heated up so as uniformly to fill such a Neptunian sphere, even if we assume that in passing through such a Neptunian mass the star cut a tunnel of ten times its own diameter, and gave to all the matter within the tunnel a velocity similar to its own initial velocity on entering. It seems to me, therefore, that we may conclude that the stellar masses which lie along the gigantic structure shown in Fig. 6 must have very small masses compared with our sun, for their density must be very small indeed compared with the density of our sun. In fact, they must be quite a different type of body from the stars we know, if their density is comparable with the average density of the resisting medium which fills the interspaces between the stars of such a cluster.

Science Notes.

An enormous meteorite, weighing nearly one ton, from Western Australia, has been received by Mr. J. R. Gregory, of Charlotte Street, Fitzroy Square. It is 1 foot 2 inches long by 2 feet 3 inches wide, and 2 feet 6 inches thick.

—“Old and New Astronomy,” p. 793

† Less than a three hundred thousandth part

From observations of the minor planet Victoria, made at twenty-one meridian observatories in 1889, Dr. Gill has obtained the value 8.809" for the solar parallax, with a probable error of $\pm 0.0066''$. An incidental result brought out by the discussion of the observations is that Leverrier's determination of the perturbation of the moon's action on the earth is too high. If this be so, then the value generally accepted for the mass of the moon will have to be decreased by about one per cent.

The *Astronomical Journal*, No. 292, contains some notes by Prof. Asaph Hall on the masses of Mars, Saturn, Uranus, and Neptune, determined by observations of their satellites. The definitive values obtained are as follows:—

Mass of Mars	-	$\frac{1}{3,104,700}$	of the sun's mass.
Mass of Saturn	-	$\frac{1}{3,486.5}$	”
Mass of Uranus	-	$\frac{1}{22,765}$	”
Mass of Neptune	-	$\frac{1}{19,149}$	”

There is still a good deal of speculation with regard to the substance which Prof. Dewar lately exhibited as solid air. The frozen mass might contain both solid oxygen and solid nitrogen, or solid nitrogen alone with liquid oxygen interspersed. Substances which possess the property of retaining liquids in an apparently solid form—like gelatine—are known as “colloids,” but it would be hazardous at present to assert that nitrogen belongs to this class. Air, however, becomes solid at a temperature and pressure at which pure oxygen retains its gaseous state.

In a review of “The Old and New Astronomy,” in the current number of the *Edinburgh Review*, the writer, whilst admitting the existence of “singular vacuities” and “star-fenced lanes” in the Milky Way, advocates the theory that “such vacancies are undoubtedly what they seem; they are obscure simply because they are destitute of stars. They are negative entities.” Though the evidence for the actual existence of dark structures is not accepted by the reviewer, he freely admits the actual existence of bright tree-like forms springing from dark areas. It is remarkable how differently various minds estimate evidence from probability, which cannot conveniently be expressed in numbers.

Two Akka girls, representatives of the pigmy race of Africa, who were rescued from Arab captors by Dr. Stuhlmann and his companions, have been brought to Europe, and will remain in Germany for some months. In the summer they will be taken back to Africa, where they will be placed in some mission house, or otherwise provided for. Though probably from seventeen to twenty years of age, they are only as tall as an ordinary boy of eight. According to a correspondent of the *Daily News*, who saw them at Naples, their behaviour is “infantile, wild, and shy, but without timidity. . . . They showed neither wonder nor admiration of the people and things around them.”

The London Geological Field Class commences its summer afternoon excursions this year on the 29th April. The excursions are planned by Prof. H. G. Seeley, who accompanies the class every Saturday afternoon, whether the weather is wet or fine, from the end of April till the end of July. The class visits classical geological sections and places of interest in the neighbourhood of London. The railway journey generally occupies from half an hour to an hour, and the distance walked is from three to six miles. The class is open to ladies and gentlemen, and the fee for the twelve excursions is one guinea.

In future *The Observatory* will be conducted by Mr. T. Lewis and Mr. H. P. Hollis, both of the Royal Observatory, Greenwich. Mr. H. H. Turner remarks, in an editorial notice, that Dr. Common and himself have withdrawn from the editorship because the many calls upon their time prevent their giving the attention to the magazine which alone could ensure its being a complete record of current astronomical events.

Lord Rayleigh, in lecturing at the Royal Institution on interference bands, exhibited as an illustration of wave action a "bird-call," whose pitch was so high as to be inaudible. The concentration of the air waves, however, on to a sensitive flame, by means of a screen, caused the flame to roar in a remarkable manner.

It is commonly known that the simple relation between planetary distances, termed Bode's law, was first discovered by J. D. Titius, of Wittenburg. Mr. W. T. Lynn points out in *The Observatory* that Titius seems to have suggested that the gap between the orbits of Mars and Jupiter would be filled by the discovery of new satellites. Bode, on the other hand, expressed the view that the gap pointed to the existence of a new planet, and when Ceres was discovered in 1801 he claimed the fulfilment of his conjecture. This probably explains why the geometrical progression of planetary distances is known as the law of Bode instead of the law of Titius.

Some experiments on the resistance of ice have recently been made in France. From the results it appears that a thickness of rather more than one and a half inches is required to bear the weight of a man on the march; a thickness of three and a half inches is sufficient to permit the safe transit of detachments of infantry in files; and with about four and three-quarter inches, guns may be transported across the ice. M. Forel points out in the *Revue Scientifique* that these estimates apply only to young ice. Ice which has been exposed to alternations of temperature for a few weeks loses much of its tenacity and breaks far more readily than younger formations.

At the Royal Society, on March 23rd, Lord Rayleigh communicated a paper on "The Densities of the Principal Gases." He has determined the absolute densities of air, oxygen, and nitrogen, by comparing the weight of a volume of each of these gases with that of an equal bulk of water. The results obtained, reduced to standard conditions, are: Air, 0.00129327; oxygen, 0.00142952; nitrogen, 0.00125718. Taking the ratio of the densities of oxygen and hydrogen as 15.882, the absolute density of the latter gas is found to be 0.0009009. If the density of air is taken as unity, the density of oxygen is found to be 1.10535, of nitrogen 0.97209, and of hydrogen 0.06960.

The following are among the lecture arrangements at the Royal Institution after Easter: Mr. John Macdonell, three lectures on symbolism in ceremonies, customs, and art; Prof. Dewar, five lectures on the atmosphere; Dr. R. Bowdler Sharpe, four lectures on the geographical distribution of birds; Mr. James Swinburne, three lectures on some applications of electricity to chemistry (the Tyndall lectures). The Friday evening meetings were resumed on April 14, when a discourse was given by Sir William H. Flower, on seals. Succeeding discourses will probably be given by Prof. A. B. W. Kennedy, Prof. Francis Gotch, Mr. Shelford Bidwell, the Right Hon. Lord Kelvin, Mr. Alfred Austin, Mr. Beerbohm Tree, Prof. Osborne Reynolds, Prof. T. E. Thorpe, and others.

The reported discovery of Prof. Emmerich, that the blood of an animal which has recovered from an infectious disease can cure another animal suffering from the same disease, seems likely to prove of considerable importance. At the last meeting of the Berlin Physiological Society some remarkable statements regarding the facts arrived at were made. Mice had been inoculated by the serum or watery portion of a horse's blood, the horse having been already cured of the disease; the result was that the mice, which had been previously inoculated with the bacilli of lock-jaw, did not die when subjected to the treatment, while those left to themselves perished. Experiments are to be tried on human beings.

In a recent lecture at the Royal Institution, Dr. E. Hopkinson remarked that the engineer only begins to realize the imperfections of all his works when he contemplates the amount of energy involved in his final purpose compared with the energy of the coal with which he starts. Beginning with the energy in a pound of coal, and tracing its loss step by step, it appears that in the case of the most economical electric railway, the energy expended on the passenger is but little more than one per cent. of the energy produced by the burning of the coal. Even this result is better than lighting with incandescent lamps, in which only about one-half per cent. of the original source of energy is utilized. When we consider that, both in transportation and lighting, more than ninety-nine parts in a hundred are now wasted, it will be seen that the future has great possibilities.

Prof. Bonney, F.R.S., in his paper read before the Royal Geographical Society on "Do Glaciers excavate?" made a vigorous attack on the theories of Sir A. Ramsay's school, which attribute to glacial action the great lakes or rock-basins of Switzerland and elsewhere, sometimes more than 1000 feet deep. His investigations as to the action of moving glaciers from 1860 to 1890 seem to show that they do little more than modify existing features of the land, rounding off prominences, scraping up gravel, and so on. Prof. Bonney's theory of the origin of rock-basins, which he brought forward twenty years ago, is that lake beds are ordinary valleys of sub-aerial erosion, affected by differential earth-movements. In support of this view he quotes many different surveys; that of the great lakes of America serving especially to confirm it. The beach of the Iroquois, for instance, is 600 feet higher at the north-east part than it is at the western end of Lake Ontario.

At a meeting of the Royal Geographical Society on Monday, March 13th, Mr. H. O. Forbes, a well-known naturalist, discussed in an illustrated lecture the question of the former extension of an Antarctic continent in relation to certain observations made during a recent visit to the Chatham Islands. He found there the remains of a large and remarkable bird, a member of the rail family, viz., the aphanapteryx, which lived contemporaneously with the celebrated dodo in the island of Mauritius, and was very similar to one of the extinct flightless birds of that island. In the Chatham Islands there still live several types of flightless birds scarcely represented elsewhere, except in widely separated oceanic islands; and to account for their distribution it is necessary to assume very different geographical conditions from the present. An animated discussion followed. Dr. Slater was against a former Antarctic continent; Dr. Henry Woodward, Dr. Gunter, and others, spoke in its favour; and the soundings of the Southern Ocean, so far, confirm the view advocated by Messrs. Forbes, Wallace, Blandford, and others.

A set of rules for estimating the quality of vulcanized caoutchouc have been drawn up by M. Vladimiroff, and are adopted in Russian naval stores. Briefly, the criteria are as follows:— (1) Caoutchouc should not give the least sign of cracking when bent to an angle of 180°, after five hours' exposure in an air bath at 125° C. (2) Caoutchouc having not more than half its weight of metallic oxides should bear stretching five times its length before rupture. (3) Caoutchouc, exempt from all foreign matter except sulphur, should be capable of stretching at least seven times its length before rupture. (4) The extension measured just after rupture should not exceed twelve per cent. of the original length. (5) Suppleness may be determined by calculating the percentage of ash after incineration. This may form the basis of choice for certain uses. (6) Vulcanized caoutchouc should not harden in cold.

Astronomy and Astro-Physics (for April) says that Mr. James E. Keeler has made a series of observations of the spectrum of the interesting variable star β Lyræ, using the Lick Observatory 36-inch telescope. The following conclusions seem to be warranted by the observations:— (1) In the spectrum of β Lyræ the bright hydrogen lines C and F, the bright D_3 line, and the dark D lines are constantly visible with a telescope as large as the Lick refractor. Certain fainter bright lines become invisible at the time of a principal minimum. (2) The variations in the light of the star are principally due to changes in the brightness of the continuous spectrum. (3) The bright lines are brightest when the continuous spectrum is brightest. (4) The bright lines are broad and diffuse, particularly when the star is at a maximum. The D lines are very hazy, so that the components are hardly distinguishable. (5) During the greater part of the period of the star no remarkable changes occur in the appearance of the spectrum. The observations fail to show any connection between changes in the spectrum and the secondary minimum of the star. (6) The most remarkable changes take place at the time of a principal minimum. The bright lines become dimmer, and perhaps sharper, and the fainter bright lines disappear. The D lines become darker. Strong absorption lines appear on the more refrangible side of certain bright lines in the green, the separation of the dark and bright lines being at least five-tenth metres. Other bright lines are perhaps similarly affected. A narrow dark line appears above the D_3 line at the same time. Shortly before the first maximum is reached the dark lines disappear.

DEEP SEA DEPOSITS.

By REV. H. N. HUTCHINSON, B.A., F.G.S., *Author of "Extinct Monsters," &c.*

[THIRD PAPER.]

WITH the exception of the red clay, described in our last paper, the famous *globigerina ooze* is the most widely distributed of all marine deposits. It occupies the greater part of the Atlantic, and a good deal of the Indian, Pacific, and Southern Oceans. Its total area is estimated at 49,520,000 square miles. Examination of Chart I. (p. 44) shows that it occupies all the medium depths of the ocean removed from continents and islands, and that it is especially developed in those regions where the surface of the sea is occupied by warm currents. The patch in the Norwegian Sea is evidently due to the northward extension of the Gulf Stream. The first specimens of this ooze were

obtained by Lieut. Berryman, United States Navy, in the North Atlantic, and were described in detail by Ehrenberg and Bailey in 1853.

As we have before remarked, there is a difficulty in drawing hard and fast lines on a chart to mark off the geographical areas of one deposit from those of another; and the reason of this is that to some extent they merge into each other. The question is, where to draw the line. For example, were all deposits containing only ten or fifteen per cent. of foraminifera to be classified as globigerina ooze, then this deposit would be found to be by far the most widely distributed of all the deep sea deposits. In all types of marine deposits, and in all latitudes, some species of these shells are present in greater or less abundance.

Messrs. Murray and Renard, however, draw the line at thirty per cent. or more of carbonate of lime; and any deposit having so much lime, or more, is put down in their report as globigerina ooze. There was at one time a good deal of uncertainty as to whether the foraminifera that chiefly go to make up the lime in this deposit lived at the surface or on the sea floor; but, after some years of doubt, it has been definitely settled that most of them lived at or near the surface. To those who are familiar with the protozoa it may be interesting to know that among the pelagic foraminifera taken in surface nets during the cruise of the *Challenger* were: globigerina (ten species), orbulina (one species), pulvinulina (five species), hastigerina* (one species), pullenia (one species). The majority of these species are limited to those deposits immediately under warm tropical waters, and only a few of them were met with in deposits dredged up from the colder regions of the ocean.

The *Challenger* naturalists found the deposit ranging in depth from 400 to 2925 fathoms (giving an average depth of 2002 fathoms); 118 samples were examined. We may say that it is most typically developed at 2000 fathoms. At greater depths than 2500 fathoms the carbonate of lime is gradually removed, the ooze becoming darker in colour until finally it gives place to a red clay. In the Atlantic, we find it covering the submarine ridges and elevated plateaux, and it borders the upper zone of the oceanic abyssal area. Its prevailing colour, far from land, is milky white or rose colour, and near land, dirty white, blue or grey. Sometimes it has a mottled appearance, due to the presence of manganese grains, volcanic ashes, pumice, &c. In tropical regions, where warmth favours growth, the foraminifera are often large enough to be visible to the naked

* Extract from WYVILLE THOMSON: "*The Atlantic*," Vol. II., p. 293.

62a., *Living Hastigerina*. "On one occasion, in the Pacific, when Mr. Murray was out in a boat in a dead calm collecting surface creatures, he took gently up in a spoon a little globular gelatinous mass with a red centre, and transferred it to a tube. This globule gave us our first and last chance of seeing what a pelagic foraminifer really is when in its full beauty. When placed under the microscope, it proved to be a hastigerina in a condition wholly different from anything which we had yet seen. The spines, which were mostly unbroken, owing to its mode of capture, were enormously long, about 15 times the diameter of the shell in length; the sarcode, loaded with its yellow oil-cells, was almost all outside the shell; beyond the fringe of yellow sarcode the space between the spines, to a distance of about twice the diameter of the shell all round, was completely filled up with delicate bulle, like those which we see in some of the Radiolarians, as if the most perfectly transparent portion of the sarcode had been blown out into a delicate froth of bubbles of uniform size along the spines; fine double threads of transparent sarcode, loaded with minute granules, coursed up one side and down the other, while between the spines, independent thread-like pseudopodia ran out, some of them perfectly free, and others anastomosing with one another or joining the sarcodic sheaths of the spines, but all showing the characteristic flowing movement of living protoplasm."



PHOTOGRAPH OF MADREPORE LAGOON, FRINGING REEF, PORT DENISON.

Reproduced from "The Great Barrier Reef of Australia," by W. SAVILLE-KENT, F.L.S., F.Z.S., Ac.

eye. It is, perhaps, hardly necessary to remark that the carbonate of lime in this deposit is not all due to foraminifera, for many other organisms contribute calcareous material, some living on the surface waters, and others on the sea bed. Thus we find that remains of molluscs, echinoderms, annelids, corals, and polyzoa were nearly always met with in dredging up samples of this ooze. Sometimes, in tropical or sub-tropical regions, the shells of *pteropods* and *heteropods* were found in great abundance, and then the globigerina ooze passes into a pteropod ooze (see Chart I). The well-known coccoliths and rhabdoliths are often abundant, and sometimes make up as much as 15 per cent. of the deposit. These curious minute organisms, which a few years ago were a puzzle to naturalists, are now regarded as calcareous pelagic algæ. Remains of the radiolaria, diatoms, and siliceous sponges are almost always present.

Life is much more abundant on the globigerina ooze areas than on those of the red clay or radiolarian ooze. Where the former ooze occurs, numerous animals (fishes and invertebrates) were dredged up. Of the 118 samples reported on by the *Challenger* naturalists, pelagic foraminifera made up on the average 53 per cent., and other organisms 9 per cent.; the bottom-living foraminifera were only over 2 per cent.

Pteropod Ooze.—Although the remains of pteropods are abundant everywhere in the surface waters of tropical and sub-tropical regions, yet their dead shells are wholly absent from the deposits in all the deeper waters. The reason of this is that the delicate shells expose a large surface to the sea water as they fall through it, and are therefore dissolved before they reach the bottom where it is deep. Pteropod ooze abounds on submarine ridges that rise to within 1000 fathoms of the surface. A few traces were sometimes met with at 2000 fathoms, but only in lesser depths do they make up any appreciable part of the globigerina ooze. In all deposits near continents and islands, where tropical oceanic waters occupy the surface, heteropod and pteropod shells are more or less abundant. Thirteen samples are described in the *Challenger* report, with an average depth of 1044 fathoms. Foraminifera made up about 50 per cent. It differs from globigerina ooze in the larger amount of carbonate of lime, due to the delicate pteropod shells. It is most typically developed on the central ridges of the Atlantic, where the depth is not more than 1000 fathoms or so (see Chart I). It is to be met with off the West Indies, the Azores, and some of the Fiji Islands. Many inter-tropical islands are apparently surrounded by this deposit.

We now pass on to *terrigenous deposits*. Omitting the coarser deposits of sand and shingle beds nearer shore, we have now to deal with fine detrital matter beyond the 100 fathom line. All these deposits are laid down on what may be called the continental slope, or that area extending from the 100 fathom line down to the ocean basins, where they merge into pelagic deposits.

Blue Mud.—This deposit is particularly interesting to the geologist, because it throws light upon the history of the numerous formations of slate, shale, and clay found in the series of stratified rocks. It is met with in the deeper waters round continental land, and in all enclosed seas, partly cut off from the open ocean. It is, of course, a product of the land denudation. Its blue colour is due to chemical changes produced by decomposing vegetable and animal substances, in presence of the sulphates of sea-water, which

* The class Pteropoda are small free-swimming mollusca, found on the surface of the ocean, often in enormous numbers. They are lower down in the scale of life than the Gastropoda, and represent the transient larval stage of sea-snails. The Heteropoda are also pelagic and free-swimming, but may or may not have a shell.

are reduced to sulphides and decompose the ferric oxide abounding in all deposits into sulphide of iron and ferrous oxide. Blue muds smell of sulphuretted hydrogen. Fifty-eight samples are described, with an average depth of 1411 fathoms. In some cases pelagic foraminifera make up 25 per cent. of the deposit, while in others there is no trace of them. Rounded grains of quartz are abundant. The mineral particles are mostly derived from adjacent land. Blue muds surround nearly all the coasts and fill most enclosed seas like the Mediterranean.

Red Mud.—Along the Brazilian coasts of South America the terrigenous deposits differ from other such in being reddish instead of blue or green. The cause of this is to be found in the large amount of ochreous matter brought down by the Amazons, Orinoco, and other South American rivers, and distributed by ocean currents. Probably there is not enough organic matter to reduce the whole of the iron peroxide to protoxide, nor does the sulphide of iron accumulate here. Similar red muds are met with off the Chinese coast, near the mouth of the Yang-tse-Kiang.

Green Muds and Sands.—These deposits are chiefly characterized by the presence of glauconitic grains and casts of calcareous organisms. They are generally met with along bold exposed coasts where no very large rivers pour their detrital matters into the sea. They do not occur in very deep water (usual depth, 100—900 fathoms). In these regions pelagic deposits are found to approach much nearer to the shores than where the blue muds prevail. So much is this the case that were it not for the grains of glauconite (a greenish mineral) they might be taken for globigerina ooze. *Green Sands* were found in rather shallower waters (average depth, 449 fathoms). Foraminifera make up 36 per cent. of the deposit. This glauconite appears to be precipitated inside the foraminiferal shells, thus forming casts of their interiors which remain after the shells have been dissolved. The chemistry of the ocean is at present little understood, but it is suggested that the glauconite may be the result of chemical changes undergone (in the presence of organic matter) by finely divided particles derived from land.

Volcanic Muds and Sands.—Oceanic islands of volcanic origin are surrounded by volcanic muds or sands formed by the wearing down of volcanic rock and its subsequent partial decomposition by the chemical action of sea water, the fragments of shells which are present being often coated with peroxide of manganese. Near shore, within the region of wave action, the deposits are mostly sands, mixed with fragments of calcareous organisms. They vary in colour, being grey, brown or black, and pass in some places into muds, or coral sands, or, with greater depth, into oozes; thirty-eight samples of volcanic muds are described, with an average depth of 1033 fathoms. Volcanic sands chiefly differ in the absence of the fine clayey and calcareous matter so abundant in the muds.

Coral Muds and Sands are formed from the debris of structures such as are shown in our plate, copied by the kind permission of Mr. Saville-Kent from one of the illustrations in his work on "The Great Barrier Reef of Australia." Several forms of coral are shown in this plate, with masses of madrepora and the shrub-like growth known as stag's-horn coral. Around such coral reefs the deposits are chiefly made up of fragments of organisms living in shallow water—such as algæ, corals, molluscs, polyzoa, annelids, echinoderms, and foraminifera. As might be expected in shallower waters, these form a coarse sand or gravel; but beyond the limits of wave-action there is a fine mud consisting principally of ground-up calcareous matter. As we get further away from the reefs and in deeper water, the deposits gradually pass into some kind of ooze. Sixteen

samples of coral mud were obtained (average depth 740 fathoms). In colour they were various shades of white, and they contain a very large percentage of carbonate of lime (about 87 per cent.).

In coral sands the fragments of organisms are larger, and the depth is less. Coral muds and sands cover a large area (see Chart I.). Geologists find analogues of these deposits in some of the jurassic limestones, such as the Bath freestone and the coral rag. The most extensive coral region is that of the Pacific Ocean.

The following table shows at a glance the relative areas occupied by the different deposits, and the depths at which they occur:—

	Mean Depth.	Square Miles.
Littoral deposits (between tide marks)		62,500
Shallow water deposits (from low water mark to 100 fathoms)		10,000,000
Terrigenous deposits (in deep and shallow water close to land).	Coral Mud	740 f
	Coral Sand	176 f
	Volcanic Mud	1033 f
	Volcanic Sand	243 f
	Green Mud	513 f
	Green Sand	449 f
	Red Mud	623 f
Pelagic deposits (in deep water far removed from land).	Blue Mud	1411 f
	Pteropod Ooze	1044 f
	Globigerina Ooze	1396 f
	Diatom Ooze	1477 f
	Radiolarian Ooze	2864 f
	Red Clay	2730 f

A word about the volcanic products, so widely distributed, and the chemical changes they are supposed to have undergone. Messrs. Murray and Renard have much to say on this subject, and they arrived at the conclusion that the manganese nodules they so frequently dredged up on red clay areas are the result of the chemical alteration of volcanic debris. But perhaps it will be wise not to accept this conclusion as final. Pumice stones occur in great numbers near volcanic centres, *e.g.*, off the Azores. They vary in size from that of a pea to the size of a football. They are most abundant in deep sea clays, from which the shells and skeletons of surface organisms have been removed by solution; and are more numerous in the Pacific than in the Atlantic. They have a rolled appearance, and have evidently undergone much decomposition. Peroxide of manganese occurs widely as nodules and incrustations on the sea floor. It is a significant fact that the manganese is in greatest abundance where there have been showers of volcanic ash, and hence it seems likely that it may be a secondary product of the decomposition of volcanic minerals. In the manganese contained in lavas and the carbonic acid of ocean waters we seem to have the requisite means for the decomposition of pumice, the solution of the manganese, and its deposition as peroxide. In some places the nodules distinctly show periods of deposition.

In conclusion, the work of the *Challenger* expedition has brought to light a fact of great geological interest; for when the deposits now forming are compared with the stratified rocks in which the geological record is contained, it is found that the latter are very similar to those forming in shallow water and *not to the deep sea deposits*—at least, not to those of the deeper depressions of the sea floor. Even the chalk formation, which in some points so much resembles globigerina ooze, presents some important differences, and was probably formed in rather shallower water. Again, rocks resembling the red clay are (with one exception) conspicuously absent from the stratified series. That exception is the "red earth" of Bermuda, which must be accounted for by a volcanic upheaval. In view of these facts many geologists have adopted the theory of "the permanence of ocean basins" as the only satisfactory explanation. In other words, they believe that the great earth-movements of the past have been confined to

the continental areas and the shallow waters by which they are bordered. No doubt there is much to be said for this theory; but then abysmal deposits like the red clay may yet be discovered in the rocks of new countries. We cannot stop to discuss this interesting question now, but will only point out that it is difficult to see why the abysmal areas should be always sinking and never rising.

ON CERTAIN LOW-LYING METEORS.

By CHARLES TOMLINSON, F.R.S., F.C.S., &c.

II.—PHOSPHORESCENT METEORS.

DURING the putrefaction of animal matter a gas may be given off which enters into combustion with the oxygen of the air. This gas, as prepared by the chemist, is a compound of three parts of hydrogen with one of phosphorus; but as seen in Nature, it is largely diluted with air, and then appears, if at all, with a glow more or less feeble. Thus, about the year 1860, the town of Thurso, in the north of Scotland, was thrown into a state of alarm by a luminous appearance which was seen during several nights in an adjoining plantation. It was supposed to be a ghost or spectre, and people preferred to go a long way out of their road rather than pass near it. At length a few bold spirits formed a committee of inquiry, and proceeded one night towards the spot, but on a nearer approach imagination had made the spectre appear so terrible that they all turned tail and retreated home—all but one brave hero, who determined to face the awful apparition, and he advanced up to the very tree that exhibited it, when he found that the light proceeded from a large fish which someone had thrown up into the tree, and this, in decomposing, had generated sufficient phosphuretted hydrogen to produce a luminous glow.

Many years ago the Curator of the Natural History Museum at Geneva had collected a considerable quantity of impure alcohol, which had been used for the preservation of fishes and other specimens. This alcohol was sent to a pharmacist with instructions to purify it and return it. He accordingly mixed it with chloride of calcium and quicklime, and distilled it. Having thus separated the alcohol from its impurities, he proceeded to expose the residue to the open air, in order to recover the chloride of calcium by evaporating the watery liquid; but when this had attained a syrupy consistence it began to pour off torrents of phosphuretted hydrogen. This lasted many hours and did not cease until the mass had become completely dry.

The phosphorus in the above case was derived from the fishes and other animals that had been preserved in the alcohol. In the process adopted for purifying the latter a phosphuret of lime had been formed. This is a compound well known to the chemist, who prepares it by distilling phosphorus over lime heated to redness. Its modern name is calcic phosphide. When a cold lump of it is thrown into water it becomes decomposed, and gives off bubbles of phosphuretted hydrogen. Each bubble as it bursts takes fire on contact with the oxygen of the atmosphere, and produces a white wreath of phosphoric acid, made up of a number of ringlets revolving in vertical planes round the axis of the wreath as it ascends with beautiful effect.

Such appearances as these do not, however, belong to low-lying phosphorescent meteors. In their most vivid form they present only a glow. In churchyards and other burial places the phosphorus of the animal body during decomposition in the presence of moisture may form

phosphuretted hydrogen in small quantities, which, streaming up into the atmosphere, may present that faint appearance known as a *corpse-candle*. In Wales an appearance of this kind was said to denote a coming funeral, and few of the people of Carmarthen formerly died without having seen their *death-light*, just as in other parts, Northumberland for example, some people saw their *waff* or *whiff* as a death token, which is similar to the Scotch *wraith*, or the appearance of a living person to himself or others. Many years ago the Austrian chemist Von Reichenbach examined a number of patients in various parts of Germany and Austria who were very sensitive to the action of light. On taking one of these by night into a churchyard, he declared that every grave was luminous.

A very sensitive eye is required to see these corpse-candles, and we need not be surprised that a good deal of superstition is connected with them. But phosphorescent meteors, as well as light carburetted hydrogen meteors, are now rarely seen. The latter have been extinguished by drainage and agriculture, and if the former occasionally appear, they do not attract much attention now that their nature is understood and their advent accounted for.

III.—ELECTRICAL METEORS.

But if the two former kinds of meteors are now but rarely seen, those of the third kind frequently appear, and are likely to continue to do so, since they belong to one of the great forces of Nature which is always active and everywhere present, while the other two are natural indeed, but local and accidental in their action.

In 1752 Franklin, by his famous kite experiment, proved the identity of lightning with common electricity. The action of a thunder-cloud is to throw by induction a portion of the earth's surface lying beneath it into an opposite electrical state. If the cloud be positive or +, the earth will be negative or -. This change is brought about by the polarization of the intervening air; that is, the upper half becomes -, the lower half +, and so throughout, until the + half of the lowest particle throws the earth into an opposite or - state. Supposing this action to go on among the innumerable particles of the dielectric or non-conducting air that separate the cloud from the earth, the + half of each particle becomes more +, and the - half more -, until the strain or tension is such that the system breaks down, and a disruptive discharge of electricity takes place between the cloud and the earth.

Soon after Franklin's experiment it was discovered that the electrical condition of the air did not depend on the action of a thunder-cloud, but that in different states of the weather, under a cloudy or a clear sky, the air is sensibly electric. In fine weather the air is + and the ground -, and in the course of the twenty-four hours certain variations take place, consisting of two maxima and two minima. The former are probably due to the conducting property of moisture, which brings down electricity from the upper regions, while the dispersion of that moisture by the heat of the sun seems to give occasion to the minima. The electricity of rain, snow, hail and fog is sometimes + and sometimes -.

But there are occasions when atmospheric electricity assumes a high potential, and gives rise to many curious and interesting effects, so varied that I cannot do much more than glance at them. One typical case, however, may admit of some little detail; it is related in the "Memoirs of General Marbot," published a year or two ago. The general accompanied Napoleon the First in his invasion of Russia, and during the retreat of his cavalry regiment he saw before him one night a number of lights, which he mistook for the bivouac fires of the enemy. He sent out scouts to ascertain what force lay before him, and it was reported at

50,000, while he had less than 700 men. While debating what course to pursue, the lights began to appear on his own men. He at once recognized them as *four follets*, a term applied by the French to low-lying meteors before their origin was understood. The general's explanation of the phenomenon cannot be accepted. He had already remarked that a marsh over which he had passed was dry, and yet he accounts for the meteor by supposing it to have been produced by the emanations of the marsh condensed by a slight frost after a hot autumn day. "En peu de temps le régiment fut couvert de ces feux gros comme des œufs, ce qui amusa beaucoup les soldats."

The general's account was written from recollection long after the event described, and may thus have been unintentionally embroidered. The imagination of the scouts who mistook the lights for the bivouac fires of a large army, and the dazed sight of the general, who saw *des milliers de feux* suddenly cover the ground he had lately quitted, were natural exaggerations. The ground just quitted he described as *situé dans un bas fond, sur un très vaste marais desséché*. Hence the marsh, being dry, could not furnish an inflammable gas, and even had it done so and the gas been set on fire, the flames would not have appeared first on the hills, and afterwards in the plain, nor could they have been seen playing upon the soldiers. The phenomena are, however, quite consistent with what is known of electrical action, a similar example of which is related by Arago as having occurred to some French engineer officers in Algiers on the evening of the 8th May, 1831. They were walking with uncovered heads on a terrace, when the hair of each stood on end, and little jets of electric light issued from them. When the officers raised their hands, similar jets played upon their fingers.

Such phenomena as these formerly struck terror into men's minds, and we ought to be grateful to science for reducing them under natural laws. Shakspeare, in his tragedy of *Julius Cæsar*, describes with his usual graphic power the phenomena, and the feeling excited by them. Cæsa exclaims:—

"Either there is a civil strife in heaven,
Or else the world, too saucy with the gods,
Incenses them to send destruction.
* * * * * A common slave
Held up his left hand, which did flame and burn
Like twenty torches join'd, and yet his hand,
Not sensible of fire, remained unscorch'd,
* * * * * And there were drawn
Upon a heap a hundred ghastly women,
Transformed with their fear, who swore they saw
Men all in fire walk up and down the streets."

What Cæsa thus graphically described, and accompanied with so much horror, now belongs to the order of natural phenomena. In June, 1880, at Clarens, near the Lake of Geneva, the air in the afternoon of the 17th was in a very excited state, and a cherry tree, measuring about a yard in circumference, was struck by lightning, and shivered into matches. A little girl who had been gathering cherries, and was now about thirty paces from the tree, appeared to be literally wrapped in a sheet of fire. Some men who were working in a vineyard close by saw the electricity play about her, but they fled in terror from the spot. In a cemetery close by, six persons, separated into three groups, none of them within 250 paces of the cherry tree, were enveloped in a luminous cloud. They said they felt as if they were being struck in the face with hailstones or fine gravel, and when they touched each other sparks passed from their fingers' ends. At the same time a luminous column was seen to descend, and the electricity was distinctly heard as it ran from point to point of an iron railing in the cemetery. None of the persons referred to were hurt; they only complained of an unpleasant

sensation in the joints, as if they had been violently twisted, a sensation which lasted for a few hours.

Many of the effects of atmospheric electricity depend upon that kind of discharge known as the *brush* and the *glow*, both of which, according to Faraday, consist of a charging of air, the only difference being that the *glow* has a continuous appearance from the constant renewal of the same action in the same place, whereas the *brush* ramification is due to a momentary independent and intermitting action of the same kind. In other words, a continuous discharge to the air gives the *glow*, an interrupted one produces the *brush*, with a kind of subdued roaring noise, while in a more exalted electrical condition we have the spark.

The brush discharge may often be seen playing on pointed bodies, as on the spears of Cæsar's legion, and in this mild form it did not produce the terror of the more energetic display already referred to. In later times, when it appeared at the extremities of the masts of ships, it was hailed as a good omen, and was known to the French and Spaniards as *St. Elmo's* or *Helmo's Fire*; to the Italians as the *Fires of St. Peter and St. Nicholas*; to the Portuguese as *Corpos Santos*, which the English sailors have corrupted into *Comazants*.

Such a phenomenon is referred to by De Saussure in the lighting up of the rocks at night, and the motion of electricity over the prairies of America. It has been compared to a miniature lightning discharge, resulting from the electrified cloud brushing over the earth, and discharging itself by thousands of sparks. In Switzerland the discharge sometimes produces loud rattling or crepitation of the stones. On the summit of Piz Turley De Saussure experienced pricking and burning sensations, and heard sounds like simmering water, emitted by sticks laid against the rocks, or by the vibrations of the alpenstocks. Professor James Forbes, while on one occasion on Mont Cervin, at an elevation of about 9000 feet above the sea level, noticed a curious sound, which seemed to proceed from his alpenstock. He asked the guide whether he heard it, and what he thought it was. "The members of that fraternity," he remarks, "are very hard pressed indeed when they have not an answer for any emergency. He therefore replied with great coolness that the rustling of the stick no doubt proceeded from a worm eating the wood in the interior." On reversing the stick, the worm was already at the other end. He next held up his fingers above his head, and they yielded a fizzing sound. There was only one explanation: the party was so near a thunder-cloud as to be highly electrified by induction. All the angular stones near them were hissing like points near a powerful electrical machine.

It is not necessary, however, that a thunder-cloud should be present to account for a similar excited state of the atmosphere when Livingstone was on the borders of the Kaluhari Desert. During the dry seasons that succeed the winter and precede the rains a hot wind occasionally blows from north to south. This wind is in such an excited state that a bunch of ostrich feathers held for a few seconds against it becomes as strongly charged as if it had been attached to a powerful electrical machine, and clasps the advancing hand with a sharp crackling sound. When this hot wind is blowing, and even at other times, the peculiarly strong electric state of the air causes the movement of a native in his *kaross* to produce a stream of small sparks. "The first time," says Livingstone, "that I noticed this appearance was when a chief was travelling with me in my wagon. Seeing part of the fur of his mantle, which was exposed to slight friction by the movement of the wagon assume quite a luminous appear-

ance, I rubbed it smartly with the hand, and found it readily give out bright sparks, accompanied with distinct cracks. 'Don't you see this?' said I. 'The white man did not show us this,' he replied; 'we had it long before white men came into the country, we and our forefathers of old!'"

Another form of low-lying electrical meteors is known as *globular* or *ball lightning* (*éclairs en boule*). A celebrated case of this kind was reported in the *Philosophical Transactions* of the Royal Society about the middle of the last century. Mr. Chalmers states that being on board the *Montague* (seventy-four guns), on November 4th, 1749, he observed a large ball of blue fire rolling along on the surface of the water as big as a mill-stone, at about three miles distant. Before they could raise the main-tack the ball had reached within forty yards of the main chains, when it rose perpendicularly, with a fearful explosion, and shattered the main topmast in pieces. So also on the Malvern Hills, in June, 1826, what was called "a ball of fire" was observed to roll along the hill towards a building where some people had taken shelter; here it exploded, and killed two of them.

These luminous balls seem to be the result of a brush discharge on a large scale. In the case of the *Montague*, the ball was seen rolling on the surface of the water towards the ship from to windward. The discharge was produced by some of the polarized atmospheric particles yielding up their electricity to the surface of the water. On nearing the ship, the point of discharge became transferred to the head of the mast; and the striking distance being thus diminished, the whole system returned to its normal state, that is to say, a disruptive discharge ensued between the sea and the clouds, producing the usual phenomena of lightning and thunder, or as it was described by the observers, "the rising of the ball through the mast of the ship." The case on the Malvern Hills is another instance of the same kind.

Another case of glow discharge was reported by Mr. Jabez Brown in a letter to the *Times*, dated Boscastle, December 1st, 1858. He says:—"Last night at fifteen minutes to nine, ascending one of the sharp hills of this neighbourhood, I was suddenly surrounded by a bright and powerful light, which passed me a little quicker than the ordinary pace of a man's walking, leaving it dark as before. The light was seen by the sailors in the harbour coming in from the sea, and passing up the valley like a low cloud."

Some electricians doubt whether these balls of electric fire have ever been seen within doors. Such cases, however, have been reported on good authority. Thus M. Trécul, in a note to the *Comptes Rendus*, states that on the 18th August, 1876, while writing at an open window between 7 and 8 a.m., he observed simultaneously with some loud thunder, small luminous columns descend obliquely on his paper, about two mètres long, and half a decimètre broad at the widest part; obtuse at the further end, but gradually thinning towards the table. They had mostly a reddish-yellow tint, but near the paper the tints were more intense and varied. In disappearing they left the paper with a slight noise like that produced by pouring a little water on a hot plate.

Arago relates a case of globular lightning within the walls of a building as reported by Maffei as occurring in September, 1713, in the territory of Massa-Canara, in Italy. He took refuge from a storm in a chateau, where he was received by the mistress of the house in a room on the ground floor. Suddenly they saw a bluish-white flame rise from the floor; it was agitated, but had no progressive motion. After gradually acquiring a considerable volume it suddenly disappeared. Maffei felt in his shoulder a

peculiar tickling sensation, some plaster detached from the ceiling fell upon his head, and an explosion occurred which did not resemble the sound of thunder.

A case is recorded in Mr. Symons' *Meteorological Magazine* for 1883 as having occurred on July 28th, about 6 p.m., in the printing office of Mr. Burt, Mount Washington, New Hampshire, U.S. Mr. Burt says:—"I saw a ball of fire as large as a man's head in front of me, not three feet off. It exploded with a tremendous noise, my left leg seemed to be completely paralysed, and I fell to the floor. Three of my printers were in the room at the time, two sitting at the table near me, and one standing up a little farther off. The latter had the skin of one hand torn, another was hit in the back, and the third escaped without injury." A tree-like mark was found on Mr. Burt's back, a not unusual figure impressed by the fiery hand of the meteor.

In conclusion, it will be seen that notwithstanding the mistakes made in the cyclopædias already referred to, it is quite possible to distinguish low-lying meteors as consisting of marsh-gas or of phosphuretted hydrogen, which are now of rare occurrence for reasons already given, while those of the third class, due to electricity, are of frequent occurrence, and will always continue to be observed.

THE FACE OF THE SKY FOR MAY.

By HERBERT SADLER, F.R.A.S.

SUNSPOTS are as prevalent as ever, some even having been visible lately to the naked eye. Conveniently observable minima of the Algol type variable δ Libræ occur at 10h. 4m. p.m. on the 2nd; at 9h. 37m. p.m. on the 9th; at 9h. 12m. p.m. on the 16th; at 8h. 46m. p.m. on the 23rd; and at 8h. 20m. p.m. on the 30th.

Only two of the major planets are observable this month, Mercury, Venus, Mars, Jupiter, and Neptune being, for the purposes of the amateur, quite invisible.

Saturn is an evening star, and is well situated for observation. He rises on the 1st at 3h. 48m. p.m., with a southern declination of $0^{\circ} 22\frac{1}{2}'$, and an apparent equatorial diameter of $18\cdot6''$ (the major axis of the ring system being $43''$ in diameter, and the minor $4\frac{3}{4}''$). On the 15th he rises at 2h. 50m. p.m., with a southern declination of $0^{\circ} 9'$, and an apparent equatorial diameter of $18\frac{1}{4}''$ (the major axis of the ring system being $42\frac{1}{4}''$ in diameter, and the minor $4\cdot6''$). On the 31st he rises at 1h. 43m. p.m., with a southern declination of $0^{\circ} 2\frac{3}{4}'$, and an apparent equatorial diameter of $17\frac{3}{4}''$ (the major axis of the ring system being $41''$ in diameter, and the minor $4\cdot4''$). He is occulted by the Moon on the 25th, but the phenomenon will only be visible in the southern hemisphere. Iapetus is in superior conjunction on the 3rd; Rhea at inferior conjunction at 10·5h. p.m. on the 4th; Titan at greatest eastern elongation at 0·8h. a.m. on the 13th; Rhea at inferior conjunction at 11·3h. p.m. the same evening; Rhea at inferior conjunction about midnight on the 22nd; Iapetus at greatest eastern elongation at 11h. p.m. on the 23rd; Titan at greatest eastern elongation at 11·4h. p.m. on the 28th. A map of the path of Saturn during May will be found in the "Face of the Sky" for March.

Uranus is an evening star, and but for his southern declination would be excellently situated for observation. He rises on the 1st at 6h. 50m. p.m., with a southern declination of $13^{\circ} 56'$, and an apparent diameter of $3\cdot8''$, the apparent star magnitude of the planet being 5·5 in the photometric scale. On the 31st he rises at 4h. 49m. p.m.,

with a southern declination of $13^{\circ} 31'$. A map of his path during May will be found in the "Face of the Sky" for April.

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

The Moon enters her last quarter at 2h. 24m. a.m. on the 9th; is new at 10h. 47m. p.m. on the 15th; enters her first quarter at 2h. 52m. p.m. on the 22nd; and is full at 3h. 23m. p.m. on the 30th. She is in apogee at 6h. a.m. on the 3rd (distance from the earth 252,430 miles); in perigee at 7h. a.m. on the 16th (distance from the earth 222,090 miles), and in apogee again at 8h. a.m. on the 30th (distance from the earth 252,500 miles).

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, Knowledge Office," and posted before the 10th of each month.

Solution of April Problem (A. G. Fellows):—

Key-move: 1. R to K8.

If 1. . . . Kt moves, 2. Q x Pch, &c.

If 1. . . . K to Q5, 2. Q to Ktsqch, &c.

If 1. . . . P to B5, 2. P x Pch, &c.

If 1. . . . P to K5, 2. B x Pch, &c.

CORRECT SOLUTIONS received from H. S. Brandreth, Alpha. Additional solution of March problem from J. E. Gore.

Alpha.—After the key-move which you sent to the March problem, there was *no mate* if Black replied 1. . . . Q x Pch. Hence the assumption that you "overlooked the check."

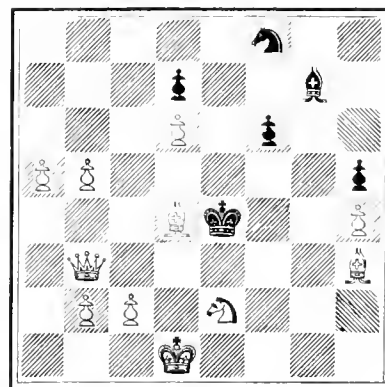
H. H. S.—Too late to reply to last month. (1) The address is: Mr. J. E. Whincop, 23, West Hillary Street, Leeds. Price 3s. 2d. post free. The "men" appear to be slips of ivory. (2) Either Gossip's "Theory of the Chess Openings," or Freeborough and Rankens' "Chess Openings, Ancient and Modern," of which a new edition is in the press. Both works are published at six or seven shillings. There are also two excellent shilling handbooks by J. Mortimer and G. H. D. Gossip respectively.

Adelaide Observer.—Received with thanks.

PROBLEM.

By G. K. ANSELL.

BLACK.



WHITE.

White to play, and mate in two moves.

The following game was played at board No. 1 in the Inter-Universities match last month :—

FRENCH DEFENCE.

WHITE	BLACK
(H. E. Atkins, Cambridge).	(R. G. Lynam, Oxford).
1. P to K4	1. P to K3
2. P to Q1	2. P to Q4
3. Kt to QB3	3. Kt to KB3
4. P to K5	4. Kt to Q2
5. P to B4 (a)	5. P to KKt3 (b)
6. Kt to B3	6. B to Kt2
7. B to Q3 (c)	7. P to QB4
8. P × P (d)	8. Kt × P
9. B to K3 (e)	9. Kt × Beh
10. Q × Kt	10. P to QR3 ? (f)
11. P to KR4 !	11. P to KR4 ?
12. Castles QR	12. P to QKt1 (g)
13. KR to Ktsq (h)	13. Kt to B3
14. P to KKt1	14. B to Kt2 (i)
15. K to Ktsq (j)	15. Q to R4
16. P × P	16. R × P (k)
17. R × P !	17. Kt to Kt5
18. R × Pch !	18. K to Q2 (l)
19. R to Q6ch	19. K to Ksq
20. Q to Q4	20. Kt to B3
21. Q to Kt6	21. R to Ktsq ?
22. R × Kt	Resigns.

NOTES.

(a) This, in conjunction with the previous move, constitutes Mr. Steinitz's attack.

(b) Quite out of keeping with the spirit of the defence. Black gives up the advantage on the Queen's side which he should get by 5. . . . P to QB4. 6. P × P. QKt to B3, without in any way strengthening his King's side. In fact, the move P to KKt3 not only gives a point of attack for White's KRP, but also weakens the effect of P to KB3, which is often a strong move for the defence.

(c) 7. B to K3 would prevent P to QB4 for the moment.

(d) 8. Kt to QKt5 is not much good, on account of the reply 8. . . . B to Bsq.

(e) Perhaps here, however, it was worth while to retire the Bishop to K2 first.

(f) Waste of time, apart from the extra power which it gives to the White Bishop. He should castle at once, or bring out one of his minor pieces. White's reply is probably intended to deter Black from castling. As a matter of fact it induces him to still further weaken his game.

(g) 12. . . . Kt to B3 at once was much better. The Knight might then be played *via* K2 to KB4.

(h) Good enough; though 13. Kt to K4 looks also very strong.

(i) He has no time for this. Kt to K2 or Q to B2 was necessary.

(j) For White might perhaps have played at once 15. P × P, R × P; 16. R × P, Kt to Kt5; 17. R × Pch, K to Bsq; 18. B to B5ch, K to Ktsq; 19. B × Kt, P × R; 20. Kt to K4, with a strong attack. Mr. Atkins' move, however, is very deep. He intends in the above variation to meet . . . Kt to Kt5 by R × B!, recovering the Queen, as Black will no longer take it with a check.

(k) Curiously fatal now, owing to the position of his Queen. He should play . . . Kt to Kt5 at once.

(l) If 18. . . . K to Bsq, 19. B to B5ch, and 20. B × Kt, attacking the Queen.

CHess INTELLIGENCE.

The Oxford and Cambridge chess match was played at the British Chess Club on March 24th. It will be seen from the score that Cambridge won by a handsome majority: though Mr. Hoffer, who adjudicated the unfinished games, is of opinion that, on the actual merits of the earlier portions of the games, Oxford should have at least drawn the match. In this match, each player was limited to one game for the first time. Clocks were successfully re-introduced.

OXFORD.

CAMBRIDGE.

1. Mr. R. G. Lynam, St. Cath. 0	Mr. H. E. Atkins, Peterhouse 1
2. Mr. G. H. Heginbottom, Pemb. 0	Mr. E. Young, Corpus 1
3. Mr. P. W. Sergeant, Trin. 1	Mr. J. H. Percival, Trin. H. 0
4. Mr. G. H. Cooper, Oriell. . . 0	Mr. C. E. Campbell, Trin. H. 1
5. Mr. E. W. Poynton, Exeter 0	Mr. P. Hart-Dyke, King's . . . 1
6. Mr. E. Lawton, Corpus. . . 0	Mr. H. J. Snowden, Queen's 1
7. Mr. D. L. Secretan, Pemb. 0	Mr. L. W. Lewis, Peterhouse 1
1	6

Cambridge is now eight matches to the good.

The undecided game in the Hants *v.* Sussex match at Chichester was adjudicated in favour of Sussex, who thus won by seven games to six. The same county again defeated Kent in the return match at Ashford, the score being Sussex 9½, Kent 5½.

Possible encounters abroad this season are Lasker *v.* Showalter in America, and Tschigorin *v.* Walbrodt at Berlin or St. Petersburg. In the former case the amount of the stakes is the point at issue; in the latter the scene of action, each player being naturally anxious to play in his own capital.

The long-expected Amateur Tournament at Cambridge took place early last month. The number of entries fell considerably below expectations. Messrs. Loman, Owen and Porterfield Rynd, who were regarded as certain to compete, failed to appear; while Dr. Hunt, and Messrs. Loeck and Miniati, who had also some thoughts of entering, were absent. In the end there were only five competitors, who decided, in view of their numerical weakness, to play two rounds. The result was as follows :— First prize, J. H. Blake (Southampton), 5½; second, W. H. Gunston, 4 (and one game unfinished). Mr. A. Dod (Liverpool) and the Rev. A. B. Skipworth (Horncastle) each scored 3½, and Dr. Deighton (Cambridge) 2½ (and one game unfinished); altogether a singularly even result.

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SPINY ANIMALS.

By R. LYDEKKER, B.A. Cantab.

IN our article on "Moles and their Like," published in the May number of KNOWLEDGE, it was shown how the adaptation to the necessities of a particular mode of life has produced a marked general external resemblance in certain burrowing mammals belonging to several more or less completely distinct groups. We now propose to point out the resemblances existing between certain other members of the same class of animals, owing to the assumption of a protective coat of spines. Although this resemblance is in some instances not so striking as among the creatures noticed in our previous article, yet it is quite sufficient to have obscured in popular estimation the real affinities of some of the spine-bearing mammals, as it is by no means uncommon to hear the hedgehog spoken of as the "British porcupine," while certain Madagascar spiny mammals are frequently alluded to as hedgehogs, and the Australian echidna is commonly alluded to as a porcupine. Moreover, the names "sea urchins" and "sea hedgehogs," applied to animals belonging to totally different classes, shows the important estimation held by spines in popular zoology. It is almost superfluous to add that the acquisition of the coat of spines in all the mammals here alluded to is solely for the purpose of protection; and how sufficient is this protection in most cases, is evident to all who have seen how the hedgehog, when rolled up, sets most dogs at defiance. Still, however, this panoply is by no means invariably

proof against all attacks, as it appears to be well ascertained that leopards and pumas will kill and eat porcupines without the slightest hesitation, and with a total disregard of their formidable spines, which may be found sticking in all parts of the bodies of the devourers. As we found to be the case with the mole-like mammals, all the spiny mammals belong to the lower orders of the class, their several representatives being distributed among the insectivores, rodents, and egg-laying groups, and the majority pertaining to the two former of these. In fact, in this respect an exact parallelism may be drawn between the mole-like and the spiny mammals, each assemblage having several representatives among the insectivores and rodents, while the former has a solitary marsupial type, and the latter two members among the egg-laying mammals. Some of these spiny mammals, such as the true porcupines and the echidnas, are burrowing creatures, and thus have a double means of defence against their enemies; others, however, like the hedgehog, rely on their power of rolling themselves up into a ball, and thus presenting a *chevaux-de-frise* on all sides. Some again, like the tree-porcupines, are more or less completely arboreal in their habits; and the whole of them, like the mole-like mammals, show how urgent has been the need for the lowly-organized rodents, insectivores, and egg-laying mammals to acquire some special means of protection in order to be able to hold their own among the higher forms. As all our readers are doubtless aware, in mammals spines are nothing more than specially modified hairs, and in a porcupine the transition from a spine to an ordinary hair can be easily seen. There are many rodents in which a certain number of scattered spines are mingled with the fur of the back, but our remarks will be confined in the main to the forms in which the spines predominate sufficiently to render them the most striking feature in the external appearance of their possessors.

Commencing with the rodents, our first representatives of the spiny mammals will be the true porcupines (*Hystrix*), which are such well-known creatures as to require but brief description. These animals conform, of course, to the ordinary rodent type in having a single pair of large

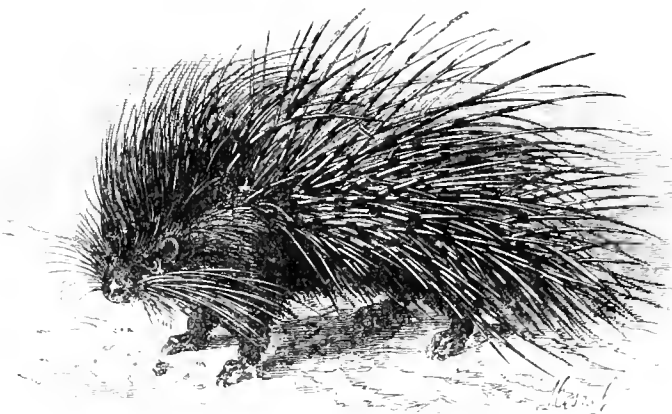


FIG. 1.—The Common Porcupine.*

chisel-like incisors in each jaw; and their spines are most developed on the middle line of the head and back, the hinder part of the body, and on the short tail. Whereas, however, those on the body are solid throughout and pointed at each end, the spines at the extremity of the short tail are in the form of hollow quills inserted by

* We are indebted to Messrs. F. Warne and Co. for the loan of the three figures with which this article is illustrated.

narrow stalks. It is these hollow quills that make the loud rattling sound heard when a porcupine is walking; and it appears to us not improbable that they may have given rise to the old legend of the porcupine ejecting its spines when attacked, as such hollow quills might well have been thought to be receptacles for the ordinary spines. Although their owner is unable to voluntarily eject the latter, their pointed bases render them easily detached, and leopards which habitually feed on porcupines are found to be actually bristling with their quills. In attacking its foes, the porcupine rushes at them backwards, and

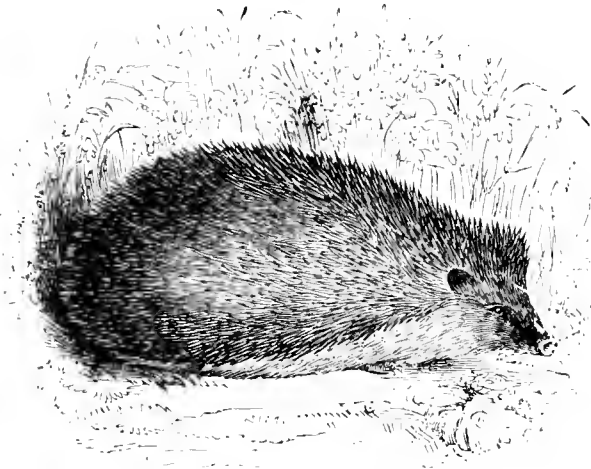


FIG. 2.—The Common Hedgehog.

thus gives full effect to its weapons. All the members of the typical genus are characterized by their large size, short tails, and highly convex skulls, and are confined to the warmer regions of the Old World. The bush-tailed porcupines (*Athurus*) from West and Central Africa and the Malayan region are, however, of much smaller size, and also distinguished by their much longer tails, which terminate in a brush of flattened spines, and are thus evidently less specialized creatures.

America is tenanted by a group of porcupines easily distinguished from their Old World cousins by having the soles of their feet covered with rough tubercles, instead of being perfectly smooth, and also by their comparatively short spines being mingled with a number of long hairs, by which they may be partially concealed. The Canada porcupine (*Erethizon*) differs from all the other American species in having a short stumpy tail, and also in its non-arboreal habits; its spines being almost hidden by the hairs. In parts of North America these porcupines are so abundant as to be a positive nuisance, and an enterprising engineer, with true American "cuteness," hit upon the original idea of utilizing their bodies as fuel for his engine—apparently with the most satisfactory results. The lighter built tree-porcupines (*Syntherisma*), which are mainly characteristic of the southern half of the American continent, are easily distinguished by their long tails, which, as in so many South American mammals, are prehensile. These porcupines are thoroughly arboreal in their habits, and it is therefore easy to understand why their spines are so much shorter than those of their terrestrial Old World cousins, who have to rely solely on these weapons for their protection.

In addition to the members of the porcupine family, there are several other groups of rodents which develop a more or less complete coating of spines. Among the most remarkable of these groups are the spiny mice

(*Acomyx*) of Syria and Eastern Africa, one of which, when it has its spines erected, is almost indistinguishable at the first glance from a diminutive hedgehog. The spiny rat of Celebes (*Echinothrix*) is another member of the mouse family having the fur thickly intermingled with spines. In a third rodent family (*Octodontidae*), nearly all the members of which are South American, there is also a genus (*Echinomys*), taking its name from the number of flattened spines mingled with the fur of the back characterizing all its representatives. It will thus be obvious that even in a single mammalian order we have several instances where a protective coat of spines must have been acquired quite independently.

This independent origin is still more clearly indicated when we come to the consideration of the hedgehog and its allies, which bear precisely the same systematic relationship to the porcupines as is presented by the true moles to the mole-voles, as described in our last article. That is to say, whereas the hedgehogs and true moles belong to the insectivorous order, the porcupines and the mole-voles are herbivorous rodents. In spite, then, of the general similarity of appearance between a hedgehog and a porcupine, or, still better, a spiny mouse, we shall find, as already mentioned, that whereas the two latter have the ordinary chisel-like rodent teeth, the former has several narrow and somewhat irregularly-shaped teeth in the front of the jaws, while its back teeth are crowned with numerous sharp cusps, instead of having nearly smooth grinding surfaces. Accordingly, from the purely systematic point of view there is no justification for calling the common hedgehog the "British porcupine"; but, on the other hand, if we allow similarities in external appearance to be our guide in nomenclature, there are just as good grounds for applying the latter title to the hedgehog as there are for giving the names of golden or Cape mole, sand-mole, mole-vole and marsupial mole to four of the creatures noticed in our last month's article. Our ancestors, to whom the hedgehog was commonly known as the "urchin," went, however, a step further than this, and, from the resemblance of its spines to those of the mammal, gave the name of sea-urchin to the *Echinus*, a title which has stuck to it ever since. Systematic zoologists need not then wax so wroth as we have known them do when the name of "British porcupine" is applied to the urchin, seeing that the analogies of nomenclature are sufficient to justify its use. As the sea-urchins come most distinctly under the title of spiny animals, it may be mentioned here that, although the spines of the common British species are not unlike those of the hedgehog, yet their structure is totally different. Thus, whereas the spines of the mammal are of a horny nature, those of the invertebrate owe their solidity to the presence of carbonate of lime, and always break with the characteristic oblique fracture of the mineral calcite. Moreover, whereas the spines of the hedgehog are implanted in its skin, those of the sea-urchin are entirely external, being movably attached by their hollow bases to knobs on the surface of the shell or "test." Whether our worthy ancestors believed that the land and sea-urchins were connected by ties similar to those which in their estimation affiliated barnacle-geese to barnacles, or how the name "urchin" came also to indicate a child, we are quite unaware.

In place of terminating in sharp points, by which they are but loosely attached to the skin, like those of the porcupine, the spines of the hedgehog terminate inferiorly in small knobs, which are placed beneath the skin, and may thus be compared to pins stuck through a piece of soft leather. Beneath the skin lies a layer of muscle known as

the *panniculus carnosus*! and it is by the action of this muscle on their heads that the spines are raised from a recumbent to a vertical position when the creature rolls itself up into a ball—an action of which all porcupines are quite incapable. Not only does the hedgehog differ from the porcupine in this respect, but it is likewise peculiar in using its spines as a means of protection when throwing itself down a vertical bank or precipice, and by this means is able to accomplish a vertical descent of over a dozen feet without the slightest harm. As regards the development of its spiny armour, the hedgehog is perhaps the most highly specialized of all the spiny mammals in spite of the inferior length of its spines as compared with those of the porcupine. Hedgehogs are now represented by about a score of species ranging over Europe, Africa, and a considerable portion of Asia; while the existing genus dates from the middle portion of the miocene division of the tertiary period. That the spines characterizing the existing forms have been independently developed within the limits of the group is pretty conclusively indicated by the close affinity of the hedgehogs to the long-tailed and spineless Malayan insectivores known as gymnuras; fossil types apparently indicating an almost complete transition from the gymnuras to the hedgehogs. In case anyone should suggest that the latter, and not the former, might be the ancestral stock, it may be mentioned that while the gymnuras have a generalized type of dentition and long tails, the hedgehogs have the teeth much reduced in number and specialized in character, and short tails.

In Madagascar the place of the hedgehogs is taken by an entirely different group of insectivores known as the tenrecs, all of which have a certain number of spines mingled with the fur, at least in the young condition, and some of which are so hedgehog-like in general appearance that by the non-zoological observer they would certainly be regarded as members of the *Erinacida*. The tenrecs differ, however, from the hedgehogs precisely in the same manner as the golden moles were shown in our last article to differ from the true moles—that is to say, whereas in the latter the crowns of the upper molar teeth are quadrangular, with their cusps arranged in a somewhat W-like manner, in the former these teeth are triangular, with their cusps arranged in a V. There are five species of tenrecs, classed under three generic headings, and all characterized by the absence or small size of the tail. The largest, and at the same time the most generalized of all, is the common tenrec (*Centetes ecaudatus*), which attains a length of from twelve to sixteen inches, and is characterized by the absence of a tail, by the rows of spines on the back being shed in the adult state, and also by certain peculiar features in the dentition which appear to indicate relationship with the pouched mammals. The spiny tenrecs (*Hemicentetes*) are much smaller animals, of the size of moles, in which the longitudinal rows of spines on the back are retained throughout life. They have the same number of teeth as fully adult individuals of the common tenrec; but whereas in the latter there are four upper molars and two upper incisors, in the spiny tenrecs there are three of each of these teeth. In the loss of the last molar these tenrecs are evidently more specialized than the common species, but the presence of the third incisor shows that they are descended from a still more generalized type. Lastly, we have the hedgehog-tenrecs (*Erinacus*), in which the whole upper surface of the body, as well as the short tail, is thickly beset with spines, thus giving the hedgehog-like appearance from which the creatures derive their name. The dentition is more reduced than in either of the upper groups, thus indicating the greater

specialization of the genus; although the presence of a short tail indicates direct descent from a tailed ancestor. Although it is quite clear that the three genera of tenrecs are divergent branches from a common stock, yet it is not impossible that they may indicate the manner in which the complete coat of spines characterizing the third group has been gradually evolved. Against this view it may, however, be urged that if the common tenrec indicated the first commencement of the spiny coat, it would be more likely to find the spines in the adult rather than in the young. Be this as it may, the wide difference between the hedgehogs and the tenrecs, coupled with the affinity of the former to the gymnuras, leaves no doubt that the spines have been acquired independently in the two groups.



FIG. 3.—The Common Spiny Anteater.

As we found the last representative of the mole-like animals among the pouched mammals, so we observe that spiny animals are represented among the still lower egg-laying mammals by the spiny anteaters, or echidnas, of Australia and New Guinea. As most of the leading peculiarities of the spiny anteaters have been already described in a former article in KNOWLEDGE, treating of the egg-laying mammals, it will be unnecessary to say much on this subject here. The two kinds of echidnas differ, however, externally from all the spiny animals hitherto mentioned in the production of the muzzle into a long, edentulous, tubular beak; and their spines are short, and in some cases largely concealed by the fur. Neither of them have the power of rolling the body into a ball; and, whereas the Australian echidna has five toes to each foot, in the Papuan species the number is generally reduced to three. The wide structural differences separating the egg-laying mammals from all other members of their class render it almost unnecessary to observe that the spines of the echidnas are an entirely independent development. Like so many of the spined mammals, the echidnas have extremely short tails and thick bodies, with the neck indistinctly marked. We have thus decisive evidence that a more or less complete coat of spiny armour has been independently acquired in the following groups of mammals—viz., in the porcupines, mice, and octodonts among the rodents; in the hedgehogs and

tenrecs among the insectivores; and in the echidnas among the egg-layers. From the perishable nature of these appendages we have, unfortunately, no evidence as to the existence of spines among fossil mammals; but, from the foregoing considerations, we are strongly inclined to think they may be mainly characteristic of later epochs.

In this connection it is interesting to notice that the spiny globe-fishes (*Diodon*, &c.), often termed "sea-hedgehogs," in which the spines are bony and therefore capable of preservation, do not date back below the tertiary, and that spiny fishes are unknown in earlier epochs. Moreover, some—although by no means all—of the palæozoic sea-urchins appear to have had very minute spines. Hence, it would rather seem as though the history of spines has been exactly the opposite of that of bony armour, which, as we have shown in our article on "Mail-Clad Animals," has tended gradually to disappear with the advance of time.

Finally, we have to notice the general similarity in appearance of so many of the more specialized spiny mammals, due not only to their bristling coat, but likewise to the general shortness or absence of the tail, and the rounded, plump form of the whole body. The bearing of this independent development of spines in so many groups of mammals, together with the acquirement of a general external resemblance in the creatures thus clothed, on questions of wider import, will (with the editor's permission) form the subject of another article, in which we shall also have to take into consideration the conclusions reached in our previous communication. Before doing this, we may, however, have to lead further up to the subject of "parallelism" by a third article.

CATERPILLARS' DWELLINGS.—III.

By E. A. BUTLER.

(Continued from page 87.)

THE third division of our subject deals with solitary caterpillars which construct portable cases, intended to be their constant, and, in some instances, life-long abode. As the caterpillar walks about, the whole of its body, except the front segments, to which its legs are attached, is enveloped in the case, which is therefore trailed along behind it. While feeding, a similar arrangement is made, but at other times the whole insect is concealed within. Case-making caterpillars are not, as a rule, large insects, and in this country they are almost without exception small species, some of them very minute. The habit is practised chiefly by species belonging to the section *Tinea*, the same that contains the little ermine moths already described. Outside of this group there is, amongst British insects, only one other family in which the habit appears, and they are a most extraordinary set of creatures. They form the family *Psychida*, which is represented in Britain by only a few small insects; in tropical regions the species are more numerous, and many of them much larger.

On the trunks and twigs of trees may sometimes be seen what look like Lilliputian bundles of sticks, each bundle being only about half an inch long, while the stick-like fragments of which it is composed are many of them much shorter than this. On pulling at one of these little piles we find that the fragments are all fastened together into one mass, and that the bundle adheres slightly to its support, but it comes away on the application of a little

force. These bundles are the cases of the *Psychida* (Fig. 9). Examination shows them to consist of small stick-like fragments of vegetable substance, such as stems of grass and stalks of leaves, which have been collected by the caterpillar, and fastened to the outside of a silken tube. Within, the tube is beautifully smooth, its walls being tapestried with silk. From the opening at the larger end the caterpillar protrudes the front part of its body, enough



FIG. 9.—Case of *Psychid*, adhering to fragment of leaf; magnified two diameters.

only to enable it to hold the food and eat. On opening such a case, it would be found to have different contents, according to the time of year. In May the inhabitant would be a caterpillar; later on, a chrysalis; and still later, at about the end of June or in July, nothing more than fragments of an empty chrysalis shell would be found if the insect whose home it was had been a male, but if a female, there would be found a caterpillar-like creature as well. The explanation of this is, that while the male of these insects is a four-winged being like other moths, the female has no wings at all, and looks very much like a caterpillar herself, or sometimes, owing to the absence of legs as well as wings, more like a maggot or short fat worm. The females of this group are in fact the most degraded of all Lepidopterous insects; the males of our British species are rather obscure-looking creatures, of a brownish or blackish colour, whence some of them are known as "chimney-sweeps."

Being utterly helpless and unable to fly, the female never trusts herself outside the walls of her cell, but remaining immured in darkness for the whole of her adult life, receives in that position the attentions of her mate, if she should be lucky enough to meet with one. But such good fortune is by no means the lot of all. The males are far less common than the females; in fact they seem to be almost a superfluous luxury amongst the *Psychida*, for the opposite sex find no difficulty in continuing the race without the assistance of partners. In other words, the curious phenomenon of parthenogenesis, or the production of fertile eggs by virgin females, prevails to a surprising extent in this group of moths, so that it is possible to breed them generation after generation and year after year without ever seeing a male. The larva of the male *Psyche*, on the approach of pupation, fastens his case to a leaf or stem by silken threads round its mouth, thus guarding against any mischance during the period of his own helplessness. He then turns round within his case and faces its free end before casting his last larval skin, so that he may be ready, when he becomes a moth, to make his exit at the only available opening, that at the free end, which had previously served for the ejection of waste matters. Like a Tortrix, therefore, he leaves his chrysalis case projecting partly from his dwelling when he abandons it for ever.

A continental species makes a spirally-coiled case, the silken walls of which are strengthened with particles of sand and other adventitious matter. In shape it somewhat resembles a small snail shell. Certain exotic species from Africa make cases which still more closely imitate the shells of the Mollusca, some being like a flat snail, and others like the pyramidal shells of some of our pond snails (Fig. 10). The larger exotic species are often called "basket-worms," in allusion to the basket-like house in which they are always found, and which, when they are resting, hangs down from the twigs and branches of trees.

Though the cases of the *Psychida* in this country are, in consequence of their small size, probably known to none but professed entomologists, the much larger species of the tropics have attracted general attention, and thus have acquired popular names. A certain South African species goes by a complex and unpronounceable native name which, it is said, may be rendered in English, "he that goes with his little house"; and again, in the Colonies, some are known as "walking chips," from the sticks with which the cases are covered. One of these now before me consists of a silken tube, the central portion of which is

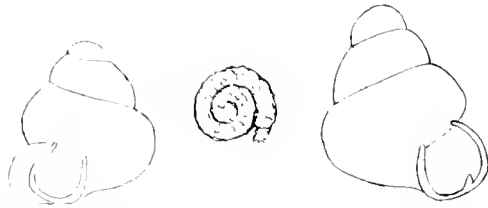


FIG. 10.—Cases of *Psychida*, imitating shells; magnified two diameters. (After McLachlan.)

strengthened and made stiff and unyielding by seventeen bits of stick placed longitudinally side by side; all, except one, are of nearly the same length, being about one and a quarter inches long; the single exception is nearly twice this length, and the extra length projects at the hinder end, since it is necessary for convenience of locomotion that all should terminate at about the same level at the mouth end. The ends of the sticks show a rounded bitten surface, where the caterpillar has nibbled them off, and remind one a good deal, though on a small scale, of the similarly rounded ends of the sticks bitten off by beavers. The parts of the tube that project beyond the sticks are covered with small fragments of bark, &c., irregularly placed, and not interfering with the flexibility of the tube; hence, when the caterpillar is on a leaf, the case bends at this part, and hangs downwards in whatever position the insect may be. Amongst nations which believe in the transmigration of souls, there has sprung up the idea that these bundle-bearing insects are the souls of men who, during a former life, have stolen firewood, and are therefore condemned to do penance by being subjected to the drudgery of perpetually carrying about burdens of such a character as to remind them of their former fault!

The cases of the *Psychida* forcibly remind us of another set of insects which make habitations almost identical in form. "Caddis worms" are well-known inhabitants of ponds and streams. They are caterpillar-like creatures which may often be seen dragging about their little tubular homes, which are ornamented on the outside with twigs, roots, bits of stick, dead leaves, sand grains, gravel and shells. Some of them, again, make cases which are spirally coiled, and so look like snail shells, thus closely resembling the spiral cases above mentioned. Now if one were to find an empty case of one of these creatures, and were to know nothing of its history, not even whether it belonged to an aquatic or a terrestrial insect, it would scarcely be possible to tell whether it was a caddis case or belonging to one of the *Psychida*: and yet the perfect insects are considerably unlike in structure, and are referred to two different orders. The caddis flies, from the absence of the scales on their wings which characterize butterflies and moths, and from peculiarities of the mouth organs, are referred to the Neuroptera, while the butterflies and moths constitute the Lepidoptera; and yet we find that certain species in each

order have acquired such closely similar architectural propensities that, although the one set are terrestrial and the other aquatic, and although the protection in the one case is apparently against fishes and in the other against birds, the products of their skill are scarcely to be distinguished from one another. Between the spiral cases of both these groups of insects and the shells of the Mollusca which they mimic, a point of contrast should be noted. The shell of a mollusc is a secretion from its own body, to which it remains attached at a certain point; it is, in fact, a skeleton rather than a house, though an external one. But the spiral case of the insect, on the other hand, is not, except for the silk it contains, a secretion of its fabricator, but is largely built up of foreign matter, and is nowhere attached to the creature's body, so that it is a true house and in no sense a skeleton; it can therefore be changed at pleasure, which of course is not the case with a mollusc's shell.

Turning now to the Tineæ, we find several groups of insects indulging in the habit of fabricating cases. Just about the present season of the year, there may be seen in woods, either resting on the fresh green leaves or fluttering about in the sunshine, a tiny moth with shining dark brown wings which have two little yellowish spots on their inner margins, and with a red head and strongly comb-like antennæ. This is called *Incurvaria muscicella*. It was hatched from the egg nearly a year ago as an insignificant and uninteresting-looking grub, which, as soon as it was out of the eggshell, set to work to mine into the leaf on which it found itself. It spent the first few days of its life as a miner, but soon forsaking this habit, it cut out the roofs of its mine in June, and fastening them together into a flat case, ensconced itself within and descended from the branches to take up a humble position on the ground. Here it lived a haphazard life, eating either dead brown leaves or fresh green ones, as occasion served, and growing very slowly, for it had a long period of larval life before it, and even by the end had not attained to any great size. It formed fresh cases for itself as its slow growth necessitated. It was full fed in October, but did not choose that time to pass into its next stage. Safely protected in its flat oblong case, it lay about amongst the dead leaves during the winter in a torpid condition. But when spring arrived, it awakened to renewed vigour and became a chrysalis, from which the moth issued as soon as the sun's beams had attained sufficient power to entice it out. Several other allied species have similar habits. The beautiful little moths called "longhorns," with metallic wings and antennæ many times as long as the body, are nearly related to these, and are also case-makers. The perfect insects, some of which are very abundant in woods just now, flutter round the tops of the bushes in the bright sunshine, and at a distance look something like gnats.

But perhaps the most noted of all the case-forming caterpillars are the members of the genus *Coleophora*, which have received that name in consequence of this habit, the word being Greek for a sheath-bearer. They are very small and inconspicuous moths, mostly of exceedingly plain appearance, and as they are of very retiring habits to boot, would certainly never be noticed by the casual observer. We have a great number of species in this country, and the caterpillars' cases are much more frequently seen than the perfect insects, though, being small, they need to be carefully looked for. Amongst the different species there is an endless variety in the shape and appearance of the cases (Fig. 11), but the habits of each species are extremely uniform, so that the nature of the case is generally a good guide to the determination of

the species that formed it. Some are made of pieces cut from the leaves of the food-plant, and the varied colour, texture, and outline of these are the causes of great diversity in the aspect of the cases. Others are composed wholly of silk, stained usually more or less black; such cases are often shaped something like a pistol, and, when cut open, remind one very much of a pipe-case. Some caterpillars, again, use the husks of the seeds they have been feeding on, and so save themselves the trouble of manufacturing a receptacle. When quite young the larvæ feed as miners in the interior of leaves or seeds; but after a while they change their habits and begin to make a case, either coming out of the mine and spinning a silken pistol-shaped tube, or, like *Incurvaria*, cutting out the two skins of the part of the leaf they have mined, and tacking their edges together with silk. A minute species that feeds on elm ingeniously saves itself the trouble of making two seams by using that part of the leaf which is close to the margin, thus taking advantage of the natural junction which unites the two cuticles there. The outline of the elm leaf, it will be remembered, is notched into a series of tooth-like projections; each of these the caterpillar neatly and carefully excavates, then cutting the cuticles along parallel to the margin, but in one continuous curve, it fastens the severed edges together, making that the lower



FIG. 11.—Cases of *Coleophora*; magnified two diameters.

surface of its case, while the upper edge retains the saw-like outline of the leaf. Whatever may be the structure of the case, its inner surface is made beautifully smooth with a lining of silk.

The caterpillar roams about over the leaves on its six front legs, with its body elevated in the air like that of an acrobat, and crowned with the case as with an extinguisher. Its prolegs, ten in number, are very slightly developed, as there is scarcely anything for them to do, and it retains its hold of the case by little hooklets at the end of its body, which it uses like grappling irons. When about to feed, it perforates a little round hole in the cuticle of a leaf, and then begins to mine into the tissues beneath, stretching itself as far forward as it can reach, and thus excavating an irregular blotch. As it grows, its little house in course of time needs reconstruction, as its accommodation is limited and it is easier to construct a new abode than to enlarge the old one. When such a time arrives, the caterpillar mines into a leaf, and having devoured the cellular tissues over a certain area, cuts out the cuticles and fastens them together for the walls of a new domicile, just as on the former occasion. When about to pupate it shrinks into its case, the mouth of which it fastens to a leaf by silken cords; its changes to a chrysalis within, and in the month of July makes its exit at the further end as a fully-developed moth. The cases of the *Coleophora* serve not only as a protection to the larvæ during their active summer life, but also, as they all hibernate in the larval condition, render them good service as snug and safe winter quarters.

THE OLDEST BOOK IN THE WORLD.

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

THE only complete work that, without question, can lay claim to being the oldest book in the world is known as the "Papyrus Prisse," and now forms one of the treasures of the Bibliothèque Nationale.

It was presented to the great library of Paris by a Frenchman of the name of Prisse, who discovered the papyrus at Thebes. The tomb in which it was found contained the mummy of one of the Entews of the eleventh, or first Theban, dynasty. The date when the manuscript was written cannot, therefore, have been later than 2500 B.C. But if the exact age of this identical copy should be doubtful, we know precisely, from the text itself, the date of its composition, as it states it was compiled by one Ptah-hotep, who lived in the reign of King Assa. The full title runs: "Precepts of the Prefect Ptah-hotep, under the King of the South and North, Assa." As this king was the last but one of the fifth dynasty, Ptah-hotep, who flourished in the reign of this Pharaoh, and held the distinguished office of "prefect," must have compiled his work about 3350 B.C. Divided into forty-four paragraphs or chapters, the work is something very much more than a mere literary curiosity. It is written in the Egyptian hieratic character; is rhythmic, if not poetic; is addressed to the educated classes, and embodies throughout high and noble principles for the regulation of individual life and conduct, and for the maintenance of good government. The man in authority is enjoined by this very ancient writer to labour at all times to be a true gentleman, lest from his own defects of character he suffer the authority given him by favour of the Supreme Being to be weakened.

An Egyptian Prefect was the highest dignity in the land, second only in authority to Pharaoh himself. It was the office held by Joseph in the Biblical story: "Only in the throne will I be greater than thou." The Prefect had the custody of the key of the Larit, or royal granaries, to which no entrance could be obtained without the production of the prefectorial seal. The holder of the office was at once the Egyptian First Lord of the Treasury, Chancellor of the Exchequer, and, in his judicial capacity, Lord Chief Justice of Egypt.

All our greatest Egyptologists bear testimony to the extraordinary civilization of ancient Egypt. The work of Ptah-hotep fully confirms this position. It testifies to a height of culture and refinement obtaining in Egyptian society 5240 years ago, that to our Western circumscribed notions of modern superiority are simply inconceivable. The teachings of the "Precepts" more than justify all that has been said by Egyptologists. "It is certain," says Prof. Renouf, "that at least 3000 years before Christ there was in Egypt a powerful and elaborately organized monarchy, enjoying a material civilization, in many respects not inferior to that of Europe in the last century." Leptius writes: "The fourth dynasty ascended the throne about 3124 B.C., and at that time, long before our usual ideas of the development of nations, there is found a people highly instructed in all the arts of peace; a state carefully organized; a hierarchy firmly founded, minutely divided, and organized even to the smallest external matters; an universally diffused system of writing, and the common use of papyrus: in short, a civilization which in all essential points has already attained its full maturity, and only by close investigation is further development in some directions discovered."

M. Mariett says: "Art under the fourth and fifth dynasties obtained a height never afterwards surpassed.

In Egypt the country had also a complicated administration, the result of efforts pursued through long years. There were civil grades as well as religious grades, bishops as well as prefects. Registration of lands was maintained. The king had his court, and a whole world of officials, powerfully and wisely organized, gravitated round him. Literature was held in honour." So also Prof. Maspero: "In one of the tombs of Gizeh, a high officer of the first period of the sixth dynasty (B.C. 3703) takes the title of 'Governor of the House of Books.' Not only was there already a literature, but this literature was sufficiently large to fill libraries, and its importance was so great that one of the court officers was specially designated for the keeping of the royal library." Lastly, Erman of Berlin, also a distinguished Egyptologist, says: "If we have hitherto believed that the immense literature of the dead arose gradually during the long history of the Egyptian people, and that it must be possible to follow the development of their ideas among the Egyptians, we can hold that view no longer. This literature was made at an epoch that lies almost beyond our historical knowledge, and later times did no more than pass it on."

The wisdom and high moral teaching embodied in the precepts of Ptah-hotep abundantly confirm this testimony. This old writer urgently enforces on rulers the cultivation of the doctrine of "Ma," an Egyptian dogma, comprehending "the true, the beautiful, the good." "Ma" is the principle of order and harmony in everything; it is the steadfast pursuit of wisdom, knowledge, and obedience—obedience as the best of all. Although, as in modern expression, we should say "extremely liberal" on many subjects, politically, Ptah-hotep displays an oriental horror of innovators and innovations. Ideas that may be new to the generation are not necessarily new to the world, and changes do not always imply progress. "Good government," he says, "can only be secured by the appointment of good governors. He who is placed in authority over a large number of men must be without reproach, and, in spite of his power, never forget that there are laws. The neglect of this principle is the cause of revolutions; when the great forget their duty, why should not the small take their place?" (Chap. 5.) According to Ptah-hotep, contemporary estimates of human actions are not always the most reliable or the most enduring. "Not of the counsel of the flatterers of to-day is it needful to take heed; it is of the judgment of posterity rather, which renders justice to righteous actions." (Chap. 14.) "Only by a consistent life of reverence for knowledge and wisdom; by observing a just moderation in everything; not abusing authority, but by seeking to inspire love rather than fear, can we hope to appear before posterity with honour." (Chap. 6.) The great man is to remember that "he is only the dispenser of the gifts of the Supreme; and if, coming of low origin, he has attained to high honour, he must not, as is too often the case, be puffed up by his good fortune, but should consider the new duties which his rank imposes on him as the steward of the Almighty." (Chap. 30.)

In sixteen different instances in which Ptah-hotep speaks of God, he does so in the singular number—an argument happily no longer needed to establish the monotheistic character of the Egyptian religion. He ends by saying: "I have reached one hundred and ten years of life, blessed by the favour of the king, among the first of those who have exalted themselves by their works, doing the pleasure of the king in an honoured position."

The work terminates with the colophon: "It is finished, from its beginning to its end, according to that which is found in writing."

"The Precepts of Ptah-hotep" have been translated from the hieratic into French by M. Virey, and retranslated into English by Prof. Osgood. They reveal throughout the mind of one who all his life has been accustomed to the higher walks of society in a well-ordered state. The sixteen pages of the "Precepts" are, in the manuscript, preceded by a few leaves of a still earlier work, written by one Kakinna, Prefect to King Seneferu, of the third dynasty. Had this work been complete, we should have been able to boast of a book older than the Pyramids, and dating from 3760 years before Christ—a book 5650 years old!

By the courtesy of the Principal Librarian at the Bibliothèque Nationale, the writer, since the above was written, has had the opportunity of inspecting the document. It is in the hieratic character, in two colours, red and black, and in a truly wonderful state of preservation. Nothing could well improve the arrangements for its safe keeping, every sheet of the papyrus being carefully covered with glass, and secured from light and dust.

Science Notes.

The last number of *Astronomy and Astrophysics* contains a remarkable photo-lithograph showing the disc of the sun covered with a network of faculae. The picture is a photograph of a drawing made from negatives taken by Prof. G. E. Hale on April 16th, 1893, the day of the recent eclipse. The solar photographs were projected on a screen of white paper with an optical lantern, and tracings were made from them showing faint details which Prof. Hale believes would have been lost in direct photographic reproductions. The solar faculae, instead of being shown as great white masses, are broken up into curving linear forms, which interlock with one another, giving the appearance of a kind of network extending over the whole of the sun's disc, though it is brightest in the southern hemisphere, and especially in the region of spot development.

The exploration of the higher atmosphere by means of balloons has led to some interesting results in France. A balloon, carrying registering meteorological instruments, was sent up by M. Gustave Hermite on March 21. Its volume was nearly 150 cubic yards, and the whole weight of the apparatus, including an automatic distributor of inquiry cards, was about thirty-seven pounds. The lowest pressure registered was 103 millimetres (four inches), that is, rather less than one-seventh of an atmosphere, which corresponds to a height of about ten miles. At a height of nearly seven-and-a-half miles the temperature recorded was -51° C., or -58.2° Fahr. The freezing of the ink of the recording instruments then caused a break in the curves of temperature and pressure. Subsequently, however, the ink was thawed (probably by the intense solar radiation), and a temperature of -5° Fahr. was indicated at ten miles. In the famous balloon ascent by Messrs. Glaisher and Coxwell in 1862, the temperature observed at a height of seven miles was -12° Fahr.

There is in use at Millwall Docks a novel and ingenious machine for discharging cargoes of grain in bulk, the principle applied being the removal of the grain by the creation of a strong current of air. The machine is erected on a barge, which is placed alongside the ship to be unloaded. One end of each of six 5-inch flexible pipes is attached to the machine, the other ends being carried into the hold or holds of the vessel and immersed a few inches in the grain. When the engine is started the grain immediately flows at the rate of one hundred tons an hour

through the pipes into receivers, whence it falls by gravity into weighing machines, and then, again by gravity, into the craft sent out by the purchasers to carry it away.

Natural Science announces that the work of remounting the great series of microscopic preparations made by the late Prof. de Bary, and acquired by the British Museum, is nearly completed. To students of botany the presence of this large collection in the country will be a great benefit.

In the last issue of the "Proceedings of the Zoological Society," Mr. R. Lydekker describes an interesting series of Cetacean remains from the eocene of the Caucasus. Among these, special importance attaches to certain bones belonging to the imperfectly-known creature designated *Zeuglodon*, which Prof. D'Arcy Thompson has recently endeavoured to remove from its assigned position among the whales to associate it with the seals. The most important specimen among the new find is a humerus bone of which but one example has been hitherto known, and the study of this leads the author to conclude that *Zeuglodon* is much more likely to be an ancestral Cetacean than a seal.

An important find of water is reported within "the London Basin" of geologists, in Windsor Forest. After boring for 1234 feet, water was found, and rose seven feet above the surface, though the site is on a hill 223 feet above sea level. This welcome supply comes from the lower greensand. As a Commission is now at work on the London Water Supply question, this discovery may have important results.

The Board of Agriculture has issued a valuable report on rust or mildew on wheat plants. It contains a complete account of the life-history of the fungus of ordinary mildew, *Puccinia graminis*, as well as that of spring-rust and mildew, *Puccinia rubigo-cera*, with a discussion of the conditions favourable for their propagation, and the best means of averting them. It is illustrated by some excellent coloured plates by Mr. Worthington Smith.

Dr. J. Rahon has recently contributed to the Anthropological Society of Paris an interesting paper entitled *Recherches sur les Ossements Humains Ancien et Préhistoriques*. This paper is the fruit of most laborious investigation. The author concludes that the bones both of men and women were rather heavier and more powerful in ancient times; also that the tribes of neolithic times in Western Europe were of a medium height, of about 1.63 metres.

The Rev. F. J. Smith, Millard lecturer in mechanics at Trinity College, Oxford, has devised a means by which pictures of old coins, and similar objects, can be made electrically. The coin, medal, or engraved plate of which a figure is required, is made to form one of the metallic coatings of an electrical condenser; a photographic plate, or a piece of bromide paper, being placed between the two. When a condenser so arranged is subjected to rapid charge and discharge, by connecting the coatings with the terminals of an induction coil, or a similar source of electricity, for a fraction of a second, the prepared surface of the dry plate is chemically altered, and upon developing the plate in the usual manner a picture of the coin or medal will be found upon it. Pictures can be produced in this manner even when the sensitized plates have been exposed to full daylight. The best results are obtained by conducting the process in oxygen gas under a pressure of about two atmospheres.

It has been resolved by the Council of the Zoological Society to award the Society's Silver Medal to Donald Cameron, of Lochiel, and John Peter Grant, of Rothiemurellus (Inverness-shire), in recognition of the efforts they have made to protect the osprey (*Pandion haliaetus*) in Scotland. The osprey, formerly common in many parts of the British Isles, has become so rare of late years that it is stated that only three pairs of this bird have been known to breed in this country for some years past.

Those who desire to keep in touch with the progress of science outside their own departments will welcome the appearance of the second volume of the "Year Book of Science" (Cassell & Co.), edited by Prof. T. G. Bonney, F.R.S. It has been extended so as to include geography and anthropology, and more space is devoted to anthropology. The list of contributors contains many well-known names. There is an index of subjects as well as one of authors.

M. Rykatchef has made an investigation of the variations in the temperature of the air over the oceans in the tropics, which is described in the *Transactions* of the St. Petersburg Academy of Sciences for October 19th. He finds that the minimum daily temperature is reached about one and a half hours before sunrise, and the maximum almost immediately after mid-day. The variation of the mean temperature throughout the whole twenty-four hours is very small, being only 2.9° Fahrenheit.

M. Angot exhibited several beautiful photographs of cirrus clouds at the French Physical Society on February 3rd. In order to stop out the blue colour of the sky, coloured screens were employed, the best results being obtained by using a solution of copper sulphate (ten parts) and potassium bichromate (one part), to which a few drops of sulphuric acid is added. With such a solution in front of the lens of a camera, and orthochromatic plates, excellent cloud photographs are obtainable.

The mammoth gum trees of Australia are the largest trees in the world, not excepting even the sequoias of California. The loftiest tree on the globe, according to Baron von Müller, is the *Eucalyptus regnans*. One of these trees in the Cape Otway ranges measured, when felled, 415 feet in length. Gum trees grow very rapidly. The *Eucalyptus globulus* grew 40 feet high in four years in Florida, with a stem a foot in diameter. Trees of the same species in Guatemala grew 120 feet in twelve years, and had a stem diameter of nine feet.

A few facts significant of progress in India are noted by Dr. H. R. Mill in a recent number of *Nature*. He says that the newly-published report of the Bengal census shows that there is a steady transference of population from the most densely to the more thinly-peopled parts of the province. Would that the same remark could be made as to the population of England! Mohammedanism is increasing rapidly in Bengal, and the custom of widow marriage among Hindoos has become common.

From measurements of an arc along the parallel of $47\frac{1}{2}^{\circ}$ in Russia, M. Venukoff has found a length of 1,446,162 metres for a difference of longitude of $19^{\circ} 11' 55.11''$, or 75,336 metres ($16\frac{1}{2}$ miles) per degree. The rate of diminution in the lengths of degrees of longitude deduced from the Russian results does not agree with that given by French and English measures; it indicates a polar compression of $\frac{1}{22965}$, whereas the value given by Clarke is $\frac{1}{29346}$.

Focal Length of Lick 36-inch Refractor, 570 inches. Scale of these enlargements, about 80 inches to the degree.



THE CLUSTER IN HERCULES (Messier 13).

Enlarged about eight times from a Photograph taken with the 36-inch Refractor of the Lick Observatory, on 24th May, 1892. Exposure 156 minutes.

THE CLUSTER IN HERCULES (Messier 13).

Enlarged about eight times from a Photograph taken with the 36-inch Refractor of the Lick Observatory, on 28th July, 1891. Exposure 122 minutes.

WHAT IS A STAR CLUSTER?

By A. C. RANFORD.

FORTY years ago, when it was generally believed that star clusters were stellar universes similar to the Galaxy which spans the heavens, it was assumed that the individual stars of clusters would bear comparison—as to magnitude and brightness—with our sun. It was then pretty generally believed that the stars of clusters were only rendered dim by distance, and that they were separated from one another by interspaces similar to the star depths which separate us from the isolated stars dotted over the heavens, many of which are evidently associated with the Milky Way; but as time went on, it was seen that the clusters and nebulae were in many instances evidently associated with the Milky Way, and that the clusters which are grouped about the Milky Way are probably at about the same distance from us as the Milky Way, and as the numerous bright stars which are evidently associated with it. Such considerations made it evident that the individual stars of the clusters associated with the Milky Way must be very small or very dim compared with the brighter Milky Way stars.

Determinations of parallax and the results derived from the observed motions and brightness of double stars seem to point to the conclusion that many of the fixed stars are actually smaller than our sun, and that, as a rule, the stars do not very greatly exceed the sun in mass or brightness. We are, therefore, forced to conclude either that (1) the Milky Way stars must be immensely large or intensely bright compared with our sun and the other stars whose mass and brightness we have been able to approximately estimate, or (2) that the individual stars of clusters associated with the Milky Way must be very small or very dim compared with our sun.

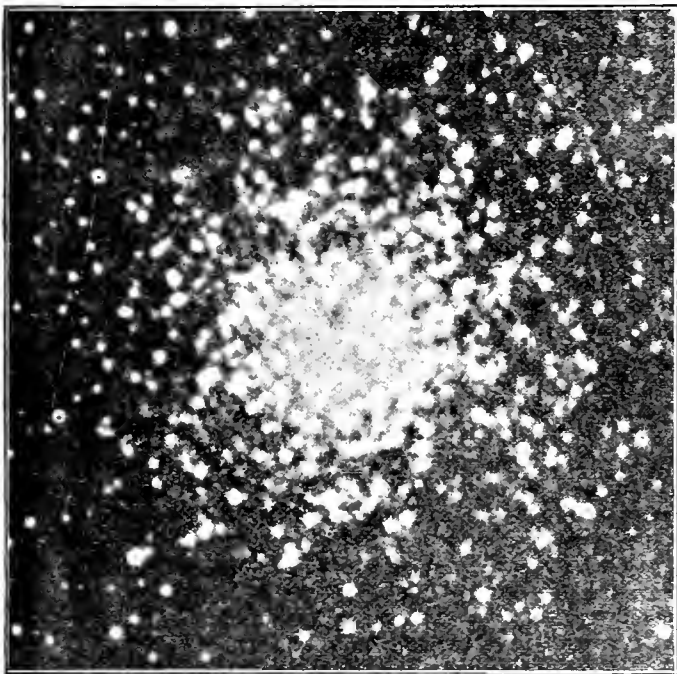


FIG. 1.—Untouched etched Block made from a Photograph of the Cluster in Hercules, taken by the Brothers Henry on the 23rd June, 1886.

The cluster in Hercules shown in our plate is just visible to the naked eye, and its total light is probably about equivalent to the light given by a sixth magnitude

star. It may be shown that (if there were no absorption of light in space) our sun would appear to shine as a star of about the sixth magnitude if it were removed to a distance

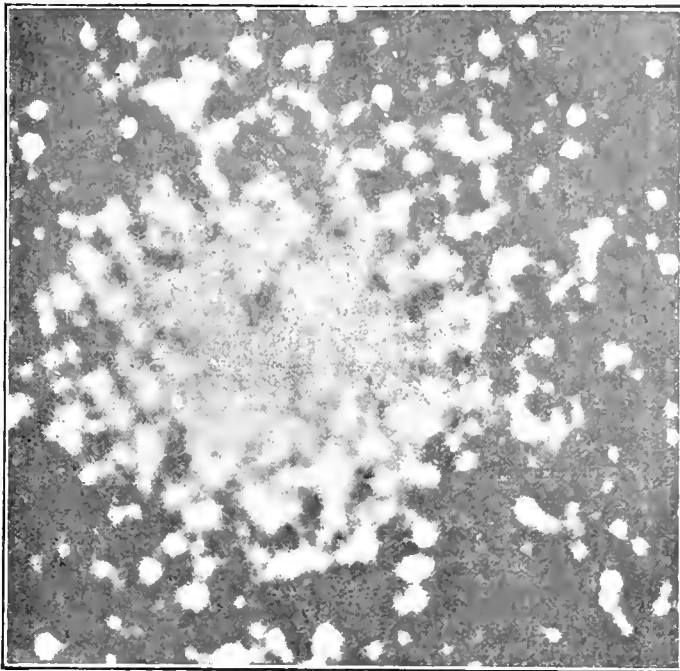


FIG. 2.—Untouched etched Block from the Henry Photograph of 23rd June, 1886, on the same scale as the Enlargements made from the Lick Photographs, shown in the Colotype Plate.

corresponding to a parallax of a tenth of a second, that is, if it were removed to a distance about seven and a half times as great as the distance of our nearest stellar neighbour, α Centauri. At such a distance our sun would give us about as much light as we derive from the whole of the stars of the Hercules cluster, and at such a distance a sphere equal in diameter to the orbit of Neptune would subtend a diameter of about six seconds, as seen from the earth; but the denser part of the Hercules cluster has a diameter of about three minutes. Consequently, if a quarter of the photosphere of our sun were torn into small fragments and scattered in space within a sphere of thirty times the diameter of the orbit of Neptune, or nine hundred times the diameter of the earth's orbit, we should (supposing the fragments of photosphere to retain their brightness and to be all placed square to the line of sight) have a cluster of small stars which, as seen from a distance seven and a half times as great as the distance of α Centauri, would present an appearance similar in brightness and diameter to the Hercules cluster. If the Hercules cluster is at double the above distance, the diameter of the cluster and of the individual stars would need to be doubled, and their volume and mass would need to be multiplied by eight. But the assumption that this cluster and the other clusters scattered along the Milky Way are at fifteen times the distance of α Centauri, forces us to assume that the brighter stars associated with the Milky Way are on a gigantic scale compared with α Centauri and the other stars whose mass and brightness we have been able to estimate. If the Hercules cluster is at only four or five times the distance of α Centauri, the individual stars of which the cluster is composed must be

* The solar disc from which we receive light only corresponds in area to half the hemisphere turned towards us, and to a quarter of the whole solar surface.

very small indeed, or very dim compared with our sun; and assuming them to have a brightness equal to the brightness of the sun's photosphere, they would not much exceed our earth in size.

When we look at the arrangement of the stars in this cluster, we find that we have evidence of the association of many of the stars into groups linked together by faint nebulous bands. Long ago Sir John Herschel noticed the curvilinear streams of stars radiating from the central regions of clusters, and, as mentioned in the last number, he remarked on the difficulties of conceiving of the permanent conservation of such a system as a globular cluster, if the individual stars are conceived of as moving round a common centre of gravity. Miss Clerke, in her "System of the Stars," remarks on the "radial alignment of the components of clusters inevitably suggesting the advance of change, whether in the direction of concentration or diffusion; either the tide of movement is setting inward, and the 'clustering power' (to use a favourite phrase of Sir William Herschel's) is still exerting itself to select stars from surrounding space, or else a centrifugal impulse predominates."

It seems to me that stars falling towards the cluster from surrounding space would probably not be arranged in rows, and that the forms of several of the radiating groups of stars which are seen to be linked together by bands of nebulous matter indicate that the group is moving from the central parts of the cluster outwards, through a resisting medium which is dense enough to contort the outward moving mass. Possibly the stars may fall back singly, or the stars and nebulous matter may fall back again to the cluster in a cooled and non-luminous form, but I do not trace any evidence of prominence forms with their heads turned towards the centre of the cluster, or any linear groups of stars forking towards the centre of the cluster. Though there are many such linear groups of stars which branch or fork outwards, the physical interpretation of these prominence-like and branching structures seems to me so important that I have made an effort to exhibit them to the readers of KNOWLEDGE. I am indebted to Mr. McClean, of Tumbridge Wells, for the excellent enlargements of the photographs of this cluster made at the Lick Observatory, which are shown in the collotype plate, as well as for the loan of a contact copy from one of the Lick negatives, a close study of which I have found very instructive. The blocks have been made from enlargements of a photograph of the cluster taken by the Brothers Henry at the Paris Observatory, and they are quite untouched, though the process has been arranged so as to

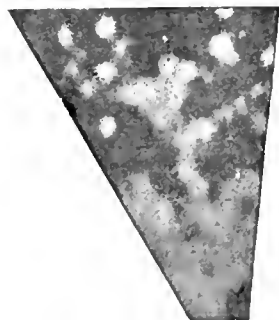


FIG. 3.—Prominence-like Structure.

give prominence to the faint ligatures of nebulous matter joining the lines of stars. The prominence-like structure shown in Fig. 3 should be compared with the collotype plate from the Lick photographs, as well as with the cluster as shown in Fig. 1. It seems to be a broad-headed structure, with a contorted, spirally-twisted stem joining it with the central mass of the cluster. In the right-hand picture on the plate made from the Lick photograph of July 28th, 1891, the narrow stem beaded with stars can be traced, while in the denser picture of May 24th, 1892, the bright head of

the prominence seems to be almost severed from the curving lower part of the stem; but an examination of all the photographs convinces me that the spreading head is joined on to the lower part of the stem by a ligature of nebulous matter which probably takes a bold spiral sweep, and joins up with the lower part of the stem at the cusp marked by the bright star. On the denser Lick photograph of May 24th, 1892, at least two faint strings of minute stars joined by a ligature of nebulous matter may be traced branching away from the bright prominence-like structure, or possibly seen in projection in its immediate neighbourhood.

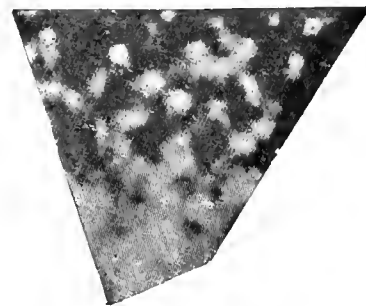


FIG. 4.—Strings of Stars linked together by Nebulous Matter.

The structures shown in Fig. 4 are from the upper part of the cluster to the right of the prominence structure referred to. The structures will be best seen by a reference to the collotype plate from the denser Lick photograph, but the strings of stars, and the nebulous matter linking them together, can also be recognized on Fig. 1, made from the Henry photograph. The streams of stars are not straight, and seem to afford evidence of having been contorted by a resisting medium.

Fig. 5 shows a very curious structure, which has the appearance of being a spiral stream of nebulous matter and stars, with a spreading or forked summit. This structure is immediately below that shown in Fig. 4, and extends radially from the right-hand side of the cluster. It is well worthy of close study, and should be compared with the Lick plates and with Fig. 1. If we admit that this is a vast spiral structure, it seems to follow that the resisting medium through which the ejected matter was projected upwards is sufficiently dense, compared with the ejected matter,



FIG. 5.—Spiral Stream of Nebulous Matter and Stars.

to permit of vast storms causing cyclonic action. We occasionally find prominence forms upon the sun, showing distinct evidence of cyclonic action. A notable instance of such a twisted solar prominence was photographed by Colonel Tennant during the total eclipse of 1868, and is well shown in the plates made from his photographs published in the "Memoirs of the Royal Astronomical Society," Vol. XXXVII., Plates 5c and 5d, and on a larger scale in Plates 6, 7, and 8 in the same volume. We know that at the level of the solar prominences the pressure of the solar atmosphere, or resisting medium through which the prominences are projected, is so small that the lines of the prominences, as shown in the spectroscopic, are quite narrow, and it seems probable that the cyclonic twist must be given to such prominence matter at a much lower level than the level of the photosphere. Similarly, it seems possible that the spiral twist shown by the structures in Figs. 3 and 5 may have been given within a gaseous envelope in the central region of the cluster. The flattened and spreading heads of prominences may be due to the rapid motion of the prominence matter through a very thin resisting medium, or even

to their motion through a fine rain of falling matter, but we can hardly conceive of a spiral form being given to an outrushing filament unless it was projected from the centre of a cyclonic storm, or was deflected in its passage through a resisting medium by lateral currents. The fact that the stellar points follow the lines of the



FIG. 6.—Branching Structure.

nebulous curves, seems to indicate that the stellar aggregations have formed within the nebulous filaments after their deflection; for if the stellar aggregations differ appreciably in density from the nebosity joining them, the resisting medium would have a less effect in diminishing the momentum of the denser portions, and the denser masses would drift on in front of the less dense portions and get separated from the general line of nebosity.

Fig. 6 represents a branching structure adjacent to the spiral form shown in Fig. 5. The narrow bands of nebosity linking the stellar regions is well shown in it, as also in the branching structure shown in Fig. 7.

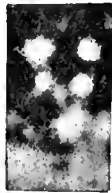


FIG. 7.—Forked Structure.

In addition to the bright structures shown in these illustrations, there seems to be evidence of the existence of dark branching forms associated with the cluster. The Earl of Rosse at Parsonstown in 1850, noticed three "dark lanes" meeting at a point considerably removed from the centre of the Hercules cluster, and the Rev. T. W. Webb describes these dark lanes in his "Celestial Objects" as visible with a nine-inch reflector. They form quite a striking feature of the cluster as seen with larger apertures, and are distinctly traceable on a dense photograph of the cluster taken by Mr. Isaac Roberts in May, 1887—a photograph of which has been well reproduced in Miss Clerke's "System of the Stars," plate 9. But the photographs now reproduced do not extend quite far enough to show the triple dark lanes discovered by the Earl of Rosse, though they can be distinctly made out upon the original copies from which the illustrations for this paper have been prepared. In these, and in the glass dia-positive of the Lick photograph lent me by Mr. McClean, there appear to be several other small dark branching structures which can be distinctly made out in different parts of the cluster. They are clearly not merely lacunæ between bright structures. They interfere with the nebulous background and with the bright regions in a way that can only be accounted for by supposing that a branching stream of light-absorbing matter is situated between the eye and the cluster, probably in the immediate neighbourhood of the cluster; a few such branching channels may be traced in the central parts of Fig. 1, though they are not very conspicuous. It, however, seems probable that the cluster is a group of nebulous structures, some bright and some light-absorbing: the bright structures being studded with brighter regions, which appear as stellar points in the telescope.

If the cluster is situated at a distance seven and a half times as great as α Centauri, the bright regions might have a diameter 500 times as great as that of our sun, and yet hardly be distinguishable, except in the largest instruments, from stars. For our sun, if it were removed to a distance seven and a half times as great as α Centauri, would only appear to have a diameter of 0.00096" as seen from the earth. Consequently, nebulous clouds with a diameter twice as great as the diameter of the earth's orbit would, at such a distance, appear to have a diameter of less than

half a second of arc, and would be hardly distinguishable, except in the largest instruments, from stellar points. We are, therefore, hardly in a position to say that the stellar points are sun-like bodies with a brilliant photosphere, and are not merely brighter regions in the nebulous streams or structures radiating from the cluster.

Mr. Burnham, in commenting on a close pair of star-like points near to the centre of this cluster, which he examined with the 36-inch Lick refractor, and found to be separated by a distance of only 0.88", says: "This is one of the principal stars, near the central portion of the great cluster in Hercules. It was the only pair close enough to be called a double star I could find on this occasion, but the conditions were not specially favourable. Of course, there are many stars within, say, 2" of each other, but in all of the bright compressed clusters which I have examined with this and other instruments there seems to be a remarkable absence of real double stars; and this seems to be true of star clusters generally."

Mr. Burnham notes four or five comparatively close pairs in the Pleiades and in the cluster in Perseus, but they may (as well as the pair in the Hercules cluster above referred to) not belong to the clusters but only be seen by projection upon them. If we accept Prof. See's theory as to the evolution of double stars from nebular masses whose velocity of rotation has been accelerated by the shrinkage of the mass due to cooling, the existence of a binary star in a cluster must be taken as indicating that the secular changes which give rise to binaries have not had time, since the isolation of the stars as separate masses, to produce their effects; and the absence of binaries may be taken as indicating the comparatively recent separation of the stellar masses.

Notices of Books.

Observational Astronomy: a Book for Beginners. By Arthur Mee, F.R.A.S. (Cardiff: Daniel Owen & Co., 1893.)—This is an excellent, honest little book, containing a good deal of out-of-the-way information about things astronomical, especially amateur astronomers and their instruments. It is profusely illustrated, though the diagrams are sometimes rather rough. The series of drawings of lunar craters by Mr. Mee, Mr. Stanley Williams, Mr. Gwyn Elger, and Mr. G. T. Davis are worthy of special attention. One of the quaintest illustrations in the book is a picture of the Orion nebula as seen by Mr. Mee with an 8½ inch reflector. It is as unlike the photographs of the nebula as any of the drawings by early astronomers collected in Prof. Holden's memoir, from which he and some other astronomers have argued that striking changes are taking place in the comparatively short period during which man has been observing the nebula. One of the most interesting parts of the book is the memoir of the Rev. T. W. Webb, Prebendary of Hereford and author of "Celestial Objects for common Telescopes." It contains a few too short extracts from some of his letters, of which there must be a great number treasured up in different parts of the world, for he was a most voluminous and interesting letter writer, always ready to assist the amateur astronomer. His letters were written in a neat small-hand which enabled him to put a great deal into the page, and they were frequently illustrated with charming little drawings as well as enlivened by the quaintest humour, which, of its kind, was as curious as De Morgan's. The woodcut from a photograph of Mr. Webb is unfortunately not a success, and

* "Astronomische Nachrichten," Bd. 127, p. 382. The place of the double star referred to is, R.A. 16h 37m Dec. + 36° 41'.

will hardly enable his friends to recognize him; but Mr. Mee gives a good portrait of Prof. Adams, of Prof. Barnard, and of the too little known and not sufficiently appreciated John Dollond, inventor of the achromatic object glass.

The Nests and Eggs of British Birds. By Charles Dixon. (Chapman and Hall).—Mr. Charles Dixon handles his subject in a scientific manner, and the book will no doubt do much to develop an intelligent study of the habits of birds. It is written in such simple and attractive language that it will easily be understood by schoolboys. Mr. Dixon's plan has been to give the British breeding area for every species treated of, with its breeding habits, description of eggs and nest, and characteristic marks for easily distinguishing one species from another. Mr. Dixon could probably have made the book still more interesting, without detracting from its scientific value, if he had added some more of his own observations in egg-collecting. He informs us in the preface that he has taken the eggs of almost every British species, and his experiences must therefore be both varied and interesting. The volume will prove a very valuable addition to ornithological literature.

Kayser's Text Book of Comparative Geology.—Text Book of Comparative Geology, by E. Kayser. Translated and edited by P. Lake. London, 1893; 8vo, pages xii. and 426, illustrated. (Swan, Sonnenschein & Co.)

Superlatively excellent as is the geological series displayed in the British Islands, from constantly studying text books which take that series as their type, English students have a tendency to become somewhat "parochial" in their geology, and we therefore gladly welcome an elementary work on that science written from a German standpoint, and now made fully available to the British geologist. In saying that the book is written from a German point of view it must not, however, be inferred that the geology of Germany has an undue pre-eminence assigned to it; the fact being that the different formations are described most fully from the regions where they are best developed. For instance, we have the chief description of the silurian taken from Britain, the devonian from the Rhenish district, the carboniferous from Britain, and the jurassic from Central Europe.

After an introduction on the general principles of geology, the various geological systems—commencing with the lowest—are in turn treated historically, stratigraphically, and palæontologically, the method of treatment being as broad and full as appears possible in a work of this size. Almost for the first time in an English text book we have the latest views as to the nature of the archæans set fully before the student, to whom it is pretty clearly suggested that the complex origin of these rocks finds most favour with the author.

The illustrations of fossils in the book are both numerous and well selected, and, although not very artistic, display the characteristic features of the types depicted most clearly. In addition, there are numerous excellent stratigraphical sections, mostly from the Continent. The geologist pure and simple will perhaps not be over well pleased to find the various groups of ammonites described and figured under the numerous generic titles which have of late years been coming more and more into use; but this is a change to which we must apparently all make up our minds.

The weakest portions of the book are those relating to vertebrate palæontology, in which the author or his translator would have done well had they sought special advice. For instance, on page 279, we find it stated that all jurassic mammals belong to the so-called pantoheria,

which are affiliated (page 234) to the monotremes; while the Stonesfield slate is mentioned as the only English horizon from which they have been obtained. Again, the distinction between ichthyosaurs and plesiosaurs (page 275) is decidedly badly indicated; while on page 324 we are surprised to learn that all the birds with teeth have biconcave vertebrae. Further on (page 351) we are told that the creodont *Provicerra* is a marsupial; while on the next page the same genus is, if we mistake not, alluded to among the carnivores as *Protovicerra*, and *Hyaenodon* is said to be allied to the hyænas! It is also news to us that *Cebocercus* is a monkey (page 353); while even the proverbial schoolboy probably knows that it is quite inadmissible to speak of the moas as the ancestors of the kiwis (page 398).

In spite of the above faults in one particular section, we can conscientiously recommend the work to geological students as a well-written, compact, and, at the same time, comprehensive text book, in which the science is treated on broad and philosophical views from the historical, stratigraphical, and palæontological aspects.

Letters.

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

SIRIAN AND SOLAR STARS.

To the Editor of KNOWLEDGE.

SIR,—I ask space for some remarks in reply to your criticisms on my letter, and also on Miss Clerke's article in your April issue.

Sirian stars, are no doubt, photographically brighter than solar stars of the same photometric magnitude, but I do not think that this can be the explanation of Prof. Kapteyn's results as to the photographic brightness of galactic stars. If the Sirian stars are more numerous in the Galaxy than in other parts of the sky (which I think has hardly been proved), this is at all events only true as an average result. So far as I have compared the catalogues, the richest region of Sirian stars (including type B of the *Draper Catalogue*) rather runs across than stretches along the Galaxy. It runs from Canis Major to Auriga. Starting from a point on the Galaxy in Monoceros, you will meet a richer Sirian region by moving nearly at right angles to the Milky Way than by going along it; but Prof. Kapteyn thinks that there is a continuous diminution of photographic brightness as we move outwards from the Galaxy. I can find no such continuous diminution of the proportion of Sirian stars as we pass outwards. Mr. Marth, I think, gives all the stars within the limits examined by him which were measured at less than 6.0 in the *Harvard Photometry*. On the other hand, Prof. Pickering's Milky Way region extends considerably beyond the limits of the Milky Way, and includes, I think, the whole of the rich Orion-Taurus region to which I have already referred. But the Milky Way elsewhere presents different features. In Sobieski's Shield, for instance, the solar stars seem to preponderate.

Of the brighter stars, no doubt many owe their high magnitude to their great mass or intense illumination. We may expect to meet with a good many of these in the Milky Way, but they are not confined to it. Betelgeuse and Rigel appear to be as remote as any bright star in the Galaxy. Altair, 61 Cygni, and η and α Cassiopeia, on the other hand, seem to be certainly nearer to us than the Galaxy, unless the true shape of the Galaxy is a disc (the sun being placed in a comparative vacuity) rather than a ring. If the Galaxy is a ring, I think it will be found that all the solar stars which are brighter than the sixth

magnitude lie between us and the ring, and that a considerable number of the brighter Sirian stars do so. As far as the solar stars are concerned, this conclusion falls in with Prof. Pickering's.

I do not think Prof. Kapteyn assumes that proper motion is to be regarded as a measure of the distance of a star. He considers it established (and I made a similar remark) by the fact that stars with large proper motion afford as striking evidence of the motion of the solar system in space as stars with small proper motion; to which it may be added, that spectroscopic observations do not show that stars with large proper motion have a greater average velocity in the line of sight. Undoubtedly, however, further observation is necessary before we can say positively that the solar stars are or are not (on the average) moving with greater absolute velocity than the Sirian. Sirian stars with considerable proper motion are not numerous, while the measurement of small proper motions involves great uncertainty. But to the objection that a fast-moving group of solar stars could not exist as a system there are many answers. First, Prof. Kapteyn seems to be of opinion that their motion is only apparently and not really faster than elsewhere. Secondly, he thinks it at least possible that the proportion of solar stars is equally great at greater distances, the faintness of remote solar stars being the only reason why this fact has not been recognized. (I have, I think, also suggested both of these points.) Thirdly, it does not follow that what may now be regarded as a cluster forms a permanent and stable system; and lastly, the apparently rapid motion of this cluster may arise (at least in part) from the sun being a runaway star, as 1830 Groombridge is supposed to be.

Prof. Kapteyn does not seem to have drawn the distinction between Capellan and Arcturian stars, which I think will prove to be of almost equal importance with that between Sirian and solar. The cluster round the sun (if it be really a cluster and not merely an average specimen of what is to be met with throughout space) seems to be pre-eminently a cluster of Capellan stars.

Truly yours,
W. H. S. MONCK.

[I was mistaken in saying that Mr. Marth's Catalogue of Milky Way Stars did not include all stars down to the sixth magnitude. His original catalogue did not, but his recent catalogue includes all stars in the neighbourhood of the Milky Way down to the sixth magnitude of the Harvard Photometric Catalogue.

Many of the stars with swift proper motions are moving athwart the direction of the sun's motion in space, and the apparent motions of some of them are more or less parallel to and in the same direction as the sun's motion. These motions cannot be accounted for as only apparent and due to the sun's motion. We may, therefore, assert with some certainty that such swift-moving stars cannot be, as it were, anchored in space, controlled by the gravity of a cluster of a few hundred stars similar in mass to our sun.—A. C. RANYARD.]

THE η ARGÛS REGION OF THE MILKY WAY.

To the Editor of KNOWLEDGE.

SIR,—Few regions in the heavens can equal this in interest when we consider the remarkable changes in the variability of the principal star and the appearances of the star-cluster and nebula surrounding it; to use Miss Clerke's expression, "the crowd of small stars embroidering one of the finest of the southern nebulae." Photography now enables some of those who have not had the advantage of seeing this glorious object directly to examine it in the

plates which Dr. Gill has brought over from the Cape; and all readers of KNOWLEDGE must appreciate the reproductions you have placed within their reach of these and Mr. Russell's photographs taken at Sydney.

I beg to offer you a few remarks on the history of the region, supplementary to those you have given. It does not appear that Halley, when he observed the star, noticed the nebulous matter adjacent to it, for it is not included in the list (only six in number) of nebulae given by him in the *Philosophical Transactions* for 1716. So far as I am aware, Lacaille was the first to observe the nebula, which he describes in the *Mémoires de l'Académie des Sciences* for 1755. He gives three lists of star-clusters and nebulae in the southern hemisphere, the third of which consists of "étoiles accompagnées de nébulosité." Of these, η Argûs is the sixth, thus described:—"Gros groupe d'un grand nombre de petites étoiles peu serrées, et remplissant l'espace d'une espèce de demi-cercle de 15 à 20 minutes de diamètre, avec une légère nébulosité répandue dans cet espace." After Lacaille, Dunlop appears to have been the first to observe this nebula, which he describes and figures in his catalogue of nebulae and clusters formed from observations made at Paramatta in 1826-7, and published in the *Philosophical Transactions* for 1828. η Argûs is number 309 in his list, and he describes it as "a bright star of the third magnitude, surrounded by a multitude of small stars and pretty strong nebulosity, very similar in its nature to that in Orion, but not so bright. . . . The nebulosity is pretty strongly marked; that on the south side is very unequal in brightness, and the different portions of the nebulosity are completely detached, as represented in the figure. There is much nebulosity in this place, and very much extensive nebulosity throughout the Robur Caroli, which is also very rich in small stars." Not many years after Dunlop's observations Sir John Herschel made his famous astronomical expedition to the Cape. It is well known that he found that some of the objects set down as nebulae by Dunlop had no real existence, the cause which misled him being probably want of sufficient light or defining power in his instrument. But to this I need not further allude. Those who have not access to Herschel's work on the results of his Cape observations will be grateful to you for the reproduction in KNOWLEDGE of his drawing of the grand nebula in η Argûs, now so beautifully brought before us in the photographs. But I scarcely think you will agree with Herschel in considering it probable that the nebulous matter is far beyond the stellar cluster, which forms a part of the Milky Way, for, apart from all other considerations, on that view how appallingly enormous would be its extent! May I ask whether the spectroscope has ever been applied to this region?

Yours faithfully,
Blackheath, May 12th, 1898. W. T. LYNN.

PHOSPHORESCENT METEORS.

To the Editor of KNOWLEDGE.

DEAR SIR,—Some twenty years ago I had an experience similar to that recorded from Thurso, in Prof. Tomlinson's paper in KNOWLEDGE.

I was staying the night with a friend. We sat up late, and when he had gone down to see that the house was safe, he returned rather promptly with the news that there was someone in the pantry, for he could see a light. Arming ourselves with the fire-irons, we crept downstairs.

The pantry was between the basement passage and the scullery, without external ventilation. As we turned towards the wire gauze door, the light was plain enough, rather bigger than a large open hand.

Advancing cautiously, we found the light came from a sole that had been skinned, and was hanging from a shelf. It had been kept too long, and looked transparent, the bones showing distinctly brighter than the rest.

Not long since I saw a notice of some "luminous eggs," which probably were not very fresh.

Yours very truly,

THOS. BLASHILL.

Superintending Architect of the L. C. C.

29, Tavistock Square, W.C.

April 29th, 1893.

ON THE DISTRIBUTION OF THE STARS IN SPACE.

By PROF. J. C. KAPTEYN.

PROF. KAPTEYN, of Groningen, read a preliminary paper on this subject on the 29th April last year. He has now included in the research all the stars of the Draper Catalogue, which have been observed by Bradley in both co-ordinates. This material embraces 2357 stars, of which 1189 belong to the *first*, 1106 to the *second*, and 62 to the *third* spectral type. The material now used permits more trustworthy conclusions than that of April, 1892, not only because it is more extensive, but chiefly because it is more homogeneous, and contains a very great number of smaller stars, possessing, nevertheless, trustworthy proper motions.

Before entering into a discussion of the results obtained, Prof. Kapteyn spoke upon the question of the best criterion for judging about the relative distances of the fixed stars. As the direct determination of stellar parallax has not as yet given results on anything like the scale wanted for the purpose, we are compelled to resort to the parallactic displacement caused by the motion of the solar system in space. This "motus parallacticus," however, cannot be separated from the real proper motion (*motus peculiaris*) for individual stars, but there is every reason to think that this "motus peculiaris" shows very little preference for determinate directions, and it may therefore be assumed, with some confidence, that, in the mean results obtained from small groups of stars, these real proper motions will destroy each other, leaving only that part which is due to the solar motion, and it is this parallactic displacement that, for the present at least, gives the most reliable measure of the mean distance of the stars under consideration. If, however, we wish to arrange the *individual* stars approximately in the order of their distances from the sun, we must look out for another measure. This may be found in the total proper motion. It is true that this motion seems only to be approximately proportional to the parallactic displacement (the researches of Ristenpart and of the speaker himself indicate a slow increase of the linear proper motion with the distance), but this is sufficient for the present purpose. There is another difficulty connected with the use of the total proper motion as a measure for distance, which may be very important in some cases. For if we compare by means of their total proper motion, *not* groups of stars which separately are distributed over the entire sky, but groups situated in different parts of the firmament, then a systematic error will be introduced, depending on the position with respect to the apex of the solar motion. For at the apex and anti-apex the whole proper motion is nothing but the *motus peculiaris*. At some distance from these points it is the resultant of the

motus peculiaris and the *motus parallacticus*. Equality of total proper motion will not, therefore, correspond with equality of *motus peculiaris* in different parts of the sky, and it is highly improbable for that reason that even stars of absolutely equal distance would show equal proper motions in different parts of the sky.

Therefore this measure, too, fails for some detailed investigations of the star-system. In those cases where a systematic error from this source seemed most to be feared, Prof. Kapteyn used another measure, viz., that projection (τ) of the proper motion which is independent of the solar motion. As, however, this projection cannot be computed without a knowledge of the place of the solar apex, an assumption had to be made as to the position of this point.

The adopted co-ordinates for 1865 are:—

$$\alpha = 276^\circ. \quad \delta = +34^\circ.$$

It was further assumed that the same co-ordinates would have been found by a separate discussion (*a*) of the stars *in and without* the Milky Way; (*b*) of the stars of the *first* and *second* spectral type.

The (at least approximate) truth of the first assumption had been proved by Mr. Bakhuyzen at the preceding meeting; the approximate truth of the second may be deduced from the fact that Messrs. Stumpe and Porter, and Ristenpart (12th March, 1893), found nearly the same position of the apex from stars of very different amounts of proper motion, a position tolerably accordant with that deduced exclusively from stars of smaller proper motion. As a matter of fact, however, we may say that the more the investigation is limited to stars of greater and greater proper motion, the more it is limited to stars of the second type. This will be proved in Proposition VI.

Having adopted the position of the apex as given, the total proper motions of all the Bradley-Draper stars were decomposed into two components, viz.:—

- σ The proper motion projected on the great circle passing through the star and the apex.
- τ The proper motion perpendicular to the former (which is evidently independent of the solar motion).

The results of Messrs. Porter and Stumpe prove indirectly for considerable proper motions, and for the sky as a whole, that the quantity τ is also a good measure for distance. *Directly*, it is proved by the consideration of the proper motions equal to or greater than $0'04$ of the Bradley-Draper stars; for, taking the means of the values of τ for stars of different amounts of proper motion, we find, if q be the mean value of the solar motion as seen at right angles from the stars under consideration:—

TABLE I.¹⁾

τ	q	Number of Stars.	Relative value of q .
$0'050$	$+0'040$	368	1
$1'50$	$+0'130$	200	3.2
$4'50$	$+0'337$	14	8.4

From this table it is evident, even for the smaller proper motion, that τ is nearly proportional to q , *i.e.*, nearly inversely proportional to the distance. The small discrepancy is in the sense found by Mr. Ristenpart.

It remains to be proved that, when we come to compare *different* regions of the sky, equality of μ , or better of τ , corresponds with equality of distance. Prof. Kapteyn tried to do this for regions of different galactic latitude, in the following way:—The small number of stars with proper motions exceeding $0''50$ being excluded, we find—

¹⁾ Translated by Prof. Kapteyn from the Dutch report of his communication to the Amsterdam Academy of Sciences, 28th January, 1893.

¹⁾ In Tables 1 and 2 the values of q furnished by stars whose distance from the apex is less than 30° , and which are necessarily very uncertain, have been omitted.

	1st Type. 2nd Type.
μ in high galactic latitude ($\pm 40^\circ$ to $\pm 90^\circ$)	= 1.60 1.36
μ in low galactic latitude (-30° to $+30^\circ$)	
q in high galactic latitude	= 1.42 1.29
q in low galactic latitude	

The agreement could not fairly be expected to be better. Somewhat less satisfactory is the comparison of the values of q and τ , as will be seen from Table 2.

Even here, however, the disagreement of the first two values of q may probably be explained by their probable errors (probable errors of each of these two values roughly ± 0.005).

TABLE 2 (1).

β (galact. latit.).	τ	q	Number of stars.
+ 40 to + 90	0.050	+ 0.034	230
- 30 " + 30	0.050	+ 0.050	138
+ 40 " + 90	0.150	+ 0.128	137
- 30 " + 30	0.150	+ 0.133	63

Further investigations on this point must be deemed very desirable.

The proper motions were originally taken from Auwers's re-reduction of Bradley. A look at the proper motion τ , however, showed at once that a correction of the constant of precession (that of O. Struve) was necessary. This correction has been deduced by L. Struve, so that the proper motion σ and τ could be readily corrected. As this was done, however, after the completion of most of the computations, some of the results as given below are still based on the uncorrected proper motion. Where this is the case it will be explicitly mentioned.

After this introduction, the speaker discussed the following propositions.

Prop. I. If stars with very small or insensible proper motions are disregarded, there remains a group of stars showing no longer a condensation towards a plane (no Milky Way).

Prop. II. Stars with very small or insensible proper motions (≤ 0.04) show condensation towards the plane of the Milky Way. This condensation exists as well for the stars of the 2nd as for those of the 1st type, so that in the arrangement of the stars of the 2nd type, too, there may be recognized an incontestable dependence on the position of the Galaxy. The condensation of the stars of the 1st type, however, is more considerable, and begins to be sensible for somewhat greater proper motions.

Prop. III. This condensation of stars of insensible proper motions is very considerable even for the brighter stars ($0^m-6^m.5$). For stars of the 2nd type it is as considerable as for the whole of the stars of the ninth magnitude. For stars of the 1st type it is much more considerable.

Prop. IV. Either this condensation is at least partly real (i.e. not optically produced by greater depth), or there is real thinning out at the poles of the Milky Way.

Prop. V. The arrangement of the stars found by W. Struve has no real existence. The cause of the fallacy of his result lies in the fact that the mean distance of stars of determinate brightness in and without the Milky Way is not the same.

Prop. VI. (Compare communication of 29th April, 1892.) The nearest vicinity of the sun contains nearly exclusively stars of the 2nd type; with increasing distance the proportion Q of the number of stars of the 1st type to that of the 2nd grows gradually. Equality of number is reached at a distance corresponding to a total proper motion of 0.07 . At still greater distances the stars of the 1st type begin to predominate very strongly.

(1) In Tables 1 and 2 the values of q furnished by stars whose distance from the apex is less than 40° , and which are necessarily very uncertain, have been omitted.

Prop. VII. It is exceedingly probable that (at least in the immediate vicinity of the sun) the variation of the value of Q must be attributed mostly to a real thronging of the stars of the 2nd type about a point not far from the sun, while the distribution of the stars of the 1st type is more nearly uniform (cluster of 2nd type stars).

Prop. VIII. The centre of greatest condensation of the stars of the 2nd type lies near the point of which the co-ordinates are

$$\alpha = 0h. 0. \quad \delta = + 12.$$

Prop. IX. This centre coincides nearly with the point which, according to the investigations and observations of Struve and Herschel, represents the apparent centre of the Milky Way (considered as a ring).

Prop. X. The stars of the first two spectral types are at equal distances if their mean total proper motion, or proper motion τ , is equal.

Prop. XI. The magnitude being equal, stars of the 1st type are in the mean 2.7 times more distant than those of the 2nd type. Or put in another way: The stars of the 1st type are in the mean seven times intrinsically brighter than those of the 2nd type.

The demonstration of Propositions I. to IV. was effected as follows:—

By parallels drawn for every 10 degrees of declination and by hour circles at different distances, the whole sky north of -30° of declination was divided into portions in such a way that every one of these contained only stars differing scarcely more than 10 degrees in galactic latitude. In every one of these portions the number of stars of determinate spectral type and determinate amount of proper motion was counted. Besides this the number of square degrees contained in every portion was computed, and the number of Bradley-Draper stars of magnitudes $0-6.5$ contained in each such area was determined.*

After this, and after having united all the areas of equal galactic latitude, it was easy not only to determine the number of stars of different type and amount of proper motion at different distances from the Milky Way, but from these numbers could be further derived the values they would have assumed for 1000 square degrees and for the case that the material had embraced all stars of magnitudes $0-6.5$.

The results of these countings and computations have been embodied in the two following tables:—

TABLE 3.—Arranged according to total proper motion. (μ)

I—1st Type.	II—2nd Type.		β —Galactic Latitude.								
	$\mu = 0.00-0.03$		$0.04-0.05$		$0.06-0.07$		$0.08-0.15$		higher.		
Limits.	Me. n.	I.	II.	I.	II.	I.	II.	I.	II.	I.	II.
+ 60° to + 90°	69	18.6	14.9	9.6	12.7	8.5	11.3	17.0	13.8	6.4	28.7
+ 50 " + 80	55	19.3	18.6	10.6	11.8	7.5	6.2	14.9	24.1	6.2	19.3
+ 40 " + 50	45	24.6	15.8	8.4	9.9	7.9	6.4	15.3	23.7	6.4	22.7
+ 30 " + 40	35	34.4	19.5	15.7	10.0	11.4	8.6	19.5	19.5	3.3	18.1
+ 20 " + 30	25	48.1	27.8	26.2	14.4	8.0	6.9	19.8	20.3	4.8	20.8
+ 10 " + 20	15	76.2	34.6	30.6	12.1	8.7	7.5	16.2	18.5	4.0	21.3
- 10 " + 10	5	85.8	48.6	27.6	10.8	12.0	6.0	13.2	15.0	7.2	18.6

TABLE 4.—Arranged according to the component τ of the proper motion.

I—1st Type.	II—2nd Type.		β —Galactic Latitude.								
	$\tau = 0.00-0.03$		$0.04-0.05$		$0.06-0.07$		$0.08-0.14$		higher.		
Limits.	Me. n.	I.	II.	I.	II.	I.	II.	I.	II.	I.	II.
+ 60° to + 90°	69	20.2	31.9	15.9	9.0	5.3	8.5	5.8	13.4	3.7	19.6
+ 50 " + 80	55	34.2	35.4	8.7	12.4	6.8	6.2	5.6	15.5	3.1	12.4
+ 40 " + 50	45	36.5	33.5	11.3	11.8	3.9	6.9	6.9	10.4	3.9	15.8
+ 30 " + 40	35	52.4	33.3	13.8	10.9	7.6	7.6	9.5	14.3	1.0	9.5
+ 20 " + 30	25	65.1	46.5	18.7	14.4	13.9	6.9	8.0	11.7	1.1	19.7
+ 10 " + 20	15	98.1	46.7	23.1	14.4	8.1	10.4	4.0	11.0	2.3	11.5
- 10 " + 10	5	112.2	62.4	19.2	10.2	4.8	5.4	7.2	13.8	2.4	7.2

* This determination was made by aid of Seeliger's Tables.

† For this table the proper motions have been used uncorrected for L. Struve's alteration of the constant precession.

From Table 3 it is evident that a condensation towards the plane of the Milky Way begins to show itself for stars of the 1st type with proper motions $0\cdot04-0\cdot05$; for stars of the 2nd type only in the stars of quite insensible proper motion ($\leq 0\cdot03$). For these, however, the condensation is not in the least dubious; it is as strong as the condensation of the whole of the stars of the ninth magnitude, and this proves conclusively that stars of this type are not arranged independently of the Milky Way, as might have been thought probable from the results obtained by Prof. Pickering ("Ann. of the Obs. of Harv. Coll.," Vol. 26, p. 462).

It is very easy to show that a systematic error in the estimation of the magnitudes of the stars in the Milky Way cannot change this result. It certainly is not improbable that such an error exists, and that this will prove sufficient to annul the slight *thinning* of the stars of the 2nd type with sensible proper motions in the vicinity of and in the Milky Way, but the condensation of the stars with insensible proper motions would then come out all the stronger.

Table 4 proves that these conclusions are independent of the motion of the solar system in space.

An attempt has been made to prove the truth of Prop. I. for fainter stars. The only fit material for such an investigation accessible to Prof. Kapteyn is furnished by the catalogue of stars of magnitudes $0-9\cdot0$ of L. Boss. The proper motions given in this catalogue, derived mainly from comparisons of the modern observations with those of Lalande and Bessel, were counted. If we assume that the number of these proper motions is incomplete to nearly the same extent as the zones of Bessel, we can derive the probable total number of the really existing proper motions. These have been given in the last two columns of the following table.

TABLE 5.

Distance from galaxy.	Number of square degrees.	Number of proper motions in Boss Catalogue.	Probable total number of proper motions.
55° to 65°	390	46	39
39 " 55	390	45	32
90 " 39	390	41	29
-20 " +20	390	35	15
			76 65
			71 50
			73 53
			72 31

For the proper motions $0\cdot10-0\cdot20$, the uniformity leaves nothing to be desired. For the more considerable proper motions there appears to be a thinning out in the Milky Way. Prof. Kapteyn thinks that this thinning out is not to be considered as accidental, but that probably it is still only apparent. For if we assume a systematic error, of which the *sense* as well as the amount ($0\cdot2$ mag.) is equal to that which Prof. Pickering really finds for the estimations of the Bradley-Draper stars in the Milky Way, this thinning out will be found to disappear.

Prop. IV.—The truth of this proposition, too, is proved by Table 3; for, as mentioned already, an unmistakable increase in the number of stars of the 1st type is visible for proper motions of $0\cdot04-0\cdot05$, *i.e.*, within what probably is a spherical shell we find a smaller number of stars near the poles of the Milky Way than near that zone itself. This evidently implies a *real* difference in the star density.

Prop. V.—The incorrectness of Struve's views appears from Prop. I. Struve assumes, and in his time any other assumption would have been hardly reasonable, that the stars of different magnitudes are included between spherical surfaces, or, in other words, he assumed that in all directions the mean distance of stars of a determinate magnitude is equal. This appears to be incorrect, for

Table 1 proves that, in the direction of the Milky Way a far greater number of stars of magnitudes $0-6\cdot5$ lie at the exterior of the sphere, the radius of which corresponds to a proper motion of $0\cdot035$, than in the direction of the pole of the Milky Way; from which it follows that the mean distance of such stars is considerably greater in the Galaxy than elsewhere. It may, however, be objected against most of what has been said, that one cannot as yet consider it as absolutely demonstrated that equal distances correspond to equality of μ or τ in the Milky Way and *outside it*, and that if this proves ultimately not to be the case, the results drawn from Tables 3 and 4 cease to be correct. It will be well, therefore, to prove the truth of Prop. V. *directly*. For this purpose the values of q (solar motion as seen at right angles from star) in high and low galactic latitudes have been compared. Values of τ above $0\cdot50$ have been excluded because they have an undue and excessive influence on the results.

TABLE 6.—Values of q .

β	Type I.	Type II.
± 40 to ± 90	+ $0\cdot0355$ (336)	+ $0\cdot0583$ (449)
- 30 " + 30	+ $0\cdot0250$ (405)	+ $0\cdot0451$ (285)

As the stars compared in both regions are of equal magnitude, it appears that for both types of stars there really exists a difference of distance at different galactic latitudes.

Prop. VI. was already discussed at the meeting of April, 1892. Then, however, the demonstration was almost exclusively based on the proper motions stars brought together by Mr. Stumpe. The stars now investigated confirm the conclusions of the preceding year in a most striking manner, as will be seen when the following table is compared with the one then given:—

TABLE 7.

μ Limits.	Mean.	Number of Stars.		Q .
		Type I.	Type II.	
$0\cdot00-0\cdot03$		553	324	0\cdot59
$0\cdot04-0\cdot05$	$0\cdot045$	233	150	0\cdot64
$0\cdot06-0\cdot07$	$0\cdot065$	118	104	0\cdot88
$0\cdot08-0\cdot09$	$0\cdot085$	85	90	1\cdot06
$0\cdot10-0\cdot15$	$0\cdot12$	130	162	1\cdot25
$0\cdot16-0\cdot19$	$0\cdot17$	29	61	2\cdot1
$0\cdot20-0\cdot29$	$0\cdot24$	25	86	3\cdot4
$0\cdot30-0\cdot49$	$0\cdot37$	13	71	5\cdot5
$0\cdot50$ and higher	$1\cdot02$	3	58	19\cdot3
		1189	1106	

The values of Q are nearly represented, with the exception of the first, by the formula:—

$$Q = 14 \mu$$

especially if we exclude the Hyades, whereby the value of Q for the proper motions $0\cdot10-0\cdot15$ becomes considerably larger.

It may be asked whether this variation of Q may be explained by the hypothesis that the stars of the 2nd type form a group of stars independent of that formed by the stars of the 1st type.

A definitive settling of this question seems difficult, but in the opinion of the speaker the following arguments seem to militate against such an hypothesis:—

1st. Both types of stars show the same sort of arrangement in respect to the plane of the Milky Way (Prop. II.).

2nd. The centre of condensation of the stars of the 2nd type seems to coincide with the centre of the Milky Way, which consists, in great part at least, of stars of the 1st type (Prop. IX.).

3rd. In groups of stars like that of the Hyades, which show a common proper motions (equal in amount as well

as in direction), and which therefore undoubtedly form a system, stars of both types appear to be mixed.

Provisionally it seems more probable to assume that the two types are different phases of evolution of stars pertaining to one and the same system. We then must assume that the temperature in this system increases from the centre towards the circumference. In harmony with this is the fact, communicated by the speaker at the meeting of 29th April, 1892, that the light of the stars of the Milky Way (*i.e.*, of stars in general more remote) seems to be richer in violet rays than the light of the rest of the stars.

It is a remarkable fact that in the group of the Hyades the *brightest* stars belong principally to the 2nd type, which for the rest is strongly in the minority in this group. This fact, together with Prop. XI., makes us conclude that these objects are by far the most bulky of the system. In this case, therefore, it is difficult to attribute the lower temperature to a more advanced state of cooling, so that, here at least, it seems more plausible to assume that the 2nd type stars are in a less advanced stage of evolution (rising temperature) than those of the 1st type. Whether this is the rule in the great system of the Milky Way seems very difficult to decide.

Prop. VII. If it is assumed that the distances are inversely proportional to the proper motion, it is easy to determine the relative volume of the spherical shells in which the stars with different proper motions are contained. The comparison of these volumes with the corresponding number of stars affords an insight into the real star density at different distances. In the following table the first column gives the limits of proper motion, the second the volume of the corresponding spherical shells. The following columns give the number of stars for unit of volume. As the numbers of the *different* columns are in no case comparable, they have been severally multiplied by such a number that the number corresponding to the proper motion 0''155—0''195 has become 1.0. If the distribution in space of the stars considered were uniform, then the numbers of each of the last four columns separately would be equal.

The third column was obtained by counting all the stars of the 1st type and of magnitudes 0.0—5.0, common to the catalogues of Stumpe (*Astr. Nach.* Nos. 2999—3000) and of Pickering (Draper Catalogue). The numbers of the fourth and sixth columns were furnished by the material Bradley-Draper; those of the last column but one were taken from Boss's zone catalogue. The number of stars belonging to the 1st type were computed in this case by taking the whole number of stars with proper motion $\geq 0''10$, and assuming that for these stars, too, the values of Q from Table 7 were valid. At the foot of every column the number of stars is given on which the computation rests.

TABLE 8.—Number of Stars per unit of volume.

μ	volume.	Type I.		Type II.	
		0m0—5m0.	0m0—6m5.	0m0—9m0.	0m0—6m5.
0''095—0''155	898.5		0.7	0.4	0.4
0.155—0.195	133.6	1.0	1.0	1.0	1.0
0.195—0.295	85.9	2.0	1.3	1.2	2.2
0.295—0.395	32.8	1.9	1.5	1.1	3.3
0.395—0.495	7.9				5.8
0.495—0.995	7.3				11.9
0.995 and higher	1.0				39.2
Total number of stars		46	200	(282)	438

If we confine ourselves to proper motions $> 0''155$, we see that the distribution of the stars of the 1st type approaches towards uniformity as we include more and more of the fainter stars in the discussion. On the other

hand, we find the stars of the 2nd type with known proper motions more strongly condensed the more we approach our system. Now it may be that future extension of the available material will increase the number of small proper motions in a somewhat greater proportion than that of the more considerable proper motions; but it seems highly improbable that this will ensue to such a degree as to change the condensation implied in the last column into a uniform distribution. It can be shown, for instance, that even if all the stars which Herschel could see with his 16-inch reflector in high galactic latitudes furnished proper motions of 0'16—0'32 at the same rate as the stars of magnitudes 0—9.0 have done (which of course is an absurdly extreme supposition), even then one would *not* find the stars of this amount of proper motion equally condensed with the stars of proper motion exceeding 3'' known *at the present moment*.

It may be objected that the hypothesis adopted, *viz.*, that the total proper motion is inversely proportional to distance, implies that the linear proper motion of the stars at different distances from the sun are equal, and that the investigations of Mr. Ristenpart ("Veröff. der Grossh. Sternw. zu Karlsruhe," IV., p. 287) seem to point to a contrary conclusion. But it is easy to show that, Ristenpart's results being admitted (and those of the present author are confirmatory), our conclusion in respect to stars of the 2nd type is valid *à fortiori*. In this case, however, we should find the stars of the 1st type, too, somewhat condensed about the sun, though, of course, to an infinitely lesser degree.

Prop. VIII. At the meeting of 29th April, 1892, Prof. Kapteyn stated that the material afforded by the Stumpe-Draper catalogues pointed to the conclusion that the centre of greatest condensation of the stars of the 2nd type does not coincide with the position of the sun, but seems to be situate somewhere in the direction of 23 hours of R.A. This result was derived from a consideration of the quotient Q .

The Bradley-Draper material has been investigated to the same purpose in two different ways:—

1st. By the consideration of the quotient Q in different parts of the sky furnished by those stars whose proper motion $\tau > 0''04$.

2nd. By the consideration of the number of stars of the 2nd type (for which $\tau \geq 0''04$) that are found per 1000 square degrees in various parts of the sky. These numbers, reduced as formerly on the supposition that *all* stars of magnitudes 0—6.5 had been included in the investigation, are given in the last column of Table 9.

In both cases the sky was divided into thirteen regions, the limits of which are given in the first two columns:—

TABLE 9.†

Limits in δ .	Limits in α .	Q .	n .
- 30° to + 20°	2 ^h 36 ^m — 2 ^h 53 ^m	1.88	48.9
"	2.53 — 6.12	0.82	46.1
"	6.12 — 9.46	0.89	43.7
"	9.46 — 14.18	0.80	41.0
"	14.18 — 16.54	0.71	39.0
"	16.54 — 20.6	1.12	40.6
"	20.6 — 23.6	0.93	39.3

The values of Q , contained in this table, have been corrected for a variation with the galactic latitude, which is not wholly insensible.

In the column of the Q , as well as in that of the n , the greatest values are found near 0h. of R.A. It is evident, therefore, that there is a certain region in the sky where the density of the 2nd type stars exceeds that of other

(†) In the computation of this table the *uncorrected* proper motions were used.

regions. If we assume that this density varies, from a certain point Ω of maximum density, in the same proportions as the cosine of the angular distance from this point, then we find by least squares for the co-ordinates A and D of the point Ω —

From the ρ	A = 0h. 9	D = + 21'
" " "	A = 23.3	D = + 62
Adopted co-ord. of Ω	A = 0.0	D = + 42'

The galactic latitude of this point is -20° .

The agreement of the two results, found by two different considerations, *inter se*, and with the result formerly derived from nearly totally different stars, speaks strongly for the reality of this centre of condensation.

The fact alluded to in the next proposition, noted by the speaker long after the above-given result had been arrived at, seems to speak not less clearly in its favour.

Sir J. Herschel, who, of all astronomers, was perhaps best acquainted with the aspect of the Milky Way in its whole course, says in his "Outlines of Astronomy," article 788, speaking of the Galaxy: "Throughout all this region its brightness is very striking, and when compared with that of its more northern course already traced, conveys strongly the impression of greater proximity, and would almost lead to a belief that our situation as spectators is separated on all sides by a considerable interval from the dense body of stars composing the Galaxy . . . within which we are eccentrically situated, nearer to the southern than to the northern part of its circuit."

Prof. Kapteyn is not sure whether by "all this region" is meant the whole space from the middle between λ and γ Argus (R.A. = 8h. 5m.) and α Centauri (R.A. = 14h. 5m.), or the more limited space between γ Argus (R.A. = 10h. 7m.) and the most southern point of the Galaxy (R.A. = 12h. 8m.). In both cases, however, the middle of this region lies near 11h. 6m. of R.A.

If, therefore, the Milky Way is to be considered as a ring, and according to what has been said, and to considerations of another order, there seems every reason for the inference, then the centre is probably to be sought in the direction of 23h. 6m. of R.A.

Further, according to the investigations of Struve, the sun is situated somewhat to the north of the plane of the Milky Way. The centre of the Milky Way, therefore, as seen from the sun, must have a small southern galactic latitude. The position of this centre agrees, therefore, with that found for the centre of condensation of the stars of the 2nd type, even within narrower limits than might have been expected.

Prop. X. The demonstration of this proposition is required in order to fully complete the demonstration of Prop. VI. It was attempted in several ways:—

a. The material Stumpé-Draper gave the results embodied in Table 10. Result:—

91 stars of Type I., mean total p.m. = μ 0''270, gave $q = +0''196$
 325 " " " II., " " " reduced to $\mu = 0''270$, gave
 $q = -0''163$

b. The Bradley-Draper stars with proper motions $\mu = 0''08$ and $0''09$ gave:—

	Type I.	Type II.
Mean p.m. $\mu = 0''085$	$q = +0''056$ (112**)	$q = +0''041$ (77**)

c. (Stars of equal τ). All the Bradley-Draper stars, for which $\tau > 0.04$ (Type I.), or between 0.04 and 0.29 (Type II.). Only the stars of which the galactic latitude is between ± 30 and ± 40 were disregarded.

* These were only omitted for the practical reason that they would have had to be computed on purpose, whereas the rest served already for Table I.

TABLE 11.

d. Stars of known spectrum and of which tolerably trustworthy parallaxes have been determined:—

	Mean value of μ .	Mean Mag.	Mean π .	Number of Stars.
Type I. ...	1''60	2.8	0''159	7
" II. ..	1''64	3.6	0''137	19

Prop. XI.—Table 12 was obtained by bringing together all the Bradley-Draper stars, with the exception only of those stars of the second type of which the spectrum is marked with ? in the Draper Catalogue.

TABLE 12.†

	Mag.	Mean Mag.	τ	μ	q	Number of Stars.	
Type I.	0.0	2.9	2.14	0''147	-0''012	+0''111	46
"	3.0	3.9	3.35	0.086	-0.023	+0.062	78
"	4.0	4.9	4.39	0.061	-0.010	+0.031	182
"	5.0	5.9	5.37	0.054	-0.013	+0.031	117
"	6.0	..	6.27	0.053	0.019	+0.027	165
Type II.	0.0	2.9	2.07	0.347	+0.026	+0.350	23
"	3.0-3.9	3.35	0.295	0.020	+0.137	62	
"	4.0-4.9	4.41	0.176	0.050	+0.096	129	
"	5.0-5.9	5.39	0.143	0.007	+0.092	322	
"	6.0-..	6.24	0.120	0.013	+0.069	326	

From this table, Table 13 was derived by simple interpolation.

TABLE 13. Values of q .

Mag.	Type I.	Type II.	q_{II}
			q_I
2.3	+0''105	+0''312	3.0 ($\frac{1}{2}$)
3.3	+0.064	+0.145	2.3
4.3	+0.034	+0.100	2.9
5.3	+0.031	+0.092	3.0
6.3	+0.027	+0.067	2.5
			— Mean 2.7 —

By this table the first part of the proposition is demonstrated. If now we imagine the stars of the first type brought down to the same distance from the sun as those of the second type, then the brightness of the former will be $(2.7)^2 = 7.3$ times as considerable as that of the latter, q. c. d.

THE FACE OF THE SKY FOR JUNE.

By HERBERT SADLER, F.R.A.S.

THE abnormal activity of the Sun still continues. Throughout the month there is no real night, but either daylight or twilight.

Mercury is in superior conjunction with the Sun on the 5th. On the 15th he sets at 9h. 23m. P.M., or 1h. 7m. after sunset, with a northern declination of $25^\circ 10'$, and an apparent diameter of $5\frac{1}{2}''$, $\frac{1}{100}$ ths of the disc being illuminated. On the 25th he sets at 9h. 44m. P.M., or 1h. 26m. after the Sun, with a northern declination of $22^\circ 53'$, and an apparent diameter of $6''$, $\frac{1}{100}$ ths of the disc being illuminated. On the 30th he sets at 9h. 45m. P.M., or 1h. 27m. after the Sun, with a northern declination of $20^\circ 50'$, and an apparent diameter of $6\frac{1}{2}''$, $\frac{1}{100}$ ths of the disc being illuminated. While visible he passes through part of Gemini into Cancer. He is near Venus on the 15th.

Venus is visible as an evening star after about the middle of the month. She sets on the 15th at 9h. 14m. P.M., or 58m. after sunset, with a northern declination of $24^\circ 11'$, and an apparent diameter of $10''$, $\frac{2}{100}$ ths of the disc being illuminated. On the 30th she sets at 9h. 23m. P.M., with a northern declination of $22^\circ 28'$, and an apparent

† In computing this table the uncorrected proper motions have served.

diameter of 10 $\frac{1}{2}$ " the $\frac{200}{1000}$ ths of the disc being illuminated. While visible she describes a direct path in Gemini.

Mars, Jupiter, and Neptune are invisible for the purposes of the amateur.

Saturn is an evening star, and is still well situated for observation. He rises on the 1st at 1h. 45m. p.m., with a southern declination of 0° 3', and an apparent equatorial diameter of 17 $\frac{3}{4}$ " (the major axis of the ring system being 41" in diameter, and the minor 4.4"). On the 15th he rises at 0h. 46m. p.m., with a southern declination of 0° 6', and an apparent equatorial diameter of 17 $\frac{1}{2}$ " (the major axis of the ring system being 40" in diameter, and the minor 4.3"). On the 30th he sets 6m. before midnight, with a southern declination of 0° 18', and an apparent equatorial diameter of 17" (the major axis of the ring system being 39" in diameter, and the minor 4.3"). He is occulted by the Moon on the 21st, but the phenomenon will only be visible in the southern hemisphere. Rhea is in superior conjunction at 7.5h. p.m. on the 7th; in inferior conjunction at 1.7h. a.m. on the 10th; Iapetus is in inferior conjunction on the 11th; Rhea is in superior conjunction at 8.4h. p.m. on the 16th, and at 9.3h. p.m. on the 25th. Iapetus is at his greatest western elongation on the 30th. A map of the path of Saturn during June will be found in the "Face of the Sky" for March.

Uranus is also an evening star, and but for his southern declination would be favourably placed for observation. He rises at 1h. 45m. p.m., on the 1st, with a southern declination of 13° 34', and an apparent diameter of 3.7". On the 30th he rises at 2h. 47m. p.m., with a southern declination of 13° 21'. A map of his path during June will be found in the "Face of the Sky" for April.

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

The Moon enters her last quarter at 1h. 43m. p.m. on the 7th; is new at 5h. 51m. p.m. on the 14th; enters her first quarter at 2h. 37m. a.m. on the 21st; and is full at 6h. 25m. a.m. on the 29th. She is in perigee at 5h. p.m. on the 13th (distance from the earth 222,280 miles), and in apogee at 2h. p.m. on the 26th (distance from the earth 252,230 miles).

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, Knowledge Office," and posted before the 10th of each month.

Solution of May Problem (G. K. Ansell) :—

1. Q to Kt8, and mates next move.

CORRECT SOLUTIONS received from H. S. Brandreth, R. B. Cooke, E. M. Jones, and one unsigned (postmark illegible).

A. G. Newberry.—After 1. P to QB4, Black moves (anything), there is no mate, the King escaping at B6 in reply to Q to B2eh.

In the problem which you send you mention both a Queen and a Rook as being on KKtsq.

R. B. Cooke.—Very glad to hear that after so many years you have succumbed to the temptation of sending in a solution.

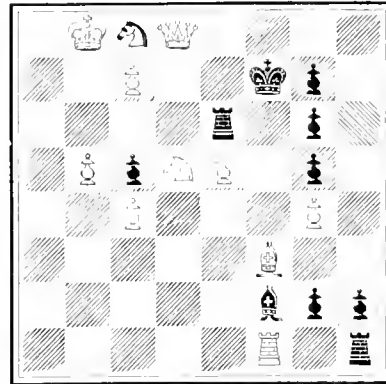
A. S. Fellows.—The problem is very pretty, and is marked for insertion in the August number.

J. F. Welsh.—Thanks for the game. It is a little short for publication in a one game monthly column. White's 20th move is a surprising stroke.

PROBLEM.

By S. LOYD.

BLACK.



WHITE.

White to play, and mate in three moves.

[In the above problem, "the main idea is expressed in the defence." The bearing of this observation lies in the application of it, and will come as a revelation to those who at first perceive a plurality of key-moves.]

The following game was played in the recent match at Kokomo, Ind. :—

IRREGULAR OPENING.

- | WHITE
(E. Lasker). | BLACK
(J. W. Showalter). |
|-----------------------|-----------------------------|
| 1. Kt to KB3 | 1. P to Q4. |
| 2. P to Q4 | 2. Kt to KB3 |
| 3. P to K3 | 3. P to K3 |
| 4. B to Q3 | 4. P to QKt3 (a) |
| 5. QKt to Q2 (b) | 5. B to Kt2 |
| 6. Kt to K5 | 6. B to Q3 |
| 7. P to KB4 (c) | 7. Castles ? |
| 8. Q to B3! (d) | 8. P to B4 |
| 9. P to B3 (e) | 9. Q to B2 (f) |
| 10. P to KKt4 | 10. Kt to Ksq (g) |
| 11. Q to R3 | 11. P to Kt3 |
| 12. P to Kt5! (h) | 12. B x Kt (i) |
| 13. BP x B | 13. Kt to Kt2 |
| 14. R to KKtsq | 14. Kt to Q2 |
| 15. Kt to B3 (j) | 15. KR to Ksq (k) |
| 16. B to Q2 | 16. P to QR3 (l) |
| 17. Q to Bsq (m) | 17. P to Kt1 |
| 18. P to KR4 | 18. P to B5 |
| 19. B to B2 (n) | 19. KR to KBsq ? |
| 20. Q to R3 | 20. P to QR4 |
| 21. Kt to R2 | 21. P to Kt5 (o) |
| 22. Kt to Kt4 | 22. P to Kt6 ? |
| 23. B to Qsq | 23. Kt to KB1 (p) |
| 24. P to R5 | 24. K to Kt2 |
| 25. Kt to B6 | 25. R to Rsq |
| 26. B to Kt4 (q) | 26. Kt to K2 ? (r) |
| 27. B x P! | 27. Kt x P |
| 28. P x Kt | 28. P x B |
| 29. Q x P | 29. R to R3 (s) |
| 30. P to R6ch | 30. K to Bsq |
| 31. Q to Q7 | 31. Q x Q |
| 32. Kt x Qch | 32. K to Ksq |
| 33. Kt to B5 | 33. R to R2 |
| 34. P x P | 34. P x P |
| 35. R to KBsq | 35. B to B3 |
| 36. Kt x P | 36. P to R5 |
| 37. Kt to Q4 | 37. R to Bsq |
| 38. R to B6 | 38. B to Q2 |
| 39. P to K6 | 39. B to Bsq |
| 40. Kt to Kt5 | 40. Resigns. |

NOTES.

(a) P to B4 is more forcible now than at any other time.

(b) In accordance with the modern fashion, which is to play these close games on the King's side. Zukertort's method consisted in castling at once and devoting his attention entirely to the advance of the Pawns on the Queen's wing.

(c) Though contrary to theory, inasmuch as the King's Pawn is left weak, this move has stood the test of recent practical play. Black's reply is certainly premature, though he cannot play 7. . . B × Kt, 8. B P × B, KtK5; 9. B × Kt, P × B; 10. Q to Kt4, winning a Pawn.

(d) A fine move, preventing Kt to K5, and therefore giving additional force to the threatened advance of the KKtP. Perhaps Black's best reply under the circumstances was B to R3.

(e) Hardly necessary, as Black cannot play P to B5; but possibly he was providing against B to R3.

(f) Quite useless. Better would have been 9. . . Kt to Ksq, followed by P to B4 or B3 according to circumstances.

(g) Now, however, he should move the Rook, in order to make room for either Knight or Bishop at K1sq, according to requirements.

(h) To prevent P to B3; threatening also Kt to Kt4 in due time.

(i) He might play 12. . . Q to K2, with a view to B × Kt or P to B3. The alternative was 12. . . Kt to B3.

(j) Chiefly, no doubt, to prevent Black from freeing his game by Kt × P. In any case 15. R to Kt4 was useless, as (apart from the reply 15. . . . Kt × P) Black could defend himself by 15. . . . KR to Ksq; 16. R to R4, Kt to Bsq, &c.

(k) This might wait till White plays R to Kt4, as in the previous note.

(l) If he intends ultimately to play P to B5, he might as well do so at once, and follow it by P to Kt4, saving a move.

(m) In order to advance the KRP, and thereby allow the Knight to play to KKt4 *vis* KR2.

(n) There is something to be said too for B to K2 with a view to Kt to R2 and P to R5 (or P to R5 at once if Black reply Kt to KB4). Black's next move is quite unintelligible.

(o) Now perhaps Kt × P would have given him chances of breaking through on the Queen's side, but it would be at the cost of exchanging Queens. His next move is very questionable, as it ultimately gives White the open Rook's file. P × P would be better.

(p) With a view to his next two moves, which lead to the shutting out of the Rook; but as White in any case threatens Kt to B6ch and P to R5, it does not appear that he has anything better to do. The position is against him, his pieces being hopelessly shut out from the King's side.

(q) P to R6ch first would be better—*vide* note (r).

(r) An oversight. 26. . . . P to R3 should be played at all hazards.

(s) There is nothing else to be done in view of the threatened P to R6ch and R to KBsq. After the exchange of Queens, which is forced, the remainder plays itself. Mr. Lasker conducted the whole game with his usual ability.

CHESS INTELLIGENCE.

Mr. Lasker recently defeated Mr. Showalter, the Kentucky Champion, in a match by six games to two, with two draws. By mutual agreement the three games of the previous abandoned match, in which each player won one game, the third being drawn, were included in the score of the later match. It is rumoured that Mr. Lasker intends to challenge Mr. Steinitz to a match for 5000 dollars, and the championship of the world. Mr. Steinitz remarks that a challenge for such a sum would be "entitled to respect," provided that the other conditions are equally fair.

Herr Walbrodt has won a match from Mr. Delmar by five games to three, with three draws. The deciding game should have been won by Mr. Delmar, who threw it away in the end game. The result of the match, with which Mr. Delmar is not satisfied, seems to show that Herr Walbrodt was either out of form or is not so difficult to beat as has generally been supposed.

The death is announced of Jean Dufresne, the opponent of Anderssen, and at one time editor of the *Schachzeitung*. He was the author of the *Lehrbuch des Schachspiels*.

C. Salvioli is now the editor of the *Nuova Rivista degli Scacchi*, the Italian chess monthly. He is well known as the leading Italian player and analyst. The May number contains an entertaining article on "Chess Knight-errants," with reference especially to Lasker and Walbrodt, and the consternation of the former on landing at Havana at finding Herr Walbrodt in possession of the soil which he (Herr Lasker) "had proposed to himself to cultivate." The following is a pretty two-move problem by G. B. Valle, from a former number:—*White*: K at KR8, Q at QR5, R at K4, B at KR5, Pawns at Kt3 and Q2. *Black*: K at Q6, Rooks at KR7 and QB8, Pawns at KR5 K4, QB4, and QB7. White mates in two moves. Solutions will be acknowledged.

On May 13th Surrey defeated a weak Sussex team at Croydon by eleven games to six. The previous match resulted in a tie.

A match of seven games up is now in progress at Simpson's Divan, between Messrs. Bird and Jasnagrodsky. The present score is Bird 3, Jasnagrodsky 2.

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TUSKS AND THEIR USES.

By R. LYDEKKER, B.A. Cantab.

MANY mammals, such as the elephant, hippopotamus, and walrus, are furnished with one or two pairs of pointed conical or compressed teeth largely exceeding all the others in length, and to which the term "tusks" is usually applied.

Lions and wolves likewise have two pairs of somewhat similarly enlarged teeth in the fore part of their jaws; and although these are proportionately smaller than in the animals above named, it will be obvious that in popular language it is difficult not to include them under the same general title. Using, then, the term "tusks" for all such enlarged simple teeth, it may be of interest to note the groups in which these attain their greatest development, and also endeavour to learn something regarding their uses. An especial interest attaches, indeed, to the subject, on account of the extreme beauty of many of these teeth, and also from the circumstance that it is these alone which yield the various descriptions of ivory.

In a great number of instances such tusks comprise a pair in both the upper and lower jaws, which are situated immediately behind the front, or incisor teeth, and, from their marked development in the dog tribe, are scientifically designated canine teeth; the name "eye-teeth" being also not unfrequently applied to them in popular language. Tusks of this sort are characterized by the circumstance that the lower one on each side bites in front of the upper one; while the latter is always the

first tooth situated in the true upper jaw-bone, the incisors, or front teeth, being implanted in a more anteriorly situated bone known as the pre-maxilla. In any ordinary carnivorous mammal, such as a lion or a wolf, the upper tusk is considerably larger than the lower, although neither project beyond the edges of the muzzle when the jaws are closed. If we examine such tusks in a dried skull we shall find that their roots (which, as in all tusks, are simple) are completely closed; thus indicating that their growth ceased at a certain period of life. Moreover, we may notice that the upper and lower pairs of tusks do not abrade against one another to any marked extent, and that consequently their summits are only subject to the ordinary wear and tear necessarily undergone during use. In many other mammals the form and structure of these tusks is, however, very different. Take, for instance,

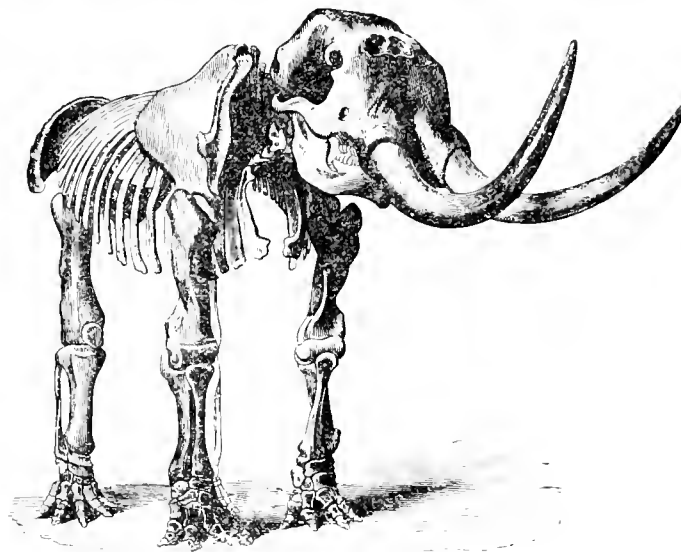


FIG. 1.—Skeleton of Mastodon to show single pair of tusks in upper jaw

a wild boar, in which the upper tusks are short and curved upwards, while the larger and more slender lower pair abrade against their outer surfaces, and are thus worn to sharp, cutting edges. Obviously such tusks, if they were incapable of growth like those of the lion, would soon be worn away to mere stumps and become useless to their owners. To prevent this, the bases of the tusks remain permanently open (as shown in Fig. 1), and contain a soft pulp connected with the vascular structures of the jaw, in consequence of which the teeth continue to grow throughout life; their rate of growth thus keeping pace with that of the abrasion to which they are subject. Tusks may accordingly be divided into two classes, which we may designate hollow and solid. The open tusks referred to above are prevented from attaining any very great length by the abrasion of the lower against the upper pair, but in other cases, as in those of the remarkable pig of Celebes known as the babirusa (Fig. 2), no such abrasion takes place, and both pairs then attain enormous dimensions, projecting in this particular instance far above the upper surface of the head, and the down-curving points of the upper pair sometimes even penetrating the skull. A babirusa may in fact be compared to a wild boar in which one pair of tusks having been broken, the other continues to grow without any abrasion by wear; only that in these animals both pairs are thus developed. In the wild boar and its allies the tusks—more especially those of the lower jaw—are purely offensive and defensive weapons;

but it is hard indeed to imagine the use of those of the babirusa. Probably Mr. Wallace is right in regarding them as an ultra-development of organs originally useful,



FIG. 2.—Fore part of skull of Babirusa.

but which have now, from some reason or another, become of no functional advantage to their owner, and have thus, so to speak, run riot.

The babirusa presents us with an instance of a mammal in which both pairs of tusks have acquired their enormous development owing to the cessation of the mutual attrition between those of the upper and lower jaws, characterizing all its allies. On the other hand, in the mastodons and elephants we have examples where the development is normal, and either one or both pairs attain a vast size. In both species of existing elephants, as in many of the mastodons (Fig. 1), only the upper pair of tusks is thus developed; but in other mastodons these organs were present in both jaws, the upper pair being, however, always much larger than the lower. In the pigs and babirusa the tusks, of which the upper pair are planted in the true jaw-bone, correspond severally with those of the lion and the wolf, and are accordingly reckoned as canines. This, however, is not the case with those of the elephants and mastodons, which grow in great part from the pre-maxillary bone, and thus correspond with one pair of the front or incisor teeth of other mammals. Consequently, much as they resemble them in general appearance, the tusks of an elephant are not homologous with those of a pig or a babirusa. As we have entered in some detail into the structure of the tusks of the elephants in a previous article devoted to that group of animals, it will be unnecessary to recapitulate the facts here; although we may mention that in modern elephants these organs consist wholly of ivory, without any investing coat of enamel. The tusks of these animals, which belong to the hollow type, are the largest developments of dental structure to be met with in the whole animal kingdom. To a great extent these organs are weapons of defence and offence, but in the African species, where they are common to both sexes, they are also largely used in grubbing up roots and overturning trees; while in an extinct species from India their length is so great that they must have quite ceased to be useful, and were

probably an actual encumbrance. Another allied extinct animal, known as the diouthere, is unique in having a large pair of downwardly-bent tusks in the lower jaw and none in the upper; the use of these being very difficult to conjecture.

A still more remarkable condition obtains in the hippopotamus, in which not only are the canine teeth developed into an enormous pair of hollow, ever-growing, curved tusks in each jaw, but the central pair of lower front or incisor teeth are so enlarged as likewise to merit the title of tusks. These incisor-tusks—which thus correspond to the lower pair of the four-tusked mastodons—are likewise of permanent growth, and project forwards from the front of the jaw in the form of two elongated cones. In thus possessing three pairs of tusks the hippopotamus is quite peculiar among animals. Largely employed for tearing up the grasses on which these monsters feed, the tusks of the hippopotami are also most effectual offensive weapons.

In the land carnivores, of which more anon, the tusks are always of the closed type; but in their aquatic ally, the walrus, we again meet with a huge pair of ever-growing tusks directed downwards from the upper jaw. On comparing the head of a walrus with that of an elephant, most persons would say at once that the tusks of the two animals were homologous. In this, however, they would be wrong, since, as we learn from the condition in the young animal, those of the walrus are true canines, whereas, as we have seen, the tusks of the elephant are incisors. We have here, therefore, a well-marked instance of the parallel development of severally dissimilar structures to attain a marked general similarity. The tusks of the walrus, which in old animals attain a great length, are mainly employed in digging up molluscs and crustaceans from the sand and shingle, and also, it is said, in aiding their owners to clamber up on the ice.

Although the whalebone-whales are entirely deficient in teeth and many of the dolphins and their allies have these



FIG. 3. The Narwhal. (After Truc.)

organs but poorly developed, there are two cetaceans which exhibit a most remarkable development of tusks. The first of these creatures is the well-known narwhal, of the Arctic seas, in which, as a rule, there is a huge spirally-twisted cylindrical tusk projecting from the left side of the upper jaw of the male, which continues to grow throughout life. Whether this solitary tusk is a canine or an incisor is not very easy to determine; but it is remarkable that its fellow of the opposite side generally remains concealed in the jaw-bone, like the kernel of a nut in its shell, while in the female both teeth are thus rudimentary. Occasionally, however, male narwhals are met with in which both the right and left tusks are developed; and it is somewhat curious that in such cases the direction of the spiral in the two tusks is the same, instead of being, as in the horns of antelopes, opposite. Although narwhals have never been known to charge and pierce ships with their tusks, after the manner of sword-fish, it is still uncertain whether these formidable weapons (which may attain a length of from eight to nine feet) are normally used for purposes of attack, or for procuring food. Doubtless, however, the narwhal's tusk is of some use to its owner; but in another cetacean, known as Layard's

mesoplodon, the tusks appear not only useless, but actually harmful. In the whale in question, which is a rare species from the southern seas, there is but one large strap-like tusk on each side of the middle of the lower jaw, both of these curving upwards and inwards over the snout, so as to prevent the mouth from opening to its full extent. The only possible use we could suggest of such a structure would be to prevent the creature dislocating its jaw by yawning; but as other animals manage to get on without such an arrangement, this is scarcely likely to be a solution of the problem. It is more probable, indeed, that we have here to do with another instance of ultra, or monstrous development.

Other examples of hollow or permanently growing tusks occur among the hoofed mammals, other than the pigs, in all of which these teeth are found only in the upper jaw, and are developed chiefly or solely in the males. Among recent forms these tusks attain their greatest development in the little musk-deer of the Himalaya, where they are frequently over three inches in length, and project considerably below the lower jaw. In form they are sabre-like, and recall the upper tusks of the feline carnivores, only being more slender, and growing permanently. Similar but smaller tusks are met with in the Chinese water-deer, in the Indian muntjac, and the little deer-like animals known as chevrotains.

The latter belonging to a totally distinct group from the others, it is evident that these scimitar-like tusks have been independently acquired in the two groups; while it is quite probable that those of the musk-deer and Chinese water-deer are likewise of separate origin. With the exception of the muntjac, in which they are very small, all these deer-like animals are devoid of antlers; and it is thus evident that their tusks have been developed in lieu of those weapons.

It is true, indeed, that the males of some of the antlered deer have small tusks, but these are of no use for offensive purposes, and are evidently organs in process of degeneration. Moreover, in the hollow-horned ruminants, such as oxen and antelopes, where the horns are permanent and generally present in both sexes, not a vestige of tusks remains.

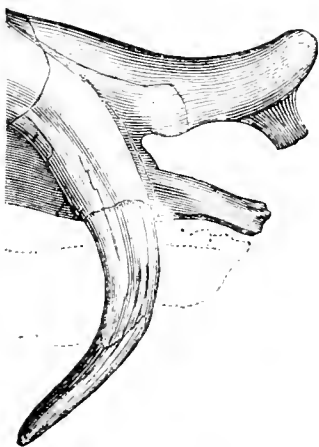


FIG 5. Extremity of the skull of a Uintatherium.

by a descending flange of



FIG. 4. Extremity of the skull of a young Chinese Water-Deer, with the base of the tusk exposed. (After Sir V. Brooke.)

Although the Asiatic rhinoceroses have procumbent tusks of considerable size in the lower jaw, none of the odd-toed hoofed mammals, such as horses and tapirs, have upper tusks of any size. In past times there were, however, in North America a group of somewhat allied creatures known as uintatheres, in which an enormous pair of upper tusks, somewhat like those of the musk-deer, was developed. Like those of the latter, these tusks grew permanently, and they were also protected

often deeper than in the figured example. As these animals had front teeth only in the lower jaw, we have here, therefore, another curious instance of the parallel development of similar conditions in totally unconnected groups. What use these creatures could have made of their tusks is, however, not very clear, as in the living condition they could have projected but little below the lower jaw, while they were too long to have been effectual when the mouth was open. These uintatheres were also noteworthy on account of having a number of bony projections on the top of the skull, which in life may have been sheathed in horn; and it is not a little remarkable that another extinct creature—*Protoceras*—belonging to the even-toed group of hoofed mammals had a skull with very similar bony projections and also similar upper tusks.

Our last instance of animals furnished with permanently growing upper tusks is afforded by the reptilian class, in which the extinct South African creatures described many years ago by the late Sir R. Owen, under the name of *Dicynodon*, are thus armed. In these reptiles, some of which attained gigantic dimensions, the jaws were mainly sheathed in horn like those of the turtle; the single pair of tusks curving downwards and forwards from near the middle of the upper one. Possibly these tusks were capable of being employed when the mouth was open, like those of lions or tigers; but otherwise it is difficult to see their use. Certain allied reptiles from the same formations, known as anomodonts, had a full series of teeth, with a large pair of tusks in the upper jaw, which may or may not have been rooted, but are exceedingly like those of certain carnivores. As these reptiles are not the direct ancestors of mammals, we have thus evidence of the acquisition of tusks in two distinct classes.

As regards solid tusks, or those in which the lower end is closed at a certain period coincident with the cessation of growth, almost the only mammals, save the rhinoceroses (where, as we have seen, there may be a forwardly-directed pair in the lower jaw) and some of the marsupials, in which they attain any marked development are the carnivores. Among these, the maximum size of tusks at the present day is attained in the larger felines, such as the lion, tiger, and leopard. In these animals the tusks are, however, never so much elongated as to bar the front of the open mouth; while very frequently their tearing power is increased by the hinder cutting edge being finely serrated. Their terrible effect in tearing and rending the animals upon which these fearsome carnivores prey is too well known to need further mention. During the tertiary period there existed certain carnivores nearly allied to the modern cats, but exhibiting a much greater development of the upper pair of tusks, with a corresponding reduction of those of the lower jaw. In these creatures, which are known as macherodonts, or sabre-toothed tigers, the upper tusks were greatly compressed and flattened, with serrations on one or both cutting edges; their length in a species of the approximate size of a tiger being upwards of seven inches. As in the uintatheres, the anterior end of the lower jaw had a descending flange to protect the end of the tusk. Manifestly, such enormous weapons would completely bar the sides of the open mouth, and consequently they could not be used in the manner of the tusks of a lion or tiger. It is still more difficult to imagine that these animals could have struck with their tusks projecting from below the closed mouth; and it would consequently seem that in this instance also the tusks attained a development which was harmful rather than advantageous—this conclusion being confirmed by the fact, for what it is worth, that the sabre-toothed tigers have become totally

extinct, while their less specialized allies continue to flourish.

Finally, as regards tusks in general, it appears that while in the land carnivores these are always canines, are present in both jaws, and have closed roots, in the other orders of mammals their development is apparently somewhat capricious, while they are very frequently present in only one jaw—almost invariably the upper—and continue to grow permanently. Moreover, they are almost as frequently incisors as they are canines; so that apparently similar tusks may be in nowise homologous with one another. Never developed to any size in animals with large cranial appendages in the form of antlers or horns, tusks are frequently wanting in those lacking the latter. Primitively their use was undoubtedly as weapons of attack and defence, or to aid in procuring vegetable food; but in many cases they have subsequently undergone a frequently sexual development beyond the needs of such purposes, and are thus in this respect analogous to the antlers of many stags. In other instances, however—and this in all the groups in which they occur—they have undergone a still further semi-monstrous development, rendering them if not actually harmful, probably in some cases inconvenient to their owners. Finally, the independent acquisition in closely allied or widely separated groups of mammals of tusks of very similar structure and appearance shows how little reliance is to be placed on external characters as indicative of relationship.

THE STORY OF θ ERIDANI.

By the Rev. T. D. ANDERSON, D.Sc.

AT a distance of 32 from the South Pole, and with a right ascension of 1h. 34m., shines α Eridani, the eighth in brightness, photometry assures us, of all the stars on the sphere. Those who have occasion to consult star maps and catalogues will have noticed that to this star is given, besides its letter α , the formidable-looking name of Achernar. Achernar means in Arabic "the last in the river," and is a translation of the *eschatos tou potamou* of Ptolemy, such being the descriptive appellation given by that astronomer to a star catalogued by him as the 34th in Eridanus, and estimated by him as of the first magnitude—one of fifteen in all which he places in that rank.

That α Eridani is the *eschatos tou potamou* of Ptolemy has been almost invariably accepted by astronomers, for except it, there is no first magnitude star anywhere near the southern end of the great celestial river. And yet the difficulties attending this identification are insuperable. Ptolemy made his observations at Alexandria (lat. 31° N.) in the first half of the second century of our era, at which time α Eridani, which has, be it remarked, almost no proper motion, was only 22° distant from the South Pole, so that Ptolemy, to see it even on the horizon, would have had to ascend the Nile to the Second Cataract. A usual explanation has been that given by Bode in his edition of Ptolemy's Catalogue (page 84): "It may be asked how Ptolemy knew anything of α Eridani, since this star in his time never rose above the horizon at Alexandria, but even when on the meridian remained nearly 10° below the horizon. He must have learned about it only from the uncertain reports of travellers who had visited the southern regions of the then known world, and have inserted it in

* It may interest readers of KNOWLEDGE, to be reminded that Dr. Anderson is the keen observer who first detected the Nova Aurige as a stranger in the heavens on February 1st, 1892, when it was only a little above the fifth magnitude. He modestly announced the appearance of the new star to Dr. Copeland on an anonymous postcard, and the discovery was only debited to Dr. Anderson after subsequent inquiries. A. C. BARNARD.

his catalogue accordingly." He consequently rejects as entirely erroneous the longitude and latitude of the *eschatos tou potamou* as given by Ptolemy.

But unfortunately for this view, we have received from antiquity a good deal more information about the Last in the River than the bare mention of its longitude and latitude in Ptolemy's Catalogue. It is one of the fifteen first magnitude stars whose risings and settings are given by Ptolemy in his Calendar, and in that work it is expressly stated (93b) that although it did not rise above the horizon where the sun's diurnal arc at midsummer is $15\frac{1}{2}$ hours (*i.e.*, lat. 45° N.), it did rise where the sun's diurnal arc at midsummer is only 15 hours (*i.e.*, lat. 41° N.) Nay more, Hipparchus, in his Commentary on Aratus, states that at lat. 37° N. the Last in the River, or as he calls it—his star nomenclature is much fuller and more sonorous than that of Ptolemy—the brightest and preceding and southernmost of all in the River, rose when 351° of the ecliptic was culminating, and set when 63° of the ecliptic was culminating (ed. Petavius, pages 241a and 241b); or in other words, it was in his time $42\frac{1}{2}^{\circ}$ distant from the South Pole.

When we bear in mind these statements of Hipparchus and Ptolemy, and remember also that α Eridani—the so-called Achernar—was in the time of Hipparchus only 21° from the South Pole, the belief becomes irresistible that we have here the case of a first magnitude star either ceasing to shine altogether or becoming reduced to a much lower magnitude. As for the latter alternative of a serious reduction in splendour during the course of 2000 years, it is certainly not unknown in the annals of astronomy.

Thus β Leonis is given by Ptolemy, both in the *Almagest* and in the *Calendar*, as of the first magnitude; at the end of last century it was still bright enough for Bode to classify it as of the 1—2 magnitude; but now it is only of the second. Thus also α Sagittarii, given by Ptolemy in his *Calendar* as of the second magnitude, and in the *Almagest* as of the 2—3 magnitude, was in Sufi's time (the tenth century) only of the 4—5 magnitude, and that astronomer was so much astonished at the discrepancy between his own estimate and that of Ptolemy that he thought some error must have crept into the current copies of the *Almagest*. For this opinion, however, although it is adopted by Schjellerup in his notes on Sufi, there appears to be absolutely no foundation. By the time of Lacaille α Sagittarii had recovered to the 3—4 magnitude. It is now usually estimated at 4.0.

The fate of Ptolemy's Last in the River has been much the same as that of β Leonis and α Sagittarii. The Last in the River—the real Achernar—is undoubtedly θ Eridani, a star estimated by Halley and Lacaille as of the third magnitude, and still remaining of that magnitude.

The great difficulty in the way of identifying θ Eridani with the *eschatos tou potamou* is that the position which we find in Ptolemy—and the same remark applies to the position deducible from the remarks of Hipparchus—does not answer to that of θ . The latitude which Ptolemy gives is almost exactly that of θ , but the longitude is nearly four degrees too great. Instead of $356\frac{1}{2}^{\circ}$, Ptolemy gives $0^{\circ} 10'$. How the longitude should be so much in error would be very difficult to ascertain. The fact may be noted, however, that Ptolemy is more than once similarly wrong as regards stars that lie far south. His longitude of β Centauri is wrong to the extent of $2\frac{1}{2}^{\circ}$, while the error in the case of Fomalhaut is about the same as in the case of the Last in the River, its latitude being given 2 too great— 23° S. instead of 21° S.

But in the catalogue of Ulugh Beg (1437 A.D.) we find the Last in the River laid down as a first magnitude star, in a position answering to that of θ with almost

mathematical accuracy. Baily, accordingly, in his edition of Ulugh Beg's Catalogue (*Memoirs of the Royal Astronomical Society*, Vol. xiii.) identifies without hesitation the *eschatos tou potamou* with θ . This had been done long before by Halley in his *Catalogus Stellarum Australium*, and the wonder is how, with the great weight of Halley on the other side, the idea should ever have gained ground that α Eridani is the *eschatos tou potamou*.

We have also from the pen of Sufi (964 A.D.) a very clear description of the Last in the River. He has been describing the three closely-adjacent fourth magnitude stars Lacaille 1198, 1244, 1248 (often called respectively *h*, *f* and *g* Eridani), and goes on to say:—

"The 34th star (in Eridanus) precedes these three, and the distance between it and that one of the three which is nearest to it" (*i.e.*, Lacaille 1198 or *h* Eridani) "is about 1 cubits" (*i.e.*, about $9^{\circ} 20'$ of arc: Sufi's cubit = $2^{\circ} 20'$: *vide* page 92 of Schjellerup's edition). "It is of the first magnitude. This is the star marked on the southern astrolabe and called Achernar. Preceding this bright star there are two others, one to the south, the other to the north. Ptolemy has not mentioned them. One of these stars is of the fourth magnitude, the other of the fifth. Following it, and at a distance of 2 cubits from it" (= $4^{\circ} 40'$ of arc), "there is a star of the fourth magnitude."

It needs only a glance at the map to see what star is meant by Sufi. The bright star that precedes *h* Eridani (Lacaille 1198), and is distant from it about $9^{\circ} 20'$ of arc, can only be δ Eridani. (The actual distance between the two stars is $9^{\circ} 11'$.) The two stars preceding δ —one of the fourth magnitude lying southwards, and one of the fifth magnitude lying northwards—are ϵ Eridani and ν Fornacis respectively. The fourth magnitude star that follows it is e Eridani (Lacaille 1060).

That the star intended by Sufi cannot possibly be α Eridani is evident from the fact that that star is distant from *h* Eridani, not four cubits but $27\frac{1}{2}^{\circ}$ of arc, or more than eleven cubits. It is much to be regretted that Prof. Schjellerup, the able and industrious translator of Sufi, has allowed this to escape his notice, and helped in the preface and notes to his work to propagate the delusion that α Eridani is Ptolemy's Last in the River. It is, perhaps, too late now to restore to θ its ancient style and title of Achernar, but α at least should be made to yield up its usurped honours.

What rank did θ Eridani hold in the heavens in ancient and mediæval times? Sufi, in placing it among his first magnitude stars, places it in an exceedingly select circle, for he has only thirteen stars of undoubted first-class rank, the other eleven, besides β Leonis and the Last in the River, being Capella, Vega, Arcturus, Aldebaran, Regulus, Procyon, Rigel, Sirius, Fomalhaut, Canopus and α Centauri. He estimates Betelgeuse and Spica as 1—2, Altair and β Centauri as 2—1, and Pollux and Antares as only 2.

One fact about θ Eridani we shall probably never learn, unless a certain contingency occurs. The fact to be ascertained is, which of the two components of θ has faded? The contingency is that the star may brighten up again. In a few centuries it will be high enough above the horizon to be visible in Britain. Will it then shine upon our land in its pristine glory as Ptolemy saw it gleam over the sands of the desert, and Sufi watched its image dancing on the waters of the Tigris?

GALLS AND THEIR OCCUPANTS. I.

By E. A. BUTLER.

IN the recent articles on "Caterpillars' Dwellings," we have seen how certain insects use parts of plants for the double purpose of board and lodging, twisting the leaves into variously-shaped coverings, the interior of which is then eaten away. In all such cases the portion of the plant operated upon is a normal vegetable product, and our interest and admiration are called forth solely by the ingenuity and architectural skill with which the insect, always in its larval form, adapts for its own purposes the materials it finds ready to hand. We propose now to consider some far more remarkable instances of association between insects and plants, in which a suitable action on the part of the *parent* insect results in the production of an *abnormal* vegetable growth, destined to provide its offspring with both shelter and food. These abnormal growths are of the most varied forms, some of them appearing as mere swellings or unsightly excrescences, others as highly ornamental additions, resembling leaves or fruit; but whatever their form and appearance, they are all included under the one name "galls." By a gall, then, we are to understand any kind of abnormal vegetable growth which results from the puncture of a plant by an adult insect, and the insertion of an egg in the puncture, the vegetable growth thus formed nourishing and protecting the larva produced from the egg, and sheltering the pupa resulting from this, till the time of its emergence as a perfect insect. Some of these galls are among the most familiar of "common objects of the country," such *e.g.* as oak-apples, oak-spangles, and robins' cushions, while the gall-nuts of commerce, used in the manufacture of ink, owe their origin to a similar cause. In these cases, the presence of the insect inhabitant, shut up as it is in the centre of the gall, is very naturally often quite unsuspected, and the oak-apple, for example, looks superficially as much like the genuine fruit of the oak tree as the acorn itself. The nature of the gall produced is no doubt to some extent dependent upon the plant upon which it is found, but it is much more largely dependent upon the species of insect that produces it, for the same kind of insect always produces the same sort of gall, while different insects will produce galls of totally different character, not only on the same tree, but even side by side upon it, where the vegetable conditions must be precisely similar.

The insects which are responsible for the formation of these monstrosities are usually sombre-coloured, fly-like, insignificant creatures, which are commonly known as gall-flies. They belong chiefly to two orders: the Hymenoptera, or order of bees, wasps, and ants, and the Diptera, or two-winged flies. The former order, however, contains all the best known species. Some few galls are produced by insects of other orders, but the consideration of these we will defer for the present. Our first concern will be with the hymenopterous gall-producers. These will fall mainly into two families—the *Cynipida*, or gall-flies proper, and the *Tenthredinida*, or saw-flies. All the species of the former family are in some way or other connected with galls, while in the latter group the habit pertains to only a few.

It will give greater definiteness to our thoughts if we select one particular species of *Cynipida* as typical of the group, and none could be found better suited for the purpose than that which produces the so-called marble or Devonshire galls of the oak tree, *Cynips Kollarii*. The galls are no doubt familiar objects to anyone who has

* Not *h*, *g* and *i*, as stated by Prof. Schjellerup in his edition of Sufi.

wandered along country lanes—perfectly spherical bodies growing on young oak trees (Fig. 1), at first green and soft, but becoming, later in the season, brown and very



FIG. 1 Marble Gall of Oak.

hard, whence their popular name. They are one of the commonest of the very numerous galls to which the oak tree is liable, and are often extremely abundant. While the leaves are on the trees and the galls themselves are green, they are, of course, not so noticeable; but as they remain on the twigs after the fall of the leaves, and pass the winter in that position, they are at such times extremely conspicuous, and the stunted oak bushes that in many places form one of the chief constituents of the hedgerows are often crowded with the dark brown marble-like balls. So abundant are they, indeed, that they are often collected in thousands to be strung on wires and worked up into rustic baskets to hold ferns.

The originator of these vegetable marbles is a little brown-bodied fly (Fig. 2, A), with four clear transparent wings, a thoroughly typical gall-insect. It has a globose and hump-backed thorax, but the abdomen is the most remarkable part of the insect. This is short, but broad and deep, and attached to the thorax by a very short and slender stalk. It is of a rusty brown colour, darker at the base. The various segments of which it is composed are very disproportionately distributed, the second being by far the largest, occupying indeed about half the abdomen; while the others lap over one another like scales. Underneath, a sharp ridge runs longitudinally along the abdomen; this covers the ovipositor, which rises from the head of the abdomen instead of farther down, as is usually the case, but part of its length is coiled up inside. The short, deep, compressed, shining body is quite typical of a gall-fly, and is one of the structural points by which the insects are most easily recognized. The venuration of the wings, again, is peculiar and is an aid to identification.

With its ovipositor the gall-fly pricks a minute hole in a young leaf bud of the oak, and deposits therein an egg. It is probable that some irritant fluid is instilled at the same time, since many of the Hymenoptera, as is well-known, secrete fluids of this kind, and it is difficult to account for the effects of the puncture except on such a hypothesis. Either then by this means, or in consequence of the mere presence of the egg, an irritation is produced in the vegetable tissue, which results in the speedy growth around the egg of a cellular mass of globular form, in a

cavity in the centre of which reposes the egg. The mother fly by its puncture taps, as it were, the current of sap along the twig, and diverts its course so as to lead to a rapid multiplication of vegetable cells around the puncture; in an incredibly short time this appears as a green spherical mass of fleshy tissue, which has no functions with regard to the tree from which it grows, but is reserved exclusively for the insect's own use, or rather for that of its offspring, and apparently interferes scarcely at all with the general well-being of the tree. If, however, the attack be very severe, thousands of galls appearing on the same tree as the results of punctures by swarms of flies, the vitality of the tree is naturally lowered through the shutting off or shunting of so much of its energy, and the effect of this would be felt first of all in its reproductive processes, and the crop of acorns would in consequence be diminished.

During the early growth of the gall, the egg remains unhatched, so that the grub is not called into independent life till the materials for its support have been duly elaborated. But, strange to say, the egg does not develop solely at the expense of its own contents, as is usually the case, but actually *grows* through the absorption of nutrient fluid from the gall; so that, though in comparison with its parent, it is proportionately large to begin with, it is considerably larger before it is hatched. From it there issues a fat, fleshy, footless grub, which has to spend its whole life in the more or less spherical chamber, just of its own size, that occupies the centre of the gall, from the rest of which it is shut off by walls of a harder consistency. It subsists at the expense of the gall itself, and the food it absorbs appears to be wholly digested, so that the grub can afford to dispense with any terminal outlet to its digestive tract, and consequently no excrement accumulates, the cell remaining always beautifully clean.

In course of time the grub turns into a pupa, which looks like a mummy of the perfect insect, with wings, legs, and antennæ folded close to its sides. This occurs towards autumn, but meanwhile a great change has been taking place in the gall itself, which is now hard and woody, and brown outside, all traces of green having disappeared as it became drier and harder. When cut open at this stage, it is seen to be composed of a brown and more or less spongy tissue, bounded within and without by a hard woody layer, the spongy intermediate mass being arranged in a radiating way from the centre (Fig. 3, A).



FIG. 2 (A) Gall Fly of Marble Gall (*Cynips Kollarici*). (B) Egg parasite (*Callinomic regius*). A is enlarged two diameters; B, three and a half.

The pupa changes to the perfect gall-fly while still lying in the central chamber, absolutely imprisoned and without pathway of escape. Of course it has been in darkness all this time, and, therefore, needless to say, it has remained of a creamy white colour; all the air necessary for its respiration has apparently been obtained by transfusion through the mass of the gall, for no direct communication with the outside is perceptible. The fly, when ready to escape, eats a cylindrical burrow for itself along a radius of the sphere, and thus reaches the outside by the most

direct route. The gall does not necessarily drop at this juncture, and, as most of the flies emerge in the autumn, the majority of the galls found during the winter on the bare trees will have no inhabitant within, or rather no legitimate inhabitant, since, as we shall see presently, they may contain other kinds of insect life. But the presence of the circular hole caused by the escape of the fly will always distinguish empty galls from those which are still inhabited by the true owner. Sometimes the galls may be seen with a large excavation in one side; this is the work of the tomtits, which delight to feed on the gall-fly grubs.

Such in general is the history of a Kollari gall, but it is often complicated by the presence of parasites. These may be chiefly of two kinds, firstly, vegetable-feeding ones, *i.e.*, other kinds of gall-flies which take advantage of the large store of food contained in a Kollari gall, and save themselves the trouble of making galls of their own; and secondly, insect-eating ones, belonging to a family of parasitic Hymenoptera which are noted for their gorgeous metallic green and golden coloration—these will be parasitic on the gall-flies themselves, both the legitimate owners

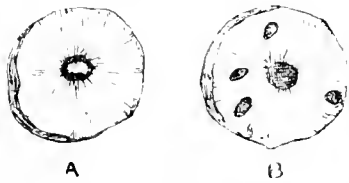


FIG. 3. Sections of Marble Gall. A, showing larva of Gall Fly in its cell; B, showing cells of parasitic Gall Flies.

i.e., species of *Cynipida* which do not appear to have the power of producing by means of the puncture of their ovipositors the abnormal vegetable growth which constitutes a gall, and therefore lay their eggs in galls already formed by other species. The mother fly in such cases is not satisfied with introducing a single egg, but a dozen, or perhaps a score, will be inserted into the one gall. Mr. E. A. Fitch records rearing twenty-three specimens of a parasitic gall-fly from only a portion of a double gall, *i.e.*, one in which two galls that had been formed in close proximity had coalesced.

These parasites, or rather inquilines, as they are more appropriately called, develop early, while the gall is still growing, and it can be easily seen that in consequence of their numbers they absorb the sap of the gall as fast as it is produced, and hence arrest its growth; so that although it contains a large family of insects it remains considerably smaller than when tenanted by only one, the legitimate occupant. It is frequently possible to detect from the outside the presence of these inquilines; there is a minute swelling lighter than the ground colour, on the surface of the gall over the spot where the invader's cell is situated, and the slight scar caused by the puncture for oviposition may also be traced. Thus the one gall becomes the nursery of at least two different kinds of insects, which are distinct enough to be referred to separate genera.

But this is not all; wherever a strange insect intrudes, it may be the means of introducing with itself any parasites which are dependent upon it, and thus a third member is imported into the society, and besides this, the legitimate inhabitant may also entice parasites of its own which will most likely be of different species from the others, and thus a fourth member may be added to the community. These parasites (Fig. 2, B), truly so called,

will very largely consist of members of the family *Chalcididae*, which subsist upon the eggs and larvæ of insects, their eggs being often laid within those of other insects, the contents being devoured by the parasite. It stands to reason, therefore, that this tribe of parasites is composed of very minute species; but what they lack in size they make up in brilliancy, and, with their polished metallic green and golden skin, they may claim as a group a foremost rank amongst insects in splendour of adornment.

To summarize what has been said and to endeavour to put into realistic form the chief incidents in gall-life: we have seen how, in the first place, a dull-coloured gall-fly, looking round amongst the trees for a suitable spot in which to prompt Nature to rear an asylum for her young, punctures a minute hole in an oak bud, and lays therein an egg, thus giving rise to the abnormal growth which is to be put to the double use of nursery and provisions. But the developing gall is soon spied by a far smaller being, a gorgeous warrior-like egg-parasite, which is also prompted by the anxieties of maternity, and is surveying the country round to discover just such a growth as this, which she instinctively knows contains the object of her quest. She has a long ovipositor with which she punctures the gall and reaches its contained egg, and in this she lays her own and then departs, having frustrated the intention of her predecessor and determined that out of that gall shall proceed, not a gall-fly, but a chalcid. But meanwhile another being, of quite a different character, dull-coloured and sombre like the first arrival, is also prowling about, ready to take a mean advantage of the juicy store which the vigour of the oak has thrown out in response to the tiny puncture that was the first link in the chain of events. As soon as the growing gall is detected, she alights upon it, and piercing it again and again, deposits in each spot an egg, she on her part determining that that same gall shall bring forth, not *one* solitary gall-fly, but a whole family, though of a different sort from what was originally intended. But her intentions, again, are to a large extent doomed to disappointment, for other members of the glistening warrior-tribe of parasites are in the air, and only await the conclusion of her labours to advance to the attack, and introduce their own little eggs here and there, ringing the death-knell of a gall-fly at each puncture. And thus in due time there shall issue from that one marble-like gall, not its legitimate occupant, but such of the inquilines as escape the second invasion, and a whole stock of brilliant freebooters, each burrowing its way through the substance of the gall into the open air. Thus the old and deserted gall will stand on its stem after the winter, not pierced with a single hole as should have been its fate, but riddled with minuter punctures on all sides, thus bearing mute testimony to the tragedies of which it has been the scene. But even this result is not a foregone conclusion, and the struggle for existence may not be over at the stage indicated, for there are insectivorous birds also on the alert, and the tomtit may pounce down on the ill-fated gall while it is still thronged with life, tear it to pieces, and devour all its inhabitants, leaving only the fragments of its walls standing like the ruins of a bombarded castle which has been attacked by a hostile force and has suffered the massacre of its entire garrison.

But the relations of our Kollari gall with insect life are hardly yet exhausted. If large numbers of these galls are collected in winter and kept in some receptacle so that the insects that emerge from them can be observed and collected, a most miscellaneous assemblage will in all probability be obtained. If the particulars of one such

collection be given, it will suffice to show how greatly these marble galls are appreciated by various kinds of insects. The collection in question was made in the winter of 1878-9 by Mr. W. P. Weston, and it included six species of small moths, all belonging to the group *Tortricæ*, the caterpillars of some of which we have lately had under examination, seven different kinds of beetles, and no less than thirty species of Hymenoptera, including sawflies, gall flies, ichneumon flies, chalcids, ruby-tails, mason wasps, and other burrowing Hymenoptera, and finally bees. We may briefly consider what was the connection between these various insects and the galls.

In many cases, no doubt, it was simply a matter of hibernation. The damaged galls especially would form excellent retreats for all sorts of insects, provided their size were not an obstacle. This would certainly explain the presence of the beetles at least. Then, again, the galls in their younger condition, when they are soft and juicy, would no doubt be as attractive as an article of diet to some other plant-eating larvæ as they are to those of the gall-flies themselves, and such larvæ would therefore frequent them for food. This was certainly the case with at least one of the moths, which is regularly an inhabitant and devourer of galls. Other caterpillars, again, might use the damaged gall as a retreat during pupahood. The presence of the sawflies would probably be explained in this way. The ichneumons were of course parasitic on the moths and sawflies, the chalcids on the gall-flies. The burrowing Hymenoptera, many of which tunnel in wood, had apparently selected the galls for their burrows, and they, again, would bring their parasites with them, which would account for the presence of the splendid little ruby-tail, whose habits are in accordance with this supposition. The bees were a very minute species belonging to a group which make their nests in all sorts of localities, such as the hollow stems of plants like brambles or docks, the deserted burrows of other insects, holes in stones and cracks in walls, and, evidently, we may add in galls also. Thus we have seen that when a *Cynips Kollaræ* makes a puncture in an oak bud and lays an egg there, she is performing an act which may have consequences of the most varied character, and may benefit not only her own offspring but hosts of other creatures as well. And what is true of this particular kind of gall applies no doubt, with modifications, to other species in like manner.

(To be continued.)

THE TREE CREEPER.

By HARRY F. WITHERBY.

THE tree creeper (*Certhia familiaris*) is the smallest of our true climbing birds, measuring only five inches in length.

The species is distributed generally over England, and although migratory in other countries, it remains with us all the year round.

On account of its unpretending habits and its general colouring, which assimilates itself to the natural haunts of the bird, the creeper is not often seen, and consequently it is usually considered to be more rare than it really is. The tree creeper is very sombre in colour. The back and head are dark brown streaked with greyish brown, the wings are the same in ground colour, but have several

bars of greyish white running across them. The tail is reddish brown, and the centre of each feather is of a dull white. The chin, throat, and belly are of a silvery white, often soiled by the bird's contact with the tree.

The favourite resorts of this bird are wooded districts and the larger kinds of trees. It is especially fond of localities in which there are a number of trees grouped together, such as an avenue of trees, so that it can move from one to another without interruption. It is a very solitary bird, and is either seen alone or in pairs, but never in large numbers.

The manner of its climbing is different from that of all other birds of its family. The creeper almost invariably commences to climb at the bottom or very near to the bottom of the tree, and it then proceeds upwards in a spiral direction, winding its way round and round the trunk, searching for insects in every possible crevice. Arrived at the top it seldom flies to a different part of the same tree, but goes to the base of another and repeats the same operation.

It is an exceedingly active little bird, and when seen is usually thus employed, seldom being at rest in the daytime.

The creeper climbs by making a number of quick movements—so rapid are they that if the bird is not carefully watched it seems to be gliding evenly up the trunk; hence, no doubt, its name, which is apparently a misnomer, for it is really a tree climber.

It climbs in its neat way by means of its claws and tail. The claws are long and curved, three pointing forwards and one backwards, and with these the bird obtains a secure hold on the tree. The feathers of the tail are stiff and pointed, and the tail itself curving downwards when



Tree Creepers on an Oak Tree containing their Nest.



PHOTOGRAPH OF THE CENTRAL PORTION OF THE MOON WHEN 136 HOURS OLD.

11. M. P. — PHOTOGRAPHED BY THE HELIOMETER OF THE PARIS OBSERVATORY, ON THE 23rd MARCH, 1893. THE SENSITIVE PLATE WAS OF THE LANTANA TYPE, AND WAS ENLARGED IN THE PRINCIPAL FOCUS SIXTEEN TIMES.

the bird is upon the tree, is invariably kept touching the bark, never being lifted from it.

The tree creeper is very shy, and rarely allows itself to be seen for any length of time; for although it does not seem to be watching, it quickly places itself on the side of the tree furthest from the observer.

Unlike the nuthatch, the creeper does not, as a rule, descend a tree, and on no occasion does it descend head foremost. I have, however, seen one, while in the act of pulling out a piece of touchwood from an old oak, take several steps backwards.

The flight of this bird is undulating, and is generally confined to short journeys from one tree to another. It utters a small, high-pitched note, often repeated, resembling the syllable "twee."

The food of the tree creeper is composed of small beetles, larvæ, spiders, and other insects, which infest the bark of trees.

The beak is about as long as the head, and, being curved and slender, can be thrust into the crevices of the bark to extract the lurking insect. It is not formed for tapping the tree like those of the woodpecker and nuthatch, and is never used for this purpose.

On account of the shape of its beak, together with its arched back and tail, the tree creeper, when seen from the side, assumes in general outline almost the form of a semicircle.

The nesting habits of this species are interesting. They sometimes build in a hole of a tree, but more usually between the bark and trunk of a decaying tree, where the bark has slightly parted from the trunk and forms a narrow crevice. The birds creep into this crevice, which is often not more than half an inch in width, and build their nest in it. One would suppose that the nest would be fixed to the tree itself, but such is not the case, for if the bark be taken off, the nest will adhere to it.

The nest itself is a handsome structure composed of fine twigs, grass, and chips of touchwood built in layers one on the top of another. It is lined with wool and feathers, and varies in size and shape according to the crevice or hole in which it is built.

The tree creeper usually has two broods in the year and lays from six to eight eggs at the first, in the month of April. It seldom lays more than five eggs at the second brood. The eggs are white with a few red spots, which are sometimes confined to the thick end of the eggs. They are almost identical in size and colour to those of the great tit (*Parus major*).

Both birds take their turn at sitting, and the young are hatched in about thirteen days. The birds sit very closely and may even be caught on the nest.

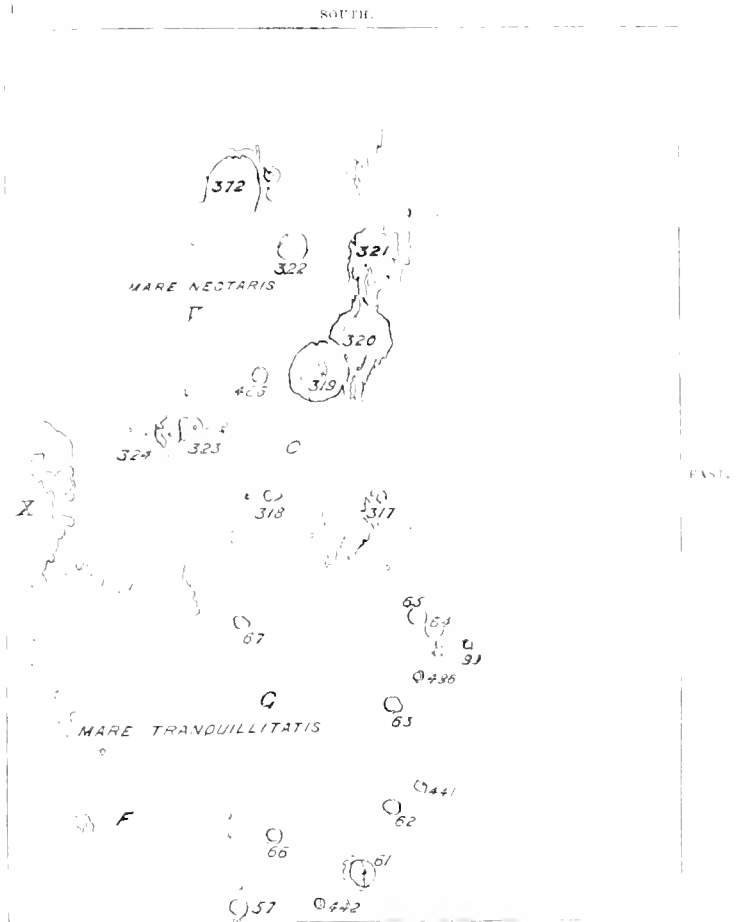
THE GREAT PLAINS ON THE MOON.

By A. C. RANYARD.

THE plate which illustrates this article has been made from a very beautiful photograph given me by Messrs. Paul and Prosper Henry, for the use of the readers of KNOWLEDGE. The photograph was taken on the evening of the 23rd of March, 1893, when the air was exceptionally steady—a condition which seems to be of far more importance for successful lunar photography than mere clearness of the atmosphere. It will be noticed that most of the *chefs-d'œuvre* of the Brothers Henry in lunar photography have been obtained in the months of March and May, during the evening hours when the new moon has a considerable altitude above the horizon. The station from which these beautiful

photographs of the moon were obtained is in the grounds of the Paris Observatory, which is now surrounded by houses and factories, that give rise to a good deal of smoke, which generally lies within a few hundred feet of the ground, and is very recognizable from the grounds of the Observatory, but it is still more strikingly visible, even on a clear day, from the top of the Eiffel Tower, where it may be seen as a whitish, hazy canopy hanging over Paris and its outskirts. It seems that the best photographs of the lunar details are obtained when the rays of the moon plunge most perpendicularly through this hazy screen—and that the screen adds to the steadiness of vision, for such sharp photographs have not been obtained during the morning hours when the canopy of smoke has been partly rolled away by the night winds.

Some of the best photographs taken by the Brothers Henry show remarkable details in the lunar plains, indicating the existence of partly submerged craters and low-lying ridges, which hardly throw any shadow even when



INDEX MAP

C. Mare Frigoris	66 Jansen.	322 Beaumont
F. Palus Soumii.	67 Maskelyne	323 Isidorus
N. Mare Facunditatis	68. M. Herms	324. Capella.
57. Vitruvius	99 Dionysius	371. Fraucastorius
61. Plinius	317. Hypatia.	441. Maclear.
62. Ross.	318. Torricelli	442. Dawes.
63. Arago	319. Theophilus.	466. Miiller
64 Ritter	320. Cyrillus.	486. Manners
65. Sabine	321. Catharina	

the sun is rising upon the lunar landscape. They are, probably, not due to mere differences of coloration in the lunar surface, for they are lost sight of as the sun rises; while the bright streaks radiating from some of the lunar

volcanoes, and other markings evidently due to differences of albedo, remain visible when the sun is at all altitudes.

One of the most remarkable of these veiled crater forms is traceable in the photograph on the Mare Tranquillitatis, a little to the west of the craters Arago (63) and Manners (186). In the photograph of the Messrs. Henry it is distinctly seen to be a double crater, surrounded by streaks or ridges which radiate from it. One of these, a double ridge, is well shown in our plate, trending up towards the circular crater Sabine (65). Though these ridges are not very lofty, they extend over an area which is very extensive compared with any of the volcanic areas on the earth. Thus the circular crater Theophilus (319) is stated by the Rev. T. W. Webb to be 64 miles in diameter—that is, it about corresponds in area to the county of Devon. The shallow or submerged crater on the Mare Tranquillitatis is nearly as large as Theophilus, and the ridges or lava streams which radiate from it extend over an area as large as Ireland.

In many instances we are able to determine the order in which lunar formations have made their appearance. Thus, Fracastorius (372), the great crater to the south of the Mare Nectaris, was evidently formed before the Mare Nectaris, or, at all events, before an overflow of matter from the Mare Nectaris broke into and partially obliterated the northern part of the ring about Fracastorius. It will be noticed, however, that the northern arc of the Fracastorius ring is still traceable, though it has evidently been much reduced in height by the matter which has overflowed from the Mare Nectaris. This is by no means a solitary instance; there are many other such partially obliterated rings upon the moon, indeed there are several traceable upon our plate—see the two half rings to the west of Maskelyne (57), and the incomplete large crater in the northern part of the Palus Somnii (F). The crater Jansen (66) seems also to have been partly broken in upon on its south-eastern side, that half of the ring being decidedly less lofty than the north-western half. There is also a partly obliterated large ring or polygonal area around Torricelli (318) in the Mare Frigoris, which seems to have been filled up with liquid matter, for the area within it is much smoother than the surrounding parts of the Mare Frigoris. The northern part of the outline of this area is more obliterated than the southern, as if the matter which filled up the crater had flowed into it from the direction of the Mare Tranquillitatis. On the other hand, the polygonal area may correspond to an overflow of matter from Torricelli (318) or to a crater which has been filled up by matter welling up from its own central orifice; but, if so, the polygonal crater must have been a mere depression without a surrounding wall. These partly obliterated crater forms, as well as the broken ring about Fracastorius (372), seem to point to the partial levelling of mountain forms by the action of a liquid which did not sweep away the ridges altogether and silt up the interiors of the craters, leaving no vestige of the previous formations, as might be expected if the obliterating action were due to water and the sediment deposited by water, but the submergence of the lunar formations seems to have been only partial, leaving relics of the previous formations which are clearly traceable on the new surface.

The theory that the lunar plains were formed by an outpouring of lava over an enormous area of the moon's surface would refer back their origin to a very early period in the moon's history, and the date of the formation of the craters invaded or partially obliterated by the lunar plains would be carried back to a still earlier period. It will be noted that these earlier craters do not present a distinctively rounded appearance indicating a

longer period of weathering, or any obvious characteristics which differentiate them in a striking manner from craters formed upon these lunar plains, of which there are many visible in our plate, ranging in size from the most minute cup-shaped depressions up to craters of the size of Plinius (61) and Arago (63).

There are also to be seen, standing upon the lunar plains, many walls and detached masses which one would not at first sight recognize as having a volcanic origin, unless they correspond on a gigantic scale to the fumaroles which are occasionally built up on terrestrial lava lakes. One of the most curious of these forms will be recognized on the photograph to the south of Jansen (66). It seems to consist of two walls which meet at an acute angle. It is very white, compared with the general tint of the Mare Tranquillitatis surrounding it, and from near the southernmost end of the longer branch a series of isolated masses are arranged in a line which trends off towards the south-east. There is another curious white wall standing out upon the plain between the Mare Tranquillitatis and the Mare Frigoris. It is a little to the west of the promontory which lies to the north-west of Hypatia (317), and a little further west of this is a curious bent wall, the northern and southern parts of which meet at an obtuse angle. They may possibly have formed the western boundary of a polygonal submerged crater somewhat similar to that around Torricelli, for there are traces of a southern wall joining up the southern end of the bent wall with a small craterlet on the edge of the rising ground to the west of Hypatia.

Stretching from the southern end of the white promontory to the south-west of Hypatia is a curious narrow dark line, which seems not to be due to any photographic defect. It skirts the high ground on the edge of the mare for a distance of more than a hundred miles, and ultimately seems to pass through or over a ridge to the south of Sabine (65). In connection with this dark line, I would call attention to a comparatively narrow dark marking which skirts the western edge of the Mare Nectaris. It is somewhat broader than the dark line on the edge of the Mare Tranquillitatis, but it seems to skirt the high ground in a somewhat similar manner.

Notice of Book.

An Account of British Flies (Diptera). Vol. I. By F. V. Theobald, B.A., F.E.S. (Elliot Stock).—Of this new venture, the introductory part of which we noticed at the time of its publication, the author has now completed his first volume. Thus far, six families have been dealt with, comprising chiefly the fleas and most of the so-called gnats. Mr. Theobald's subject in the present volume is in many respects a tempting one. The chief drawbacks the student has to encounter are the extreme fragility of the perfect insects, and the obscurity of their colours and forms. In fact, they do not look interesting, and this circumstance, coupled with the difficulty of their preservation, has no doubt acted largely as a bar to their systematic study in this country, so that probably at the present moment there are very few people to whom the group is other than a neglected one. And yet it has very much to recommend it. It would be difficult to find in any other order of insects six consecutive families which exhibit so great a variety of habits, or such remarkable diversities of life-history. Some of the species, moreover, are associated with extremely interesting biological problems, and amongst them are to be found several which have an immense influence on man and his works and ways. It

is often the case that the most insignificant and uninteresting-looking insects are just those that have the profoundest influence on the world around them, and are the most concerned in adjusting the relations between organic and inorganic nature. Few better exemplifications of this could be found than in these apparently uninteresting and fragile flies. Thoughts such as these, of the great variety of insect life and the wide-reaching power of little things, constantly rise before the mind as one reads this account of the first half of the British Nematocera, or "thread-horned flies." Thus, in the fleas, we have excellent instances of the animal parasite and all the annoyances occasioned by such habits; and yet the parasitism is imperfect, the insects living upon the blood of their victims only in their adult condition, while in their larval stage they are non-parasitic, and subsist on solid animal matters. Their wingless condition, too, no doubt connected with their parasitic habits, cannot but excite interest and stimulate speculation. In the next family we get into totally different surroundings. There we find the gall-gnats, which are associated with the vegetable world, and imitate the habits of the hymenopterous *Cynipida* by forming excrescences, beautiful or disfiguring, on various plants, and more or less interfere with their economy, by arresting their growth or rendering their reproductive function abortive. Amongst these are not merely the little gnats that produce the hairy galls so common on nettles, the rose-shaped galls on willows, the tufts on white-thorn branches, the swellings on the stems of aspen leaves, and many other more or less harmless monstrosities, but also such serious pests as the wheat midge and the notorious Hessian fly, which are so destructive to cereals. Amongst this same group, also, we find that most remarkable of phenomena, asexual generation, and that, too, not merely by an unfertilized adult, but even by a larva, the stage which is usually totally unconnected with the functions of reproduction. In the fungus gnats, so called from the food of the larvæ, we have the remarkable and utterly unexplained phenomenon of the migration of vast hosts of the maggot-like larvæ in one continuous line "from twelve to fourteen feet in length, two or three inches broad, and half an inch thick, containing countless numbers, as close together as they can be packed." To this long worm-like composite body, which looks like a thin grey snake slowly working its way over the ground at the rate of something under an inch per minute, has been given the name of "army-worm." In the *Bibionida* we have the so-called fever-fly, which does damage to the hop-gardens, as well as the black, sluggish, sprawling flies that often appear in countless numbers in our streets for a few days in spring or early summer, and then vanish as suddenly as they appeared. Perhaps the best known of these are the St. Mark's and St. John's flies, named from the regularity of their appearance about the time of the days sacred to those saints in the calendar. In the *Simuliida*, or sandflies, we pass into quite other surroundings again; for here we come across small flies which persecute man and beast after the fashion of mosquitoes. Here, too, we are introduced to the curious phenomenon of the assembling of the male flies in large numbers, to fly in circles round and round and execute the airy "dances" which are so fascinating to watch. And lastly, amongst the *Chironomida*, or midges, another set of dancers, we have the frequent inhabitants of the water-butt, the red, wriggling, aquatic larvæ called "bloodworms," which are incipient house builders, inhabiting, during their moments of leisure, tubes of their own construction at the bottom of the water. Their beautifully plumed locomotive pupæ, which are such familiar objects in ponds in spring, are still

more attractive, and nothing can be more beautiful than the delicate tracery of their cast skins as they float at the surface of the pond with their exquisite white rosettes of breathing hairs. This again is a group which, like the gall-gnats, has got into irregularities over their reproductive processes, and exhibits the phenomenon of parthenogenesis. We have, perhaps, said enough to show that this volume deals with subjects of much and varied interest, and to induce some to follow Mr. Theobald's guidance in undertaking the study of the group. Very much yet remains to be done before anything like finality is reached in our knowledge of British gnats, so that there are abundant prospects of reward in the discovery of new facts to anyone who has the time and patience to devote to what, it must be confessed, is a somewhat intricate study. A copious bibliography has been added for the benefit of the earnest student, and there are a number of illustrations explanatory of structural and anatomical points, as well as showing typical species. A little more care might usefully have been expended on "editing." There is a list of errata, but this might have been considerably augmented, there being many misprints not recognized therein, especially in the scientific names.

Science Notes.

Sir Joseph Hooker is publishing, with the aid of the staff of the Herbarium at Kew, an index to the names of all flowering plants. It will be published in four quarto volumes, and will be entitled "The Index Kewensis." Sir Joseph, in giving an account of the origin of this important work, says: "Shortly before his death Mr. Darwin informed me of his intention to devote a considerable sum in aid or furtherance of some work of utility to biological science; and to provide for its completion, should this not be accomplished during his lifetime. He further informed me that the difficulties he had experienced in accurately designating the many plants which he had studied, and ascertaining their native countries, had suggested to him the compilation of an index to the names and authorities of all known flowering plants and their countries, as a work of supreme importance to students of systematic and geographical botany, and to horticulturists, and as a fitting object of the fulfilment of his intentions. I have only to add that, at his request, I undertook to direct and supervise such a work."

In a recent number of the *Kew Bulletin* we have a remarkable illustration of the influence of mankind upon local climates. In Africa, the country between the Nile and the Red Sea is notable for its general barrenness. But the present condition of things has probably been brought about by human agency. In fact, this is largely proved by the names of localities. Thus, the Arabic names of the valleys are those denoting the names of trees, although now not a single tree is to be met with. It is suggested that the Arab and his camel have been the means of converting a wooded country into a waste. The camels eat the leaves and shoots of the trees, and the Arabs have burned the trees for charcoal.

At the Royal Society *soirée* on the 7th June, Captain McEnvoy exhibited the hydrophone, which, in connection with a new instrument named a kimesiscope, is intended to be used at night, or in foggy weather. It has for its object the prevention of surprise attacks from torpedo boats, or other hostile vessels approaching. It will give

warning of their movements when they are several miles distant, by ringing bells, flashing lights, &c. It may also be employed to warn vessels off dangerous points of the coast. Lord Kelvin exhibited illustrations of the molecular tactics of crystals, and Prof. H. G. Seeley exhibited fossil skulls from the Karoo rocks, Cape Colony.

One of the simplest methods by which micro-organisms can be removed from water is by the addition of alum. Experiments carried out at Leeds a few years ago showed that the addition of one-half a grain of alum to a gallon of water reduced the number of microbes by ninety-nine per cent., and the material has recently been used for purifying water on a large scale in America. It is found that in all cases after agitating water to which a small amount of alum has been added, an absolutely sterile liquid is obtained, though as many as 1200 microbes originally existed in a cubic centimetre (0.06 cubic inches).

At the Royal Society *soirée* on May 10th, Prof. Marshall Ward lectured upon his experiments on the action of light on the spores of bacteria and fungi. He has proved that solar and electric light rapidly kills such spores; hence "sweetness and light" were very appropriately coupled together by Matthew Arnold. The destruction of the spores seems to be a direct action of light, and not due to elevation of temperature, or to any indirect poisoning or starving process incident on changes in the food materials. By exposing parts of the same culture of the anthrax bacillus behind screens transmitting blue and violet rays, and behind screens which cut off those rays, it was found that the bactericidal action is almost entirely confined to light of high refrangibility. From observations of plants, it appears that the part of the chlorophyll which absorbs the blue-violet rays is a screen to prevent the destruction of easily oxidizable bodies as they are formed in the chloroplasts; indeed, Prof. Ward concludes that the colours of spores, pollen grains, &c., are of the nature of colour-screens, preventing the passage of those light-rays which would destroy reserve substances in the plant by promoting their rapid oxidation.

We recently referred to the scheme now in progress for obtaining motive power from the Niagara Falls. Mr. A. B. H. Thwaite has a plan for the distribution of electric power over a considerable portion of England. His idea is to burn the fuel at the mines, where it costs but little, and then to transmit the power resulting from the combustion of the coal (and gas) by high pressure alternating currents. He proposes to use gas engines of not more than 500 horse power to generate the currents. From one station he would supply the centres of industry of Lancashire and the area adjoining the Ship Canal; from a second, those of Yorkshire; from a third, those of the Midlands and London. This is a great scheme, but experiments might be made on a small scale in order to test its advantages.

Mr. Norman Lockyer writes in *Nature* of May 18th on "The Early Temple and Pyramid Builders." In his previous articles on Egyptian astronomy he has shown that it is possible to divide Egyptian temples into solar and stellar temples. In the present paper he states that the worship of the bull, Apis, preceded the building of the pyramids. The sun at the vernal equinox 1500 B.C. was in the constellation Taurus. Biot has shown that the equinox occurred with the sun near the Pleiades in 3285 B.C.

If all the rain that falls in a year were spread evenly over the surface upon which it was precipitated, the average depth of water in the area drained by the Thames would be twenty-eight inches. Compare this with the following remarkable diurnal rainfalls described by Mr. Clement L. Wragge, as occurring at Crohamhurst, on the western slope of Mount Blanc, in South-Eastern Queensland:—For 24 hours, ending 9 a.m. February 1st, 10.775 inches; ditto, February 2nd, 20.056 inches; ditto, February 3rd, 35.714 inches; ditto, February 4th, 10.760 inches. The rainfall of February 3rd is certainly one of the highest ever recorded, though it has been exceeded on the Khasi Hills of Bengal.

An Indian gazette gives an account of the protective effect of certain colours against the sun's rays. It is urged that no one has ever been a victim to sunstroke or sun fever through a dark source of heat, and it is asserted that the chemical rays do the mischief. A correspondent writes to say that he has had all the linings of his hats and coats made of yellow material, with the satisfactory result that after a trial of five years (often under circumstances of extreme exposure) he has had no return of either fever or sunstroke, to both of which he declares that he was previously a frequent victim.

Extremely useful high-temperature thermometers have been constructed by Messrs. Baly and Chorley by replacing mercury with an alloy of sodium and potassium, which is liquid at ordinary temperatures and remains so through a long range. When a very hard glass is employed to hold the liquid alloy, it becomes possible to determine directly the temperature of any source of heat up to 1150° Fahr.

Natural Science for June gives a translation of a paper by S. Carl Berg, from the *Anales de la Sociedad Científica Argentina* of November, 1892, in which the author describes cases of cannibalism among insects, which he has himself observed. The most voracious of the Noctuids, he says, is the caterpillar of *Heliothis armiger*; a single one of these consumed in twenty-four hours six or seven other caterpillars. Hitherto cannibalism among crickets has been noticed only among captives, but the author records a case among locusts in the free state. This was in the drought of 1883, in the Banda Oriental. He says, "I saw different attacks, in which the conquerors, two or three at a time, got hold of the weaker members of their own kind, throwing them over, and opening the abdomen in order to devour the entrails, these being the softer and more savoury portions, since they contained some of the vegetable food."

At a recent meeting of the Anthropological Institute, Dr. E. B. Tylor exhibited a collection of the stone implements of the Tasmanians, which are unground (*palæolithic*). Rough flakes of chert or mudstone, edged by chipping one stone with another, and grasped in the hand without any handle, they serve the purposes of notching trees for climbing, cutting up game, and scraping spears and clubs. The Tasmanians seem to have kept up this rudimentary art until the present century; and perhaps their state of civilization may throw some light on that of the palæolithic age in Europe.

Professor Dewar, at a recent Royal Institution lecture, showed an air barometer which could measure differences of pressure in a column of air as small as one-millionth of an atmosphere. With a water barometer, which is thirteen times more sensitive than a mercury barometer, such a difference could not even be detected.

A discussion by Lieutenant-General Strachey, of the daily curves of temperature made at Greenwich Observatory for twenty years, shows that the time of afternoon mean temperature throughout the year is a little before or after 7 p.m. In the summer the time of absolute minimum is between the hours of 3 a.m. and 6 a.m. Sunrise in December is about an hour and a half before the time of mean temperature; while in June it is more than four hours earlier. In the former month sunset is rather more than three hours before the time of mean afternoon temperature, and in the latter it is about half an hour after that time.

Letters.

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

To the Editor of KNOWLEDGE.

DEAR SIR,—To designate the point nearest to the sun of a planet's orbit the word "perihelion" is used. Similarly for the moon the word "perigee," for a star the word "periastron," and for one of Jupiter's satellites the hybrid word "perijove." I do not know what the proper words are in the cases of the satellites of Mars, Saturn, Uranus, and Neptune. Would it not be better, and more convenient, to have one word which could be used in every case; say, some word derived from the Greek meaning "nearest to the focus"? I have forgotten (if I ever knew) the Greek for focus, but I suppose there is some word. In default of a word for focus, "pericentre" (κέντρον) might be used; "centre," of course, being used in the sense of centre of force. Can you suggest a word?

Yours truly,

4th June.

J. R. HOLT.

To the Editor of KNOWLEDGE.

DEAR SIR,—Would you kindly correct, in the next number, the following mistakes which have been made, mostly in the printing of the tables:—

Page 115, second column, line 34, instead of "Bradley-Draper," read "B. D. (Bonner Durchmusterung)."

Page 117, Table 9 is incomplete: add—

Limits in δ	Limits in α .	Q	n .
+ 20° to + 60°	22 ^h 42 ^m — 3 ^h 29 ^m	1.43	57.7
..	3 29 — 8 15	0.90	31.7
..	8 15 — 13 25	0.64	42.7
..	13 25 — 17 59	0.71	55.8
..	17 59 — 22 42	1.07	48.4
+ 60 to + 90°	0 0 — 24 0	1.64	47.5

Page 118, Table 11 is omitted. Read—

Result for the mean value of τ = 0.082
 230 Stars of Type I gave q = + 0.062.
 338 .. Type II. .. q = + 0.074.

Page 118, second column, line 7, instead of "mean mag. 3.6," read "3.9."

Page 118, Table 12, the letters τ and μ to be interchanged.

Page 118, second column footnote, add these words—
 "The necessity of a correction of the constant of precession, alluded to before, is evident from the values of τ in this table."

By making these corrections, you will oblige,

Yours sincerely,

Groningen, 3rd June, 1893.

J. C. KAPTEYN.

To the Editor of KNOWLEDGE.

SIR,—Mr. Monck expresses a doubt in his letter on "Sirian and Solar Stars," in your June issue, as to the

continuous diminution in the proportion of Sirian stars as we pass outwards from the plane of the Galaxy toward the galactic poles, such as would result from a continuous diminution in photographic brightness, found by Prof. Kapteyn.

Without identifying myself with Prof. Kapteyn's position, I may state as a simple fact that such a diminution in the proportion of Sirian stars in passing from the Galaxy to its poles does not occur; but that a diminution does take place as we move from a zone included between 30 S. galactic latitude and the southern edge of the Galaxy in the direction of the galactic poles. The following table shows the position:—

Class.	N. G. P. 70°	75°	80°	to N. edge of Galaxy.	S. edge of Galaxy to 60°	65°	70°	75°	S. G. P.
AB	55.5	65.1	51.9	64.3	69.8	74.6	58.0	48.6	50.0
EEG	20.2	12.7	18.7	15.6	15.8	11.2	20.6	24.6	18.4
HIK	21.8	20.6	26.4	18.8	12.4	13.4	19.1	24.0	30.6

The above table I formed last summer when constructing charts of the Draper catalogue stars, described in the paper "On the Distribution of Stellar Types in Space" (*Astronomy and Astro-Physics*, January, 1893), in which the stars were inserted according to spectrum; and the set from which the above proportions are taken excludes all stars the "observed brightness" of whose spectra falls below 6.5 on a scale of 4.0 = bright, 8.0 = faint, adopted by Pickering, 6.5 being the limit at which the spectrum of the star could be deciphered reliably.

The region recognized as the Galaxy is that of Proctor's Atlas.

As Pickering's galactic divisions "M" (*Annals Harr. Col. Obs.*, Vol. xxvi., Table xli.) include 2804 stars against 1208 present in the Galaxy of Proctor's Atlas, the fact that his percentages are

A	F	EG	HIK
63	11	65	16

against my

A	F	EG	HIK
662	112	646	124

shows that the extension on each side of the Galaxy brings a diminution in the proportion of Sirians for "observed brightness" 6.5, as compared with the more limited area of the Galaxy used by me. The theory of galactic condensation derives no support from the extension of the galactic area, as Mr. Monck supposed.

The following table for stellar magnitude down to 5.99 (*Harr. Photom.*) brings me into strict line with Mr. Monck's argument, who is working at that limit:—

Class.	N. G. P. 70°	75°	80°	to N. edge of Galaxy.	S. edge of Galaxy to 60°	65°	70°	75°	S. G. P.
AB	630	700	600	697	707	80.8	680	540	590
EEG	330	170	151	142	144	8.1	9.8	230	190
HIK	40	120	224	170	113	8.5	196	250	190
	24	71	152	224	270	270	112	69	16

1208 stars.

The first table, however, furnishes a more satisfactory induction, considering that the number of stars employed is almost four times as great, and we have Prof. Pickering's assurance of the reliability of the spectrum-reading at the limit of "observed brightness" used.

It will be seen that the diminution is not "continuous," nor could it well be expected to be so, for the condensation of Sirian stars about the Galaxy does not conform with any symmetry to the lie of the galactic plane, not to speak of extra-galactic condensations of a thoroughly local, though extensive nature. In fact, comparison of the contents of zones upon galactic co-ordinates, where the contents are so unevenly distributed along the zone, as they are for the stars of the Draper catalogue, can only serve to level the inequalities of distribution which it is the set purpose of such comparisons to detect.

There is a zone to which the main line of condensation of Sirians conforms, and that zone is the great belt of bright stars. This accounts for the fact that the axis of

condensation in the rich Sirian region (Puppis) Canis, Orion, Taurus, lies off the southern border of the Galaxy before cutting through it in Perseus and Cassiopeia, whilst after that point the whole mass of Sirian condensation passes north of the southern edge of the Galaxy, from which it recedes further northward as we descend through Cepheus, Cygnus, Lyra, Hercules, and Ophiuchus to Scorpio, the southern limit of the Draper catalogue. There is not a doubt that the completion of the Harvard spectroscopic survey will show the main line of Sirian condensation to be coincident with the great belt throughout its course.

Mr. Monck says that Solars seem to preponderate in Sobieski's Shield. As may be seen from the curves of distribution published with the paper mentioned, there is a very decided preponderance of Solars in this region, and, as I remarked at the time, this is the only point where the Solars gain supremacy over the Sirians in the Galaxy, a fact more remarkable still when it is remembered that this rich solar group, unique in its nature, lies immediately off the break, equally unique, which occurs in the great belt of bright stars in its passage through Ophiuchus. If this break be not physical, then it can be optically produced only by the proximity of the sun to the great belt at this point, causing an apparent dispersion of its constituent stars; and this solar group, I feel sure, is in some way involved. I am, Sir, yours faithfully,

Stretford, Lancashire, J. MACLAIR BORASTON.
June 6th, 1893.

To the Editor of KNOWLEDGE.

Groningen, 12th June, 1893.

DEAR SIR,—Will you allow me some space to say a couple of words in answer to some remarks made by Mr. Monck in the April and June numbers of KNOWLEDGE.

In the first, he remarks that it seems as if the diminishing of the difference between the photometric and photographic magnitudes, as we pass outward from the Galaxy, might be explained by systematic error in the eye estimations of the stars in the Galaxy.

To a great extent this must doubtless be conceded. It can only be called in question if the *direction* and the *amount* of this systematic error, as determined by photometric methods, proves sufficient to explain the divergencies found. My discussion of the whole matter has been published in the "Bull. du Com. intern. pour l'exéc. fotogr. de la Carte du Ciel," tome II. (1892).

In consulting this publication Mr. Monck will find that I carefully considered this point, with the result that, as the photometric observations as yet published seem to make it inadmissible to attribute to the error in question a value exceeding 0.2 m. or 0.3 m., this error is insufficient to cover the facts.

In regard to the letter inserted in the June number, I may say at once that I am fully aware of the fact that several points investigated by myself, in respect to the distribution of stars in space, have been independently suggested by Mr. Monck, and I feel very happy to find our results in general mutually confirmed. This extends to the remark made by him about the distinction to be drawn between Capellan and Arcturian stars. Though I was led to this same conclusion, even at the time of my first publication, I have not as yet published anything about it because I hoped to be able shortly to investigate a far greater number of stars, and especially because Prof. Pickering's sub-classes are less trustworthy and to a large extent dependent on the magnitude. Now that attention has been called to the fact it may be well to state the rude results arrived at.

Of 371 stars of the 2nd type with proper motions exceeding 0".16 (Stumpe's stars)

40	per cent.	belong to	Pickering's	class	F
18	"	"	"	"	G
12	"	"	"	"	K

Prof. Pickering finds for *all* his stars (without regard to proper motion)

22	per cent.	belonging to	class	F
26	"	"	"	G
52	"	"	"	K

So that, of the stars of the 2nd type, those of the class F seem to be especially condensed about the sun.

I feel less inclined to agree with Mr. Monck about the question of the equality of the absolute velocity of the 1st and 2nd type stars, and I think he exaggerates our ignorance on this point. I feel somewhat confident that, after having carefully considered the proof of my Prop. X. in the June number, he will agree with Miss Clerke that it is difficult to contest, in the present state of knowledge, the conclusion that stellar rates of travel are independent of spectral distinction.

In conclusion, I may perhaps be allowed to state more clearly than I have perhaps done as yet, that my paper on the systematic difference of photographic and visual magnitudes in various parts of the sky, as well as those on the distribution of stars in space, are to be considered as *provisional* only—several points require a more exhaustive research, partly to be based on yet more extensive materials.

Especially the question, "Is it true that galactic and extra-galactic stars have equal linear velocities, and if not, in what proportion do they vary?" seems to call for a far more exhaustive investigation. Only the consideration that these investigations will take of necessity a very considerable time, has determined me in publishing results that cannot be considered as quite definitive.

Yours sincerely, J. C. KAPTEYN.

THE GOVERNMENTAL INQUIRY AND THE FIELD-VOLES.

By W. F. KIRBY, F.L.S., F.E.S., *Assistant in the Zoological Department, British Museum (Natural History), South Kensington.*

BLUE-BOOKS dealing with scientific subjects are more common now than formerly, and much information which will be useful both to naturalists and agriculturists has been brought together in a convenient form, in the recently published "Report of the Departmental Committee appointed by the Board of Agriculture to inquire into a plague of field-voles in Scotland, with minutes of evidence and appendices, and a copy of the minute appointing the Committee."

The field-voles are small animals resembling mice, which appear from time to time in enormous numbers in various countries, and cause very serious injury to the crops. During 1891 and 1892, the southern counties of Scotland have been devastated by the short-tailed field-vole, and, according to Mr. R. F. Dudgeon's estimates, drawn up early in 1892, "in Roxburghshire, 30,000 to 40,000 acres had been affected, of which he considered 12,000 to 15,000 acres had been rendered useless; in Dumfriesshire, 40,000 to 50,000 acres, and in the stewartry of Kirkcudbright, 10,000 to 12,000 acres were described by him as infested by voles."

So serious became the evil that a Committee of Inquiry was appointed by a minute dated the 28th May, 1892; and it is their report which has just been issued. In the spring of 1892, Dr. Loeffler, a German bacteriologist, announced that he had discovered a new bacillus, producing a disease

which he called "mouse-typhus," in mice and voles, when swallowed by them, but perfectly innocuous, so far as yet known, to all other animals. At this time the Plain of Larissa, in Thessaly, was suffering from a plague of voles, and Dr. Loeffler was invited by the Greek Government to apply his new method of destroying them in that country, which he afterwards claimed to have done with perfect success.

In January, 1893, Sir Herbert Eustace Maxwell, the Chairman of the Committee of Inquiry into the plague of voles in Scotland, and Mr. James Edmund Harting, Librarian of the Linnaean Society, and Secretary to the aforesaid Committee, proceeded to Greece to make inquiries on the spot into the practical success of Dr. Loeffler's method, and on its applicability to Scotland. Their verdict is one of "not proven." Yet the evidence adduced appears to show that the pest was noticeably diminished, and that the remedy was perfectly safe. The apathy of the natives is admitted, and although the infection is probably spread owing to healthy voles devouring their sick comrades, this is discredited, because it does not appear to have been observed among voles in a state of nature. Such a pest could not be stamped out without the remedy being applied thoroughly and on a large scale, for the voles in surrounding fields would soon overrun the fields which had been cleared of the pest. One large land-owner alone, M. Anastasiades, whose estate of 7500 acres had been cleared of the voles by Dr. Loeffler's method, expressed himself fully satisfied with the result. Is there any proof that if the same method had been honestly applied to other estates, the result would not have been equally satisfactory?

We are told that the peasants, both Christians and Mohammedans, look upon the pest as a visitation of God; and that the Mohammedans were about to send a ship to fetch "holy water" from Mecca to stay the calamity. This is not the spirit of persons who would give reliable evidence on the success or non-success of a scientific remedy.

Although Dr. Loeffler reports that Scottish voles are just as susceptible to the virus as other species, the Committee pronounce against his method for three different reasons.

FIRSTLY:—The expense (or estimated expense) would render it inapplicable to Scottish hill pastures.

SECONDLY:—"Mouse-typhus is not contagious; it can only be communicated to those animals that will swallow some of the virus. The allegation that healthy voles will become infected by devouring the bodies of the dead has not been satisfactorily proved. That Greek voles, when in captivity, have been observed to feed upon the corpses of their fellows, hardly warrants the assumption that Scottish voles, in a state of liberty, will do the same; and unless the disease were communicable from one animal to the other, it is not easy to see how the remedy could prove effective on extensive hill pastures."

Of course, unless the remedy could be applied universally, it would not exterminate the voles, or prevent immigration from adjoining districts; but it might materially reduce their numbers. As for the doubt that Scottish voles would devour their dead and dying fellows, it ought not to have been expressed in the absence of such an easy experiment, which in all probability Dr. Loeffler has already made. Why should not Scottish voles possess the cannibal propensities of other voles and mice? Even the common mouse will devour those of its own kind which it finds in spring traps, as every housewife must be aware.

THIRDLY:—"The fluid loses its value in about eight days after preparation; consequently much disappointment

might ensue if, after a supply had been obtained, a fall of snow or wet weather were to interfere with its distribution over the land."

This statement is not clearly explained, but probably refers to fluid prepared in large quantities, and exposed to the air. There is no reason, that we are aware of, why virus enclosed in hermetically-sealed glass tubes should not preserve its infective properties for a much longer period. The rest of this objection simply indicates settled weather as the best time for making the experiment. It is clear that if a piece of ground, swarming with voles, was charged with infected bread, the voles would not wait so long as eight days to devour it, if they touched it at all.

The Committee practically confine themselves to advising "periodical and timely burning of grass and heather, followed by active pursuit of the vermin by men using wooden spades and dogs"; and they also advise the protection of owls and other natural enemies of the voles. But why did they not begin by obtaining a supply of the virus from Dr. Loeffler (especially as it is acknowledged to be quite harmless to all the larger animals at least), and experiment with it in Scotland on a small scale in the first instance, and then report on the results? Would it not have been more satisfactory to have done this before travelling to Greece to make inquiries through interpreters, obtain doubtful evidence, and then pronounce against a method which certainly appears to deserve a fair trial in Scotland, whether it was fairly tried in Thessaly or not!

CHEMISTRY AND CUISINE.

By VAUGHAN CORNISH, M.Sc., F.C.S.

THE male portion of mankind seldom inquire too closely as to the means by which its food has been prepared. Our diet, indeed, is so varied that it is not a very easy matter to find out what quantities of the necessary food-stuffs one has eaten during the day. It is, however, worth while to take the requisite trouble to find this out, more particularly for the numerous class of men of sedentary habits who often have the idea that they are over-eating themselves, and who are so frequently assured by anxious relatives that they "don't eat *half* enough."

The weight of food taken during the day may be most readily determined by using one of the spring balances employed for weighing letters and parcels. The plate or cup, with its charge of food, may be placed upon the disc of the letter-weighing balance, and after the experimenter has eaten all or such part as satisfies him, the plate or cup is again placed on the disc, and the difference of the two weighings is entered in a note book. With the spring balance the weight is read off at once on the dial, so that the weighing can be done sufficiently quickly not to let the food get cold.

Having thus conscientiously recorded the amount of food, solid and liquid, taken in a day, the next thing to do is to calculate out the amount of the various "food-stuffs" in the daily ration, and compare them with a standard ration such as may be found in a book on the chemistry of food. The daily ration required by a man depends upon the daily bodily waste, which, again, depends upon the weight and upon the amount of bodily work done.

The standard ration given below is calculated for an eleven stone man supposed to be taking moderate exercise. If hard bodily work is to be done, the amount of food containing starch and fat must be increased.

Though our foods are so varied, the different kinds of feeding materials or "food-stuffs" they contain are few,

or at least for practical purposes may be reckoned under a few heads. Thus—

FOOD-STUFFS are—

1. Albuminoids and other substances containing nitrogen.
2. Fat, starch, and sugar.
3. Mineral substances, chiefly common salt and phosphates.
4. Water.
5. Food adjuncts.

The principal functions of the above classes of food-stuffs are as follows :—

1. Albuminoids, &c., are oxidized by the air which is inhaled into the body, and go to form the muscle and flesh. The process of oxidation gives out heat, and hence these *flesh-forming* foods assist also to keep up the heat of the body.

2. Fat, starch, and sugar are oxidized in the body, thereby acting as *heat-givers*, but they do not form muscle and flesh. In hard bodily work it is necessary to increase the supply of heat-giving food. The waste of muscle and flesh does not increase with increased bodily labour in nearly the same proportion as does the demand upon the heat of the body. Fat has about $2\frac{1}{3}$ times the warming power of starch and sugar, there being a larger proportion of carbon and hydrogen to be oxidized. Hence fat is the principal food-stuff to be added to the diet to meet the demand of extra bodily work or the corresponding tax of a colder climate. Fat can be stored up in the body (as a layer under the skin), where it acts as a store of heat-giving material which can be drawn upon as required by the system.

3. Of the mineral substances taken into the body the lime salts and phosphates form the solid fabric of the bones.

4. Water constitutes about two-thirds by weight of the substances of the body. The water taken in as food is required both as a constituent of the body and also as a carrier of food in and through the system.

5. Food adjuncts are of importance more on account of their effects (whether stimulating or sedative) upon the nervous system and on account of their effect on the palate than for any actual power of nourishing or sustaining the fabric of the body. The most important are alcohol, and the alkaloids contained in tea, coffee, and cacao.

The daily ration of an adult under ordinary conditions, according to Prof. Church, should contain the different food-stuffs in *about* the following quantities :—

DAILY RATION.

1. Water	88·66 oz. avoirdupois
2. Albuminoids	4·25 ..
3. Starch and sugar	11·40 ..
4. Fat	3·77 ..
5. Mineral food	1·03 ..

109·11

The small quantity of food adjuncts is not included in the above table. The actual weight of food eaten will exceed the above total by about one ounce on account of fibrous material, either vegetable or animal, which is taken with the food, but which is not assimilated by the body. The food-stuffs 3 and 4 have the same function, viz., that of keeping up the heat of the body. Weight for weight, fat has about $2\frac{1}{3}$ times the heating power of starch. As starchy and fatty foods are to some extent interchangeable in diet, a convenient way of expressing the daily ration is to multiply the amount of fat by $2\frac{1}{3}$, which gives the quantity of starch equal to the fat in heat-giving value. In the above case the amount of fat is 3·77, which,

multiplied by $2\frac{1}{3}$, gives 8·8, which, added to 11·40, the amount of starch and sugar, gives a total of 20·2 ounces of heat-giving food *reckoned as starch*. We may, therefore, write the daily ration thus—

Water.	Flesh-formers.	Heat-givers (reckoned as starch).	Minerals.
88·66	4·25	20·2	1·03

Let us now return to the practical calculation of the quantities of the food-stuffs contained in a day's diet, the weight of which we have supposed to be taken during meals by aid of the spring letter-balance. This may be done by setting out the results of the weighings in a tabular form as follows :—On the left, in the first vertical column, set down the names of the various foods eaten; bread, butter, milk, &c. In column 2 set down opposite the names of the foods the weight of each which has been eaten during the day. In some work on the chemistry or the composition of foods find the percentage composition of the food eaten, and hence calculate the weight of each food-stuff in the several articles of food taken. Enter the water in vertical column number 3, the flesh-formers in column 4, the heat-formers in column 5, and the minerals in column 6. The vertical columns are then added up and we obtain at the foot of column 2 the total weight of food taken, and at the foot of the other columns the total weight of each food-stuff. It then remains to compare the results obtained with the standard ration given above, or with some other ration suited to the particular nature of the daily employment of the person. Of course it is not only the quantity of the food-stuffs which has to be taken into account in judging whether the diet is a suitable one or not; we must also take account of the proportion between the amounts of the different food-stuffs. The most important ratio, the actual value of which should, however, depend upon the amount of bodily work done, is the ratio of flesh-formers to heat-givers. If the fat be calculated according to its "starch equivalent," the ratio should be about $1:4\frac{3}{4}$. The ratio of flesh-formers to heat-givers is termed the *nutrient ratio*, and a table of the nutrient ratio of different classes of food is a valuable guide in the determination of a diet. Such knowledge is absolutely necessary where a uniform diet has to be prescribed for persons who are not at liberty to select and vary their food according to their inclination, as, for instance, prisoners. Generally speaking, the flesh-forming foods containing nitrogen are the most expensive. Nitrogen, though so abundant in its uncombined and inert form in the air, generally becomes expensive when wanted for any useful purpose, whether as manure for the land or as food for man. How this curious fact comes about we hope to have another opportunity of explaining. The most important flesh-formers are the lean of meat and green vegetables. The starchy foods, as rice and potatoes, are generally speaking cheap and easily obtained. The fat of meat supplies the heat-givers in a more concentrated form, though not so cheaply. The form in which the various food-stuffs may be taken must depend largely upon the mode of life. Thus, a labouring man who works in the fields may make his dinner off a dish of cabbage and fat bacon, deriving the flesh-formers from the vegetable and the heat-givers from the animal food. For men of sedentary habits such a combination would be scarcely suitable. A lean chop with potatoes—a very usual luncheon for a business man—supplies the same food-stuffs in a lighter form. In this case the flesh-formers are derived from the animal food and the heat-givers from the vegetable. Needless to say, this is a more expensive meal than the first. Cheese is one of the cheapest forms of nitrogenous food, and may be taken as a substitute for lean meat.

The agricultural labourer is too poorly paid often to afford lean fresh meat, but the nature of his occupation enables him to consume a quantity of hard cheese such as would be impossible for persons engaged in the more highly paid but sedentary occupations.

The effect of *cooking* is, in the first place, to soften the food, and thus render it easier to masticate. The heat may be applied as dry heat as in roasting, or moist heat as in steaming, but in either case the large quantity of water which is contained in all foods makes the various processes of cooking largely a matter of steaming. This assists the softening of the fibres, &c. Another important change produced by the action of heat is the solidification of the albuminous material which forms so important a constituent of lean meat and of the other flesh-forming foods. The coagulation of the albumen is familiar to all in the process of boiling an egg, the boiling temperature being necessary in order that the white shall "set." The same setting of the albumen in meat occurs at the surface of the meat during the roasting of a joint. In this process, in which the object is not to extract but to retain all the goodness of the meat, a fierce heat is at first applied all round the surface of the joint. This solidifies the albumen near the surface of the joint. The joint is then moved rather further from the fire, and cooked at a somewhat lower temperature. A great deal of water evaporates from the meat, but most of the juices are confined in the joint by means of the bag or sack of coagulated albumen. If the joint were kept too near a hot fire after the first coating of coagulated albumen has been formed the coagulation would go on throughout the joint, and the meat would become hard and indigestible. When a well-cooked leg of mutton is cut it is full of juices, which flow out readily. If the joint had been put down before a slow fire, and at some distance from it, the water drawn out of the joint by the heat would have carried with it much of the juice and of the fat which should be kept in by the coagulated albumen. In those processes of cooking in which the object is to extract the juices from the meat, the coagulation of the albumen has to be avoided. In cooking starchy food, such as potatoes, the most important change produced by the heat is the swelling up and bursting of the starch granules, producing a light and floury consistency, a change which is necessary if starch is to be digestible. In order to effect this bursting of the starch granules, a temperature as high as boiling point of water must be used; hence the rule that vegetables always require, for a part of the time of cooking at any rate, a high temperature equal to that of boiling water, but that meat should, as a rule, be cooked at a temperature below that of boiling water.

ON SOME RECENT INVESTIGATIONS OF THE GEOLOGY OF THE PUNJAB SALT RANGE.

By G. W. BULMAN, M.A., B.Sc.

THE Salt Range is one of the many special features of interest in Indian geology: many new geological ideas are suggested by a study of its various formations. In the rocks of the Salt Range, Dr. Waagen made his important discovery of *ammonites* associated with *productus*, *spirifer*, *streptorhynchus*, &c.—in other words, they contain rocks of carboniferous age; in them Dr. Oldham found indications of a palæozoic ice age in India, in the form of the celebrated boulder bed. In them, again, Dr. Warth has discovered the first remains of *trilobites* yielded by Indian rocks, and in the Salt

Range the almost universal break between the palæozoic and mesozoic rocks is absent; carboniferous rocks pass up without interruption into triassic.

Among the more special features of interest in the rocks of the Salt Range may be mentioned: (1) the clear and unbroken succession of the different systems, uncomplicated by igneous intrusions, and unobscured by metamorphism or crumpling; (2) the distinctness of the sections owing to the absence of vegetation, and the well-marked colours of the different formations; (3) the occurrence in the carboniferous system, along with its own characteristic fossils, of *ammonites*, and the distinctly triassic form *ceratites*; (4) the peculiar nature of certain beds—as, for example, the palæozoic boulder-clay known as the boulder bed, and the salt marl.

Two interesting and very suggestive papers on these rocks were published in the "Records of the Geological Survey of India" for 1891.

In the first of these, Mr. Middlemiss refers to the vivid impression produced by the first sight of the wonderful features of the Salt Range, where in a single section the eye can take in a series of sharply-defined formations, ranging from palæozoic to tertiary, and following each other in apparently unbroken succession; where we may see series of strata as free "from the dust of time as an uncut volume fresh from the binder's hands." One of the main objects of Mr. Middlemiss's survey of the Salt Range was to verify Dr. Warth's discovery of fragments of trilobites (*conocephalites* and *oleuus*): and this was fully accomplished, fragments of trilobites and brachiopoda having been found, fixing the age of the rocks in which they occur as Cambrian. A remarkable fact about these ancient rocks is that, in spite of their great age, they have been unaffected by disturbances of the earth's crust during the whole of the enormous period which has elapsed since their formation.

The more important features in the two papers referred to are the investigations of the lower bed known as the salt marl.

In the "Manual of the Geology of India," the remarkable resemblance of this formation, with its thick beds of rock salt, its gypsum, and its anhydrite, to the trias of our own country is pointed out, and a similar origin suggested. In other words, this salt marl, of probably Cambrian age, is supposed to have originated in a salt lake or lakes. The main point in Mr. Middlemiss's interesting paper is the total rejection of the marine hypothesis, and the suggestion that the salt marl has originated from what may be termed smothered volcanic action.

Mr. Middlemiss notes the following points which seem to be inconsistent with the idea that the salt marl is of Cambrian age and of sedimentary origin:—

1. Its soft and homogeneous nature.
2. The absence of definite stratification.
3. Its method of occurring mixed up with different formations.
4. The occurrence on the other side of the Indus of other salt-bearing beds, only a short distance off, and yet supposed to be of tertiary age.

In its structure and composition the salt marl is a remarkable formation. It is a soft red marl, associated with immense masses of rock salt and gypsum. Except where it encloses masses of dolomitic rock, or where associated with beds of gypsum and rock salt, it never shows any signs of stratification, or traces of divisional planes. Seen even in large masses on the hill-sides it shows no structural planes; nor does it exhibit any trace of colour banding. Another peculiarity is the absence of grains of sand and pebbles of foreign origin, which shows

that it is not a sedimentary rock. The total absence of organic remains tends to the same conclusion. There is, in fact, a lack of all positive evidence for a sedimentary origin of these beds.

Gypsum and dolomite occur in the red marl in a remarkable manner, which receives from Mr. Middlemiss an ingenious explanation in accordance with his view as to the origin of the formation. The gypsum occurs as a network, or sponge-work of anastomosing strings; the dolomite in vesicular or honey-combed lumps of irregular shape and size. Besides these, there occur in the marl numerous pale greenish-grey patches, varying in size from an inch across to mere specks. Every gradation may be traced from these to the honey-combed dolomite. As the latter become more honey-combed, they split up into corroded fragments of dolomite, and these latter, again, into the greenish grey specks and patches. They become, in fact, a part of the marl. As Mr. Middlemiss remarks, the red marl "seems to have devoured the dolomite, to have absorbed or digested it just as a pot of molten lead absorbs the solid bits thrown into it."

A parallel change from dolomite to gypsum also occurs. Roughly-bedded dolomite, solid in its central portion, is found to be crumbling and honey-combed at the edges. The following series of changes occur:—

First, the hard, flinty-looking rock becomes dotted with minute punctures in rows or nebulous patches. Then larger ragged holes appear, themselves bordered by minute punctures. Canals, sometimes roughly following the joint planes of the dolomite, join these larger holes. Another phase in the gradual change is dolomite with a honey-combed structure. The joint planes are converted into widened fissures, and along the cracks and holes gypsum takes the place of the dolomite. Finally lumps of dolomite are honey-combed to a spongy, and then to a reticulate fibrous texture, the holes and meshes being occupied by gypsum.

The general position and stratigraphical relations of the salt marl furnish further arguments against its sedimentary origin. Above the red marl lies the purple sandstone, and it has been held that there is a normal passage of the red marl into the purple sandstone, such as to indicate a continuous sequence between the two formations. Mr. Middlemiss contends that there is not such a normal passage. Continuous sequence, he asserts, is best shown by the *interbedding* of the one formation with the other; alternating layers of the one and the other dovetailing the two formations together. This is not found; nor could Mr. Middlemiss satisfy himself that there is any rock intermediate in composition between the marl and the sandstone between them. In exposed sections showing the junction, it is pointed out that the layer of rock marking the junction is brecciated. In one section the junction-marking breccia of fragments of purple sandstone in a matrix of marl is explained by Mr. Middlemiss as possessing the appearance of one formed by *the intrusion of one rock into another*.

Other sections are brought forward to show that the red marl must have possessed a plasticity and power of movement *after* the deposition of many of the formations above it. Where the marl is overlaid by a boulder bed, the latter never contains fragments or boulders of marl. At the same time the boulder bed does contain fragments of dolomite similar to the unaltered portion of the dolomite of the red marl. From this Mr. Middlemiss infers that the dolomite of the red marl represents an original rock at least older than the boulder bed; while the red marl, gypsum, and altered dolomite are of more recent age. And in a section where the marl occupies the core of a

sigma-flexure, while the other formations included in the flexure are sheared, the marl is not. The conclusion from such a section seems to be that the marl band had been forced in a plastic or liquid condition among the other rocks, and had solidified under conditions of no strain. In another section the red marl exhibits one of the distinguishing characters of intrusive rocks; it alters its horizon with regard to the accompanying sedimentary beds—that is to say, from a position in one place below the speckled sandstone, it passes to one above it. In other places the salt marl is overlaid by the orange series (younger tertiary), and it is concluded that the junction cannot be a normal one due to the deposition of these beds on an exposed reef of salt marl.

To account for all the above remarkable, and on the sedimentary theory anomalous, features of the red marl of the Salt Range, Mr. Middlemiss suggests a remarkable hypothesis of arrested volcanic action. The striking absence of all outward tokens of volcanic activity, metamorphism and disturbance generally, in the region under consideration is pointed out. Thus it would appear that the subterranean magmas have remained sealed up since the earliest era of sedimentation; but the upper surface of the molten mass would solidify, and it is suggested that the scum thus formed is represented by the salt marl. The dolomitic masses are accounted for by the alteration produced on overlying dolomitic rocks by this subterranean mass.

In the second paper, Mr. Holland furnishes some interesting notes on the chemical and physical characters of rock specimens from the Salt Range, and in a certain degree confirms the hypothesis suggested by Mr. Middlemiss. We have first an examination of the bi-pyramidal quartz crystals, the "Marl diamonds" of the natives. These crystals are found embedded in the gypsum, and vary in size from a millet seed to that of a walnut. In colour they vary from white through shades of pink to brick red, and in the centre of each crystal there is a white or pink translucent core. The perfection of the crystals, and the absence of all traces of rounding, is held to be rather characteristic of their formation in a yielding liquid magma than in an ordinary sedimentary formation. Microscopical examination and analysis showed that these translucent cores are due to inclusions of anhydrite. The conclusion to be derived from this seems to be that the quartz crystals were formed in the midst of a matrix of anhydrite, and that afterwards the anhydrite was hydrated to gypsum; and a study of the gypsum itself shows clearly that it has been formed by the action of water on anhydrite. Specimens examined were found to be partly anhydrite and partly gypsum. In some the alteration to gypsum occurred along cracks and cleavage planes. The expansion which accompanies this change has left its mark, and displacements of fragments, faulting of twinning and cleavage planes, are observable under the microscope. In some cases the crystals have been fractured, and the fragments scattered along lines so as to produce a foliated structure, sometimes observable in hand specimens.

Mr. Holland concludes from his studies that the gypsum masses are not of aqueous or sedimentary origin. He suggests further that the anhydrite may have been produced by the action of sulphuric acid on limestone at high temperatures, and with presence of superheated waters.

As to Mr. Middlemiss's hypothesis of arrested volcanic action opinions may differ, but it must be admitted that these two papers render extremely probable the conclusion that the red marl of the Salt Range is not an ordinary sedimentary rock.

THE FACE OF THE SKY FOR JULY.

By HERBERT SADLER, F.R.A.S.

SUNSPOTS are still very prevalent. There is no real light till after the 20th of July, but either daylight or twilight. A maximum of the beautiful red variable star, R Leonis, occurs on July 1th.

Mercury is an evening star, and sets on the 1st at 9h. 43m. P.M., or 1h. 26m. after the Sun, with a northern declination of 20° 23', and an apparent diameter of 6 $\frac{1}{2}$ " $\frac{5}{100}$ ths of the disc being illuminated. On the 5th he sets at 9h. 36m. P.M., or 1h. 20m. after sunset, with a northern declination of 19° 2', and an apparent diameter of 7 $\frac{1}{4}$ " $\frac{5}{100}$ ths of the disc being illuminated. On the 10th he sets at 9h. 23m. P.M., or 1h. 9m. after sunset, with a northern declination of 16° 6', and an apparent diameter of 8", $\frac{4}{100}$ ths of the disc being illuminated. He is at his greatest elongation (26 $\frac{1}{2}$ °) on the 12th. On the 15th he sets at 9h. 7m. P.M., or 58m. after the Sun, with a northern declination of 13° 49', and an apparent diameter of 8 $\frac{1}{2}$ " $\frac{3}{100}$ ths of the disc being illuminated. After this he approaches the Sun too closely to be observed. While visible he describes a direct path through part of Cancer into Leo.

Venus is an evening star, and sets on the 1st at 9h. 20m. P.M., or 1h. 3m. after the Sun, with a northern declination of 22° 15', and an apparent diameter of 50 $\frac{1}{4}$ " $\frac{5}{100}$ ths of the disc being illuminated. On the 15th she sets at 9h. 13m. P.M., or 1h. 4m. after the Sun, with a northern declination of 18° 20', and an apparent diameter of 10 $\frac{1}{2}$ " $\frac{5}{100}$ ths of the disc being illuminated. On the 31st she sets at 8h. 49m. P.M., or 1h. 2m. after the Sun, with a northern declination of 11° 54', and an apparent diameter of 11" $\frac{5}{100}$ ths of the disc being illuminated. She is in conjunction with Mars at 2 P.M. on the 9th, Venus being 18' to the north. She describes a direct path from Gemini across Cancer into Leo.

Both Mars and Neptune are, for the observer's purposes, invisible, and as Jupiter does not rise till 11h. 18m. P.M. on the last day of the month we defer an ephemeris of him till August.

Saturn is an evening star, but should be looked for as soon after sunset as possible. He sets on the 1st at 11h. 50m. P.M., with a southern declination of 0° 20', and an apparent equatorial diameter of 17" (the major axis of the ring system being 39" in diameter, and the minor 4·3"). On the 15th he sets at 10h. 56m. P.M., with a southern declination of 0° 39', and an apparent equatorial diameter of 16 $\frac{1}{2}$ " (the major axis of the ring system being 38 $\frac{1}{4}$ " in diameter, and the minor 4 $\frac{1}{2}$ "). On the 31st he sets at 9h. 54m. P.M., with a southern declination of 1° 8', and an apparent equatorial diameter of 16" (the major axis of the ring system being 37 $\frac{1}{4}$ " in diameter, and the minor 4·7"). He will be occulted by the Moon on the 19th, but the phenomenon will only be visible in the southern hemisphere. Iapetus is in superior conjunction on the 21st. A map of the path of Saturn during July will be found in the "Face of the Sky" for March.

Uranus is also an evening star, but, like Saturn, should be looked for as soon after sunset as possible, as his great southern declination is a bar to observation. He rises on the 1st at 2h. 43m. P.M., with a southern declination of 13° 21', and an apparent diameter of 3·7". On the 30th he sets at 10h. 34m. P.M., with a southern declination of 13° 22'. A map of his path during July will be found in the "Face of the Sky" for April.

Shooting stars are fairly numerous in July, though the 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 enters her last quarter at 10h. 5m. P.M. on the 6th; is new at 6h. 17m. P.M. on the 13th; enters her first quarter at 5h. 2m. P.M. on the 20th, and is full at 8h. 10m. P.M. on the 28th. She is in perigee at midnight on the 11th (distance from the earth 224,130 miles), and in apogee at 2h. A.M. on the 24th (distance from the earth 251,610 miles).

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, Knowledge Office," and posted before the 10th of each month.

Solution of June Problem (S. Loyd) :—

Key-move, 1. Kt to QKt4.

If 1. . . . R x P, 2. Kt to Q6ch, &c.

If 1. . . . R to Kt3ch, 2. Kt x R.

If 1. . . . R to Q3, 2. Kt x Reh.

If 1. . . . R to Ksq, 2. B to Q5ch.

If 1. . . . Anything else, 2. B to Q5, &c.

In spite of the hint appended to the diagram last month, no correct solutions have been received. Those who have sent in 1. Kt (Q5) to Kt6 (why not equally Kt to B3 or K3?) have overlooked the ingenious defence provided by the composer. This defence is not mentioned above, as after the correct key-move it loses its merit. Perhaps solvers would like to search for it again. As a direct clue, we give the following position (ascribed to Mr. W. Donisthorpe):—*White*: K at KKtsq, B at QRsq, Kt at KB6, P at KR6. *Black*: K at KRsq, B at QB3, P at KKt6. White mates in five moves. The point is that there is no mate in four moves, the idea being similar to Mr. Loyd's. Solutions will be acknowledged.

Alpha, H. S. Braudreth, R. B. Cooke, R. Inwards.—Nearly right, but the position is worth looking at again.

A. E. W.—See solution above.

A. G. Follows.—Your third problem arrived just too late to notice last month. You can hardly have examined the position, at least four solutions being easily discoverable.

Solution of Prof. Valle's Problem.

1. R to QKt4, and mates next move.

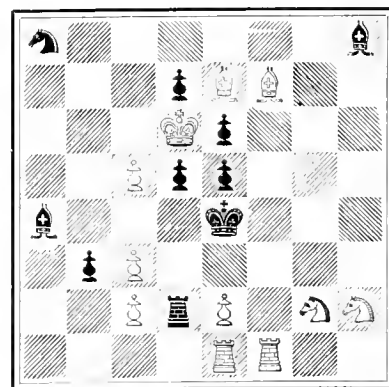
Correctly solved by Alpha and R. B. Cooke.

The near "try," R to QR4, is met by R x QP.

PROBLEM.

By G. K. ANSELL.

BLACK.



WHITE.

White compels Black to mate in two moves.

The following game was recently played in a match at the Metropolitan Chess Club. The score is from the *Daily News*:—

“VIENNA OPENING.”

WHITE (H. Jacobs).	BLACK (R. Loman).
1. P to K4	1. P to K4
2. QKt to B3	2. KKt to B3
3. P to Kkt3	3. P to Q4 (a)
4. P > P	4. Kt x P
5. B to Kt2	5. B to K3
6. Q to K2 (b)	6. QKt to B3
7. Q to Kt5 (?)	7. P to QR3 (c)
8. Q to R4	8. B to K2
9. Kt to B3	9. Castles
10. Castles (d)	10. KKt to Kt5
11. P to QR3	11. P to QKt4
12. Kt x KtP	12. P x Kt
13. Q x P	13. R to R4
14. Q to K2	14. Kt x P
15. R to Ktsq	15. KKt to Q5
16. Q to Ksq	16. Kt x Ktch (e)
17. B x Kt	17. Kt to Q5
18. B to K4 (f)	18. B to R6
19. P to Q3 (g)	19. R to B4
20. P to QKt4	20. R to B7 and wins (h)

NOTES.

(a) This gives White the Steinitz defence to the “Three Knights game,” with the advantage of a move ahead. We much prefer 3. . . B to B4, followed by P to QR3 (to preserve the Bishop); and, directly White Castles, P to KR4, with a dangerous attack.

(b) White elects to use his “move ahead” as an aid to Pawn-hunting. Kt to B3 and Castles would be a much better course.

(c) Prettily played. If now 8. Q x KtP, Kt to QR4 wins the Queen.

(d) This loses a piece. Q to K4 was now essential.

(e) 16. . . B to R7 is more decisive. 16. . . B to B5 would equally win the exchange.

(f) Nullifying the effect of B to R7 and B to B5, but letting the Bishop in at another door.

(g) Probably overlooking the fact that he can avoid further loss by 19. B to Kt2, B x B; 20. K x B, Q to Q4ch; 21. P to B3, Q to R7; 22. Q to K4, P to B4; 23. Q to Q3. This and his next move simply bring the Black Rook into play.

(h) *E.g.*, 21. B to Kt2, Kt to K7ch, followed by B x Bch and Q to Q4ch.

CHess INTELLIGENCE.

The match between Messrs. Bird and Jasnagrodsky was finally abandoned as drawn, each player having won six games, with three games drawn.

Messrs. Loman and Herbert Jacobs are now playing a return match at the Metropolitan Chess Club. Mr. Loman won the first match somewhat easily by 5 games to 1.

The annual match at Paris between a weak team of the British Chess Club and the Grand Cercle des Echees resulted in a victory for the Parisians by 4½ to 2½.

At Cambridge chess and mathematics go hand in hand. Mr. H. E. Atkins, the best undergraduate player at either University for the last three years, is bracketed ninth wrangler this year.

A match was played at Brighton on June 10th between Sussex and the City of London Chess Club. The London Club was not very strongly represented, but strong enough to win the match by 11 games to 9.

The *Hackney Mercury* announces a sui-mate Tourney for two, three, and four movers. Problems, not more than two in any one section, should be sent to 101, Queen’s Road, Dalston, N.E., before September 1st.

Chess History and Reminiscences, by H. E. Bird (Dean and Son). Mr. Bird, though not so old as he looks, is still the *doyen* of English Chess Masters, and a volume of his reminiscences, ably edited, should be entertaining reading. Unfortunately, Mr. Bird felt also called upon to write a history of chess as she *was* played many centuries before his time. The result is merely a *résumé* of what has been written before, and certainly has not the atoning quality of good arrangement. Mr. Bird’s historical style lacks the vivacity of his games, and the punctuation of the book is simply the worst on record. Still, the information here collected may, if correct, be not without its value to some future historian.

Mr. Bird has acquired some curious knowledge in his time. He knows, for instance, that “Italian sermons are unmethodical and unconnected, and full of sentences and maxims” (perhaps Italian preachers might retort with the *Tu quoque direct*). On the other hand, he “really does not know whether Homer really was ‘neglected’ (Mr. Bird’s emendation for ‘starved’) by his country or not.” After all, no man is omniscient.

The modern reminiscences are at times amusing, though some of the autobiography is perhaps not in the best possible taste, and many of the best anecdotes have already appeared in Mr. MacDonnell’s *Chess Life Pictures*. But then Mr. Bird expressly states that he is “not a funny man, most reserved among his superiors, yet looks good-humoured.” Like Mr. Pitt, he was formerly known as “the enemy of the human race,” though no doubt the title lent itself to abbreviation.

The author’s views on chivalry, enthusiasm, Ruskin, and rapidity are well known, and are naturally repeated here.

The book contains a portrait of the writer, without his characteristic expression, and deficient in the “lines of thought.” But then we are told “many working men have sought wrinkles from Bird”; and this, perhaps, is the explanation.

For the “Chess Player’s Annual and Club Directory, 1893 and 1894” (price 2s. 6d.), the authors, Mr. and Mrs. T. B. Rowland, Rus-in-Urbe, Kingstown, invite the following particulars of chess clubs:—Town, club name, year established, place of meeting, days, hours, number of members, annual subscription, laws, president, hon. secretary’s name and address. Printed forms will be had on application.

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PARALLELISM IN DEVELOPMENT.

By R. LYDEKKER, B.A. Cantab.

IN the course of our three preceding articles in KNOWLEDGE it has been to a great extent our aim to show that certain animals may resemble one another very closely in general external appearance, or may possess certain peculiar structural features in common, without being in any way intimately related; thus rendering it evident that such similarities of form or structure have been independently acquired, and are not inherited from a common ancestor. It has been shown, for instance, that mammals belonging to several distinct orders, or to different families of the same order, may assume such a marked external resemblance to the common mole as to be designated in popular language by the same general title; while in other cases a more or less striking approximation to the type of the ordinary hedgehog has resulted from the independent development of very similar spines in totally distinct groups. Furthermore, it has been pointed out in the third of the three articles that large tusks of very similar form may be independently developed in the jaws of totally different distinct groups of mammals; and even that certain extinct reptiles have acquired tusks which are almost indistinguishable from those of some of the carnivorous mammals, there being no direct relationship between the members of these groups.

With regard to the external similarities of form in the

above-mentioned instances, we have seen reason to believe that their inducing cause has been either similarity of habit or the need of protection; while in the case of the tusks the similarity may in certain instances be due to the necessity for efficient offensive weapons. Be their causes, however, what they may, it is evident that such resemblances among animals, which are, so to speak, accidental, indicate what may be termed a kind of parallel development; and as such parallelism in development, or shortly "parallelism," has recently attracted a good deal of attention among biologists, we propose in this communication to present to our readers some of the more striking instances of such similarity. In the instances above alluded to, the parallelism is either to a great extent shown in external characters, or in structures which are easily modified; but, as we shall indicate in the sequel, in other cases it affects deeply-seated structures; and its inducing cause is then very difficult to surmise on any of the ordinarily accepted doctrines of evolution. It will, moreover, be obvious that the acceptance of parallelism in development—and accepted to a certain extent it must undoubtedly be—throws a new difficulty in the interpretation of the affinities of animals, since before saying that an identity in some structural feature between the members of any two groups indicates their relationship, we have first of all to determine whether such similarity of structure is due to parallelism, or is inherited from a common ancestral type. As is so generally the case when any new theory is started, a host of enthusiastic writers have welcomed parallelism with acclamation, and have attempted to apply it in a number of instances where there is not at present sufficient evidence of its existence. We have been told, for instance, that the American monkeys have no relationship with their reputed cousins of the Old World; that whalebone whales are not allied to the sperm-whale and dolphins; that cats have no kinship with civets or other modern carnivores; and that the egg-laying mammals have been evolved from a reptilian or amphibian stock, quite independently of all other members of the mammalian class—their resemblances being solely due to parallelism. At present, we confess, we are totally unable to accept any of these conclusions, and we think it somewhat improbable that if the members of either of the above-mentioned pairs of groups had an independent origin, they would have presented such a similarity, both externally and internally, as we find to be the case. Still, however, it must be borne in mind that there is a considerable amount of evidence that the modern horses of the Old World and their extinct cousins of the New have been independently derived from earlier horse-like animals; and if this be confirmed, it will be one of the most remarkable known instances of parallelism, and will tend to show that many others may exist. Turning from these more or less problematical cases, we proceed to notice *sciatim* certain well-marked instances of parallel development as to the existence of which there can be no doubt; commencing with those displayed in external features, and then referring to such as are more deeply seated.

As regards external resemblances, it is, of course—and more especially so far as the lower animals are concerned—not always easy to distinguish between parallelism and mimicry. The above-mentioned instances of mole-like and hedgehog-like animals belong, however, clearly to the former category. The external resemblance existing between swifts and swallows, which have no sort of relationship to one another, likewise comes under the same head. Another striking instance is to be found in the assumption of a snake-like form, accompanied by

abortion of the limbs, by certain lizards, such as the familiar English "blind-worm," it being very doubtful, to our thinking, if this can be explained by mimicry. Still more remarkable is the external resemblance presented by whales and dolphins to fishes, and by the extinct fish-lizards (Ichthyosaurs) to both: such resemblances being clearly due to parallel development induced by the needs of adaptation to a purely aquatic life. If, moreover, it should prove that the whalebone whales have no connection with the dolphins, we should then have a far more remarkable instance of this feature, and one extending to internal structure as well as to external form. A similar remark will also apply to the case of the true seals and the eared seals, which it has been suggested may be of independent origin. The independent acquisition of wings by birds, bats, and the extinct flying dragons, or pterodactyles, may likewise certainly come under the heading of parallel development, so far as external form and the adaptation to a particular mode of life are concerned: although here, as in the instance of whales and fishes, the structural features, by the aid of which the adaptation has been brought about, are very different in the respective groups.

In respect to the teeth and dentition, many very well-marked instances of parallelism may be adduced. We have already referred to the similarity of the tusks in different groups of mammals: while in our last article we noticed the loss of upper front teeth, not only in the modern ruminants, but likewise in the peculiar even-toed ungulate known as *Proboscis*, of which the skull is figured on page 143. The rhinoceroses likewise show a gradual tendency to the loss of front teeth, resulting in the African forms in the disappearance of the whole series from both jaws. More remarkable, however, is the tendency to a complete loss of the whole of the teeth in certain groups of all the higher classes of vertebrates, as exemplified by all modern birds, by turtles and tortoises, as well as certain of the extinct flying dragons and fish lizards among reptiles, and by the great ant-eater, the scaly ant-eater, and the echidnas, or spiny ant-eaters, among mammals: in all of which teeth are completely lacking. Moreover, in many of these animals, such as birds, tortoises, and probably the toothless flying dragons, the beak-like jaws thus produced were sheathed in horn, thus showing a kind of double parallelism, viz., the loss of teeth coupled with the acquisition of a horny sheath to the jaws.

Another instance of parallel development afforded by teeth relates to the gradual heightening of the crown and the production of a flat plane of wear not only among several distinct groups of hoofed mammals, such as the elephants, horses, and ruminants, but likewise among the rodents. In a previous article, on "Teeth and their Variations," it was pointed out how these high-crowned teeth had been independently evolved in the three great groups of hoofed mammals, of which the above-named creatures are typical representatives: and it may be added here that the molars of horses and ruminants present a further evidence of parallelism in their assumption of a more or less decidedly crescent-like (selenodont) structure, the essential peculiarities of which are described in the article mentioned. This resemblance between the molars of horses and ruminants is, however, comparatively remote, but in the latter group and the camels these teeth are so alike as to require an expert to distinguish between them. Nevertheless, there is good evidence to show that the camels and the ruminants, if not also the chevrotains, have acquired their crescent-like molar teeth quite independently of one another, and it therefore yet remains for those writers who explain evolution by some mode of what they are pleased to call natural selection to account adequately for

the similarity thus existing between structures of such totally different origin, when they could have been made equally efficient if unlike.

Passing from the consideration of teeth to that of limbs, we may mention that in previous articles we have already called attention to the remarkable similarity displayed in the mode by which the lower segments of the limbs of the even-toed and odd-toed hoofed mammals have been gradually elongated by the formation of a cannon-bone and the disappearance of either three or four of the lateral digits: the cannon-bone in the horse consisting of but a single element carrying one digit, while in the ruminants it comprises two united elements supporting a pair of toes—this being clearly a case of parallelism in development attained by a slightly different modification of principle. The parallelism does not, however, stop here, since (as shown in our article entitled "Giant Birds") an essentially similar type of cannon-bone has been produced in birds; only that in that group (with the exception of the ostrich) three long bones enter into its composition, which is further complicated by the addition of a bone from the ankle above. Seeing that in all these groups the parallelism has been arrived at by a different structural modification, the explanation of its mode of evolution is much less difficult than in the case of the molars of the camels and ruminants, where, as we have seen, the structure is practically identical.

Recent discoveries in North America have brought to light the existence of a kind of secondary parallelism among certain peculiar mammals which may be included among the hoofed or ungulate division of that class. In



Front and side views of the hind foot of *Artibeus*.
(After Osborn.)

the even-toed group of that division, as exemplified by the pigs and ruminants, it is the third and fourth digits which are symmetrical to one another, and tend to develop at the expense of the others; while in the odd-toed group it is the third or middle digit which is symmetrical in itself and tends to an ultra-development. Now there are certain extinct creatures which, while having claws instead of hoofs at the ends of their toes, yet are so closely related to the hoofed mammals that their separation therefrom is almost impossible. In one of these, which has long been known in Europe as the chalicotheres, the third digit, as in the odd-toed hoofed mammals, is symmetrical in itself, and larger than either of the others; whereas in the newly-described animal known as *Artibeus* the third and fourth digits resemble those of the even-toed division of the hoofed mammals in being larger than the others and symmetrical to a line drawn between them. While, therefore, we have clearly a parallel development on different lines between the odd and even-toed hoofed animals in the development of a cannon-bone, these extinct clawed, hoof-

like mammals (for want of a better expression) show a parallel parallelism (to coin another expression) which, if it had continued, might have resulted in the development of a two-clawed ruminant and a two-clawed horse. To our thinking, this is indeed one of the most curious phases of development yet discovered.

In addition to the parallelism in the evolution of their molar teeth and limbs, the hoofed mammals likewise exhibit the same feature in regard to the second vertebra of the neck. As most of our readers are probably aware, the first or atlas vertebra of the neck turns with the head when the latter is moved sideways, the axis of rotation being formed by a process—the odontoid process—arising from the second or axis vertebra, and projecting into the central hollow of the atlas. Now in pigs and likewise all the primitive hoofed mammals, the so-called odontoid process is (as in ourselves) in the form of a flattened peg. On the other hand, in the ruminants, the modern horses, and the camels, which, as we have seen, represent three distinct *phyla* of the order, this peg has, however, become modified into a spout-like half-cylinder, which must clearly have been separately evolved in each of these three groups. It is true that such a half-cylinder affords a far better basis of support for a heavy skull than does a mere peg; but the curious part of the matter is why these half-cylinders should be so exactly alike in the different groups, seeing that as it would not be difficult to design some other structural modification by which the same end might have been attained, there is no necessity for their similarity.

Our last example of parallelism will be drawn from two groups of extinct North American hoofed mammals, to which brief allusion has already been made in our article on "Tusks and their Uses"; the one group being known as



Skull of *Protoceras*. (After Osborn.)

nintatheres, while the second is represented by a single species to which the name of *Protoceras* has been applied. Now, although the nintatheres have five-toed feet approximating in structure to those of elephants, while in *Protoceras* each foot approximated to the ruminant type, in both groups the skull, as shown in the accompanying figure, was armed with several pairs of large, irregular, bony processes, which during life may have been sheathed in horn; while in each case a pair of long tusks projected from the upper jaws, which were totally devoid of front or incisor teeth. Had such skulls been discovered without any indication as to the nature of the limbs with which they were associated, they would inevitably have been assigned to the same group of animals. The resemblance existing between them is, however, clearly due to parallel development, and we are thus shown another striking instance of caution necessary in endeavouring to determine the affinities of extinct animals from the evidence of incomplete remains.

Our last instance of parallelism has been already alluded to in an article entitled "The Oldest Fishes and their Fins," in the course of which it was shown that while both the most

ancient birds and the oldest fishes had long tapering tails with the joints of the backbone gradually diminishing in size, and each carrying either a pair of feathers or a pair of fin rays, in all the modern representatives of the former group, and in a large section of the latter, the end of the vertebral column has been aborted into a composite bone, from which either the feathers or the rays of the tail diverge in a fan-like manner.

In conclusion, we may say that although there is no very great difficulty in satisfactorily accounting for external parallelism obviously due to the necessity for adaptation to a particular mode of life, or in explaining those instances where a particular result has been brought about by different methods, yet when we find precisely similar structural modifications in different groups of animals which clearly cannot be traced to a common ancestry, and for which equally efficient substitutes could be readily suggested, we are fain to confess that the ordinarily accepted explanations of evolution appear to us altogether inadequate. Putting this aspect of the matter aside, our readers will, however, see from the imperfect sketch given above what an important factor in evolution parallel development really is, and how largely it is likely in the future to modify our present views as to the mutual relationships of animated nature.

GALLS AND THEIR OCCUPANTS.—II.

By E. A. BUTLER.

(Continued from page 128.)

NO other English tree is such a favourite with gall-flies as the oak; nor is this to be wondered at, since the same tree is by far the most popular in the insect world at large. About fifty species of gall-flies are known to attack the two kinds of oak tree which are found wild in this country, and many others are dependent upon the oaks of other lands. No part of the tree is exempt from attack. The unexpanded leaf-buds, the full-grown leaves, the male catkins, the acorns, the young twigs, the leaf-stalks, the bark, and even the roots, all have their special inhabitants, each producing its own characteristic excrescence. Many of these galls are small and insignificant, and hence not generally known; but in addition to these inconspicuous things, the oak supplies both the conspicuous marble galls already described, and also several other very well-known kinds. One of the most familiar is the "oak-apple," a soft, exceedingly succulent, somewhat irregularly spheroidal mass of tissue found on the young twigs in the position of a terminal leaf-bud. Its colour is pale yellowish or brownish white, dashed with rosy pink where the sun has shone most directly upon it. It does not turn hard as the marble gall does, but, though like a juicy apple at first, becomes ultimately a light brown, dry and spongy mass, resembling a small shrivelled apple. When picked in this dried condition it is found to be astonishingly light.

The oak-apple results from the punctures of the gall-fly named *Andricus terminalis*. In the centre of its mass it contains a number of hard, oval, woody cells (Fig. 1), each the home of a gall-fly larva. It is not therefore like the marble gall, which in its normal condition



FIG. 1. Section of Oak-apple, showing cells of Gall-flies.

It is not therefore like the marble gall, which in its normal condition

is a one-celled structure; but it is naturally many-chambered, and normally provides accommodation for a family of gall-flies, irrespective of parasites, which of course also occur in it. This is a springtide gall, the fly issuing at the end of May or the beginning of June. The galls, being fully formed by the end of May, and being just at that time by no means inelegant objects, were formerly in considerable request as buttonhole decorations on the 29th of May, "Restoration Day," whence their popular name of "King Charles's apples." When the galls have yielded up their rightful occupants they still do not cease to be useful. Those resplendent green beetles, the rose-chafers, find them out in June, and devour the softer parts, leaving the hard oval cells exposed to view in a cluster at the end of the twig. But even if the softer part be not eaten off by insects, it still disappears, flaking away piece by piece, so that if the galls are looked for in the winter, only the clusters of hard cells will be found. From these, however, parasites often issue, sometimes even as late as the second year.

Another gall-fly, called *Dryophanta scutellaris*, makes spherical galls on the under side of the oak leaves; these, when young, bear considerable resemblance to the marble galls, which, as we have seen, are the produce of quite a different insect. When mature, however, they could not be confounded; the present galls become yellowish, and finally red like a ripe fruit on the side turned towards the sun, whereas those of *Cynips Kollarii* become dark brown and woody. Their situation, too, on the *leaves* instead of the twigs, helps to distinguish them; the flies, moreover, mature later than the generality of those from the marble galls. When these galls are fully grown they are about the size and shape of cherries, and this, coupled with their rosy sides, has acquired for them the name of "cherry galls."

Yet another globular gall may be found pretty frequently on oak leaves, the so-called "berry gall," smaller than the last, semi-transparent, and very juicy. Save for its colour, it reminds one of a currant, and hence, when found growing on the pendant catkins of the male flowers of the oak (for it occurs in this way as well as on leaves) it gets the name of "currant gall." The name of its founder is *Spathogaster baccarum*. The growth of this gall is remarkably rapid; only about three weeks elapse between the first

appearance of the gall and the emergence of the fly. It is only in May, therefore, that we should expect to meet with the galls, for after the escape of the insect they shrivel up and soon disappear. If any are to be seen later they will be found to be inhabited by parasites.

One of the most remarkable of oak galls is that known as the "artichoke gall" (Fig. 5), inhabited by *Aphilo-thrix gemma*. Un-



FIG. 5. Artichoke Gall of Oak Tree.

til a section of the gall is made, and the insect found therein, it seems impossible to believe that we have before us any-

thing more than a normal vegetable production. Galls can hardly be regarded in any other light than as pathological features in the life-history of the plant, tumours, as it were, resulting from a deranged condition of the tissues; and yet in such instances as the present there is no trace of any irregularity of form, or shapelessness and malformation, such as we should expect in a diseased product, but all is beautifully symmetrical and regular, the parts being arranged according to the ordinary laws of plant structure. Of course there are galls which are obviously abortions and monstrosities, and which greatly disfigure the plant on which they occur, but that is not the case with any of those we have yet considered, and least of all with the artichoke gall. It is of a pale whitish or yellowish-green colour, reminding one very forcibly of an artichoke flower in miniature. It is in reality a modified bud, but still one modified without distortion; and therefore there are a number of leafy scales overlapping one another perfectly regularly, and making a rather stumpy conical body, like the head of a thistle. On turning back these leaves, an oval object is seen standing erect in the centre; this is hollow, and is the abode of the grub of the gall-fly, hence it is the really important part of the gall, the rest being merely accessories. About the end of August this hollow chamber falls to the ground, and remains there throughout the winter, the insect issuing from the gall during the next spring.

A large woody gall is sometimes found on the roots of the oak tree, just where they leave the trunk, and therefore only slightly below the surface of the ground. This is occupied by a gall-fly called after the locality in which the gall occurs, *Aphilo-thrix radiceis*. In form it is something like an oak-apple, but it is much harder and more fibrous; moreover, it is usually much larger, being indeed the largest of our British galls, and attaining sometimes the size of a man's fist. Like the oak-apple, it is tenanted by large numbers of the flies, each inhabiting a hard-walled oval chamber. The colonies are sometimes extremely extensive, giving one some idea of the high degree of fecundity often attained by gall-flies. Westwood records having obtained as many as eleven hundred specimens of the rightful occupant from one gall of this kind, which was about five inches long by one-and-a-half broad. The flies appear in April.

Galls have been for a long time known to science, as indeed, from the conspicuousness and attractive appearance of some of them, might have been expected. Theophrastus, a Greek philosopher who lived about three hundred years before Christ, the author of one of the earliest botanical treatises extant, mentions them; and Dioscorides, a writer on medicine, who lived some four hundred years later, discusses their medicinal virtues in a work which became one of the standard medical treatises of the Middle Ages. In consequence of the tannin they contain, they were valued for their astringent properties, and were largely used as a remedy for affections of the mucous membrane of the mouth, and other similar complaints. By the ancients they were always treated as purely vegetable products, and the true nature of the connection between the plant, the gall, and the insect does not seem to have been suspected till comparatively recent times. Even Bacon speaks of oak-apples as an "exudation of plants joined with putrefaction." The great difficulty about them was always felt to be the presence of an insect inside a portion of a plant, without any apparent means of entrance; this greatly puzzled the learned, and led to many curious conjectures as to the possible method of its introduction. It was evident that the insects were hatched in the place in which they were

found, but the question was, how could the eggs, supposing the insects to have originated from eggs, get into the centre of a mass of vegetable tissue, when no pathway thither could be discovered? The difficulty was of course enhanced by the prevalent belief that the galls were a natural product of the plant, not diseased excrescences, and were, in fact, a sort of fruit of the plant, as much so as its ordinary and legitimate fruit.

Many explanations of the mystery were proposed. One theory was that the eggs were derived from the ground, and that they passed into the roots of the tree, and along its vessels with the ascending sap, till ultimately they reached their proper receptacle, which had been already provided for them, and in which they were destined to mature. Or, again, it was thought that there might be germs floating in the air, which at last came in contact with some part of the plant, to which they adhered, and then the plant, pursuing its natural growth, grew round the germs, and finally enclosed them. Another explanation was offered to the effect that, though the insects themselves belonged to the animal kingdom, yet they were a direct product of the vegetable life which animated the plant in which they were found; that in fact they did not arise from eggs or germs, but that whatever forces those were that produced the growth of the ordinary parts of the plant, leaves, flowers, fruit, or what not, the same forces also led to the formation of the insects found in the supposed secondary fruits. Indeed, it was gravely asserted that one of the express purposes of the formation of fruits at all was that they might beget and nourish these insects found inside them. And yet, in this last supposition, absurd as it may seem, we have—since the sole purpose of the gall, so far as we can see at present, is to nourish and shelter the contained insect—a sort of half-truth obscured by the idea that the galls are a natural product of the tree, of the nature of a fruit, but destined to produce and perpetuate an animal offspring instead of a vegetable one. In the fact that the oak tree produced not only its ordinary vegetable fruit, the acorn, but also an animal fruit as well, the gall-insect, some saw a reason why the ancients dedicated the tree to Jupiter. And then, lastly, there was of course also the doctrine of spontaneous generation, which could be fallen back upon when every other explanation failed.

The mystery thus attaching to the gall and its imprisoned inhabitant served not unnaturally to connect them with occult science, and they were used for purposes of prognostication. They were the repositories of Nature's secrets, and it was according to the form their occupants assumed that the character of the forthcoming season would be determined! The unpierced galls were believed to contain either a fly, a spider, or a worm. The fly was of course the fully-matured gall-insect, and the worm was its larva; what the spider was it is not so easy to see, unless galls containing mites or beetles were referred to. However, if on opening the gall a fly was found within, it was a presage of war; if a worm, the price of the commodities of life might be expected to rise; but if the prisoner turned out to be a spider, this was an ill omen indeed, and the season would bring a dismal record of pestilence and death.

Of quite a different character from any of the galls we have already considered are those pretty adornments of oak leaves called "spangles." They are flatish, circular bodies, of a reddish or brownish colour, and attached in considerable numbers to the underside of the leaves (Fig. 6). They are fastened to the leaf at one point only, by means of a minute stalk, so that they look something like a tiny fungus, for which in fact they

were at one time mistaken. They are formed by various species of a genus called *Neuroterus*, and the economy of the insects is very different from that of the species we have already considered. They are

long in coming to maturity, and indeed scarcely begin their development as long as the galls remain attached to the tree. The spangles appear in the autumn, and after a certain period of growth become detached from the leaves through the severance of their short little stalk, and fall to the ground, leaving only a small spot on the leaf to show whence they have come. They lie about at the foot of the tree through the winter, absorbing moisture from

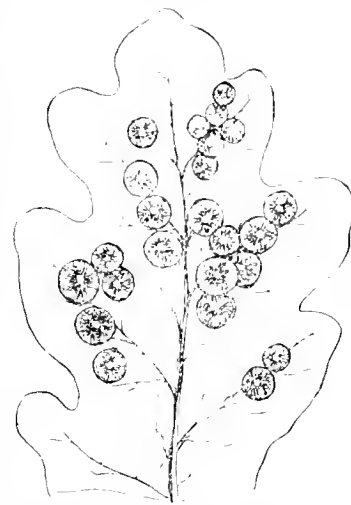


FIG. 6.—Portion of Oak Leaf with Spangles (*Neuroterus lenticularis*).

the damp ground, and swelling considerably. Thus, although severed from the tree that produced them, and cut off from its supplies of sap, they are yet able to remain succulent, and indeed to become still more so than when on the leaves, and so can contribute to the growth of their occupants. The grubs, therefore, which are exceedingly minute till after the spangles fall, feed chiefly during the winter, and the flies become mature by about February or March in the following year. Two of the best known of these spangle-galls are those of *Neuroterus lenticularis* and *numismatis*. The former are lens-shaped, hairy galls of a reddish colour, and the latter are of a golden brown, like little silk buttons. Both are gregarious, that is to say, large numbers of the galls are found on the same leaf, sometimes so close together as to interfere somewhat with one another's growth.

An exceptional interest attaches to these oak spangles and their occupants, inasmuch as they constitute one of the best instances of the remarkable phenomenon of heterogamy, or that particular variety of the alternation of generations which consists of the regular succession of two types of creatures, the one consisting of both males and females and producing eggs in the ordinary manner, the other consisting of females only and producing eggs without impregnation, the whole series constituting in reality but one species. We have spoken above of the flies that issue from the currant galls and spangles by the names by which they are generally known, and therefore it will be seen that they are referred not merely to different species, but even to different genera; it remains now to point out that they are in reality not two distinct insects, but only two stages in the history of one. It will be remembered that the currant galls and spangles do not appear at the same season, but that the former are very short-lived, lasting for less than a month, while the spangles appear later in the year, after the currant galls have passed away, and last much longer. Thus one might naturally wonder what becomes of the inhabitants of the currant galls during the other eleven months of the year, and what condition they are in, since they only take one month to pass through their entire metamorphosis. It now appears that during the rest of the year they exist in another form, as inhabitants of the spangles. The discovery of these remarkable facts was first announced by

Dr. Adber about fifteen years ago, and they have since been confirmed by Lichtenstein and others.

In brief, therefore, the entire life-history of this insect is as follows. If we start with the currant galls, either on the leaves or on the catkins, these produce at the end of May the fly which is called *Spathogaster buccarum*. Both males and females are produced, and the females, after mating, pierce the oak leaves and deposit their eggs in the punctures: but from these punctures there do not proceed, as might be expected, a further crop of currant galls, but, on the contrary, a collection of spangles. These, after maturing during the latter part of the summer, drop to the ground in October, there swell and develop the contained insect, which is now known as *Neuroterus lenticularis*, and emerges in the following spring. This spring crop of flies, however, are all of the same sort; no distinction of sex can be observed and no males are known. They all produce eggs which they deposit in punctures on the leaves or on the catkin stems, and from these punctures are produced again, not spangles like those the flies came from, but the currant galls of *Spathogaster* with which we commenced the series. From these issue, as before, male and female insects belonging to *Spathogaster buccarum*, and the whole cycle is gone through again the next year. Thus in the course of one year the same insect appears in two successive phases, one of which has both males and females and the other females alone, and which make galls so utterly unlike in character as to have been referred to two distinct genera.

The phenomenon of parthenogenesis occurs in many other species of gall-flies, but is not necessarily associated with that of dimorphism, *i.e.*, the occurrence of the same insect in two distinct forms, and even in some cases, where the males are known, their number bears an exceedingly small proportion to that of the females. The marble gall is an excellent illustration of the former peculiarity. Mr. F. Smith, the zealous hymenopterist, obtained in the year 1857 about a bushel and a half of Kollari galls from Devonshire, as they were not then to be found in the neighbourhood of London. At the beginning of April in the following year flies began to emerge, and continued to do so for two months. Altogether about twelve thousand specimens were obtained, and all as they came out were examined: every one proved to be a female. About sixty of the galls had been placed in separate boxes, and when the flies issued from these they were conveyed to different localities in the neighbourhood of London and placed on box oaks and hedges. On revisiting these spots in August, Mr. Smith found, in about two-thirds of the cases, galls on the trees on which he had placed the flies, but on none in the vicinity. These galls were again collected, and the next year the flies bred from them: these, again, proved to be females. They were at once taken to other and isolated spots and left on trees as before. Again, in the summer galls were found in the same proportion as before. Thus it was shown that the insect could breed from year to year without males at all.

The same observer obtained from one example of a root-gall one thousand two hundred flies of *Aphibothric radialis*, all of which proved to be females. Hartig, again, speaks of having examined fifteen thousand specimens of different kinds of gall-flies without ever discovering a male. On another occasion, from an enormous collection of twenty-eight thousand galls of a species resembling the cherry gall, he obtained between nine and ten thousand flies, all of which were females. In fact, one may state generally, that none of those species of oak gall-flies that are single brooded are known to possess a male at all.

(To be continued.)

THE SUN AS A BRIGHT-LINE 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.

BY far the most remarkable pair of lines in the solar spectrum are those known, since Fraunhofer observed and named them, as "H" and "K." They lie high up in the violet—so high up, that they can be much more easily photographed than seen. Intense absorptive action is indicated by the depth and extent of their central obscurity, which seems besides as if veiled in diffusive shadow. They are distinctive of the metal calcium, which, however, emits them conspicuously only under the stress of powerful electrical excitement: thus they may be provisionally termed "high temperature lines." In the near neighbourhood of the sun they are ubiquitous. The substance from which they emanate rises to the summits of the loftiest prominences; it enters largely into the composition of the chromosphere; it shines even in "white prominences" and facule. These facts, although they have been securely established by the recent investigations of Prof. Hale and M. Deslandres, do not easily fit into the narrow framework of existing theories. Yet of their profound importance to solar and stellar physics there can be no doubt; nor can they receive too close or too careful consideration.

There is evidence, to begin with, that the lines in question (of wave-lengths 3968 and 3931 tenth-metres) claim, in the sun, a three-fold origin. The wide dark bands in the ordinary solar spectrum are produced by an absorbing layer necessarily cooler than the photosphere, and probably in its immediate neighbourhood. Calcium-vapour seems here to be affected very much as it is in the core of the electric arc, where the H and K lines, just traceable in a magnesium-flame, come out strong and diffuse. Their centres are marked (as Prof. Hale has noted) by thin, extra-black lines, possibly due to the arresting action of the chromosphere. The chromosphere, as the readers of KNOWLEDGE are well aware, completely envelopes the solar globe with a tossing incandescent ocean. The bright calcium-lines forming part of its spectrum reach us clear, sharp, and undimmed from the edge of the sun. Hence, evidently, the Fraunhofer absorption takes place at a lower level than that at which they are generated. Otherwise they would be hopelessly cut off from transmission to outer space: they would be swallowed up by the superposed, powerfully absorbent vapours. And the same reasoning applies, of course, to the chromospheric rays of hydrogen. The H and K of the chromosphere are of the same character with the lines radiated by calcium during the passage of the electric spark. They might, then, be supposed to indicate a higher temperature than that corresponding to the dark bands in the solar spectrum. But in our present inability to discriminate between effects of simple heat and effects of electrical agitation, no definitive judgment can be formed upon this point. It appears certain, on the other hand, that the chromosphere is not hotter than the photosphere; for if it were, the calcium-lines of the ordinary solar spectrum should be reversed all over the sun—that is to say, a fine, brilliant ray would shine at the middle of each dusky band. In fact, however, there are (as we have said) fine, dark rays in these positions, most likely as the result of a two-fold light-stoppage. But with a chromosphere of over-twofold radiative intensity we should get, instead of double absorption, absorption plus emission.

In facule, on the contrary, reversals, which the chromosphere is apparently incompetent to produce, do

actually take place. These extraordinary objects display a continuous, in addition to a bright-line spectrum. Their constitution would thus seem to be almost identical with that of "white prominences." They must be enormously hot—hotter, certainly, than the photosphere, since certain ingredients of their light stand out vividly against the background furnished by it. Prof. Hale has, in fact, succeeded in photographing them, through their H and K emanations, on all parts of the sun's disc. Their unexpected importance has thus been directly brought into view. Far from being confined to the vicinity of spots, faculae are now perceived to cover the spot-zones with an almost unbroken network, and to occur sporadically even to the very poles. They show no marks of absorption by the cooler chromospheric gases, and may hence be inferred either to attain to a higher level, or to be in some other unknown way protected against their inroads. For it must be admitted that Kirchhoff's law, although true so far as it goes, does not at all completely express the relations of emission to absorption in celestial bodies.

The effectiveness of facular light in modifying the spectrum of the sun, taken as a whole, obviously depends upon the proportionate amount of it present. Increase it sufficiently, and its bright-line ingredient will eventually become first distinctly perceptible, and at last conspicuous. Under these circumstances, then, of augmented facular development, the sun observed, for example, from Sirius would appear as a bright-line star. And it might very well be that his appearances under that aspect would be periodical; for the faculae emblazoning his surface become much more numerous and intense with the growth of sun-spots, and attain, concurrently with them, a maximum once in about eleven years. Hence the periodicity of the sun might, with a slight intensification of existing conditions, be ascertained from distances at which he would be reduced to the status of an insignificant point of light.

This is no mere theoretical inference. On occasions when faculae were unusually numerous and lustrous, M. Deslandres has actually succeeded, by treating the sun as a star—that is, by admitting into his apparatus the whole of its rays simultaneously—in photographing vivid reversals of the calcium-lines. The sun was then, *pro tanto*, a bright-line star. The aggregate of his light, in other words, contained evidence of gaseous emissions. But other stars of the solar type are presumably subject to similar vicissitudes. Capella, Arcturus, Aldebaran, undergo, we are entitled to suppose, cyclical agitations marked by the fluctuating encroachments upon their photospheres of spotted and faculous areas. These ought, at least in some cases, to betray themselves spectrographically by the creeping-in of fine lines of light into the dense bands of calcium-absorption characterizing all solar stars. But the anticipated appearance might have to be long waited for. Numberless negative results would probably put a severe strain upon the patience of the investigator. A single positive one would, however, be no trivial success. It would imply the opening of a hitherto closed door. It would give the means of determining the flow of change in suns inconceivably distant and immeasurably vast. Through the prosperous issue of such a research the spot-maxima, say, of Arcturus might come to be known more accurately than those of our own "bright particular star." The study of solar periodicity, moreover, could hardly fail to reap advantage from comparisons of corresponding phenomena in sun and stars; and the problem of stellar variability might even be brought a step nearer to a solution.

In Mira Ceti, and probably in other periodical stars of the same class, H and K are no less dark and broad than they are in the sun; but they appear to originate under

very different conditions. The evidence regarding these depends upon the circumstance that H is double. Both hydrogen and calcium have commonly a share in its production. A member of the hydrogen series, in short, falls so near the calcium ray that when either is much widened it conceals the other. Thus the diffuse H in the spectrum of white stars like Vega appertains to hydrogen. The presence and state of the nearly coincident calcium line can only be inferred from the rule of its approximate correspondence with its twin K, which, in Vega, has shrunk into insignificance. Conversely, the hydrogen H, if present at all in the sun's absorption-spectrum, is plunged so deep in the shadow of the calcium-band as to be undistinguishable. In order, then, to avoid these ambiguities, K is taken as the representative of the calcium pair; and its value as an index to stellar constitution, pointed out thirteen years ago by Dr. Huggins, has been in no small degree heightened as the result of recent discoveries.

Now the Harvard College "spectrograms" of Mira show six brilliant hydrogen-rays, namely, G, *h*, with four of the ultra-violet sequence. But the intermediate H is invisible. Few, however, will venture to assert that the continuity of the harmonical progression is really broken. The gaseous molecules cannot conceivably be agitated in such a manner as to cause them to drop out this particular quality of vibration. There is, moreover, an obvious reason for its apparent absence.* It is obliterated by the strong calcium-band falling near its place in the spectrum. This implies that the absorbing calcium-vapour is situated between our eyes and the glowing hydrogen, the radiations of which, so far as they come within its grasp, are cut off by it. In other words, the region of this particular kind of absorption, which, in the sun, is sunk below the region of bright-line emission, overlies it in Mira. There is, apparently, no escape from this conclusion. We are then forced to admit that what might have been taken for the natural arrangement in order of vapour-density does not invariably prevail in stellar atmospheres. What the counteracting influences may be, we know not; we can only note the effects of their exertion. These certainly deserve very close attention; for there are few facts in astro-physics more curious than the seemingly inverted positions of the absorbing and emitting strata in the sun and Mira. Yet the subject has attracted up to the present singularly little attention. Data for its profitable discussion are much needed, but are not forthcoming. They could, nevertheless, be easily procured with the aid of very moderate spectrographic appliances. A few photographs of the spectra of long-period variables showing bright lines, such as γ Cygni, R Andromedae, R Leonis, and many more, would at least tell whether the eclipse of the hydrogen H by the calcium H is a peculiarity common to the class. A few additional photographs would answer the farther question as to whether the eclipse is a permanent condition, or merely a transient phase in each individual star.

Nova Aurigae was unique among sidereal objects in its display of bright calcium-lines. Nor did they persist even here. They became extinct during the temporary invisibility of the star during the summer of 1892. Yet, considering the predominance of H and K in the spectra of solar appendages, and their easy reversibility, their inclusion as vivid rays might have been anticipated in a great number of emission-spectra. They remain, nevertheless, hitherto unrecorded in nebulae, bright-line stars,

* See an article by the present writer in *The Observatory*, Vol. xi, p. 81.

and variables of short or long periods. This general statement of their absence, however, since it rests upon purely negative evidence, may need more and more qualification with the advance of photographic research.

Note by the Editor.

Everyone will admit the extremely interesting nature of the questions discussed in Miss Clerke's paper, and though we may not all agree with her in the very definite conclusions she draws as to the existence of stratified layers of absorbing vapour about the sun and stars, and as to their relative positions and temperatures, the mere discussion of such questions is likely to be instructive. I wish, however, to guard myself, as Editor, from being supposed to put forward her views as generally received.

Personally I am disposed to doubt the existence of the shallow layer of cool vapour above the photosphere which Miss Clerke, as well as other writers, have assumed to exist in order to account for the dark lines of the Fraunhofer spectrum. Nearly all the lines of the Fraunhofer spectrum, whether they are broad or thin, hazy or dark, do not change in breadth and intensity in passing from the centre of the sun's disc to the solar limb: whereas with a shallow absorbing layer, we should expect to find much greater absorption near the limb, where the distance of transit obliquely through a shallow stratum and the consequent absorption would produce a greater blackness of the lines than at the centre of the solar disc, where the light has only to pass through the vertical thickness of the stratum.

Prof. Hale's photographs, as well as direct observations, prove that in the region of the faculae the H and K lines are very bright compared with the light of other wavelengths emanating from the sun's disc. If the vapour which absorbs the Fraunhofer lines extends to a great height above the faculae, we should expect it to reduce the light of the faculae as well as the light of the photosphere. To take a simple example, let us suppose that it halves the brightness of light of K wave-length and reduces the light of the continuous spectrum of the photosphere so that a line is produced in the K region which appears relatively dark compared with the continuous spectrum on either side of it. But the K light from the faculae may be so bright that after half its brightness is absorbed it still appears bright compared with the continuous spectrum on either side of it. It will be noticed that it is only the brighter central part of the K line that gets through and appears bright as compared with the spectrum on either side of it; the fainter wings of the bright line are so reduced as to be lost, and at a very little distance they are reversed so that the central part appears bright in the midst of a nebulous dark band—the intensity of absorption evidently to some extent depends on the difference of temperature of the emitting and absorbing medium—and it seems probable that the proportion of light absorbed from the hot photosphere would be greater than the proportion absorbed from the cooler incandescent gas above the photosphere. The absence of the H line in the Mira spectrum cannot be taken as proving that the cool calcium-vapour is above the glowing hydrogen. The absorbing calcium-vapour may be in the same region, and intermixed with the glowing hydrogen. It is only necessary to suppose that hydrogen glows with H light at a lower temperature than calcium-vapour, and that each foot in depth of calcium-vapour absorbs the H radiations emitted by the preceding foot of hot hydrogen.

The many vertical eruptions in the chromosphere and corona, as well as what we know of the law of gaseous diffusion, seem to render it improbable that there is any horizontal stratification of gases into thin layers upon the

sun, and to lead to the conclusion that the appearance of stratification presented by the lower regions of the chromosphere and by the even surface of the photosphere is due to the difference of temperature at different levels, the isothermal surfaces about the heated nucleus of the sun being a series of concentric spheres.—A. C. RAYBARD.]

Mr. M. Glover, of 124, Stephen's Green, Dublin, writes, enclosing two photographs of a mock sun which he observed at Dublin on the evening of the 30th of June last. The phenomenon was first noticed about 7.30 p.m., and remained visible for about twenty minutes. The photographs were made with very short exposures, and show the sun's disc seen through cirro-stratus cloud, with a spurious image of the sun also seen through cloud at a distance of about 25° from the sun, and at about the same altitude above the horizon. A similar image was seen by Mr. Glover on the left hand of the sun, but it had faded away before the photographs were taken.

Prof. W. W. Payne, of Carleton College, Northfield, Minnesota, is about to issue a new astronomical magazine, to be entitled *Popular Astronomy*. It will be issued monthly, except in July and August, and is intended to meet the wants of "amateurs, teachers, students of astronomy and popular readers."

Scientific investigators are beginning to consider very seriously the problem of a too rapidly accumulating literature. The essence of scientific research is the marshalling and comparison of facts, but as each of the multiplying class of investigators brings in his contribution the need is felt of some authoritative organization of these units into a larger body of knowledge. Scientific publications overlap excessively and there is no reliable index, so that unless a specialist is so happily situated as to see all of the great number of periodicals which may contain work affecting him, he goes in constant danger and dread of missing what may be of vital importance to his own enquiries. Even if he has access to all the literature, the time he will have free for original work is considerably diminished by his study of the work of other men, and by his searches through the chaos of published papers. So much is this the case that it would not be hard to point to men who are not so much scientific enquirers as scientific scholars, devoted almost entirely to keeping pace with the infinite ramification of current work. A clearer definition of the province of certain scientific magazines may possibly do a little to diminish the difficulty, but the trouble will only be fully met by the establishment of subject indices. One of our contemporaries, which is always ready to advocate any scheme for getting money from the Government, urges that a general subject index of Science should be established on a generous scale. It seems to us that the red tape methods of officialism are not suitable for such an undertaking, and that the work would be more satisfactorily accomplished if each of the learned societies would publish annually or quarterly a full subject index in its own department; and that the best results would be obtained if each specialist could be induced to give with each book and paper issued full references to the authorities he has used.

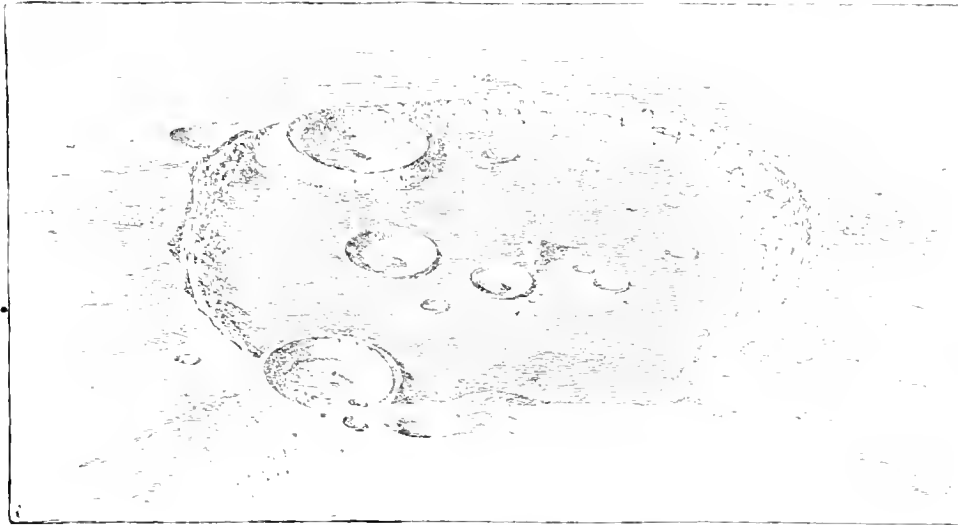
Local telegrams are now transmitted through pneumatic tubes in most of the principal cities of Great Britain. At present about 50 miles of such tubes are in operation, requiring an aggregate of 100 horse-power and transmitting a daily average of 105,000 messages, or 30 millions annually. More than half of these are in London.

THE GREAT LUNAR CRATER TYCHO.

By A. C. RANYARD.

THE late Prebendary Webb used to speak of Tycho as the metropolitan crater of the moon. Though by no means the largest of the lunar craters, it is one of the most striking features of the lunar landscape, especially when the moon is near to the full, and the shadows of the mountains have all disappeared. The crater of Tycho is then seen as a conspicuously white spot, from which radiate in all directions

many of the moon's craters are evidently intimately connected. Many able men have doubted whether there is any true analogy between terrestrial volcanoes and the gigantic lunar ring mountains and circular depressions which we ordinarily speak of as craters. The ring of Tycho is 51 miles in diameter, and the great crater Clavius, which lies to the south of it, is more than 110 miles in diameter; but Clavius is by no means the largest of the lunar craters. If the lunar Apennines and the other mountains forming a broken ring round the Mare Imbrium are the remnants of a crater, it must have had a diameter of over 600 miles, while the largest terrestrial craters are not more than 15 or 16 miles in diameter. Vesuvius and the Monte Somma would appear as insignificant little hills if they were dropped into the centre of the crater of



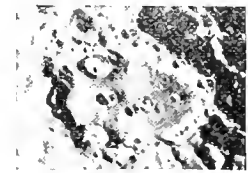
Clavius, from a drawing by Mr. G. K. Gilbert.

a great number of whitish rays that extend over more than a third of the visible hemisphere of the moon, indicating that the crater has been the centre of a colossal disturbance which seems to have shattered the lunar crust in all directions. We have, as far as I am aware, no evidence in the terrestrial geologic record that a corresponding cataclasm has ever similarly shattered the earth's crust;

cup-shaped pits formed on the surface of boiling mud by escaping vapour, and the idea has been a fascinating one to many minds since his day, though it needs but little consideration to recognize that bubbles or blisters formed in a plastic material on a scale corresponding with that of the lunar craters would rapidly sink down and be obliterated.

Tycho, whose ring wall towers to a height of 17,000 feet above the plain it encloses.

Robert Hooke compared the lunar craters to the



Clavius, from a photograph by MM. Henry.



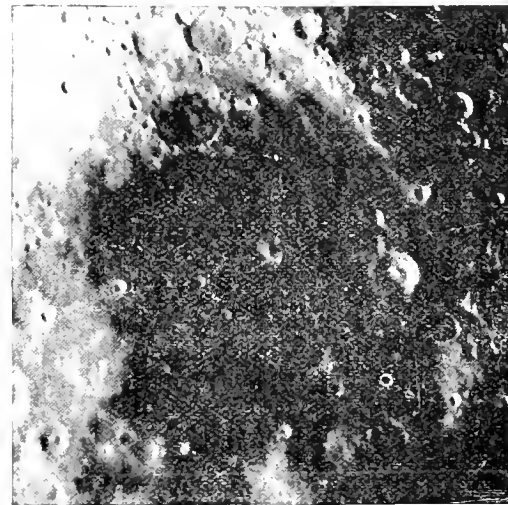
Arzachel

Alpetragius

Alphonsus

Ptolemeus

Thebit



Bullialdus

The Mare Nubium.

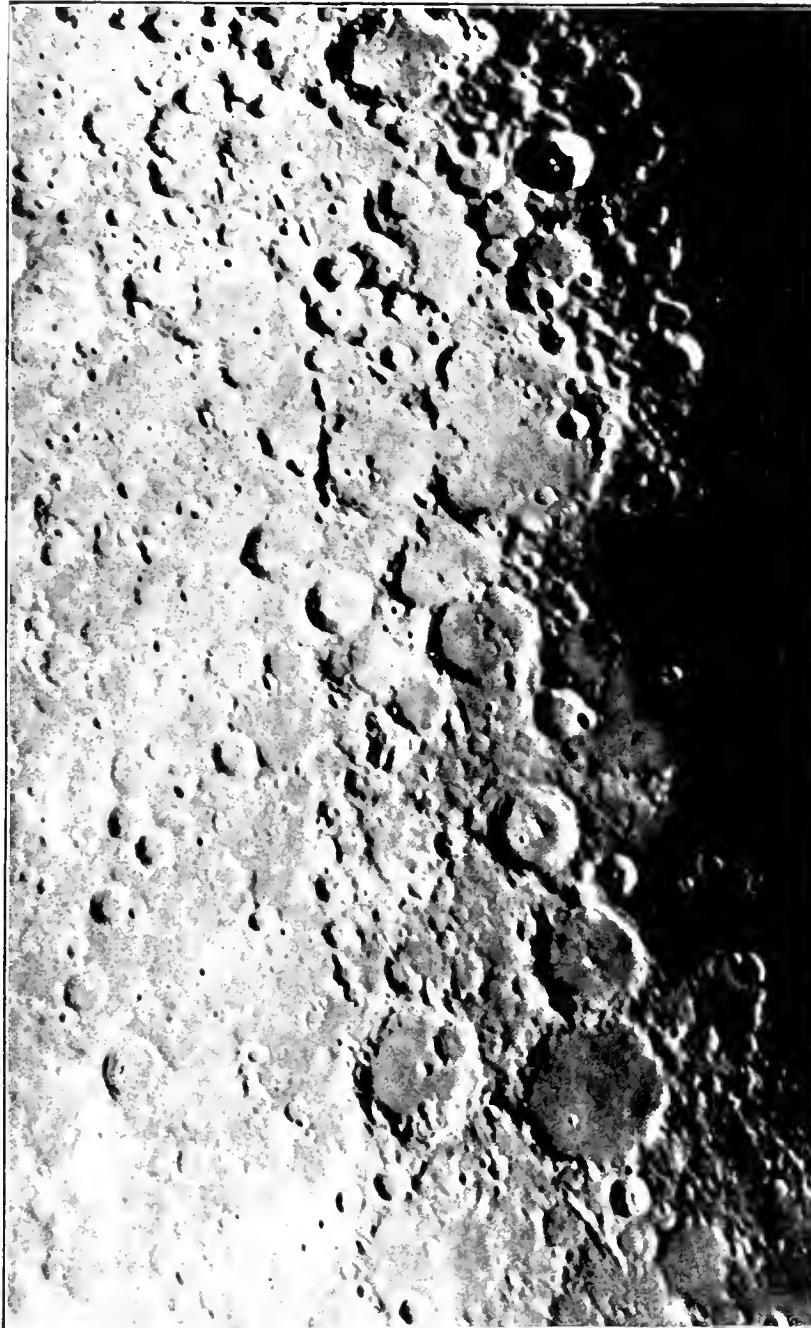
but our terrestrial volcanoes are puny things compared with the giant craters of our smaller companion planet.

As might be expected, the strange phenomena presented in so unparalleled a degree by Tycho have been a fruitful stimulus to speculation as to the origin of the lunar craters and the radiating systems of rays with which

Mr. S. E. Peal has ingeniously advocated a theory which seems to me almost equally untenable. He assumes that the lunar surface consists entirely of ice, and that the

* According to Mr. G. K. Gilbert, in a paper published in the *Bulletin of the Philosophical Society of Washington*, vol. xii., p. 247, (1) the old crater containing Lake Bombon, Isle of Luzon, is

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 above the level of surrounding plains. Putting on one side the difficulty of conceiving of nearly perpendicular ice cliffs of 17,000 to 20,000 feet high, standing for ages without flowing down as glaciers to the plains at their feet, we have to account for the fact that the lunar plains and the floors of the deeper lunar craters are generally of a much darker tint than the higher ground upon the moon; while if the whole of the lunar surface were composed of ice and snow there would be no reason for such a difference of tint, unless, as Mr. Peal suggests, the lunar plains are surfaces of virgin ice while the mountains are formed of snow. But virgin ice would reflect the light of the sun specularly, and in the equatorial and tropical parts of the moon from which the sun's rays could be



From a photograph of the Moon taken by the Brothers Henry on the 29th March, 1890.

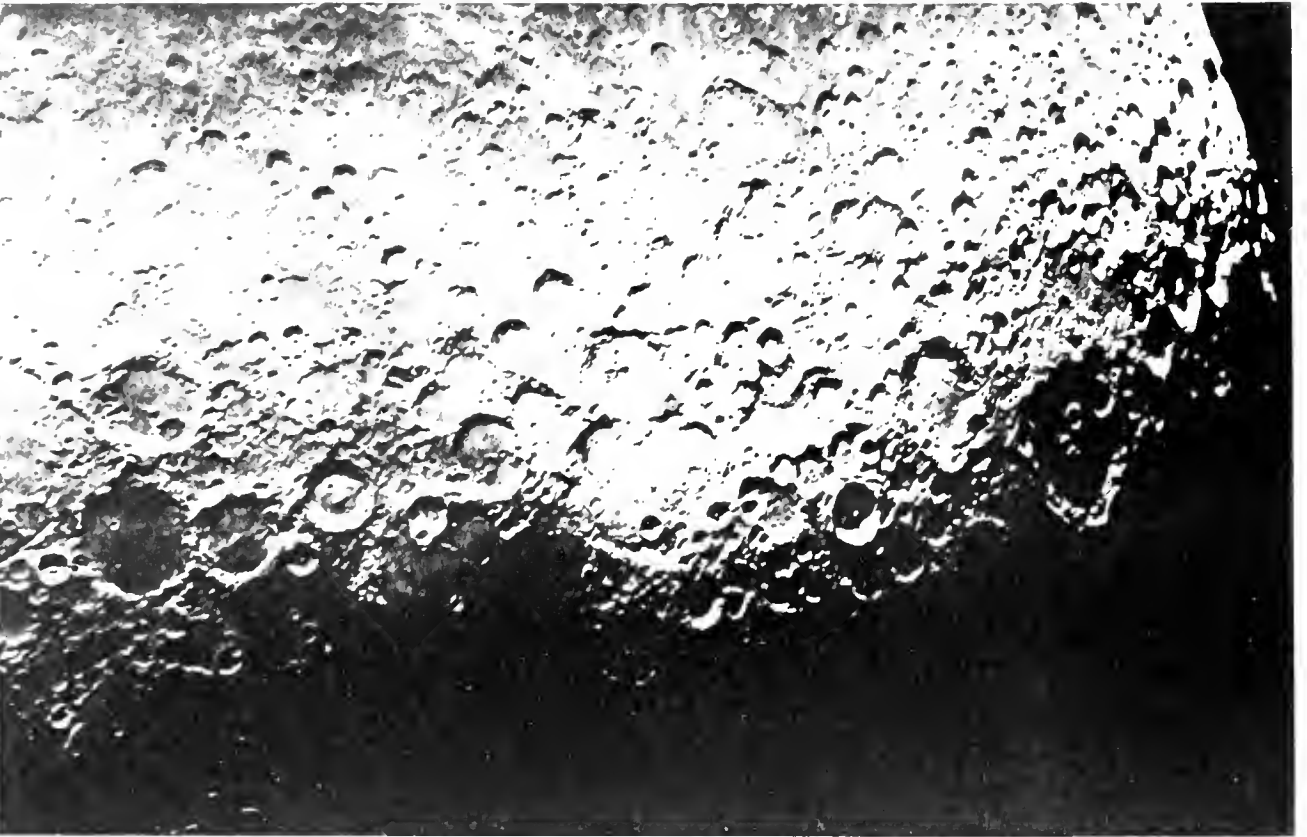
mapped (Reclus) as 16 by 14 miles in extent; (2) the crater of Aso-san, Isle of Kjusiu, Japan, is 15 miles across (Mibne); (3) Scrope mentions a circular crateriform lake, about 15 miles in diameter, in Northern Kamschatka ("Volcanoes," second edition, London, 1862, p. 157); (4) an imperfect crater cirque on Mauritius, mentioned by Charles Darwin, is mapped (Admiralty) as about 15 by 16 miles in extent; (5) the crater walls surrounding Lake Bolesna, Italy, are mapped as 11 by 9 miles in extent; (6) the crater containing Lake Maninjau, Sumatra, is mapped (Reclus) as 15 by 7 miles in extent.

specularly reflected to us there are no traces of such specular reflection. The theory also fails to account for the small craters frequently found on the rims of larger craters and on the sloping sides of mountains; such small craters are far above the assumed rock surface of the moon and warm water issuing from them would flow down the sides of the mountains, leaving marked traces of its flow.

The meteoric theory of the formation of lunar craters has also had many advocates. It is alleged that if a pebble be dropped into mud the scar produced has a raised rim and a central hill, which resembles a lunar crater. Even Mr. Proctor had an inclination for this theory. At page 346 of his book on the moon, he says:—"So far as the smaller craters are concerned, there is nothing incredible in the supposition that they were due to meteoric rain falling when the moon was in a plastic condition. Indeed, it is somewhat remarkable how strikingly certain parts of the moon resemble a surface which has been rained upon, while sufficiently plastic to receive the impressions, but not too soft to retain them. Nor is it any valid objection to this supposition, that the rings left by meteoric downfall would only be circular when the falling

matter chanced to strike the moon's surface squarely; for it is far more probable that even when the surface was struck obliquely, and the opening first formed by the meteoric mass or cloud of bodies was therefore markedly elliptic, the plastic surface would close in round the place of impact until the impression actually formed had assumed a nearly circular shape." After inviting attention to the lunar photographs published with his book, Mr. Proctor continues:—"It will be seen that the multi-

SOUTH



WEST

PHOTOGRAPH OF THE MOON'S SOUTHERN POLE.

Taken when the Moon was 21 1/2 hours old by MM PAUL and PROSERPINE HERVY at the Paris Observatory on the 27th May 1890

SOUTH



WEST

EAST

PHOTOGRAPH SHOWING THE REGION TO THE WEST OF TYCHO

Taken when the Moon was 2 1/2 hours old by MM PAUL and PROSERPINE HERVY at the Paris Observatory on the 28th May 1890

EAST

SOUTH



WEST

EAST

PHOTOGRAPH OF THE REGION ABOUT THE LUNAR CRATER TYCHO.

Taken by MM. PAUL and PROSPER HENRY, with the Blanch refractor of the Paris Observatory, on the 29th May 1890, the Moon being 265 hours old. The sensitive plate was placed behind an eye-piece which enlarged the image in the principal focus direction.

tudinous craters near the southern part of the moon are strongly suggestive of the kind of process I have referred to, and that, in fact, if one judged solely by appearances, one would be disposed to adopt somewhat confidently the theory that the moon had had her present surface contour chiefly formed by meteoric downfalls during the period of her existence when she was plastic to impressions from without.

I am, however, sensible that the great craters, under close telescopic scrutiny, by no means correspond in appearance to what we should expect if they were formed by the downfall of great masses from without. The regular, and we may almost say battlemented, aspect of some of these craters, the level floor, and the central peaks so commonly recognized, seem altogether different from what we should expect if a mass fell from outer space upon the moon's surface. It is, indeed, just possible that under the tremendous heat generated by the downfall, a vast circular region of the moon's surface would be rendered liquid, and that in rapidly solidifying while still traversed by the ring waves resulting from the downfall, something like the present condition would result."

More recently the meteoric theory of the formation of lunar craters has been taken up and considerably elaborated by an American, Mr. G. K. Gilbert, who has made the theory the subject of an address, delivered when retiring from the presidency of the Washington Philosophical Society, on December 10th, 1892. Recognizing the difficulty alluded

to by Mr. Proctor, viz., that most of the lunar craters are circular, while if the meteoric bodies came from outer space many of them ought to strike the moon's surface very obliquely and produce elliptic rings, Mr. Gilbert made a series of experiments in the laboratory, and found that when projectiles were thrown obliquely against a target of plastic materials a crater-shaped hole of elliptic contour

was formed. In order to obviate this objection to the theory, he assumes that the bombarding masses which gave rise to the lunar craters did not come from outer space, but were originally parts of a ring about the earth, similar to the ring which encircles the planet Saturn. From this ring he supposes that the moon was gradually formed, the small bodies constituting the ring having first coalesced into a large number of moonlets, which finally all united into a single sphere. According to this hypothesis the lunar craters are the scars produced by the collision of the moonlets which last surrendered their individuality; and, according to Mr. Gilbert and a mathematical friend who aided him in the investi-



From a photograph of the Moon taken by the Brothers Henry on the 29th May, 1890.

gation, 58 per cent. of the moonlets would under the circumstances imagined strike the surface of the moon, making an angle of less than 20° with the vertical, while 70 per cent. would strike at an angle of less than 30° , and 80 per cent. at an angle of less than 40° . From laboratory experiments, Mr. Gilbert found that the ellipticity of the scars on his plastic target increased slowly up to an incidence of 40° to the vertical, and that beyond that incidence the resulting scars

showed considerable ellipticity. He assumes that, owing to the flat character of the Saturnian ring about the earth, the moonlets must have approached the moon approximately in the plane of its equator; but the fact is not attested by the grouping of the craters in a medial zone. Mr. Gilbert therefore assumes that the axis of the moon's rotation has shifted under the successive impulses of the bombardment, and that the moon's equator has occupied successively all parts of its surface. He assumes that the velocity of impact due to the moon's gravity would be sufficient to melt the rocks of the lunar surface, and that they would during a short period behave as if they were composed of plastic material, but would become hardened before the crater could subside.

The theory does not at all commend itself to my mind. M. Roche, of Montpellier, showed that a ring about a



Riphaean Mountains and the crater Euclides.

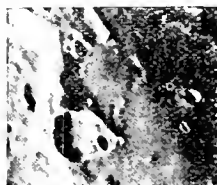
planet would break up if it extended beyond a distance of $2\frac{1}{2}$ ths the radius from the centre of the planet; and if the density of the planet increased towards its centre, the maximum limit to which a ring could extend would be still further contracted. A moon formed just outside such a ring would have an ellipticity greater than that of an ordinary hen's egg; and as tidal action carried the moon away from its primary it would gradually approximate to a spherical form. One can hardly conceive that such a change of shape could take place without obliterating scars on its surface; but there is another objection to the theory, which, to my mind, is even more conclusive. There are upon the moon many lines or strings of small craterlets which fall very evidently into line with one another. If we are forced to treat them as scars upon a target, we must regard their alinement as the result of mere chance distribution; but the number of such strings precludes any such assumption; there must therefore be a physical reason for the alinement, and the most obvious assumption seems to be that the craterlets mark out a line of weakness in the crust of the moon and lie along a volcanic fissure or lunar fault.

There is every gradation in size and in type from the small craterlets or cup-shaped depressions up to the gigantic walled rings, and any theory which professes to account for craterlets must account for the types of crater into which they gradually merge. We therefore seem driven back to the volcanic hypothesis, and have to explain why upon the moon, which is so much smaller than the earth, the volcanic outbreaks have been on so colossal a scale. We are not even in a position to say that the moon is made of similar materials to the earth—indeed, we know that its average density is considerably less, the earth being about 5.66 times as heavy as a similar globe of water, while the moon is only about 3.39 times as dense as water, or, according to Dr. Gill's recent determination, about one per cent. less. We must not, however, conclude from this difference that the moon is made of different materials from the earth, for we know too little as to the behaviour of solids under the enormous pressures that they must be subjected to at even a few miles beneath the earth's surface. The average density of the rocks of which the earth's surface is composed is only about two and a half times that of water, but it does not follow that the central parts of the earth are composed of different and heavier material. The great rigidity of the earth under the tidal strains imposed upon it by the sun and moon points to the conclusion that the solid materials of which the earth is built up are rendered rigid by compression, and that the idea of a fluid interior must be

abandoned. Mr. George F. Becker, of the United States Geological Survey, has recently pointed out that the slags into which most of the stratified rocks of the earth's surface would be reduced by melting, increase in bulk on fusion, and are not like iron and water, which expand on solidifying; consequently, he argues that any crust which formed on the surface of a molten sphere of slag would speedily break up by its own weight and sink, and that the process would go on until the whole mass had been reduced in temperature by such upheavals to near the melting point of the slag. But if the liquid slag, or other materials of which the earth is composed, were capable of being reduced by the pressure of the superincumbent mass to the solid condition, such upheavals would not take place, and under such circumstances it is possible that the heat of the earth may go on increasing to its centre.

If below the surface of the earth large masses of highly-heated rock are kept solid by the enormous pressure of overlying rocks, earth movements caused by the cooling and contraction which crumple up the stratified rocks of the surface and give rise to the upheaving of mountain chains, may occasionally take off some of the weight from the rocks beneath, causing the highly-heated rocks to run off into the liquid state again and find their way to the surface, causing the phenomena we know as volcanic action.

If we adopt this theory of volcanic action, and assume that the moon is made of similar materials to the earth, we shall with lunar gravity only equal to one-sixth of terrestrial gravity need to pass to a depth six times as great upon the moon in order to obtain the pressure necessary to solidify liquid lava at a temperature equivalent to that at which it is solidified beneath the earth's surface, and any change of pressure that releases a stratum of rock from the solid to the liquid state would upon the moon release a stratum approximately six times as thick, other



Thebit



Birt

Straight Black Channel between the craters Birt and Thebit.

From two photographs taken by the Brothers Henry.

conditions being similar, and would presumably give rise to lava flows on a gigantic scale compared with terrestrial evolutions. Added to these considerations, we must remember that under the feeble action of lunar gravity crater rings and cliffs may be built up of similar material much more steeply upon the moon than at the earth's surface.

There are many formations upon the moon which do not take the form of crater rings. The Riphaean Mountains, shown in our photograph of May, 1890, is a very good instance to cite. I should like to draw special attention to a curious straight black streak between the craters Birt and Thebit. It is spoken of by Webb as a wall, but it rather seems to be a narrow valley or fault. It is shown on several of the photographs taken by the Brothers Henry. I would also draw the reader's attention to three dark spots on the floor of the crater Alphonsus, which are shown in all good photographs, as well as the curious marking, like a capital G, near to the centre of the Mare Nubium.

* In an article on the subject by Mr. Becker in the *North American Review* for April, 1893, he states that granite and allied rocks increase in bulk on fusion by about ten per cent.

The imperfect skull of a simply enormous lemuroid animal, from south-west Madagascar, has been exhibited by Dr. Forsyth Major at the Zoological and Royal Societies. It is part of a find sent to the British Museum, and including also some very remarkable *Epyornis* remains. The front portion of the mammalian skull is injured, and only the molar and premolar teeth (of a distinctly lemuroid type) are preserved. There is a high and outwardly projecting zygomatic arch, and the inter-orbital part of the frontals has enormous lateral developments above the orbits. All the bones of the skull are greatly thickened. The brain case is remarkably small, and the cranio-facial angle very obtuse. The remains were exhumed from a marsh covered by a stratum of shell marl about two feet in thickness.

Letters.

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

ON THE FORMATION OF CLOUDS IN THE ATMOSPHERE OF MARS.

To the Editor of KNOWLEDGE.

SIR,—It is generally supposed that the atmosphere of Mars is very rare, and we know from observation that it is generally clear and free from clouds. This has been attributed to the rarefied atmosphere being unable to contain much aqueous vapour, and it has also been concluded that the snow-line is very low, probably reaching the ground in all extra-tropical latitudes. It seems to me that these conclusions have been arrived at by straining an imperfect analogy too far, and that the observed facts can be explained in another, and it seems to me, more probable way. At a fixed temperature aqueous vapour can attain a certain maximum tension. When it does attain this tension, we speak of the air as being "saturated," suggesting an analogy between a salt dissolved in water and the aqueous vapour "dissolved" in the air; and also suggesting that if the *quantity* (apart from the volume) of this air was lessened, the amount of aqueous vapour necessary to saturate it would be lessened also. As a matter of fact it is not so. The maximum tension is quite independent of atmospheric pressure; at the same temperature it would be the same for a vacuum as for our air at sea-level. It is therefore a mistake to suppose that, because the atmosphere of Mars is rare, it cannot contain much aqueous vapour; volume for volume, it can contain exactly as much as our atmosphere could at the same temperature, whatever be its degree of rarity. The explanation of the observed facts must, then, be sought somewhere else.

Let us consider how clouds are formed on our earth. Water is evaporated at sea-level in the form of a transparent and invisible vapour, which rises rapidly, expanding and losing heat as it rises, till on attaining a certain level it has lost so much heat that it can no longer remain in the state of vapour; a considerable portion condenses into the liquid form, forming our lower or cumulus clouds. This level may be called the level of watery condensation. The portion of aqueous vapour which has escaped condensation continues to rise, and as it rises to expand and lose heat, till a higher level is reached at which it can no longer remain in the gaseous state. It then in its turn condenses, but its temperature is so low that it condenses in the solid form, forming our cirrus clouds. This level may be called the level of ice precipitation. I

say ice and not snow, because the snow-level proper is a very different thing, and much lower. There is no snow-level in the air; it is confined to the solid surface, generally mountains, but coming down to sea-level in high latitudes. Probably the aqueous water, if rapidly forced up, as by ascending currents of air in blowing over a mountain slope, is, to a great extent, forced past the level of watery condensation, and when condensation does occur, a good deal of the aqueous vapour passes at once into the solid form, and is deposited as snow. Now let us consider how all this would be modified in the case of Mars, and for the present we will leave out of consideration the greater distance of Mars from the sun, and consider it as if it were at the same distance as the earth, or, at any rate, had the same temperature at the surface. Although the density of the Martial atmosphere is much less than ours, there would be just as much evaporation from an equal area of water surface as with us. Perhaps there would be even more, because evaporation would go on more readily into a rare atmosphere than into a dense one, although ultimately the quantities taken up would be equal. Now this aqueous vapour would rise on Mars as it does with us, but much more slowly, as the density of the Martial atmosphere diminishes much more gradually. This is not conjectural; it can be *proved* that, owing to the diminished force of gravity at the surface of Mars, the atmospheric density, which is halved at a height of three and a half miles with us, would only be halved there at a height of about nine miles. Moreover, the aqueous vapour would not only rise more slowly, but would attain a much greater height before precipitation would occur. If we suppose that on earth it occurs when the vapour has expanded to twice its original volume—that is, at a height of three and a half miles—an equal expansion would only occur on Mars at a height of nine miles. As a matter of fact, precipitation would not occur even then, because the aqueous vapour absorbs a certain amount of heat, partly by stopping the direct solar radiation, partly, and to a much greater extent, by intercepting the reflected radiation from the body of the planet. On the earth, where the vapour rises rapidly, and to a height of only three and a half miles, the amount so absorbed may be inconsiderable, but on Mars, where the vapour rises much more slowly, and to a height of nine miles, the amount absorbed must be much greater, and would raise the level of watery precipitation still further, say to a height of eleven miles. Hence the great height of the Martial clouds, and the slowness with which the vapour rises. We might expect that instead of our dense cumulus clouds, the prevailing cloud in the Martial tropics would be a high and thin stratus, covering nearly the entire sky. Now, we know from experience that a thin veil of stratus cloud interferes but little with the definition of objects seen directly through it—in fact, not unfrequently it improves definition: so that we might expect the centre of the disc would be clearly visible, and as we would have no unclouded portion for comparison, we might not suspect the existence of clouds at all. On the other hand, near the edge of the disc, the light from below coming very obliquely, would be almost entirely intercepted, while the clouds themselves would reflect a diffused white light. Consequently we might *a priori* expect that definition would be good in the centre of the disc, while the edges were surrounded with a whitish margin. Of course, the greater distance of Mars from the sun must modify this to some extent, but the close agreement between our theoretical deductions and the actual results of observation makes me think that the modification can only extend to altering details, leaving the general features the same.

The intensity of the solar heat received by Mars is, we know, only about two-fifths of that received by the earth; but if the earth only received two-fifths of the heat which it does now, the temperature would be so low that the seas would be completely frozen. Mars is probably considerably colder than the earth, especially at night, but it does not appear to be as cold as the distance of Mars would lead us to expect. There must, then, be some cause in the circumstances of the planet itself, preventing it from getting as cold as the earth would under similar circumstances.

The only causes of heat that appear to be possible are (a) internal heat, and (b) a peculiar constitution of the atmosphere. It does not seem likely that the internal heat of Mars can exceed (or even equal) that of the earth, so that we are almost compelled to conclude that the atmosphere is the cause. We know that a superabundance of aqueous vapour in the atmosphere would produce the effect; and we cannot suggest any other cause which appears reasonably probable. But if it be due to aqueous vapour, the atmosphere must be much damper than ours, because ours would not produce the effect, or anything like it.

Yours faithfully,

Dublin,

J. R. HOLT.

[The precipitation of aqueous vapour into cloud in the earth's atmosphere is evidently dependent on other conditions besides temperature, or clouds would form and spread over the heavens every evening as the sun sets. Recent investigations seem to show that the dust-laden condition of our atmosphere is intimately connected with the formation of clouds, and it seems probable from *a priori* considerations that the atmosphere of Mars is less dust-laden than the atmosphere of our earth. Other conditions remaining unchanged, the amount of dust in the atmosphere is dependent on the velocity of the wind, and the feeble gravity at the Martial surface would, as Mr. Maunder pointed out in his article on "The Climate of Mars," published in KNOWLEDGE for September, 1892, lead us to conclude that the Martial winds blow more feebly than terrestrial winds, for all winds have their origin in rising currents of heated air. If the atmosphere of Mars were as dense and vapour-laden as our own, we should expect to see sunset tints on the limb of Mars when gibbous; but no such tints are traceable, and we can hardly expect that the atmosphere of Mars is damper than our own, for as Mr. Holt correctly points out, the amount of aqueous vapour in the Martial atmosphere must depend upon the temperature of the Martial surface, and not on the density of the Martial atmosphere. I am therefore inclined to conclude that the surface of Mars is much colder than the earth's surface, and that the white material which is deposited at the Martial poles, when turned away from the sun, and which melts or disappears as the poles turn towards the sun, cannot be snow, but is more probably some vapour which is precipitated as snow at a far lower temperature than 32° Fahr. Carbonic acid gas when frozen forms a very white, snow-like substance, and an atmosphere similar to our own, or any other mixture of gases forming an atmosphere about the planet, would, if solidified into small crystals, appear white and snow-like. A. C. RAYBARD.]

To the Editor of KNOWLEDGE.

DEAR SIR, The question raised by Mr. Holt in your last number is well worthy of consideration. The Greek word corresponding to the Latin "focus" is *ὄρθη*, but as that word has never, I believe, been applied in a mathematical or astronomical sense, I fear "periestia" would hardly be an appropriate word to express the point in the orbit of a satellite which is nearest to its primary. The objection

to "pericentron" is that its etymological meaning would be ambiguous. If I might venture on a small pleasantry (to be taken in a courteous sense), I would kick against that suggestion, as reminding one of a Greek proverb about an ox-goad.

Independently of "focus" being a Latin word, in the mathematical sense every ellipse has two foci, one towards each apse; so that if there were a Greek word exactly corresponding, the prefixing "peri" to it would not make it clear whether the point nearest to or farthest from the primary planet were intended. Now for these two points collectively we have already the word "apsides"; and if it be desired to coin a word to distinguish that which is nearest the centre of force, perhaps "protapsis" might do as the principal or most important apse, whilst "hyperapsis" (upper apse) would do for the other—the two corresponding to perihelion and aphelion in the orbit of a primary planet. As Montucla points out, the word "focus" was introduced into the conic sections by modern mathematicians from its optical signification; the ancient geometers designated the point by the Latin expression, *punctum comparationis*, and its Greek equivalent.

Mr. Holt alludes to the *hybrid* word "perijove," which has obtained some currency and is decidedly objectionable, though probably the correct form could never be adopted. Unfortunately, there are many instances of want of sufficient care in the formation of words from the Greek. In a conversation I had recently with Prof. Barnard on the fifth satellite of Jupiter, he informed me that many persons in California (with whom he did not himself agree) wished him to name it Eureka, the word being on the seal of that state. There are obvious objections to this application of the word; but it is unfortunate that it has been adopted into English in an erroneous form, for it certainly should have an aspirate and be spelt Henreka, as doubtless pronounced by Archimedes when fresh from his bath.

Blackheath.

Yours faithfully,

July 18th, 1893.

W. T. LYNN.

THE SPECTRA AND PROPER MOTIONS OF STARS.

To the Editor of KNOWLEDGE.

SIR,—As I am just leaving on a vacation trip, during which I shall be away from books and documents, I must defer for the present any remarks on the letters of your correspondents Prof. Kapteyn and Mr. Boraston. We undoubtedly require more research before arriving at definite results, and the extension of the Draper Catalogue to the southern hemisphere, when completed, will furnish very important materials. I may mention that, suspecting that many faint stars with considerable proper motion described as Sirian in the Draper Catalogue were really solar, I wrote to Prof. Pickering, who kindly directed a re-examination of the spectra of the stars mentioned in my letter, and has lately sent me the result. A very considerable proportion of these stars turn out to be really solar stars, mainly of the Capellan type. I made some further inquiries with respect to Capellan stars whose proper motion appeared to be smaller than I expected, but in these instances the new examination led, in the great majority of cases, to the same result as the old. The principal exception is Rigel or β Orionis, whose spectrum is not F but B—this spectrum, according to my view, denoting the most brilliant, and therefore the most distant (relatively to their magnitudes), of all stars. The spectrum of 1830 Groombridge is G.

Truly yours,

16, Earlsfort Terrace, Dublin, W. H. S. MOXER.

July 5th.

Notices of Books.

Moral Teachings of Science. By Arabella B. Buckley. (Edward Stanford.)—Unlike most of Miss Buckley's works, the present little book is not specially addressed to young people, but to those who, as she says in her preface, "feeling puzzled and adrift in the present chaos of opinion, may welcome even a partial solution, from a scientific point of view, of the difficulties which oppress their minds." It is an earnest and sober attempt to throw the light of optimism upon some of the most serious of the problems which beset the thoughtful and sympathetic student of human life. Starting with an exposition, accompanied by illustrative details, of the grand generalizations which have been amongst the proudest achievements of modern science, she endeavours to show that they tend in the direction of hope rather than of despair, even when their operation seems most ruthless; and thus she claims that the great facts of evolution, natural selection, and the uniformity of law have a bearing upon the sphere of morals and duty, and that they tend to give the advantage in the long run to right rather than to might. There rings through the book a healthy tone, which is likely to be beneficial and to make it helpful in building up a sturdy and robust habit of thought.

Happy Hours. By Martha Hill and Friends. (George Bell and Sons.)—An old friend in a new dress. The six volumes of the "Parents' Cabinet," originally projected by Mrs. Hill, have been re-issued with the above title, under the editorship of Miss Constance Hill, daughter of the original foundress. They comprise a collection of short pieces on all imaginable subjects interesting to children. Brief articles on natural history, scientific inventions, biography, &c., are judiciously interspersed with juvenile tales of a more general character; and all are written in a bright, pleasant, and more or less conversational style, which will be as welcome to the rising generation of to-day as it was to their predecessors of forty years ago. The scientific articles are generally accurate and up to date, as well as suited to the comprehension of the auditory for whom they are composed. In these volumes, each of which is complete in itself, mothers will find a useful addition to the nursery library, containing as they do matter suited to varied ages and tastes.

The Apodida: a Morphological Study. By H. M. Bernard, M.A. (Macmillan & Co.)—This is a remarkable book. To none but experts will the title be likely to convey much information, for the Apodida are not a very widely known set of animals. They are a numerically small group of fresh-water crustaceans, constituting a family of the order Phyllopora. The specimens upon which Mr. Bernard's work was done were chiefly received from the Arctic regions, and especially from Spitzbergen. It is much more than a mere detailed account of the morphology of this curious group; it is the laborious investigation of a thorough-going phylogeny-hunter, carried out with zeal and energy under the inspiration of a bold and original speculation, and the problem whose solution is proposed gradually grows from that of the origin of this particular group to so large a generalization as the genealogy of the whole class Crustacea. The theory the author endeavours to establish is primarily that the Apodida are derivable from an annelid or primitive worm that adopted a certain peculiar habit of life, and that in fact they represent the original stock of the Crustacea and constitute a transitional form between that class and the Annelida. His argument proceeds upon the assumption that a primitive carnivorous worm exchanged the habit of capturing its prey by the protrusion of its pharynx for a

browsing method of feeding, and that "the further development of this habit would lead to a *bending round* of the head sufficient to enable the animal to use its anterior parapodia for pushing prey into its mouth; in time the bend of the head would become fixed, and the parapodia modified as jaws and maxilla." The argument depends entirely upon this assumption of the *bending* of the first five segments of the worm's body, and one would have expected the author therefore to be a little more anxious to show the reasonableness of his preliminary hypothesis. It is not easy to see what should have tempted this primitive worm to adopt as an established habit a method of taking its food which seems as though it must at first have been extremely awkward; and yet the results of such adoption were not, according to the author, either insignificant or temporary, but of the most far-reaching consequence, for from this bent annelid he proposes to derive the innumerable forms of both existing and extinct Crustacea. Apart from this initial difficulty the argument is conducted with much ingenuity, though occasionally the author appears to allow his enthusiasm to outrun his caution, and he is surely venturing on risky ground when he says, speaking of the possibility of deducing the various crustacean organs, one by one, from structures known to exist in the Annelida, "it is enough for our argument if we can show that such a deduction is *possible*: it is not essential to our theory that we should show exactly *how* the inner transformation actually took place." Such a statement seems to need a more comprehensive qualification than is contained in what follows, that "the validity of our argument can only be seriously weakened by showing . . . that the improbability of such a transformation is so great that no experienced morphologist would accept it."

THE MIGRATION OF BIRDS.

By G. W. BULMAN, M.A., B.Sc.

IN his book on "The Migration of Birds," Mr. Dixon has focused the scattered rays of knowledge we possess on this subject. For the first time, he claims to have gathered together in one volume an outline of the whole science of the subject. The book commences with a sketch of the history of ancient opinions on the migration of birds, and passes on to a discussion of hibernation. On this question Mr. Dixon is careful not to commit himself to any decided opinion. It is, indeed, a delicate subject to handle, and it is hardly possible for an ornithologist to touch the pitch of the hibernation theory without being defiled; or as it has been said, "it is as much as a virtuous ornithologist's name is worth for him so much as to whisper hibernation, torpidity, and mud."

In spite of this danger, and "at the risk of being 'handled without gloves' by some mud and torpor despising bruiser critic," Mr. Dixon expresses his conclusion as to hibernation thus:—

"I neither accept nor deny it, although fully believing it possible, considering that such an attitude is the most scientific position to assume until the subject has been more fully investigated."

From the connection in which the name of Olaus Magnus is mentioned, a careless reader might imagine he was a contemporary of Aristotle. Mr. Dixon might have mentioned that he was a Swedish divine, who lived in the sixteenth century, and wrote on the natural history of his country. Olaus Magnus was acquainted with the idea held by others, that swallows migrated to warmer countries for the winter, but expressed his own opinion thus:—

* "The Migration of Birds," by Charles Dixon. London, 1892.

"In the beginning of autumn they assemble together among the reeds, where, allowing themselves to sink into the water, they join bill to bill, wing to wing, foot to foot."

Many recorded cases of hibernation are quoted by Mr. Dixon from various authorities, and they are on the whole difficult to explain otherwise. Yet he brings forward nothing as the result of his own observation, and this, he it remarked, is usually the case in the literature of hibernation. A more recent example than any of those given by Mr. Dixon is one recorded in a letter written by an observer, Prof. Carlo Spegazzini, living in the Argentine Republic, published in *Nature*, July 4th, 1889. Writing to a friend in Italy, he says:—

"The bird known here by the name of Golondrina, and which I think is *Progne domestica*, is subject to hibernation. Last year, while the zinc roof of a small house was being taken up in the month of August, just in the middle of our winter, I found underneath about a hundred martins, all accumulated one over the other and lethargic, but in good health, so that, exposed to the sun, they awoke and flew away very briskly. This year, again, having seen some holes on a barrancho, a steep bank over the Plata, I began to dig at them, hoping to get some bats; but there I found several hundreds of martins, of the same kind as above mentioned, clustered and in a state of lethargy. Is such a thing known to naturalists?"

"For upwards of 250 years," says Mr. Dixon, "the hibernation of birds has more or less excited the curiosity of man." But it was a familiar idea more than 1400 years ago, as the following lines from the Roman poet (Claudian (A.D. 408) show:—

"Vel qualis gelidis plumā labente pruinis
Arboris inmortur trameo brumalis hiruendo."

And 400 years earlier still, Pseudo Albinovanus, a friend of Ovid, also alluded to the hibernation of the swallow:—

"Conglaciatur aque, scopulis se condit hirundo
Verberat egelidos garrula vere lacus."

The old state of doubt as to what became of the migratory birds is expressed in Pope's lines:—

"A bird of passage, lost as soon as found;
Now in the moon perhaps, now underground."

And Mr. Dixon reminds us, that with all our recent advance in the science of migration, the winter home of two of our common summer migrants, the house martin and the sand martin, is still practically unknown.

One of the most interesting results established by the researches of the British Association Committee is that, with rare exceptions, the young of the year migrate before the old. This seems to preclude the idea held by many, that the young learn the route by experience, being led over it in the first case by the old. But Mr. Dixon tells us, that while the main body of the young do migrate before the main body of the old, yet the first to take the field are certain individuals which have not been able to breed, or have lost their eggs or young. These old birds act as *avant-courrières* of the migratory host, and guide the inexperienced young birds. Another fact which may be thought to lessen the wonder of the young finding their way is, that large numbers of them are lost. The mortality during migration is enormous, and according to Mr. Dixon is largely due to young birds *losing their way*. Taken together, these two facts may be accepted by many as sufficient explanation of the young birds finding their way when migrating before the old; in my opinion, however, they do not go far enough. In the case of the first, supposing it firmly established that a few old birds do take the lead, can we suppose there would be a sufficient number of them to act as guides to the young

over large districts? A few here and there would hardly suffice. And the absence of breeding cares can hardly be considered a sufficient cause for the migration of these stray individuals, when we remember that the *main body* of the old birds remain behind after such cares have ceased, and even after the young have left the country. Breeding cares, again, are not *in themselves* sufficient to keep the old birds in the country, as we know from the case of certain individuals breeding exceptionally late, which have actually left their young in the nest in order to migrate. In other words, they will stay after breeding cares have ceased, and breeding cares are not sufficient to keep them after a certain time. As to the second, it is perhaps impossible to prove that the mortality is really greater among young birds through losing their way than among the old.

The marvellous way in which birds find their way across thousands of miles of land and sea in their annual migrations has long excited the wonder of naturalists. Dr. Von Middendorff suggested that birds might be endowed with something which rendered them sensitive to the magnetism of the earth, so that they were able to adjust their course as a mariner does his by the magnetic compass.

Prof. Weismann, in an essay on migration, considered the faculty to be due to *experience*, not of the *individual* but of the *race*. In other words, he believed the sharpened faculties of one generation were transmitted by heredity to the next: a conclusion upon which his own recent investigations on acquired characters throw doubt.

According to Mr. Dixon, the "mysterious sense of direction" with which many writers have gifted migratory birds is a "myth." Their power of finding their way, he thinks, is due to their keen sight, and the fact that they usually fly sufficiently high to take a bird's-eye view of a great part of their route at once. And in crossing the sea, in which the distance passed over is usually not more than 300 miles, it is supposed that the height at which they fly enables them to take in the land-marks on the opposite shore. This power of sight, added to a very retentive memory for land-marks, is thought to be sufficient to account for their power of finding their way. In regard to the question as to the height at which migrating birds usually fly, Mr. Dixon suggests the use of a captive balloon from which to make observations.

There are four classes of lines of migration, viz.:—sea routes, coast routes, river routes, and mountain routes. Of these, the first two are of special interest, as suggesting old vanished coast lines and land connections. Birds in their migrations seem usually to choose those lines which present the least expanse of water to be crossed, and the routes by which our summer visitors reach us and return are by the Straits of Gibraltar, Corsica and Sardinia, and Sicily and Italy; and these routes correspond with the old land connections between Europe and Africa, as seen, for example, in Prof. J. Geikie's map of prehistoric Europe. It is supposed by many that the passage of the migratory hosts by these particular lines is due to the conservatism of a habit practised by their remote ancestors when the present water-way was land. As the land gradually sank, successive generations of birds passed over the gradually increasing distance of sea without experiencing much lengthening of the journey. In this way, the studies of the geologist and the ornithologist confirm each other.

It is to be remarked, however, that if, as Mr. Dixon believes, birds fly at a sufficient height to take in at a glance vast extents of country, we may well suppose that individual birds at the present day may, from such a view, be enabled to *choose for themselves* the shortest route without any aid from inherited habits.

Perhaps the most interesting indication of an old land surface is that suggested by the migration of the orange-legged hobby (*Falco amurensis*). Breeding in Eastern Siberia, Mongolia, and North China, it migrates to winter quarters in India and South-East Africa. Its suggested route is by the Maldivé Islands, the Chagos Archipelago, and the Saya de Malha Banks, and in this passage it is supposed to be following an ancestral habit acquired when India was connected with Africa, and the migration could be performed by land.

Such an Indo-African continent has also been suggested by the geologist from the study of the rocks of the two areas, and by the zoologist from a study of their faunas.

In the Indian rocks, forming what is known as the Gondwana system, an assemblage of organic remains are met with, presenting such a remarkable similarity to those of South Africa and Australia that Dr. Blandford has been led to advocate the existence of an expanse of land connecting India with these continents during the Gondwana period. And naturalists studying the present faunas, and finding a striking similarity between that of India and that of Madagascar and the adjacent islands, likewise require an Indo-African continent to explain their facts. The name Lemuria has been proposed for this continent, since it is supposed to have been the original home of the family Lemuridae, now divided by the Indian Ocean into the two separate regions of Madagascar and South Africa on the one hand, and South Asia on the other. It is to be remarked, however, that the migration of the orange-legged hobby, and the distribution of the Lemuridae, require a *much more recent* land connection than the ancient Gondwana continent of Dr. Blandford.

Coast migration, again, has suggested the existence of former coast lines. Thus the knot, the bar-tailed godwit, and the grey plover migrate up the east coast of England as far north as Spurn Point, and then strike across the sea eastwards. They are supposed to be following an old coast line once reaching from Spurn Point to Denmark or Holland; and geologists have certainly given us a restored Britain, in which our eastern sea-board was united to the Continent. Yet the northern coast of this uniting land was far away to the north of Spurn Point. Still, if we suppose the submergence of the land was gradual, and from the south northwards, there may have been a time when the coast line, after trending north to Spurn Head, turned eastward to the Continent. And if this phase in the physical geography of the land was a comparatively permanent one, the peculiar line of migration followed by the grey plover might have been learned. It seems a more reasonable supposition, however, that birds which had learned to follow a *coast line* would continue to follow a *gradually altering* coast line, rather than take to the sea.

It is interesting to note that birds, in migrating over continental areas, make large use of valleys and water-courses, and less frequently of mountain ranges and passes. And just as many of the species inhabiting warmer regions retire north to breed, so others ascend the mountains for the same purpose. Thus in India, for example, birds retire to the hill stations for coolness, just as do the human inhabitants.

Like other writers on the subject, Mr. Dixon attributes the origin of migration to lack of food and unsuitableness of temperature; and he considers that these causes have been largely brought into operation by the climatal changes of the glacial period. Birds, he considers, have only been subject to one glacial period, for he rejects the evidence for any of them between that known as the Great Ice Age and Permian times. Migration, as we see it now, commenced with the glacial epoch. Mr. Dixon illustrates the initiation of

migration by taking the spotted fly-catcher as an example. During a mild period it was a resident species in one unbroken area from the Arctic woodlands to the Pacific. As the cold period came on, the spotted fly-catcher was driven further and further south. Then they began to leave their northern haunts in autumn, and gradually, as the cold increased, their journey was lengthened. As glaciation ceased, they began to move north again, and also to journey north in spring to breed, returning south in winter, as they had learned during glaciation. Migration, then, consisted at first of very small journeys, gradually increasing as the ages rolled on.

In relation to the ornithological axiom, that "the birds which go the furthest north to breed go the furthest south to winter," Mr. Dixon expresses the belief that the habit indicates an ancient migration from pole to pole. Many birds which breed in the Arctic regions extend their winter migration far south of the Equator, as the sanderling, which reaches the Malay Archipelago, Cape Colony, and Patagonia; and the curlew sandpiper, which flies as far south as Australia for the winter; and quite possibly some species may even yet perform the journey from pole to pole. Thus Mr. Hudson, in "The Naturalist in La Plata," mentions certain species which come from the Arctic regions to winter on the Pampas, and of which species individuals also reach the same area from Antarctic regions. May not some of these be birds which have actually passed from the Arctic to the Antarctic regions? And Mr. Dixon suggests that these flights for vast distances southwards are due to inherited love of home; for he believes that during the glaciation of the northern hemisphere the species were transferred from the north polar basin to the more genial south; and now, when their home and breeding place is in the milder northern regions, they show their hankering after the old home by flying as far south during the northern winter as circumstances permit.

Emigration, as distinct from migration, refers to the colonizing movements of birds by which they permanently leave their old haunts. And Mr. Dixon considers that the emigration of birds has had a vast influence on the origin of species. It leads to isolation of a number of individuals from the main body of the species, and the absence of intercrossing with the latter is supposed to be sufficient to allow of their developing into a new variety, and finally *species*, under their new and slightly different conditions.

Besides the great north and south migrations, by which our winter and summer visitors come and go, great east and west migrations in spring and autumn have been established. And, strange to say, the species moving in these latter are to a very large extent such as have always been looked upon as residents. Starlings, larks, sparrows, buntings, and many others leave Britain in immense numbers in autumn, and their place is taken by similar numbers of the same species from the Continent. In the spring the two streams are reversed, the one returning to Britain from the Continent, and the other passing back to the Continent from Britain. Almost all our native birds take part, more or less, in these migrations.

"With very few exceptions," runs the report of the British Association Committee, "the vast majority of our British birds, such as are generally considered habitual residents—the young invariably, the old intermittently—leave these islands in the autumn, their place being taken by others, not necessarily of the same species, coming from more northern latitudes, or from districts of Eastern Europe. . . . These immigrants on the approach of spring leave, moving back to the Continent on the same lines,

but in the reverse direction . . . at the same time also our own birds return from the Continent to their nesting quarters in these islands."

The reason of such migratory movements can scarcely be explained as the result of lack of food and unsuitability of climate, since multitudes of the same species as those which leave pass the winter in the same country.

An interesting and apparently inexplicable fact recorded by the British Association Committee, and not alluded to by Mr. Dixon, is a migration westwards from the west coast of Ireland. Thus, in their report for 1887, they write:—

"At Rathlin O'Birne (West Donegal) immense flocks of birds—starlings, thrushes, and fieldfares—passed west from December 18th to 23rd. The nearest land to the west of this rocky island is America. This is not an isolated occurrence. The westerly flight of land birds at stations off the west coast of Ireland has been noticed on other occasions; the movement is apparently as reckless as that of the lemmings."

Certain naturalists have suggested, in all seriousness, that the westward migration of the lemming is in search of the lost Atlantis, to which their ancestors were wont to roam. Will they accept this westward migration of birds as a further illustration of the former existence of the Platonic continent?

THE FACE OF THE SKY FOR AUGUST.

By HERBERT SADLER, F.R.A.S.

NEITHER sunspots nor facule show very perceptible signs of decrease. Conveniently observable minima of Algol occur at 11h. 39m. p.m. on the 11th, and at 8h. 28m. p.m. on the 11th.

Mercury is too near the Sun during the first portion of the month to be visible, he being in superior conjunction on the 8th. On the 20th he rises at 3h. 31m. a.m., or 1h. 23m. before the Sun, with a northern declination of $15^{\circ} 39'$, and an apparent diameter of $8\frac{1}{2}''$, $\frac{2}{100}$ ths of the disc being illuminated. On the 25th he rises at 3h. 22m. a.m., or 1h. 40m. before the Sun, with a northern declination of $16^{\circ} 1'$, and an apparent diameter of $7\frac{1}{2}''$, $\frac{4}{100}$ ths of the disc being illuminated. The next morning he is at his greatest western elongation ($18\frac{1}{2}^{\circ}$). On the 31st he rises at 3h. 35m. a.m., or 1h. 38m. before the Sun, with a northern declination of $11^{\circ} 47'$, and an apparent diameter of $6\frac{1}{2}''$, $\frac{5}{100}$ ths of the disc being illuminated. While visible, Mercury passes through a portion of Cancer into Leo, without approaching any conspicuous star.

Venus is an evening star, setting on the 1st at 8h. 33m. p.m., or 59m. after the Sun, with a northern declination of $11^{\circ} 27'$, and an apparent diameter of $11''$, $\frac{2}{100}$ ths of the disc being illuminated. On the 18th she sets at 8h. 13m. p.m., with a northern declination of $3^{\circ} 8'$, and an apparent diameter of $11\frac{1}{2}''$, $\frac{5}{100}$ ths of the disc being illuminated. On the 31st she sets at 7h. 45m. p.m., or 57m. after the Sun, with a southern declination of $3^{\circ} 34'$, and an apparent diameter of $12\frac{1}{2}''$, $\frac{7}{100}$ ths of the disc being illuminated. Her brightness at the beginning of the month is about one quarter of what it will be at the beginning of next January. During August she passes from Leo into Virgo, being near the 4th magnitude star γ Leonis on the 8th, and the 1th magnitude star σ Leonis on the 12th. On the evenings of the 18th and 19th she is not far from the $3\frac{1}{2}$ magnitude star β Virginis, and on the 25th she is near the 1th magnitude star γ Virginis, and at the end of the month to the south-west of Saturn.

Mars is invisible; and as Neptune does not rise till after

midnight at the beginning of the month we defer an ephemeris of him till September.

Jupiter rises after 11h. p.m. at the beginning of August, and is getting into a favourable position for observation. He rises on the 1st at 11h. 15m. p.m., with a northern declination of $18^{\circ} 41'$, and an apparent equatorial diameter of $37\cdot5''$, the phase on the p limb being perceptible. On the 19th he rises at 10h. 9m. p.m., with a northern declination of $19^{\circ} 8'$, and an apparent equatorial diameter of $39\cdot4$. On the 31st he rises at 9h. 25m. p.m., with a northern declination of $19^{\circ} 19'$, and an apparent equatorial diameter of $40\cdot8''$, the phase on the p limb amounting to $0\cdot4$. He is in quadrature with the Sun on the 23rd. During the month he describes a short direct path in Taurus, being about 1° south of the Pleiades on the 1st, but without approaching any naked eye star during the month. At half an hour after midnight on the 29th a 9·5 magnitude star will pass behind the centre of the planet a little to the north, the occultation lasting about four hours. The following phenomena of the satellites occur while Jupiter is more than 8° above and the Sun 8° below the horizon:—On the 2nd a transit egress of the shadow of the second satellite at 1h. 5m. a.m., and of the satellite at 1h. 26m. a.m. On the 6th a transit ingress of the shadow of the first satellite at 2h. 25m. a.m., and of the shadow of the third satellite at 3h. 12m. a.m. An occultation reappearance of the first satellite at 3h. 6m. a.m. on the 7th. A transit egress of the first satellite at 0h. 26m. a.m. on the 8th. A transit ingress of the shadow of the second satellite at 1h. 19m. a.m. on the 9th. An occultation reappearance of the third satellite at 0h. 6m. a.m. on the 10th. An occultation reappearance of the second satellite at 1h. 29m. a.m. on the 11th. An eclipse disappearance of the first satellite at 1h. 29m. 31s. on the 14th. On the 15th a transit ingress of the first satellite at 0h. 10m. a.m.; a transit egress of its shadow at 0h. 59m. a.m.; a transit egress of the satellite at 2h. 21m. a.m.; an occultation reappearance of the first satellite at 11h. 30m. p.m. An occultation disappearance of the third satellite at 2h. 40m. a.m. on the 17th. On the 18th an eclipse reappearance of the second satellite at 1h. 17m. 56s. a.m., and its occultation disappearance at 1h. 49m. a.m. On the 21st an eclipse disappearance of the first satellite at 3h. 23m. 16s. a.m. On the 22nd an ingress of the shadow of the first satellite at 0h. 41m. a.m., a transit ingress of the satellite at 2h. 4m. a.m., and a transit egress of its shadow at 2h. 53m. a.m. An occultation reappearance of the first satellite at 1h. 21m. a.m. on the 23rd. On the 21th an eclipse disappearance of the third satellite at 1h. 6m. 1s. a.m., and its eclipse reappearance at 2h. 31m. 10s. a.m. On the 25th an eclipse disappearance of the second satellite at 1h. 39m. 41s. a.m., and its reappearance at 3h. 53m. 52s. a.m. It is stated by Webb that only four observations of the disappearance and reappearance of the second satellite on the same night are on record. A transit egress of the second satellite at 0h. 52m. a.m. on the 26th. On the 29th a transit ingress of the shadow of the first satellite at 2h. 35m. a.m.; a transit ingress of the satellite at 3h. 58m. a.m.; an eclipse disappearance of the first satellite at 11h. 15m. 28s. p.m. On the 30th an occultation reappearance of the first satellite at 3h. 17m. a.m. On the 30th a transit egress of the shadow of the first satellite at 11h. 16m. p.m. On the 31st a transit egress of the first satellite at 0h. 37m. a.m. The following are the times of superior and inferior conjunctions of the fourth satellite:—Superior, August 16th, 3h. 9m. p.m.; Inferior, August 8th, 7h. 12m. a.m., 25th, 1h. 38m. a.m.

Saturn is still just visible in the evening, but must be looked for in the early twilight to be seen at all. He sets

on the 1st at 9h. 50m. p.m., or 2h. 4m. after sunset, with a southern declination of $1^{\circ} 10'$, and an apparent equatorial diameter of $16''$ (the major axis of the ring system being $37\frac{1}{4}''$ in diameter, and the minor $4\cdot7''$). On the 31st he sets at 7h. 56m. p.m., or 1h. 8m. after sunset, with a southern declination of $2^{\circ} 22'$, and an apparent equatorial diameter of $15\frac{1}{2}''$ (the major axis of the ring system being $36''$ in diameter, and the minor $5''$). Iapetus is at his greatest eastern elongation on the 11th, and in inferior conjunction on the 30th. A map of the path of Saturn during August will be found in the "Face of the Sky" for March. He is in conjunction with the beautiful pair γ Virginis shortly after 10h. a.m. on the 7th, the planet being $31'$ south of the star.

The above remarks as to the visibility of Saturn apply also to Uranus. He sets on the 1st at 10h. 30m. p.m., with a southern declination of $13^{\circ} 23'$, and an apparent diameter of $3\cdot6''$. On the 31st he sets at 8h. 33m. p.m., with a southern declination of $13^{\circ} 40'$. A map of his path during August will be found in the "Face of the Sky" for April.

This month is one of the most favourable ones for the observation of shooting stars. The most noted shower is that of the Perseids with a radiant point at the maximum display on August 10th in R.A., 2h. 52m., dec. $+56^{\circ}$. Observation of this region of the heavens with an opera glass will no doubt show stationary meteors, or meteors which shift their positions very slowly. Their place, and the direction of their shift, should be noted for the purpose of determining whether the radiant is a geometrical point, or a circle, or an elliptic area, as suggested with regard to the November meteors. (*Monthly Notices of the R.A.S.*, Vol. xlvii., pp. 69-73.) The radiant point souths on the 10th at 5h. 37m. a.m.

The Moon enters her last quarter at 4h. 23m. p.m. on the 5th; is new at 8h. 48m. p.m. on the 11th; enters her first quarter at 9h. 52m. a.m. on the 19th, and is full at 8h. 43m. a.m. on the 27th. She is in perigee at 9h. p.m. on the 8th (distance from the earth 227,130 miles), and in apogee at 7h. p.m. on the 20th (distance from the earth 251,150 miles).

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, Knowledge Office," and posted before the 10th of each month.

Solution of July Problem (G. K. Ansell):—

Key-move, 1. R to B5.

If 1. . . . K x R, 2. P to K4ch.

If 1. . . . P x R, 2. B x Pch.

If 1. . . . Anything else, 2. R x Pch.

CORRECT SOLUTIONS received from R. B. Cooke, Alpha.

The defence to 1. Kt (Q5) to Kt6 (or B3, or K3), in Mr. Loyd's problem in the June number, is 1. . . . P to Kt8, becoming a Bishop. If then 2. . . . B to Q5 Black is stale-mated. R. I. has taken the hint and discovered this.

In Mr. Domsthorpe's problem the Bishop must work his way to KKt7, but he must capture the Black Pawn *en route* should Black play 1. . . . B to R8, for otherwise Black will secure a stale-mate by 2. . . . P to Kt7. The only key, therefore, is 1. B to K5.

This problem is correctly solved by R. I. and Alpha.

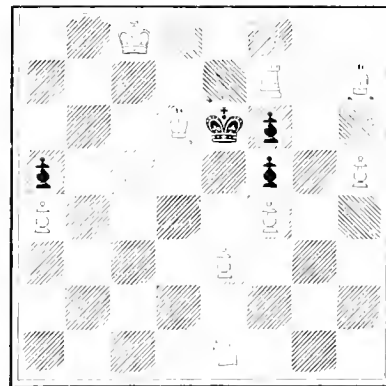
W. James.—If 1. Kt (B8) to K7, Black defends himself by checking with the Rook, either at once or on the second move.

Alpha. The mysterious defence is given above. Many thanks for the position appended.

PROBLEM.

By A. G. FELLOWS.

BLACK.



WHITE.

White to play and mate in three moves.

The following position from a Sanserit work (translated in 1818) is contributed by "Alpha." The solution is more showy than difficult:—

White.—K at KB8, Q at QR2, R at KKt7, Kt at KB6, P at KKt5.

Black.—K at KRsq, B at QKt8. White to play and mate with the Pawn in four moves.

The late Mr. Rosenbaum once composed a somewhat neater and certainly more difficult problem, with precisely the same conditions:—

White.—K at KR6, R at K7, Kt at QB7, P at Kt.

Black.—K at KRsq. White mates with the Pawn in four moves.

The following game was played on the Atlantic last month, the players being A. Walbrodt, on his way to Berlin, and Max Judd, the recently appointed U.S. Consul at Vienna. The score is from the *Illustrated London News*:—

"FRENCH DEFENCE."

WHITE (Max Judd).	BLACK (A. Walbrodt).
1. P to K1	1. P to K3
2. P to Q1	2. P to Q4
3. QKt to B3	3. KKt to B3
4. B to KKt5	4. B to K2
5. P to K5	5. KKt to Q2
6. B x B	6. Q x B
7. Q to Kt4 (a)	7. P to KKt3 ?
8. P to KB4	8. P to QR3 (b)
9. Castles	9. P to QB4
10. P x P	10. Kt x P ? (c)
11. Kt to B3 ? ? (d)	11. Kt to B3
12. P to KR4 (e)	12. P to KR4
13. Q to Kt5	13. P to QKt4
14. B to Q3	14. B to Kt2
15. Q x Q	15. K x Q
16. Kt to Kt5 ?	16. KR to Qsq
17. KR to Ksq	17. Kt to Kt5
18. P to R3	18. QKt x B
19. P x Kt	19. QR to Bsq
20. P to Q4	20. Kt to R5
21. R to Q3	21. P to R4

- 22. K to Ktsq
- 23. Kt x KtP
- 24. R to Kt3
- 25. Kt to KB3 (g)
- 26. P to Rt
- 27. R to R3 (h)
- 28. P x B
- 29. R to Kt3
- 30. K to R2 (j)
- 31. R to K2
- 32. R to Kt4
- 33. R x R
- 34. R to QB2
- 35. Kt to Q2 (l)
- 36. R x Kt
- 37. K to Ktsq (m)
- 38. R to KB2
- 39. P to KKt3 (n)
- 40. K to B2
- 41. K to B3 (o)
- 42. P to QKt1 (p)
- 43. P to Kt5
- 44. K to Kt1
- 45. R to B2
- 46. K to R5 ?
- 47. P to Kt6
- 48. R to B3
- 49. R to QR3
- 50. K to R6
- 22. Kt to Kt3 (f)
- 23. B to R3
- 24. Kt to B5
- 25. R to QKtsq
- 26. Kt to Kt3
- 27. B x Kt (i)
- 28. Kt to B5
- 29. R to Kt2
- 30. KR to QKtsq
- 31. P to R5! (k)
- 32. R x P
- 33. R x R
- 34. R to Kt6!
- 35. Kt x Kt
- 36. R to Kt6
- 37. R to Kt5
- 38. R x RP
- 39. R to RSch
- 40. R to R8
- 41. P to R6
- 42. R to KKts
- 43. R x Pch
- 44. K to Q2
- 45. R to Kt8
- 46. R to Kt8
- 47. R to Kt7
- 48. P to R7
- 49. P to R5
- 50. P to R6 and wins.

NOTES.

(a) Inferior to the usual 7. Q to Q2, P to QR3; 8. Kt to Qsq, P to QB4; 9. P to QB3, because it leaves the Queen's side weak. Black's reply, however, is feeble, castling being quite safe.

(b) The customary preparation for P to QB4 in this opening. White's reply is perhaps a little premature.

(c) A strange oversight, followed by a still more strange omission on the part of White. He should of course play 10. . . QKt to B3 at once, as the Pawn will keep. Possibly the moves were incorrectly transposed in the score.

(d) 11. Kt x P obviously wins at once, whether the Knight be taken or not.

(e) The weakness of Pawns caused by this advance ultimately loses him the game (*vide* Black's 36th and 37th moves): but he has already some inferiority.

(f) A very enterprising line of play: the Pawn sacrificed is not regained for several moves.

(g) Showing the futility of his 16th move.

(h) 27. Kt to B3 would not save the Pawn—*e.g.*, 27. Kt to B3, Kt x P; 28. R x R, Kt x Ktch, etc.

(i) 27. . . Kt x P might also be played, the Bishop in such a position being worth more than the Knight.

(j) More desirable would be 30. R. to K2 at once, with a view to manœuvring the Knight *via* Ksq to Q3, etc.

(k) A fine move, which leaves White in a cramped position after the exchanges.

(l) This soon loses a Pawn; 35. K to Rsq, with a view to R to B3 is certainly no worse.

(m) A strange position. White is compelled to make some disadvantageous move: for if 37. R to KB2, R to Q5 wins.

(n) 39. K to R2, R to R8; 40. K to R3, R to RSch; 41. K to Kt1 looks more promising.

(o) Even now 11. R to B3 might save the game.

(p) For if 42. R to B3, P to R7!; 43. R x P, R x Pch; changing Rooks and winning with the RP. The ending is very cleverly played by Herr Walbrodt.

CHess INTELLIGENCE.

"KNOWLEDGE" THREE-MOVE PROBLEM TOURNAMENT.

This will commence in the November number of KNOWLEDGE, and is open to the world.

The Proprietors of KNOWLEDGE offer the following prizes:—

- 1st Prize.—A full-sized Set of Staunton Chess-men.
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The Conditions are as follows:—

1. Each competitor may send not more than one three-move unconditional direct mate problem (diagrammed).
2. Competing positions must be original and unpublished.
3. Each problem must be accompanied by a motto and full solution, with a sealed envelope containing the composer's name and address.
4. Competing positions must reach Mr. C. D. Loeck, Burwash, Sussex, England, on or before October 10th, 1893.
5. The Chess Editor reserves the right of excluding manifestly impossible, unsound, or inferior positions.
6. Should more than twenty positions be received, the Chess Editor may, with the assistance of an expert, select the best twenty for competition. In that case the remainder will be returned to their respective composers without delay.
7. The adjudication will be partly by solvers and partly by a recognized expert.

All solvers who solve correctly every problem will be entitled to vote on their merits, the Chess Editor having also one vote. The six or seven problems thus selected will then be submitted to an expert, whose decision on their respective merits will be final.

A SOLUTION TOURNEY will commence at the same time. Particulars will be given next month.

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TOOTHED WHALES AND THEIR ANCESTRY.

By R. LYDEKKER, B.A.Cantab.

WITHIN the entire limits of the great mammalian class, there are, perhaps, no creatures which arouse a larger amount of interest both among the general public and among naturalists—than those included under the names of whales, dolphins and porpoises, and collectively known as cetaceans. One reason for this universal interest is, doubtless, that among these denizens of the deep are comprised the largest animals, not only of the present day, but likewise, so far as our information allows us to speak, of all epochs. Then, again, the fact that such apparently fish-like creatures are really warm-blooded mammals, suckling their young in the manner distinctive of other members of the class, and being under the necessity of coming to the surface at certain intervals for the purpose of breathing, cannot fail to strike even the most unobservant mind as being something quite beyond the ordinary. Moreover, the momentary glimpses which in general are all we obtain of these animals, and the halo of mystery which still to a great extent enshrouds their mode of life, are likewise important elements in generating the wide-spread interest they arouse. To the zoologist, cetaceans are indeed not only of prime importance as being the sole mammals which have assumed a purely fish-like form, and

have become so thoroughly adapted to a completely pelagic life as to be unable to exist on land, but their study gives rise to many problems as to their origin and relationships, and the mode in which they attained their present condition.

As we have already alluded to some of the leading external features of cetaceans in our articles on "Swimming Animals," we need not enter very fully upon these here; merely pointing out that while the general contour of the body is fish-like, the tail-fin, or flukes, differs essentially from that of a fish in being horizontal instead of vertical; while in place of the two sets of paired fins characterizing a fish, a whale has but a single pair of flippers representing the greatly modified fore-limbs of other mammals. The hind limbs have, indeed, been completely lost externally, although more or less imperfect traces of them may still be detected deeply imbedded among the muscles of the body. In the great majority of the group the back is furnished with an upright fin, very similar in appearance to the unpaired back-fin of a fish. Whereas, however, such a dorsal fin is constantly present in fishes, in cetaceans it may be absent or present in different species of the same genus; while if we were to cut through such a fin we should find a total absence of the slender spine-like bones characterizing those appendages in a fish; a similar condition also obtaining in the flukes. In marked contrast to the scaly armour of the majority of modern fishes, the skin of a cetacean is for the most part completely naked; although the frequent presence, in the young state at least, of a few scattered bristles in the region of the mouth is of itself sufficient to indicate the derivation of these strangely modified creatures from more ordinary mammals. As regards their coloration, we may again, however, note a similarity to most pelagic fishes, in that while the upper parts are generally dark, the lower surface of the body is of a light hue; this arrangement being, of course, designed to render all these animals as inconspicuous as possible when viewed in the water either from above or from below. Although the flippers show no external indications of digits, and are unprovided with nails, yet their internal skeleton comprises the same elements as occur in the limbs of any ordinary mammal, and is thus quite different from that of a fish. This structural similarity is, however, to a certain degree obscured by the alteration in the form of the bones, and also by the circumstance that the number of joints in the skeleton of the individual digits is increased beyond the normal. As external ears would be mere useless incumbrances, these appendages are absent; while the aperture of the ear itself is reduced to an extremely

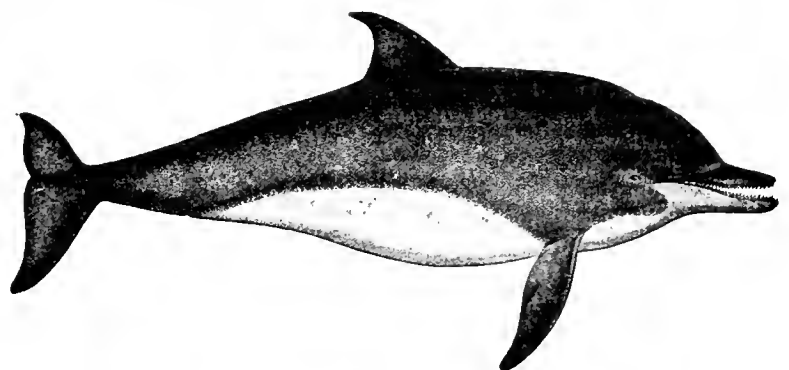


FIG. 1.—The Bridled Dolphin. (From True *Bull. U. S. Nat. Museum*.)

minute size. To prevent the ingress of water during the periods of submergence, the apertures of the nostrils, which may be either double or single, can be completely closed

at will, and are only opened at such times as the creatures come to the surface to breathe, when a column of water is generally thrown up by the rush of expired air let loose shortly before the head reaches the surface. In all their internal structures, as well as in the mode of production and nourishing of their young, cetaceans conform strictly to the ordinary mammalian type; and we accordingly see that their assumption of a fish-like form is, with the exception of the loss of the hind limbs and the modification of the front pair into flippers, mainly superficial. In departing from the fish-type in having the expansion of the tail-fin horizontal instead of vertical, the necessity of having an organ capable of bringing them rapidly to the surface has been the inducing cause; while in order to prevent their blood from being reduced below the proper temperature by the chill of the surrounding water, the whole body is invested with a thick layer of oily fat, commonly known as the blubber, beneath the skin.

As we have had occasion to mention incidentally in previous articles, existing cetaceans are divisible into two great groups, distinguished as the whalebone whales and the toothed whales; the latter group including sperm-whales, together with the grampuses, porpoises, and dolphins. The most obvious distinction between these two groups, as the terms applied to them indicate, relates to the presence or absence in the adult condition of true teeth.



FIG. 2—The last six upper teeth of the Killer Whale. (After Sir W. H. Flower.)

Confining our attention in the present article to the toothed cetaceans, of which the dolphins and their allies are the best specialized representatives, we find that the two jaws may be in some cases provided with a full series of teeth, while in other forms the number of teeth may be reduced to a single pair, or even, as in the male narwhal, to a solitary tusk. Whether, however, the teeth be many or few (and in the female narwhal there are none of any functional importance), the structure known as whalebone is never developed in the mouth; while all the members of the group are further distinguished from the whalebone whales by the circumstance that the nostrils invariably open by a single external aperture, which is very frequently in the form of a transverse crescentic slit, closed by an overhanging valve. In the latter respect these cetaceans are more specialized than are the whalebone whales; and as the presence of teeth in the former indicates that they could not have been derived from the latter, it is evident that the two groups are of extreme antiquity, and have undergone a parallel development. Till recently, it has indeed been considered that they were divergent branches from some common ancestral type; but, as mentioned in our article on "Parallelism in Development," it has been lately suggested that each may have had a totally distinct origin, although the evidence in favour of such a view is, at present at least, far from conclusive.

In the structure of their teeth, the modern-toothed whales differ very widely from the generality of mammals. In the first place, their teeth are always of the simple

structure shown in Fig. 2, having conical or compressed crowns, and undivided roots; while, secondly, there is only one single series developed, the replacement of the anterior ones characterizing the majority of mammals being wanting. From this simple structure of their teeth it has been argued that these cetaceans are among the most primitive of all mammals; but, altogether apart from the conclusive evidence that all whales (as proved by their breathing air) are derived from land mammals, it has recently been shown by the researches of Dr. Kükenthal, of Jena, that this view is quite untenable. By examining embryos of young cetaceans of this group, that observer has demonstrated that there actually are rudiments of a second series of teeth, which, although never coming to maturity, serve to show that there were once two complete sets, and that the permanent teeth correspond, in part at least, to the milk-teeth of other mammals; thus indicating that the present state of the cetacean dentition is a degraded one. Hitherto it has not, indeed, been shown by embryology that the teeth of this group were originally of a complex type (although in the case of the whalebone whales this has been demonstrated), but, fortunately, here paleontology comes to our aid. Thus in the middle of the tertiary period there occur remains of what may be termed shark-toothed dolphins (squalodonts), in which the permanent teeth are differentiated into distinct series, corresponding to the incisors, canines, pre-molars, and molars of other mammals; while, for all we know to the contrary, there may also have been a regular replacement of the more anteriorly placed teeth. In these shark-toothed dolphins the molar teeth, instead of being of the simple structure of those represented in our illustration, were severally implanted in the jaws by two perfectly distinct roots; while their large, laterally compressed, and somewhat fan-shaped crowns were furnished with a number of cusps on their hinder cutting-edges. Indeed, these teeth much resemble the pre-molar tooth of a dog or the molars of a seal; and they obviously serve to indicate a transition from the modern toothed cetaceans towards ordinary mammals. This, however, is by no means all, since in a still earlier portion of the same division of the tertiary there occur other cetacean-like animals known as zeuglodonts, which have still more complicated teeth, and otherwise depart further from the modern cetacean type—so much so, indeed, that they have been regarded by some writers as more nearly allied to the seals. In our opinion they are, however, undoubtedly primitive cetaceans, and thus serve, not only to connect the present group with other mammals, but also, in conjunction with the shark-toothed dolphins, to show that the simple teeth of the former are clearly produced by degeneration from a complex type. As regards the particular group of land mammals from which whales were derived, we have stated in the article on "Swimming Animals" that it has been thought that their nearest allies are with the ancestors of the pig-like hoofed mammals. This, indeed, is the view of Sir W. H. Flower; but we confess that from the nature of the teeth of the two extinct groups above mentioned, coupled with certain resemblances of the skeleton of the zeuglodonts to those of the seals, we are rather more inclined to look among flesh-eating land mammals for the lost ancestors. Still, however, it must be remembered that in the early eocene period, which is probably the very latest epoch at which cetaceans could have originated, the distinction between carnivorous and hoofed mammals was but imperfect, so that, after all, the ancestral cetacean stock may well have been of an extremely generalized type. At present, however, we are almost completely in the dark in all that concerns this interesting subject.

By far the largest of all the toothed whales is the gigantic sperm-whale, the typical representative of a family characterized by the absence of teeth in the upper jaw of the adult, while those of the lower jaw are very variable both as regards form and number. In the sperm-whale, of which the male attains a length of between fifty and sixty feet, the lower teeth vary in number from fifty to sixty on each side, and are characterized by their large size and pointed crowns, upon which there is not a trace of enamel. Another characteristic feature of this animal is the enormous size of the head, which terminates in an abruptly truncated muzzle of great depth, and in a cavity of which is contained a peculiar oily substance, yielding when refined the well-known spermaceti. An even more valuable product of this animal is ambergris, which, while accumulated as a concretion in the intestine, is generally found



FIG. 3.—The Indian Porpoise. (From True, *Bull. U. S. Nat. Museum*.)

floating on the surface of the sea; in appearance it is an amber-coloured substance, containing a number of the horny beaks of the squids on which the sperm-whale subsists.

Omitting mention of the lesser sperm-whale—the only other member of the first division of the family—we pass on to mention the bottle-nosed and beaked whales, characterized by having all the lower teeth, with the exception of a single pair, rudimentary, and concealed in the gum. In the bottle-noses—so named from the extreme convexity of the crown of the head of the adult males, which rises suddenly above the short beak—there is but a single pair of teeth, situated in the front of the lower jaw, and even these are invisible during life. These whales, of which there is but a single well-defined species (*Hyperoodon rostratus*), although not exceeding some thirty feet in length, are valuable on account of their oil, as well as from yielding spermaceti from their skulls. In contradistinction to the sperm-whale, they carry, in common with the beaked whales, a large dorsal fin. In the beaked whales, of which there are three existing genera, the skull is produced into a long beak, of which the upper half is formed by a solid bone of ivory-like density; while in the lower jaw there are either one or two pairs of teeth, which, although variable in position, are generally of large size. It is one of these whales (*Mesoplodon layardi*) which is alluded to in the article on "Tusks and their Uses," as being provided with teeth of such a size as to actually impede the free opening of the mouth. From their general avoidance of the neighbourhood of coasts, and their apparently somewhat solitary habits, extremely little is known of the life-history of the beaked whales, of which the skeletons are but poorly represented in our museums. At the present day very rarely seen in the English seas, during the pliocene period these whales must have been extremely numerous in the North Sea, since their fossilized beaks are amongst the most common vertebrate fossils obtained from the crags of Suffolk and Essex. The same deposits, together with others of corresponding age on the Belgian coasts, have also yielded teeth of a number of extinct whales, more or less closely allied

to the sperm-whale, thus indicating that the latter is the last survivor of a once numerous group. The teeth of many of these fossil sperm-whales differed, however, from those of their living cousins in having their crown capped with enamel.

In the general presence of numerous teeth in both the upper and the lower jaws, the dolphins and their allies—the porpoises, killers, and white whale differ from all the above-mentioned forms, and thus constitute a second family—the *Delphinida*. The group is a numerous one, which is split up into a number of genera, some of which are by no means easy to distinguish. They may, however, be roughly ranged under two main divisions, in one of which the muzzle is short and rounded, as in the porpoises and black-fish, while in the other, as represented by the dolphins (Fig. 1), it is produced into a longer or shorter beak, of which the base is marked off from the main portion of the head by a distinct re-entering angle. The most aberrant member of the first group is the spotted Arctic narwhal, of which a brief notice, accompanied by a figure, was given in the article on "Tusks." Allied to the narwhal is the beautiful white-whale (*Eschscholtzia*), which is likewise a northern species, distinguished by its glistening white skin, the absence of any tusk, and the presence of numerous well-developed teeth in the fore part of the jaws; neither of these species having a back-fin.

Although the name "porpoise" is applied indiscriminately to several members of the family, it should properly be restricted to a few comparatively small-sized species characterized by the presence of some twenty-five small and flattened teeth with spade-shaped crowns on either side of each jaw. Porpoises are among the most common and familiar of all cetaceans, their rolling gambols being well known to all who have made a voyage; but whereas the common porpoise has a distinct back-fin, in the species represented in our illustration that appendage is lacking. Less familiar, on the other hand, are the much larger and handsomely coloured killers, or grampuses (*Orcas*), differing by the great size of their teeth (Fig. 2), which are usually twelve in number on each side, and the great development of the back-fin. Attaining a length of about twenty-five feet, the killer derives its title from its rapacious habits; a single specimen having been known to swallow several whole seals in succession, while not unfrequently several individuals have been known to combine their forces to attack and kill the larger members of the order. Killers may always be easily recognized while swimming near the surface by the

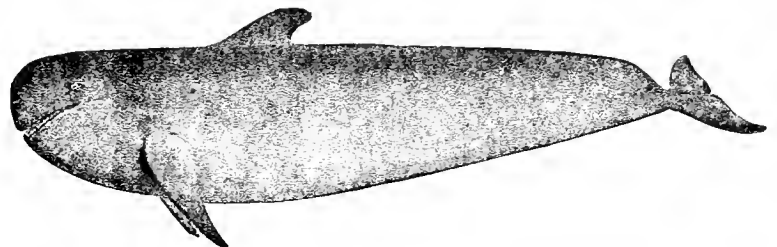


FIG. 4.—The Pacific Black-Fish. (From True, *Bull. U. S. Nat. Mus.*)

great height of their nearly vertical back-fins. Allied cetaceans with smaller teeth (*Orcella*) frequent the Bay of Bengal and ascend some distance up the Irrawadi. Another well-marked type is the black-fish, characterized by its remarkably short and rounded head, the uniformly black hue of the skin, and by the eight or twelve small and conical teeth being confined to the front portion of the jaws.

There are other less well-known representatives of this group which we have not space to notice; and we accordingly pass on to say a few words about dolphins—a term which should be restricted to those forms having a distinctly marked beak. Since, however, sailors will persist in speaking of dolphins indifferently, either as bottle-noses or porpoises, the inexperienced landsman must accordingly be on his guard not to confound them when thus spoken of either with the bottle-nosed whales or the true porpoises. Dolphins, which are divided into numerous genera, according to the number of their teeth, the length of the beak, and other characters, are all comparatively small species, seldom exceeding some ten feet in length; and while the great majority are marine, a few ascend some of the larger tropical rivers, such as the Amazon. Fish of various kinds constitute their usual prey; but one peculiar species recently described from the Cameroons district is believed to subsist on sea-weed. Of the better-known types, the common dolphin represents the genus *Delphinus*, the bottle-nosed dolphins constitute a distinct genus (*Tursiops*), while the long-beaked dolphins are separated as *Steno*.

To the foregoing group of beaked dolphins the ordinary observer would, doubtless, be disposed to refer three peculiar species severally restricted to the larger rivers of India, the Amazon, and the mouth of the La Plata river, but as these differ more or less markedly from other dolphins in certain structural features they are referred to a distinct family. Moreover, since these peculiarities approximate to a more generalized type, while their fresh-water habits and scattered distribution indicate extreme antiquity, it is not improbable that these three dolphins are the most primitive of all existing cetaceans. At present we have, indeed, no evidence of fossil forms allied to the susu or Gangetic dolphin (*Platanista*); but in the older tertiary deposits, both of the United States and Europe, there occur the remains of dolphins evidently nearly allied to the two existing South American species (*Uta* and *Stenodelphus*), and thus clearly proving the antiquity of those types. It is almost superfluous to add that it is most probable that the ancestors of the cetaceans which first took to an aquatic life were inhabitants of fresh-water, and it is therefore only what we should expect that the most primitive of the existing representatives of the order were likewise of fluviatile habits.

GALLS AND THEIR OCCUPANTS.—III.

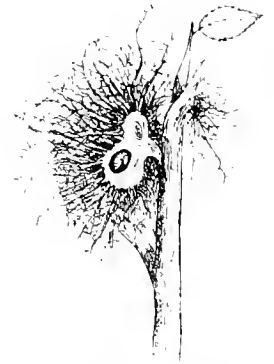
By E. A. BUTLER.

(Continued from page 116.)

LEAVING now the oak tree, which we have found so rich in the products of gall insects, and looking about in other directions, we find very few galls formed by the true gall-flies (*Cynipidae*) that are sufficiently common and conspicuous to have obtained popular names, and only one or two need be referred to. Everyone is, of course, familiar with the bright crimson or greenish-red mossy balls which often appear on the wild rose bushes, and which, formerly known as "brier-balls," and still dear to the heart of childhood under the name of "robin's pincushions," form one of the prettiest ornaments of English hedgerows. These, too, are galls originated by a *Cynipid*, a gall-fly which, though itself of no great beauty, yet owns as its home the most elegant of these fairy-like structures. In this instance, the swollen mass of tissue forming the gall proper is

completely concealed by a quantity of moss-like filaments (Fig. 7) like those that envelope the buds of moss roses; these filaments run out from the entire surface of the gall. Each "pincushion" contains a family of the gall-fly (*Rhodites rosa*), and if they are picked when fully ripe, there is no difficulty in rearing the little red-bodied fly from them. The gall insects, however, are subject to the attacks of a pretty *Ichneumon* fly, which is also red-bodied, and hence one must not too readily conclude that any transparent winged creatures that issue from the mossy ball are its legitimate inhabitants. But if attention be paid to the number and arrangement of the nervures of the wings, and to the shape of the body, as described in a former paper, there will be no difficulty in determining whether it is the *Rhodites* or its parasite that is escaping from the gall.

FIG. 7.—Section of Bedeguar of Rose, showing two cells, one containing larva of Gall-fly.



This gall is also known by the name "bedeguar," though that name belonged in the first instance to another object and was incorrectly applied to this. The word is an Arabic one, and originally signified the thorny white flower of a kind of thistle. But, apparently in consequence of a misunderstanding as to its etymology, it was thought to mean some growth connected with a rose tree, and hence was applied to the gall in question. Under the name bedeguar, therefore, the gall was sold in the shop of the apothecary as a drug, and was considered a specific against various serious ailments, being for this purpose ground up and administered as a powder. Its medicinal use is of long standing, and Pliny recommended that it should be mixed with honey and wood-ashes before being taken.

In this rose gall there is not such a disparity in the numbers of the sexes as is found in the various galls of the oak. So far from there being always a preponderance of the female element, the case is sometimes reversed—*e.g.*, from three galls of bedeguar, Schlechtendal once bred thirty-two males and only two females; but the experience of collectors is not uniform in this matter, and Mr. Cameron records a proportion strikingly the reverse—*viz.*, one male to one hundred females. But though males are known and are sometimes numerous, still the insect follows the usual law of the group, and parthenogenesis is not infrequent.

On the under surface of the leaves of wild roses may frequently be seen beautifully coloured, berry-shaped galls, which, save for their opacity, forcibly recall the currant galls of the oak. Some are quite spherical, others consist of globes with three or four long and sharp spikes projecting from them, and remind one of the spiked balls carried at the end of the warlike clubs and maces of olden times. All these galls belong to the same genus as the bedeguar, but each contains only a solitary fly. If cut open, they



FIG. 8.—Sections of Gall of *Rhodites cglanterior*. A, normal; B when containing *Ichneumon*. (After Fitch.)

and to have, therefore, a large central cavity (Fig. 8, A); at least this is their condition if they are free from parasites, and the gall-fly is allowed to develop naturally,

But their internal structure becomes altogether altered if parasitic gall-flies—"inquilines," as we have already called them—take up their abode within. The galls then become many chambered, a number of cavities for the parasites surrounding the cell of the true owner (Fig. 8, v).

But it is time to pass on to another group of gall-makers. The insects called saw-flies, like the gall-flies, also belong to the order Hymenoptera, and like them too, they are vegetable feeders. As a rule they live exposed, and their larvæ differ greatly from the footless grubs of the *Cynipidae*, and closely resemble those of moths; but the rule of external feeding is not without exceptions, and a few species are to be sought for inside their food-plant, and then comes the possibility of gall-growth. The eggs of saw-flies are generally laid in small slits cut into various parts of plants by means of the pair of "saws" with which the female is provided at the extremity of the abdomen, and usually this incision has very little effect upon the plant attacked. But in some cases an irritation is set up which results in the formation of a gall just as with the true gall-flies; the egg, therefore, becomes enclosed in a vegetable excrescence, and the species is rendered gall-inhabiting. This habit is practised principally by certain species of the large genus *Nematus*, to which belongs the well-known pest that so often strips gooseberry and currant bushes of their leaves. This garden plague, however, is not a gall-producer, but, as everyone knows, feeds on the leaves without any shelter, while clinging to their edges.

The gall-forming section of this genus contains insects which are largely addicted to willow trees, and one of the commonest saw-flies we possess in this country is a minute one called *Nematus gallicola*, which makes oval swellings

on the leaves of various kinds of willows (Fig. 9). Everyone must have noticed these reddish swellings on the long, narrow leaves, bulging out on both sides of the leaf, and attaining a length of from a quarter to half an inch, with a breadth of about half as much, seeming as though a fiery blister had been raised by some caustic process. Sometimes several are to be seen on the same leaf, and Mr. P. Cameron, the historian of British saw-flies, records having found a leaf which was disfigured by no less than thirteen specimens. This is an exceptionally large number, for there are generally not more than two or three, and very frequently only one. As half the gall is above and half below the leaf, it is not easy to see its real shape without cutting away



FIG. 9.—Gall of Saw-fly on willow leaf.

the leaf from around it, and then it is found to possess something of the form of a bean.

These saw-fly galls differ in a good many ways from those of the gall-flies proper. In the first place, the egg, though it grows like that of the *Cynipidae*, is not hatched till the gall is fully formed, and therefore the young caterpillar, from the moment that it begins its life, finds itself surrounded by a compact mass of vegetable substance, not more succulent than the rest of the leaf, which has been built up for its special use, and is a store large enough to last its lifetime. It can afford, therefore, to take its time about its development, and consequently feeds up in a leisurely way, not any more rapidly than its companions that adopt the open air life. The cynipid, on the other hand, hatches early, while the gall is still growing, and hurries to get through its larval life while the gall remains very succulent, lest the hardening and drying process should set in before it has obtained all the nutriment it

requires. The saw-fly grub, again, eats the greater part or the whole of the contents of the gall, often leaving it ultimately a mere empty bladder of skin; the cynipid, on the other hand, uses only the central portion, making a cavity just large enough to contain itself, while the rest forms a more or less hard wall around it. The saw-fly grub in course of time nibbles a hole through its gall at one end, which it makes use of for sanitary purposes, while the gall-fly proper remains hermetically sealed up throughout its larval life. Finally, the saw-fly grub often leaves its gall when fully grown, or even before that time, and forms its cocoon elsewhere, very frequently in the earth, or on the bark of the tree; the cynipid much more frequently becomes a chrysalis inside the gall, and does not gain the outer air till it has reached its final condition.

The creature that makes these blistering swellings on the willow leaves can be very easily distinguished from a true gall-fly. It has a squarish head, and a more or less cylindrical body attached to the thorax by the whole of its base, and the four wings carry an elaborate network of nervures arranged after a special and rather intricate pattern. By noting these points there can be no difficulty in distinguishing a saw-fly. They are heavy-bodied, sluggish creatures, and most of them are much larger than the gall-flies proper, though, of course, those that inhabit galls are among the smallest of the group. The grubs, too, are very easily distinguished from those of the *Cynipidae*. Inside the above-mentioned gall there would be found a small white caterpillar with a black head, which would be at once recognized as a different sort of being from what would be found inside an oak-apple or a marble gall. Saw-fly galls are not always soft and fleshy, nor are they always found on leaves. One species makes hard woody galls on the twigs of a certain kind of willow, and sometimes does much damage by dwarfing the twigs and ultimately destroying the trees. Some saw-flies do not go quite so far as to make an actual gall—*i.e.*, a complete enclosure—but merely distort the leaves by turning down and blistering their edges.

For our next group of gall-producers we must go to a different order—the Diptera or two-winged flies. In this order we find more than one group responsible for the disfigurement (or otherwise) of vegetation by abnormal growths, and we shall select for our illustrations two groups of very opposite character. The first of these are called "gall-midges" or "gall-gnats," and constitute the family *Cecidomyiidae*. They are very minute flies like gnats, thin-bodied and long-legged, the very personifications of delicacy and fragility. Though so insignificant in size, they are often pretty little things, red, yellow, or black, but their beauties need the help of the microscope before they can be fully brought out. The galls they make are often conspicuous and elegant productions, and are much better known than the insects that make them. The other family is the *Trypetidae*, a stout-bodied, short-legged group, more like house-flies in shape. They are prettily coloured, and their wings are marked most distinctly with strongly-coloured bands, a species of adornment which makes them some of the most striking of all dipterous insects. Their galls, which are often formed in the ovaries of plants, are inconspicuous or even quite concealed from view, and even if visible are merely unsightly swellings, so that in this case the flies are more likely to be noticed than their galls.

The larvæ of the gall gnats are generally yellowish or orange footless maggots, of course of very small size. One of the easiest ways to find specimens to illustrate the group is to look out for a hawthorn hedge and to note those twigs that have a sort of tuft of leaves at the tip, twisted, crumpled, and crowded together. On opening

out the crumpled leaves, a number of little orange maggots may be found, which are the larvæ of one of our commonest gall-gnats. Here the gall consists of little more than a tuft of distorted leaves, but this must not be taken as a universal type: there is every variety of form as well as position, and the plants attacked are as varied as the galls. Thus we have swellings on the midribs of ash leaves and the stalks of aspen leaves; warts, pads, and other deformities on the margins of willow leaves; tufts and rosettes of leaves on willow and yew, and on the pretty little blue speedwell and yellow St. John's wort; bud-like bodies on broom and furze; distorted flowers on cabbage and other cressworts and on the yarrow; blisters on bedstraw, water-cress and box; woody swellings on willow twigs and bramble stems; spongy galls on barberry; woolly galls on weasel-snout; hairy galls on nettles; horns on beech leaves and cylindrical tubes on ground ivy, together with many others too numerous to mention.

As in other cases, so also with the gall-gnats, the most remarkable facts concerning them are connected with their reproduction. We have already seen that amongst the true gall-flies parthenogenesis is an extremely common phenomenon, so that the continuance of the race is doubly secured—first, by the fact that the plant responds to the touch of the insect, as if it had been that of a fairy's wand, and forthwith there upsprings with mushroom-like rapidity a structure combining board and lodging; and secondly, by the fact that there is no need to wait for the meeting of a suitable pair of individuals before fertile eggs can be produced, but that the female, often the only representative of the species present, can proceed at once to lay the foundation of the next generation. And with the gall-making saw-flies the same is true. Mr. Cameron says that he has often bred the fly of the willow-gall above described, but has never met with a male. Mr. F. Smith, however, was more fortunate: but still in his case there was only a single male to several hundreds of females. But when we come to the gall-gnats we find examples of a still more remarkable method of ensuring the perpetuation and multiplication of the race. The reproductive power is carried two stages back in the history of the insect, and we find not merely the perfect insect, but even the *larva* gifted with the power of producing young, for which reason the process is called "pælogenesis." Fig. 10 shows the larva



FIG. 10. Larva of *Cecidomyia* containing five young larvæ. (After Pagenstecher.) Much magnified.

of a cecidomyid which contains within itself five other larvæ. These are produced where they are seen, and they subsist upon the tissues of the parent larva, ultimately absorbing all the contents of the skin, within which they lie free. Rupturing the skin, they escape and proceed with their development. Sometimes several generations of larvæ are produced in this way before we revert again to the full-grown flies. Of course this process involves the destruction of the parent larva, which has no more chance of completing its own development than if it had harboured a set of ichneumon maggots. But notwithstanding this, there is a net gain in the number of individuals ultimately existing, so that the species is in the long run benefited, though by the sacrifice of some of its members.

Our last instance of dipterous galls is from the brilliant and banded-winged *Urophora*. The best known of this group, no doubt, the common thistle gall. The stem of

one of our commonest thistles (*Cnicus arvensis*) are often seen to be swollen near their tips into a large, green, oval, wen-like body. This is the gall of the very handsome dark-bodied fly whose wing is shown in Fig. 11. Its name is *Urophora cardui*.

The gall is sometimes partly concealed by the leaves of the thistle, the growth of which it does not interfere with. On cutting open the gall we find a solid mass of tissue, in which are excavated a number of pear-shaped chambers, each containing a single white maggot. There may be as many as eight of these cells in



FIG. 11. — Wing of *Urophora cardui*, Gall-making fly of thistle. Magnified seven diameters.

a single gall, or there may be no more than one; usually, however, there are several. The fly is very common, and is pretty sure to be found in plenty wherever the thistle grows. Another species belonging to the same genus attacks the flower-heads of the common "knapweed" or "hard-head," an extremely abundant weed with thistle-shaped but not prickly flowers. In this case, however, the gall is invisible till the flower-head is pulled to pieces, as it occupies the position of the ovaries of the florets, and is therefore concealed by the scaly cup, or involucre, which surrounds them. But though invisible they can be felt from the outside. If the dead flower-head be squeezed between finger and thumb, it will yield to the pressure and more or less flatten out when no gall is present; but when the gall is there, it will be felt as a hard lump which will prevent collapse.

(To be continued.)

THE LIGHT-CHANGES OF γ CYGNI.

By MISS A. M. CLERKE, *Authoress of "The System of the Stars" and "A Popular History of Astronomy during the Nineteenth Century,"* &c., &c.

ACQUAINTANCE has so far been made with nine variable stars of the Algol type. They are essentially characterized by normal steadfastness of light, interrupted at intervals of a few days or hours by brief phases of darkening. These sudden dips to a lower magnitude represent stellar eclipses; for the certainty on the point, attained spectroscopically in the case of Algol, may safely be extended to its sister stars. They are all, then, very rapid binaries, the orbits of which lie edgewise towards the earth. Plainly, however, this latter condition is extrinsic to the systems themselves; our position with regard to them determines its realization. If it remained unfulfilled, the loss, so to speak, would be ours. The mutual relationships of the stars would be just the same; only we should remain ignorant of them unless the spectroscope came to our assistance. This it could only do if the combined brightness of the revolving bodies sufficed to bring them well within range of our present instruments, and if, in addition, a large proportion of their orbital velocities were directed, at quadratures, in the line of sight.

Two such spectroscopic binaries are particularly well known, and each exemplifies a variety of the class. Thus, Spica (α Virginis) is composed of a brilliant sun, and a relatively obscure, though powerfully attractive body; β Anrigæ of two nearly equal suns. We should accordingly expect to find the same varieties represented among eclipsing binaries. And the companion of Algol seems, in fact, to be completely dark; for if it gave any sensible light, a minor obscuration should be recorded without fail just half way from each principal eclipse to the next.

That extraordinary star, S Antlia, on the other hand, is certainly made up, like β Auriga, of twin suns, for it undergoes, once in seven hours and three-quarters, phases lasting five hours; and since an eclipse longer than half the time of revolution is a patent absurdity, there can be no hesitation in admitting (with Mr. Backhouse) that the stars occult each other twice while they traverse their orbits once. Nor is any systematic difference perceptible between successive phases. The effect is the same whether number one occults number two, or number two occults number one. The connected stars are hence probably alike in size and brilliancy, although their eclipses can only be partial, the loss of light being less than one-half.

There is another Algol star, however, in which the loss of light is exactly one-half. This in itself suggests alternating occultations by two equal stars, revolving in *twice* the period of variability. The presumption has been accurately verified.

Y Cygni was detected as an Algol variable by Dr. S. C. Chandler on December 9th, 1886. Its phases, carrying it from 7.1 to 7.9 magnitude and back once in about thirty-six hours, had a duration assigned to them of eight hours, equally divided between decline and recovery. But their recurrences were soon found to be subject to enormous irregularities. Towards the middle of 1888 they were no less than seven hours behind their calculated times, which soon after began to be largely anticipated. Never before had perturbations on such a scale been betrayed by the light-changes of an eclipsing binary; still, Dr. Chandler thought that, like those of Algol, they might prove to be dependent upon the varying length of the journeys of light in travelling hither from different parts of a large orbit described by Y Cygni round an unseen primary. The possibly undulating line of its proper motion might even, it was hoped, serve to make these hypothetical revolutions directly measurable.

The problem has, however, received a different solution. M. Dunér, director of the Upsala observatory, took the star in hand in April, 1891, and observed its minima steadily until April, 1892. But when he came to discuss the results, and compare them with those obtained elsewhere in Europe and America, he was at once struck with a persistent discrepancy between the odd and even sets of minima. The first, third, fifth, seventh, and so on, from a given epoch, obeyed a law quite distinct from that conforming to by numbers two, four, six, eight, etc. The lapse of time, in fact, from an even to an odd minimum proved to exceed, in November, 1891, the lapse of time from an odd to an even minimum by the startling amount of 9 hours 42 minutes 55 seconds! Not these discrepant intervals, then, but their appreciably constant sum, represents the circulatory period of the mutually eclipsing stars. Since, moreover, they run through corresponding phases twice in each revolution, they must stand at practically the same level as regards light-giving; while the marked inequality with which the phases divide the period amounts to a demonstration that the path pursued is an ellipse, the major axis of which, although lying in the same plane, makes an angle with the line of sight. The disclosure of these peculiarities has been much hampered by the circumstance that successive minima, being separated by a *mean* interval of a day and a half, cannot, as a rule, be watched by the same observer. The various sets of data refer, accordingly, to odd or even series, the strict comparison of which could alone show the true character of the star.

* *Astr. Nach.*, No. 3091; "Sur les éléments de l'étoile variable Y Cygni," communicated to the Academy of Sciences of Stockholm, September 14th, 1892.

The amplitude of each phase is three-quarters of a magnitude. In other words, just half the light is temporarily cut off. This is as much as to say that the eclipses are total. For if they were partial (as are probably those of S Antlia), we should still receive the full light of the eclipsing body plus a fraction of its companion's light; so that their combined rays would be diminished each time by less than one-half. And the identical character of successive eclipses implies, not only the agreement of the stars in lustre, colour and bulk, but the exact coincidence of the plane of their orbits with the line of sight from the earth.

These orbits are perfectly similar ellipses traced out in opposite directions round a common focus, also necessarily the common centre of gravity of the moving bodies, which are presumably twins, as in other respects, so also as regards mass. If this be so, the ellipses they traverse agree not in shape only, but also in size. Now it is scarcely necessary to explain that stars forming an undisturbed binary combination are always two right angles apart. They are situated at opposite ends of a right line passing through the centre of gravity, and at distances from it inversely as their masses. But this line, unless it should happen to coincide with the major axes, divides the orbital ellipses unsymmetrically. The section on the periastron side is both smaller, and is traversed at a more rapid rate, than the apastron section. Thus, if the stars occult one another (as viewed from the earth) a short time (say) after their nearest approach, they cannot again fall in with our visual ray until they have slowly wended their way round the far sides of their orbits. Alternating phases are thus anticipated and retarded, the disparate intervals taken together representing a single period of revolution a little short of three days in length.[†]

But while their sum is constant, their difference is very far from being so. It amounted in 1886 to about three hours and a half; it reached, in November 1891, nearly nine hours and three-quarters. The rapid growth of the inequality is thus positively ascertained, and it may well be that the inclined balance is by this time in course of restoration. M. Dunér's explanation of these changes, although given under reserve, and needing confirmation, is of great interest and promise. He supposes that the line of apsides of the eclipsing stars revolves under the influence of an invisible perturbing body, just as the lunar apogee progresses through the disturbing action of the sun. Obviously, when the line in question is pointed towards the earth, there can be no discrepancy between the light-periods, the eclipses taking place symmetrically at apastron and at periastron. This condition prevailed, according to M. Dunér's calculations, a short time before the recognition in 1886 of the star's variability in light. The inequality so fruitfully discussed by him then began to develop, and seemed likely to reach a maximum in seven or eight years. This should occur when the parameter of the two orbits coincides with the line of sight—when the stars, that is to say, come to be eclipsed at opposite ends of a line drawn through the common focus at right angles to the major axis. This arrangement gives the greatest possible diversity of minimum-epochs, because the stars, in order to reach the points of eclipse, traverse by turns the entire periastron, and the entire apastron sides of their orbits. Or, putting it otherwise, we may say that the period of revolution is divided into two equal periods when the ellipses traversed lie lengthwise towards the earth, but into two unequal periods when they are any

[†] The precise duration is 2 days, 23 hours, 54 minutes, 43.26 seconds (Dunér).

otherwise situated, the inequality reaching a maximum when the same ellipses lie right athwart the visual ray.

The fundamental part of M. Dunér's theory of Y Cygni may be accepted without the smallest hesitation. His research leaves no doubt that the star really consists of two equal components describing, in a period of nearly three days, elliptical orbits situated in the same plane with our line of vision. The application of the spectroscope will give the dimensions of the ellipses in linear measure, whence the mass of the system can be at once deduced. And this unconditionally, because the stars being both bright, their relative velocity—if not their separate absolute velocities—can be determined directly from a photographic plate, while the mass of a bright and dark combination such as Algol can be fixed only on some precarious assumption regarding mean density.

The striking inequality between the alternate light-periods of Y Cygni is then fully explained by the ellipticity of their orbits; while the view that the changes in that inequality are due to a revolution of the line of apsides, although highly plausible, must be regarded as still on its trial. A comparison during the next few years of the predicted and observed dates of minimum ought to prove decisive as to its truth; and the test will be made more stringent if the spectrographic method can be satisfactorily turned to account. For differences in the velocities of the stars in the line of sight, at the elongations preceding alternate minima, should, on this hypothesis, correspond strictly with the varying time-intervals separating the minima, and should disappear with their equalization.

A further criterion is provided by the duration of the eclipses, which, by the nature of the case, must depend upon the quicker or slower movement of the stars. When, accordingly, owing to the line of apsides being pointed towards the earth, they occur by turns at apastron and periastron, the phases at successive minima must be considerably lengthened out and hurried up. In intermediate positions of the line of apsides, moreover, the phases should progress unsymmetrically, the loss of light being retarded at one side of the orbit, the recovery of light at the other.

These irregularities have not yet been definitely observed. They may, however, eventually serve to measure the eccentricity of the ellipses pursued by the components of Y Cygni. And the same element is of course involved in the extent of opposite deviations from the mean epoch of what we may call complementary minima. M. Dunér has indeed already shown that the eccentricity must exceed 0.1, while falling short of 0.2. It would then be small for a telescopic binary, although it appears large for a spectroscopic revolving pair. On the basis of Dr. Sec's theory of the growth, through an effect of tidal friction, of stellar orbital eccentricity, the stars of Y Cygni can be inferred to be much more widely separated and materially further advanced in development than the components of Algol. And since the period of both systems is nearly the same, the former ought to prove greatly more massive than the latter, its inferiority in brightness being probably due to its much greater distance from the earth.

Satisfactory progress has now been made towards investigating the inequalities of two Algol variables. The results are noteworthy, both for their likeness and for their unlikeness. A third sensibly dark body appears to be included in each combination, and in neither has any evidence been gathered of variation in the circulatory period of the occulting pairs. But the phases of Algol are believed to be affected by a light-equation consequent upon revolution in a wide orbit; while the irregularities conspicuous in those of Y Cygni depend upon their un-

symmetrical relations to the elliptical paths of the mutually eclipsing pair. Moreover, the irregularities themselves are subject to change, probably through a revolution of the apsidal line, with the position of which they are intimately connected. Here, then, the presence and power of a disturbing body appear to be betrayed. But the unseen third member, if really there, must form a revolving system of a higher order with the close pair. And the plane of the large orbit is unlikely to deviate widely from that of the small ones. If this be so, however, the eclipses of Y Cygni must show the effects of a light-equation similar to that of Algol. They have yet to be detected, and may prove inconsiderable. They are almost necessarily so, if the mass of the bright stars be large as compared with that of the dark body which is reasonably supposed to influence their motions.

Dr. G. B. Longstaff, in an interesting paper on "Rural Depopulation," read before the Statistical Society, brings together evidence to show that the flow of population from rural districts to towns has been taking place not only in the United Kingdom, but also in France, Germany, Norway, Austria, Hungary, Switzerland, Italy, Spain, Canada, the United States, Victoria, and New South Wales. The rural depopulation amounts, as a general rule, only to a small fraction of the initial population, while the towns and urban districts have been increasing in population more rapidly than the whole community. Thus the total loss of population in the Welsh counties varies from 0.9 per cent. in Carnarvon to 4.0 per cent. in Flint and 16.7 per cent. in Montgomery. Dr. Longstaff shows that the phenomenon of rural depopulation is not due to any faulty system of government, for it is as prevalent under republican institutions as under military despotisms and constitutional monarchies. It does not seem to be due to any system of land tenure, for it is as marked in France as in England, and under the land systems of the United States and Canada, as under those of the continent of Europe. Freeholds and leaseholds are alike affected; large holdings and small. The peasant proprietor of France, on his much treasured scraps of land, feels the impulse no less than the yeoman of Ontario. Dr. Longstaff conceives that many causes contribute to the flow of the rural population into towns. Agricultural implements, waggons, tools, which were formerly made in the village smithy, are now more cheaply made in the larger manufacturing towns. In the last century locomotion was slow, inconvenient, and expensive; it is now rapid and cheap. Men, by the press, learn where there is a demand for labour, and they easily migrate to it. The dream of the free-trader is fast being realized—we are learning to do in each place that for which each place is most advantageously circumstanced; and, above all, the towns, with their gas and life, and excitement, possess greater attractions than ever to the countryman.

Mr. Ernest Hart was emphatic upon the nature of cholera before the British Institute of Public Health. For all practical purposes he asserts cholera is an exclusively water-carried disease, and caused only by water poisoned from human sources. "You may eat cholera and drink cholera, but you cannot catch cholera." He traces all cholera to Mecca, which he styles the "nursery of cholera," and he makes a series of suggestions to meet the dangers to the world arising from the Mahommedan pilgrimages thither.

THE GREAT LUNAR CRATER COPERNICUS.

By A. C. RANYARD.

THE scale of the lunar craters, as compared with the little planet on which they are found, will probably be best realized by a comparison with terrestrial objects. If the moon could be cut in half, and one of its hemispheres placed upon the earth's surface without altering its shape, it would form a dome-shaped mountain about a thousand and eighty miles high, the circular base of which would about correspond in size with the western hump of Africa comprised between the Gulf of Guinea on the south and Morocco and Algiers on the north.

The great crater Copernicus, the photograph of which we are about to examine, is fifty-five miles in diameter; so that if London were situated upon its southern edge, Cambridge would lie within its northern border. This great crater is only the central region of a district more than five hundred miles in diameter which was evidently violently disturbed by the forces that built up the central ring; for stretching in all directions around the crater will be noticed a series of curiously curved and branching whitish rays, the connection of which with the crater as a centre is unmistakable, although they do not radiate from it in straight lines like the streaks diverging from the crater of Tycho.



FIG. 1.—Copernicus at Sunrise.

Copernicus, in spite of its gigantic size, presents many analogies to terrestrial volcanoes. It is not quite circular in outline, but the craters of many terrestrial volcanoes are not circular, and are sometimes distinctly polygonal. In Plate I. a string of little craters will be noticed on the western slope of Copernicus, midway between the great crater and Eratosthenes (110).

Many similar strings of little craters are found around terrestrial volcanoes, usually marking a line of fissure which can sometimes be distinctly traced. Thus Prof. Judd, in his book on "Volcanoes" in the International Science series, states that during the eruption of Etna in 1865 a line of eight scoria cones formed along a fissure on the flanks of Etna. Similar lines of craters have at times formed on the sides of Vesuvius, and a study of the sections of volcanoes dissected by denudation affords convincing evidence that volcanic cones generally originate upon lines of fissure. The string of little craters between Eratosthenes and Copernicus should be examined with a magnifying-glass; they are best seen on Plate I., but can be traced on Plate II., though a photographic defect in this plate partly

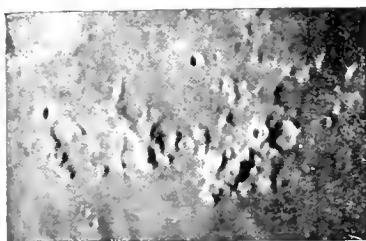


FIG. 2. The Lunar Carpathians.

obliterates the crater of Eratosthenes. Two strings of smaller craters may be traced branching from the main stream, which extends along the flank of Copernicus for a distance of more than one hundred miles, and then crosses the Apennines in a valley or gap between Eratosthenes and the rugged range of the Carpathians which lies to the

north of Copernicus. After crossing the Apennines it debouches on to the Mare Imbrium at the head of a curving white ray, or lava stream, that runs for more than three hundred miles over the Mare Imbrium, reaching far beyond the craters Timocharis (121) and Lambert (122).

The question whether this whitish curving ray and the other similar rays which radiate from Copernicus correspond to streams of liquid matter which once flowed from the crater, or whether they are mere discolorations of the surface which follow the course of fissures in the lunar crust, is one of very great interest, and I would invite the reader to spend a few minutes in carefully examining the course

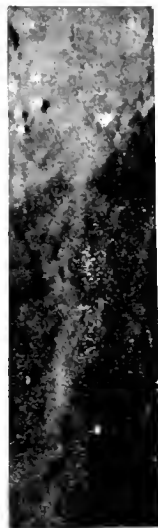
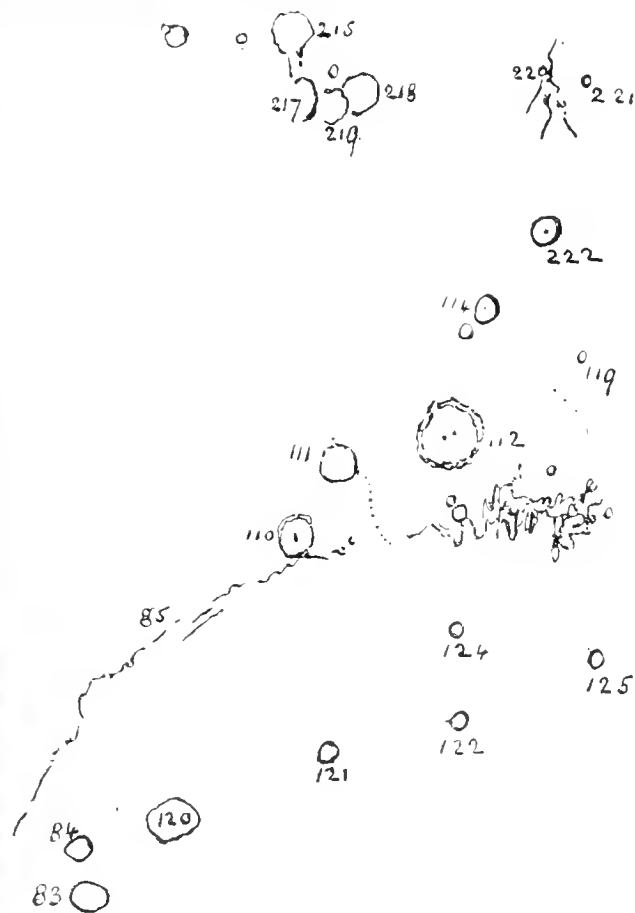


FIG. 3.—Ray from Copernicus.



FIG. 4.—Eratosthenes, and streaks from Copernicus.



INDEX MAP. - FIG. 5.

- | | | |
|--------------------|------------------|---------------------|
| 83. Aristillus. | 119. Hortensius. | 217. Parry. |
| 84. Autolyeus. | 120. Archimedes. | 218. Bonpland. |
| 85. Apennines. | 121. Timocharis. | 219. Fra Mauro. |
| 110. Eratosthenes. | 122. Lambert. | 220. Rhiphaeu Moun- |
| 111. Stadius. | 124. Pytheas. | tains. |
| 112. Copernicus. | 125. Euler. | 221. Euclides. |
| 111. Reinhold. | 215. Guericke. | 222. Landsberg. |

of some of these rays. If they correspond to lava streams, it will be evident that the lava must have been in a very liquid condition when they ran over the plain; but they do not seem to have run into valleys forming lakes of lava, or to have spread out at their ends like terrestrial lava streams when they reach a level area.

Some of the streaks appear to extend across the ridge which stretches southward from Eratosthenes (see Fig. 4). It may be argued that this ridge may have been raised after the epoch when the lava flowed down from the crater of Copernicus. But a similar assumption can hardly be made with regard to the two great rays, one of which crosses the Apennine range close to Eratosthenes, and the other of which crosses the western end of the Carpathians; for if these ranges, which form the border of the Mare Imbrium, had been raised after the era of the lava flows from Copernicus, the lower ends of the lava streams, where they run over the plain, would have been obliterated by the molten sea which levelled the Mare Imbrium.

These long rays cannot be much raised above the level of the surrounding surface, for they do not throw any recognizable shadows while the sun is rising. They have hazy, nebulous edges, and both sides (that towards the sun and that away from the sun) seem equally soft and indefinite; on the other hand, the smaller forking streams which appear to have run down from the south side of the crater throw distinct shadows. One is therefore led to conclude that the long white rays stretching from Copernicus, like those which radiate from Tycho, are merely surface markings, and that they probably follow the lines of volcanic fissures, the whitish colour on either side being produced by some exhalation which has issued from the fissure, and has been precipitated on the surface near to the vent.

It will be noticed on comparing Plates I. and II. that the central regions of these rays are the brightest, and that they decrease in density or whiteness on either side, as might be expected if vapour issued from a narrow vent running along their centre. Thus, if water vapour issued from the vent, it might, on reaching the cold surface, be deposited as snow or hoar-frost on either side, the amount of

the deposit being greatest close to the vent. In connection with this assumption it should be borne in mind that, owing to the small intensity of lunar gravity, evaporation must take place more energetically for any given change of temperature at the moon's surface than at the earth's surface.

Thus, from laboratory experiments it is known that the elastic force of water vapour at a temperature of -32° Cent., is such that it will raise the mercury in a barometer through about a third of a millimetre (0.32 mm.), while at a temperature of 0° Cent. it raises the mercury through more than $\frac{1}{2}$ millimetres (1.6 mm.). This increase of pressure is independent of the pressure of the atmosphere or other gases. It cannot reasonably be doubted that water vapour would behave in precisely the same way upon the moon as it does here, but in order to raise the pressure of the lunar atmosphere by any required amount, about six times as much water vapour would need to be evaporated into the lunar atmosphere as

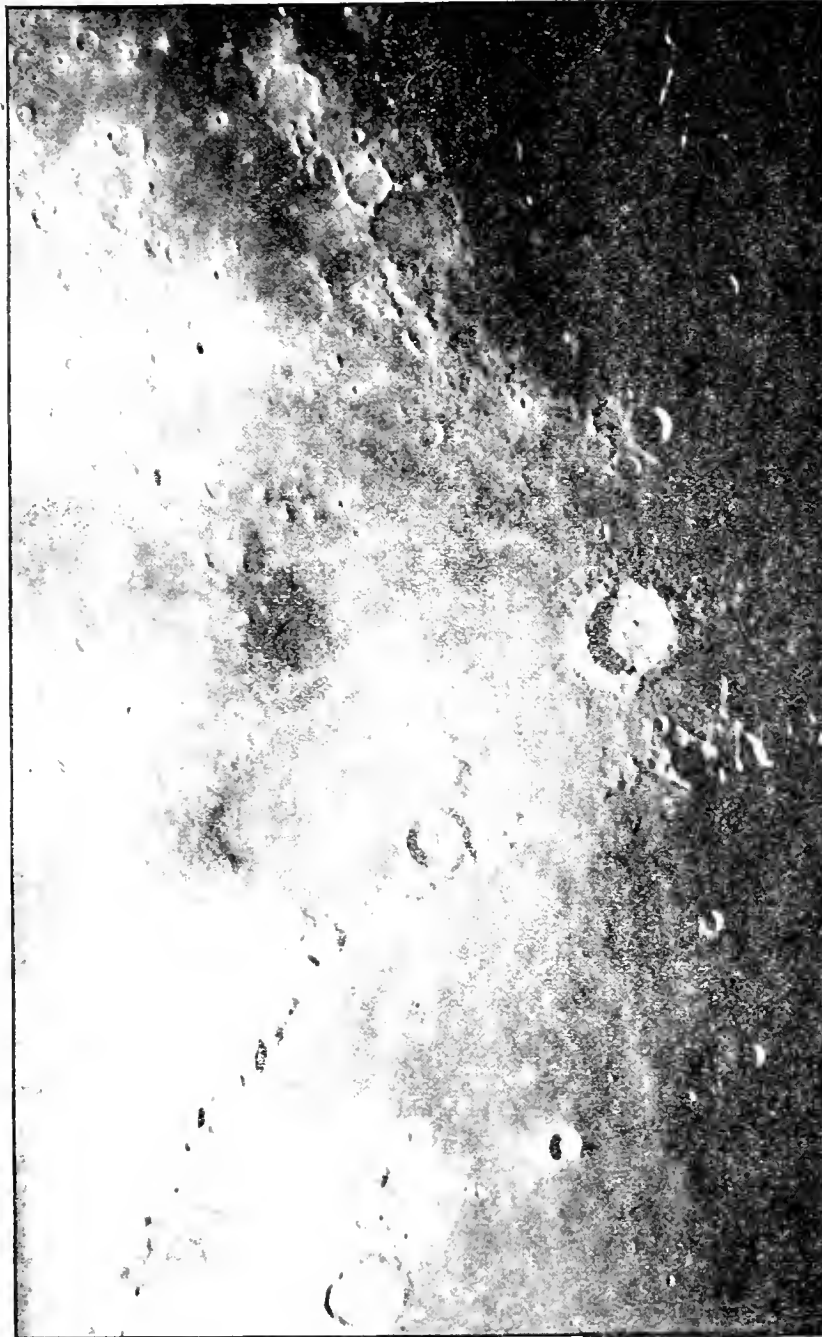


FIG. 6.—From a photograph taken by the Brothers Henry on 28th May, 1890.

would need to be evaporated into the earth's atmosphere, where gravity is six times as great. The pressure of water vapour is a physical quantity dependent on the energy of the molecules, and it could be made to depress or raise a spring balance. But the depression of a spring balance which would raise a column of mercury 1 millimetre on the earth would raise a corresponding column about 24 millimetres on the

SOUTH

WEST

EAST



Plate I.--THE REGION AROUND COPERNICUS, AS SEEN WHEN THE MOON WAS 21⁰ HOURS OLD.

Reproduced by permission of the U.S. Government, from the original photograph taken at the Paris Observatory by the Brothers Henry on the 24th of May, 1890. An angle of 200 microns was thrown by means of a pin on to the photographic plate; its scale is about 150 miles to the inch.

SOUTH

WEST

EAST

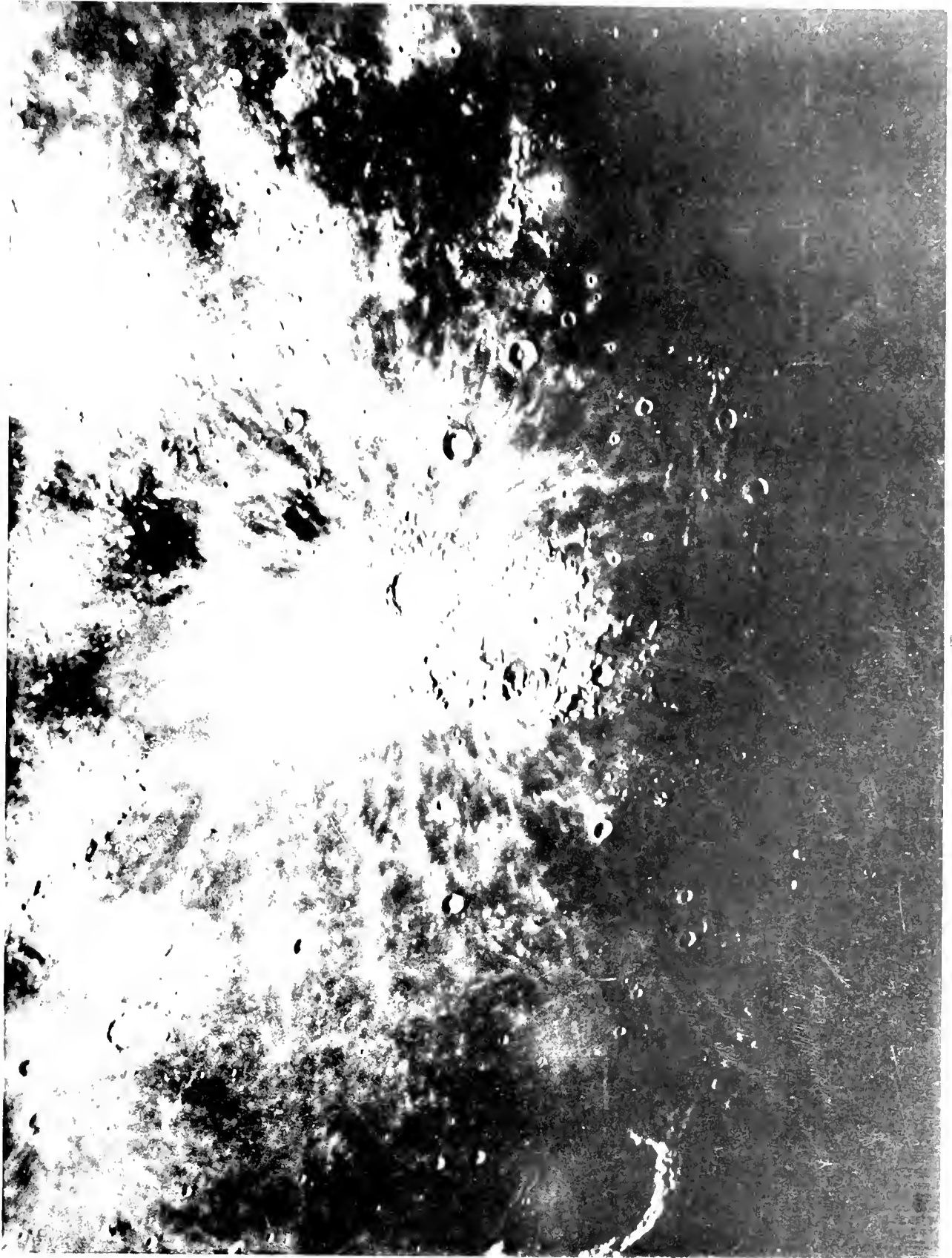


Plate II.—THE REGION AROUND COPERNICUS, AS SEEN WHEN THE MOON WAS 265 HOURS OLD.

Reproduced from a photograph taken at the Paris Observatory by MM. PARR and PROUZE, HENRY, on the 29th of May, 1890. The sensitive plate was placed behind an eyepiece which enlarged the image in the principal focus of the 13-inch photographic refractor used in the International Survey of the Heavens.

moon.* This will, I trust, make it clear that the amount of evaporation for a given rise of temperature is much greater at the moon's surface than here, and it need hardly be remarked that the difference of temperature between the lunar midday and lunar midnight is probably much greater than 30° Centigrade. But the white streaks do not melt away or disappear during the lunar day. It is therefore evident that if they are caused by a snow-like deposit on either side of volcanic vents, the deposit must be thick enough not to be melted during the lunar day, and yet the deposit must be thin enough at its edges to only partially whiten the ground; but this is perhaps possible on a rough surface. I would refer readers who take an interest in the theories as to these bright streaks to a paper published in *KNOWLEDGE* for May, 1890.

Some of the dark markings on the moon are even more mysterious than the white ones. On examining our plates, they might at first sight be taken for photographic defects, but a close comparison of two photographs shows that many of the smallest dark marks are exactly repeated, and a comparison with other photographs proves that very little change takes place in the appearance of these dark spots when the sun is at different altitudes. Take, for example, the curious dark spot on the Mare Imbrium in the fork of the ray between Eratosthenes and Archimedes. It looks like the half of

an elliptic crater surrounded by a black line, with an intensely black spot at its southern end. If this marking, as shown on Plates I. and II., is compared, very little doubt will be entertained as to the real existence of its smallest details. See also the two dark and two lighter lines across the floor of the crater of Archimedes, and examine the numerous small black tree-like markings on the southern and eastern sides of its elliptic ring; they look as if small dark-coloured lava streams had overflowed from the crater and spread out at its base.

There are many similar dark markings—see, for example, on Plate II. the curious dark tree-like structure to the north-east of Copernicus reaching almost from the rim of the crater to the spurs of the Carpathians; and there are other somewhat similar markings on a still larger scale extending from the southern rim of the crater towards the south and west, to a distance of nearly double the diameter of the crater. These dark markings, unlike the bright rays which diverge from Copernicus, spread out at their ends, and they are connected with the region about the crater by comparatively narrow streams. Whether they correspond to streams of dark-coloured lava which once flowed from the crater, or to drainage areas from the high ground—they are on an enormous scale compared with similar terrestrial phenomena. A river like

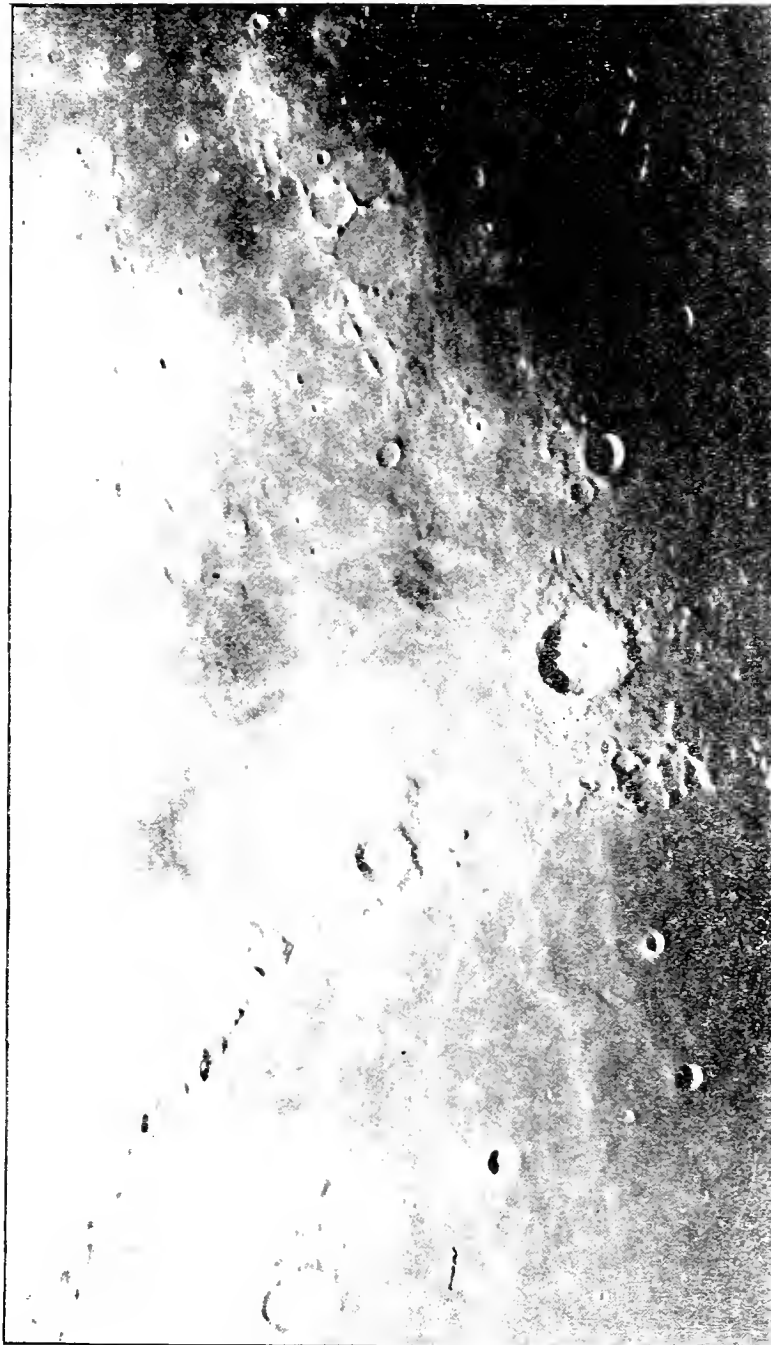


FIG. 7.—A deeper-etched block from the same photograph as that reproduced on the opposite page.

the Thames would appear as a very narrow meandering line beside them, so that it seems difficult to conceive of them as the drainage areas from hot springs. But if lunar eruptions are, like terrestrial eruptions, accompanied by a great evolution of steam which rapidly falls as rain, thickly charged with volcanic dust, vast rivers of mud may have flowed down and discoloured the surface during the erup-

* This relation between the force of gravity and the amount of evaporation is probably the cause of the intense energy of the evaporation phenomena which are observed when a comet approaches the sun. The pressure of an atmosphere of vapour, about a small body like a swarm of stones, must be so small that the whole of any volatile substance would, with a small increase of temperature, be driven off before the pressure corresponding to saturation is reached.

tions of this great volcano. If this theory affords the true explanation of these dark markings, it would follow that in this region of the moon the colour of the lunar surface is not masked by snow or other white deposit which is being continually deposited and evaporated.

If the reader will examine Plate II., he will see just to the north of Timocharis a curious narrow dark circle with a dark centre. After having made sure of this marking

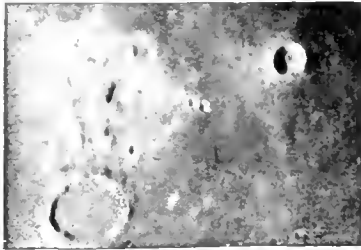


FIG. 8.—Archimedes and the smaller Crater Timocharis.

We have evidently much to learn from these mysterious dark markings.

Terrestrial volcanoes will sometimes pour out a dark-coloured lava at one eruption and a grey or whitish lava at the next. The colour of the lava seems to depend on the character of the rocks melted at no great distance beneath the surface, for if the lavas all came from one general reservoir at the centre of the earth we should expect them all to be similar in character.

And if upon the moon we were to find lavas of different colours, we might take it as evidence that the moon is either stratified or formed of different materials in different parts.

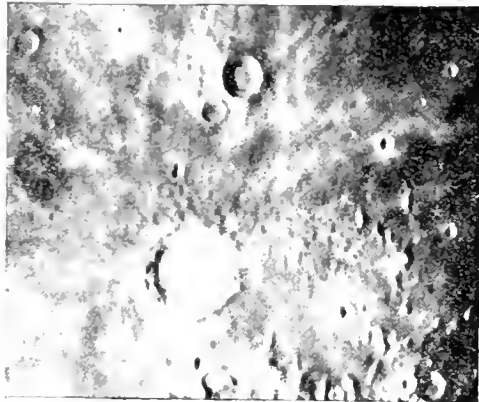


FIG. 9.—Copernicus, showing dark streams from crater.

There are no very striking differences of colour or even of tint to be detected on the moon, but there are very striking differences of whiteness of the lunar surface, and it becomes a very interesting question to determine whether these differences of whiteness are really due to differences in colour of the lunar rocks, or whether they are due of something which covers the lunar surface in some places and leaves the dark rocks exposed in others. Thus, as has been suggested, the dark regions might be

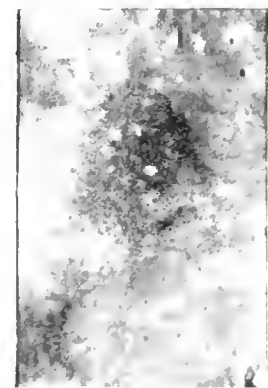


FIG. 10.—The dark patches on the western slope of Copernicus.

caused by the action of warm springs, which on the earth,

always accompany volcanic action. But even if we are ready to conceive of warm springs so copious as to affect areas as large as those corresponding to the streams which seem to have flowed from Copernicus, it seems improbable that warm springs could affect the colour of large areas such as the dark patches on the western slope of Copernicus or the great Maria. As a general rule, plains and low-lying ground upon the moon are dark, while the high ground and mountain-tops are white, and some lunar mountains are much whiter than others. This very markedly points to the conclusion that the whiteness is due to something covering the lunar rocks, and that the covering is more thickly deposited on high ground, as snow is on terrestrial mountains.

The dark markings to which attention is here directed are those which retain their relatively dark appearance as the sun rises, and which can still be traced at full moon; they cannot, therefore, be explained as due to rough surfaces, causing an admixture of shadow that darkens the natural tint. The narrow dark line between the craters Birt and Thebit, in the top left-hand corner of Plate I., is clearly due to a shadow, for it becomes narrower as the sun rises, and is ultimately lost sight of.

The curious dark spots on the floors of many lunar craters, and markings like that to the north of Timocharis, however, point to the conclusion that there are striking differences in the light-reflecting power of areas which appear to correspond with lunar volcanic formations, and they further point to the conclusion that there is a real difference in the colour of the lunar rocks, or that there are local differences of temperature, or other local causes corresponding to such formations, which affect the covering that masks the true colour of the lunar surface. But it must be remembered that differences of colour of the lunar rocks, if conclusively proved to exist, would not prove that the rocks were different in composition, for differences of tint may be due to weathering action; thus, many terrestrial lavas when first formed are black, but they subsequently become reddish or brown.

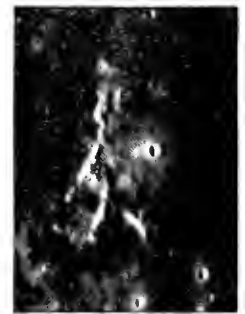


FIG. 11.—The Riphæan Mountains.

Science Notes.

The mass of the earth, as re-determined by M. Alphonse Berget, is 5.85×10^7 grammes, its density 5.41.

The *Lancet* refers to the confirmed "stoop" which has already been manifested by cyclists. The dorsal curvature posteriorly, which used to be rare in boys under fourteen years of age, is now very frequently met with, particularly among those bicyclists whose spinal column is developing more rapidly than the ligaments and muscles. The use of Indian clubs is recommended.

A novel kind of cab has lately been tried in Berlin. In appearance it is not unlike a large bath chair with two seats, and is propelled by a petroleum-naphtha motor. It has three wheels, and carries only two persons, including the driver. The motor is of nearly two horse power, and produces, on good roads, a speed of about eleven miles an hour.

It is proposed to utilize peat moss, and possibly other vegetation, as a source of alcohol, by first converting its cellulose into sugar. This change may be effected by heating the vegetable substance to 115-120° C. with dilute sulphuric acid. The expressed liquor is then fermented with yeast. In this way from 62 to 63 litres of alcohol may be obtained from 1000 kilos of dried turf.

Sir J. B. Lawes recently received, through the India Office, a consignment of phosphates from Madras, with a view to their commercial value being ascertained. The specimens are well-formed nodules, with a nearly smooth buffish coat, and internally appear very pure. Unfortunately, they show no traces of fossils. They come from a region where there are both cretaceous and eocene beds.

The place having the lowest mean temperature in the world is Werkojansk, in North-Eastern Siberia. A temperature of -88° Fahr. has been registered at that cold spot, and the mean minimum is -61° Fahr. The Colorado River Desert affords an example of a climate of extremes, for the atmosphere has there shown a maximum of 120° Fahr., and the annual range of temperature is 200° Fahr. When this is compared with the range of temperature experienced in London it becomes evident that we have much for which we should be thankful.

A rival product to celluloid, but without its disadvantage of excessive inflammability, has been described by Messrs. Cross, Bevan, and Beadle. Alkaline thiocarbonates of cellulose are obtained by treating that substance with a strong solution of caustic alkali, and subsequently exposing to the vapour of carbon disulphide. The result is a swollen mass of bright yellow colour, the solution of which has an enormous viscosity and from which the cellulose may be regenerated by means of common salt or alcohol. The cellulose is obtained in its new form as a gelatinous hydrate, and the degrees in its gradual regeneration are marked by an increasing tendency to form an insoluble jelly. It is suggested that it will be available to technologists for such purposes as an adhesive substance, for sizing and filling textiles, for producing casts and moulds, as a paper indestructible by water, for photographic films, and for numerous other purposes.

In the *Revue Générale des Sciences* (No. 11) there is an interesting summary of the general progress of bacteriology by Dr. P. Achaïme, after which the pathogenic activities of *streptococcus*, characteristic of erysipelas, are particularly discussed. The varying character of the action of this microbe in various media, and according to the nature of the previous medium, and with variations in the method of transporting and of the region of inoculation, are dealt with at length. The virulence and even the nature of the influence exerted are profoundly affected by the previous pathological condition of the subject. Affections connected with streptococcus are always particularly severe with sufferers from diabetes and Bright's disease, and erysipelas upon the face is a frequent appearance in the later stages of hepatic disease. MM. Roux and Yersin have shown a reciprocal exaltation of virulence between the bacillus of diphtheria and streptococcus, and a large proportion of the eruptive phenomena of scarlatina and other affections are "streptococic." Dr. Achaïme uses the term microbic "symbiosis" for such morbid conspiracies. He concludes by insisting that the narrow doctrine of specific microbes must be replaced by an admission that "a plurality of morbid effects may be produced by one microbe, and that a plurality of microbes may engender the same symptomatic complex."

Some important results have recently been obtained by Heider, who has been experimenting with disinfectants at higher temperatures and testing their effects on bacteria. In the majority of cases the bactericidal action is markedly increased by raising the temperature. Hot or even boiling solutions should be used for killing spores; a little of a hot solution goes a long way.

The *post-mortem* excitability of nerves and muscles has been shown by M. A. d'Arsonval to continue much longer than is commonly supposed, and during the *rigor mortis* condition. This he has demonstrated by means of the myophone, an arrangement of the microphone to detect small muscular contractions. Muscular excitability was shown to exist in a rabbit ten hours after death.

The announcement of fossil relics of colossal corkscrews from the miocene beds in Sioux County, Nebraska, is suggestive of burlesque. The remains in question are described by Mr. E. H. Barbour in "University Studies," published by the Nebraska University. The spire of the corkscrew is from two to nine feet in length, and invariably vertical, and there is always a horizontal transverse piece below answering to the handle and about three feet in length. The ranchmen have given these remarkable forms the name of "Devil's Corkscrews," a title Mr. Barbour would preserve in the decently-veiled form of *Daimonelix*. He regards them as fossil sponges, but the occurrence of a well-preserved rodent skeleton in the stem of one suggests that they are after all simply filled-up burrows. The tunnels of some species of *Thomomys*, it may be noted, are spiral.

Letters.

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

THE EFFECT OF THE ATMOSPHERE OF MARS ON THE TEMPERATURE OF THE PLANET

To the Editor of KNOWLEDGE.

SIR.—Since writing my letter "On the Formation of Clouds in the Atmosphere of Mars," I have made a rough calculation as to the effect of such an atmosphere on the temperature at the surface. The result surprised me, and, if correct, must considerably modify the opinion expressed in the last paragraph of that letter as to the dampness of the atmosphere. I have, however, considerable doubt as to its correctness, and would like an independent opinion on the subject.

I assume that the atmospheres of Mars and the earth are about equally damp. Let us take four miles as the average height of clouds on the earth, and twenty miles as the corresponding height for Mars.

Let H be the amount of solar heat which falls in a given time on, say, one thousand square miles of the earth's surface. Were it not for the aqueous vapour in our atmosphere, this heat would be all radiated away again, and lost in space. Suppose that when this quantity H of heat is traversing the atmosphere on its outward journey, a quantity aH is absorbed by the aqueous vapour. Then this quantity aH of heat represents the amount which goes to raising the surface temperature, or as we may word it, the amount *conserved*.

Let G be the quantity of solar heat which falls in the same time on one thousand square miles of Mars' surface. Then, when this heat is being radiated away (the atmospheres being supposed equally damp), a quantity aG is absorbed in the first four miles of atmosphere, and $(1-a)$

G passes through. Of this, $a(1-a)G$ is absorbed in the second four miles, and $(1-a)^2G$ passes through. Proceeding in this way, the heat which finally escapes from the fifth four-mile layer is $(1-a)^5G$, and therefore the total heat absorbed in the atmosphere is $a(5-10a+10a^2-5a^3+a^4)G$.

We do not know what a is exactly; however, we may be pretty sure that it represents a fraction which is not very large nor yet infinitesimally small. Consequently, we may take the above as probably between $1aG$ and $2aG$.

We know that G is about $4H$.

So, if the heat conserved on the earth be aH , that conserved on Mars is probably between $6aH$ and $8aH$.

This would account for a surface temperature not very different from our own, but probably a little warmer. Since Mars is probably colder than the earth, the conclusion I draw is that the atmosphere is somewhat drier than ours.

Of course the figures I took, four miles and twenty miles, are uncertain. But the general argument does not involve the exact figures: the gist of it is that in estimating the effect of the atmosphere of Mars on the temperature, the great thickness of the absorptive stratum must be taken into account, and will cause the atmosphere to conserve much more of the incident heat than ours does.

The same line of reasoning applied to the planet Venus would make it excessively hot.

J. R. HOLT.

[I agree with Mr. Holt that the density of the aqueous vapour present in the lower strata of the atmosphere of Mars will depend upon the temperature of the Martial surface, and not upon the density of the Martial atmosphere, for at any given temperature as much aqueous vapour rises into a vacuum as into a dense and dry atmosphere. With gravity at the surface of Mars equal to only 39 per cent. of gravity at the earth's surface, the density of the Martial atmosphere will be halved at a height about two and a half times as great above the surface of Mars as the height above the earth's surface at which the density of the earth's atmosphere is halved; consequently, an atmosphere of aqueous vapour of any given density at the surface of Mars will, if it is not precipitated into cloud or ice particles, extend to about two and a half times (not five times) as great a height above the surface of Mars as it would extend above the surface of the earth, and any absorption due to aqueous vapour would correspond to the absorption of a layer of similar density two and a half times as thick above the earth's surface. But if I understand rightly, Prof. Langley's bolometer observations have thrown great doubt upon the theory that aqueous vapour transmits solar heat while it absorbs the non-luminous heat of long wave-length radiated by the earth's surface; and it will be remarked that if Mr. Holt's theory held good, the moon's surface, with lunar gravity equal to only about a sixth of terrestrial gravity, ought to become in the course of the lunar day much hotter than the earth's surface, but if the observations of Profs. Langley, Very, and Boys are to be relied upon, this is not the case.—

A. C. RANFORD.

To the Editor of KNOWLEDGE.

SIR.—Would not the establishment of a "Scientific Review of Reviews," published monthly, and including summaries of the transactions of the learned societies, be

* It follows from this that about two and a half times as much aqueous vapour would for any given temperature be evaporated from the surface of Mars as from an equal area of the earth's surface.

the best method of solving the problem you refer to in the August number of KNOWLEDGE (p. 148)? A mere index, without some sort of indication as to the drift and bearings of the article in question, would hardly lessen the difficulty very much. Such a review would have to be edited by one of those you term scientific "scholars," assisted by a strong staff of specialists and correspondents. The necessity of keeping the review within reasonable limits would prevent its injuring the already existing magazines by doing more than just summarize their articles. So many of our greatest feats in science have been achieved by private individuals that it would be a great pity to intrust so important an undertaking to any department of the Government.

Yours faithfully,

Malvern.

H. ST. A. ALDER.

[Such a review would certainly not pay commercially. The work would probably be most satisfactorily done if the various learned societies could induce specialists to contribute an index of papers in their own special departments. *Précis* of scientific papers, similar to the head notes of cases published in Law Reports, would be most difficult to prepare.—A. C. R.]

To the Editor of KNOWLEDGE.

DEAR SIR.—If I might be permitted to make a small criticism upon Dr. Anderson's interesting article in the July number of KNOWLEDGE, it would be with reference to the sentence:—"It is perhaps too late now to restore to θ its ancient style and title of Achernar, but α at least should be made to yield up its usurped honours." But α Eridani is really "the last star in the river" as we know the constellation, so that one hardly sees why it should be deprived of the name Achernar, which has that meaning, because Ptolemy called another star (our θ Eridani) "the last in the river"; it being the last in the stream which was visible in his latitude. The proper thing, it appears to me, would be to retain Achernar as the name of α Eridani, and to call θ Eschatos or Ptolemy's Eschatos.

It is certainly very remarkable that in his time (and for centuries afterwards) there should have been a star of the first magnitude at the extreme end of Eridanus as visible in Alexandria, and that there should also be a star of the first magnitude at the extreme end of that river as extended by observations made further to the south in more recent times, whilst Ptolemy's first should have faded down to the third magnitude. But there are more strange things in heaven and earth than our philosophy dreams of, and there seems no escape from the conclusion. The nature of the variability, then, of θ Eridani would seem to be almost unique; for it is not a case of gradual diminution through the centuries. Ptolemy, Al Sûfi and Ulugh Begh found it of the first magnitude; Halley, about two centuries after the latter, observed it of the third magnitude, at which it has remained ever since. Gould, in the *Uranometria Argentina*, registers 2.6 as the precise magnitude when he formed his catalogue.

But there is a further difficulty connected with it, which is this. Bayer, in the tables accompanying his constellation maps (published in 1603) assigns to θ Eridani its modern magnitude, the third. How did he obtain his knowledge of this, which carries back the change of magnitude to nearly a century before the time of Halley? Tycho did not observe it, for the best of all possible reasons; and it would almost seem as if Bayer took more trouble about some of his data than has generally been supposed. His α Eridani (marked of the first magnitude) is undoubtedly that in the far south which is now commonly called

Achernar—a name, in my opinion, which it should still retain.

I may here point out an *erratum* in the B. A. C., which has not, I think, been noticed before. It affixes the letter *a* not only to Achernar but also to a star of the fourth magnitude, numbered 12 in Flamsteed's list of the stars in Eridanus. The source of this mistake can be traced; it evidently arises from the circumstance that that star is called *a* Fornacis by Lacaille.

Yours faithfully,

Blackheath, August 16th, 1898. W. T. LYNN.

P.S.—In my letter to you of the 18th July (printed in the last number, p. 154), the Greek word *ἑστία*, corresponding to the Latin *focus*, is advertently spelt with the smooth breathing. If a word were coined from it similar to “perihelion,” it would be “perihestian,” but there would be many objections to such a word. Mythologically, *ἑστία* corresponds to the Latin *vesta*; and, moreover, it has never been used in a mathematical sense, like *focus*, which (as I pointed out in my “Celestial Motions”) is a term transferred from optics to mathematics and astronomy. “Perigee” (which surely should be “perigeen”) and “perihelion” are too firmly imbedded in astronomical books now to be displaced, and there seems no objection to the more recent “periastron.” But, as Mr. Holt points out, this is not the case with some of the hybrid words used in reference to the planets. “Perijove” (if such a word must be used) should be “perizena”; “perisaturnum,” in Greek mythology, would be “perikronon.”—W. T. L.

—♦—
To the Editor of KNOWLEDGE.

SIR,—As it would appear from your August number, containing some further reproductions of lunar photographs by the skilful Brothers Henry, that the interesting and as yet hardly-opened study of selenology is likely to continue to occupy your pages a little longer, may I refer back to your number for July last, and to that marvellous photograph of “the moon when 136 hours old,” in order to refer to some little points apparently not yet fully noticed, and which perhaps would have passed unobserved by me but for certain observations and photos made in Melbourne some twenty years ago, when I was in charge of the great telescope.

At this distance in time and space my notes are not available to refer to, but certain appearances have remained indelibly impressed upon my mind, awakened as it then was to the importance of selenology, as furnishing analogies highly useful in the study of our own geology.

In your article on “The Great Plains on the Moon” (July), you remark upon “a curious, narrow, dark line which seems not to be due to any photographic defect. It skirts the high ground on the edge of the Mare (Tranquillitatis) for a distance of more than one hundred miles, and ultimately seems to pass through or over a ridge to the south of Sabine (65).” You then point out another similar but broader line, “skirting the western edge of the Mare Nectaris.” The first of these (permit me for convenience* to call it Ranyard *a*) I remember to have seen, and on the photo-plate it is to my eye undoubtedly an imperfectly filled fault or fissure in the substance of the plain, the

* While thanking Mr. Macgeorge for his kindly-intended compliment, I trust he will permit me to change the proposed names in the remainder of his letter to Tranquillitatis *a* and Nectaris *b*, names which seem to me to be decidedly preferable, because they roughly indicate the position of these curious markings, and because it does not seem to me to be desirable to name portions of the moon or planets after living people.—A. C. R.

date being probably subsequent to the formation of Sabine (65), the southern buttress of whose crater-wall it cuts and breaks down in its course. Less distinct, but apparently a similar formation, is that on the west of the Mare Nectaris (Ranyard *b*), which to my eye seems terminated by a minute craterlet, into which several branching creases of the surface also dip and disappear.

You have already observed that such small craters are probably on the line of unseen faults in the lunar crust, since they have a tendency to occur in strings or lines. Your surmise is doubtless correct, since I have seen, in the four-foot reflector, these two things in plain visual connection. And even in the Henry photographs your theory receives good support, since not only does Nectaris *b* end in a craterlet, but Tranquillitatis *a* seems to terminate also in the direction of a well-marked small crater east of Sabine (65); while a southern parallel fault, branching from Tranquillitatis *a* at mid-length, not only cuts but dislocates to the east considerably the southern buttress of Sabine, at a few miles distance, and then disappears towards a low crater in the shadow of the other side. The effect of this whole duplicated fault and dislocation is not only to bear out your view, but, when coupled with the roller-like undulations of the Mare advancing upon Sabine and Arago (63), to give the impression of an extensive disruptive flow of the lava-plateau towards the east, and which had found its southern limit here.

Before leaving this interesting rill, it may be observed that Tranquillitatis *a*, at its western end, also disappears in a craterlet, which may be seen at the northern termination of the mountain ranges forming the buttresses of Hypatia (317); but not before leaving, as a depression in its very bed, a tiny craterlet, at a point a little to the east of where a small pit with a whitish edge (probably also in connection with this “fault”) nearly touches its northern edge.

Nearly parallel with this rill and well on the other side of Sabine will be found another fault, of older date than the last, since it is almost effaced on the lower levels of the plain, and entirely so where a low spur of Sabine cuts it near its N.E. end. This fault ends in a well-marked craterlet of very low ring-wall, on the plain between Sabine and Manners (186).

At its other extremity it gradually disappears amongst the partially dislocated and small isolated ridge west of the S.W. extremity of Tranquillitatis *a*.

Northwards, and still upon the Mare Tranquillitatis, there appears a curious scar, straight, and with its steepest edge to the west, and situated on the plain nearly half-way between Sabine and Maskelyne (67), which can hardly be a photographic defect. It is even more distinct than the little crater-pit a short distance further west, and it has a curious parallelism with the meridional scars, creases, or wrinkles which commence in the wall of Sabine and which end somewhat convergently in or near Manners (186), again supporting the theory as to faults and craters. It is difficult to imagine these to be photographic defects, since they appear also in the ring-wall of Sabine, both outside and in, and take there a corresponding curvature. They are probably rents produced by eruptive force in Sabine, and consequently of later date.

West of Arago (63), and in a line due north from Theophilus, commences (again in some minute craterlets or fumaroles) another fault, whose course has been almost obliterated by subsequent fusion or degradation, but which trends, with slightly curving south-westerly course, until it ends in the low wall of Maskelyne (67), a half-sunk crater of apparently older date.

Turning further to the north, we may observe a curious fine bright line, making as it were a continuation of the

bayonet-shaped ridge which issues from the S.W. side of the breached and half-effaced crater-ring of Jansen (66). At first sight it might pass for a photographic scratch, but the way in which it traverses first a tiny crater at the bayonet's point, looping slightly to the crater's shape, and then two sharply defined and larger craterlets well out on the plain—all these, with the "scratch," being in one straight line—leads one to regard it as the raised ledge of a fault or dyke, touched sharply by the morning light.

Fainter still in its course, though still traceable, is another system of rills to which the eye may be guided as follows:—Nearly in the line of Sabine (65) and Maskelyne (67), and lying at about an equal distance west of these, is the southernmost of two small crater-pits; a little to the north of the northernmost of the two commences one branch of the main rill, which the eye can follow downwards until opposite to a low, small, cup-topped hill. A little east of this the branch, with some other still smaller ones, falls into a somewhat wider straight rill, trending N.E. Following this until nearly opposite to a third pit (having a smaller companion a little further west) is the point of junction of another branch rill, which has its rise in some minute flat depressions nearly opposite our starting point, to the south. Leaving this junction, and continuing N.E. on the main rill, we pass—on the left, and quite close at hand—two minute pits in succession, which also join in to our main rill by short channels. A little further, the photo-engraving ceases to mark the course distinctly, but upon the same N.E. line we observe numerous little pits and depressions, which gradually guide the eye to a small crater in the hill-country west of Jansen (66).

Doubtless, by reference to the original photograph, you will be able to check any error in the foregoing, or point out any features which may be called photographic defects.

There are other formations of both plains and mountains which I will not here touch upon, but which all go towards proving the theory as to craterlets being on the line of faults, even when these do not at once strike the eye—and there is also some evidence to show that the larger craters have had to do with the production of these faults, fissures, rills, ridges, and ledges; and all that we can see upon the moon or its photographs tends to make us feel inclined to put aside—at least as chief agent—the projectile theory, the ice theory, and every other but the volcanic theory.

While in a general way agreeing with your observation that the earlier craters "do not present a distinctively rounded appearance, indicating a longer period of weathering," permit me still to say that although few portions of the mountainous regions of the moon show distinct traces of weathering (although on the plains, smoothened and softened outlines prevail in the older parts), yet there are to be found evidences of degradation, of veiling with newer lava and scoria, and even of extensive re-fusion from below, sufficient to mark an older date.

To my eye—possibly prejudiced by great telescope observations—Theophilus (319) is very markedly fresher and sharper in outline, especially interiorly, than the older and more degraded Cyrillus (320), upon which it trenches, and this, again, is still superior in definition to Catharina (321). Most degraded and age-softened of all, and, as it were, half-re-melted into the crust, is the diffused fourth great crater-ring beyond, with its central twin-crater of somewhat later date. The order of formation would seem to have begun here upon the course of a great fissure, and the disruptive force to have acted in the curved line indicated by Catharina and Cyrillus, ending with Theophilus and Madler, whose newer and whiter *débris* have

freshened the whole combined western slope down to the level of the Mare Nectaris.

Pardon the length of this communication.

Yours obediently,

Riviera, 15th August, 1893.

E. F. MACEGEORGE.

THE SUN AS A BRIGHT-LINE STAR.

To the Editor of KNOWLEDGE.

DEAR SIR,—In response to your courteous invitation to comment upon Miss Clerke's most interesting and valuable paper in the August number of KNOWLEDGE, I should like to say that the most important point of the paper appears to me to be the emphasis placed upon the singular spectrum of Mira Ceti, with the suggestion for further observations bearing on the questions which it raises.

I may, perhaps, be allowed first of all to differ from one expression in the earlier part of Miss Clerke's paper, viz., the description of the faculæ as "enormously hot; hotter, certainly, than the photosphere." This does not appear to me to be proved to be the case. Faculæ are elevations above the photospheric level. They are subject, therefore, to less of the *general* absorption of the solar atmosphere, that absorption evidenced by the diminution of light near the limb; they are also subject to less of the *selective* absorption evidenced by the Fraunhofer lines. They also have a special luminosity of their own as seen by the reversal of the H and K lines. And yet with all these advantages they are so little brighter than the photosphere that they are ordinarily invisible near the centre of the disc, and are only to be seen near the limb, where the photosphere is seen through a great depth of absorbing atmosphere. It seems to me that, could we view faculæ and photosphere under equal conditions, the probability—indeed, the certainty—is, that the photosphere would shine out as the brighter of the two.

This brings us to the *crux* of the entire problem, for it accentuates the difference between the spectrum of Mira Ceti and that of the sun. In the sun we trace the lines of hydrogen and the supposed lines of calcium to the same distance above the photosphere. The two elements are therefore intermingled, and at the same temperature. Nevertheless, in the region of the faculæ we find the calcium lines, rather than those of hydrogen, bright, whilst Mira gives us the precise reverse.

It seems impossible under these circumstances to adopt the suggestion that in Mira we have an atmosphere of mingled hydrogen and calcium which behaves in an exactly opposite manner, the hydrogen lines being very bright—far up in the ultra-violet, too, sure sign of an exalted temperature—and the calcium lines very dark; *but* the calcium atmosphere eliminating, for the H line of hydrogen, the effect of the radiation of the glowing hydrogen immediately below it. If the calcium, rather than the hydrogen, glows in the faculæ of the sun, ought it not to do the same in Mira?

On the other hand, how can we accept the conclusion from which Miss Clerke tells us "there is no escape"? Is it possible to conceive a star with a photosphere overlaid by a stratum of much more highly-heated hydrogen, and that again by a dense layer of cooler calcium? If the two gases are intermingled in the sun, why not in Mira? What conceivable power keeps the dense, the colder and heavier gas in the upper stratum, and the hotter, lighter gas below?

There are two ways of escape which suggest themselves to me, but neither of which I feel myself free to accept. The first is, that "the continuity of the harmonical progression" may, in the case of Mira, be really broken. That the lines of hydrogen in the spectra of

different stars do not vary equally and simultaneously is obvious, and I cannot therefore regard it as inconceivable that in this instance the H line may be truly missing. The existence of two lines on the one side and of four on the other render it, however, very improbable.

The other suggestion is, that we have to do with two distinct bodies, and that the body giving rise to the bright hydrogen lines lies behind that surrounded by the dense calcium vapour. This, again, for obvious reasons is very improbable. It remains only to confess that at present I see no solution of the difficulties before us, and I think that it is from the intricacy of the problem, and not from any oversight, that the spectrum of Mira Ceti has received so little comment hitherto. Spectroscopists are the more indebted to Miss Clerke for her suggestion as to the next observations to be secured. The more perplexing the problem before us is, the more complete and fruitful will its solution be when we at length possess the key.

E. W. MACNDER.

ABSORPTION IN THE SUN.

To the Editor of KNOWLEDGE.

SIR,—My article on "The Sun as a Bright-line Star," in the last number of *KNOWLEDGE*, was written without prepossessions for or against any general theory of solar absorption. My object was simply to draw some inevitable conclusions (as they appeared to me) from certain well-ascertained facts. If the constitution of the "reversing-layer" is largely implicated, the responsibility rests with the facts, not with my inferences from them. But since you, sir, have, in a courteous editorial note, expressed doubts as to their validity, it is necessary to reconsider them.

Following your example, I will take the K-line alone. This quality of radiation comes to us bright from faculae on the disc of the sun. The vapour emitting it is then hotter than the photosphere: it is, to a still greater degree, hotter than the absorbing stratum, which, because cooler than the photosphere, stops the whole of its light of the same wave-length as K. I say the whole, because the remnant of K-illumination in the solar spectrum comes from the absorbing layer itself, not from the photosphere. The screening action is complete, but the screen is self-luminous. Between this absorbing layer and the faculae there is, accordingly, a wider difference of temperature than between it and the photosphere. If, then, it arrests all the photospheric light agreeing with K in refrangibility, it should, *à fortiori*, if situated at a higher level than the faculae, arrest all the K-light derived from them. The fact that, to all appearance, none of it is arrested, evidently relegates the absorbing calcium-stratum to a lower level.

Another circumstance seems equally demonstrative to the same effect. If the chromosphere were enveloped in vapour absorbing and emitting K-light, a line drawn through it to the edge of the sun should be many times longer than a line drawn to the centre of the sun. Hence any action exercised by it upon faculae should be vastly intensified as regards our spectroscopic view of chromosphere and prominences. Nevertheless, the K-line is scarcely less brilliant in them than in faculae. Moreover, a calcium-stratum profound enough to render the difference in question negligible, is totally inadmissible. Even if it had a depth equal to the sun's radius, the ratio of the lines penetrating it to the centre and limb of the sun would still exceed one-half; and in this case, the rays emitted by it, showing bright off the sun, should invariably and everywhere attain a height above the limb of 15'.

Passing to the spectrum of Mira, our editor maintains that the absence from it of the bright H-line of hydrogen

"cannot be taken as proving that the cool calcium-vapour is above the glowing hydrogen." The absorption by the calcium H of the nearly coincident hydrogen ray may, we are told, be entirely due to difference of temperature. But how can one gas be cooler than another if they are intermixed, as it is assumed they are, in one and the same locality?

Yours faithfully,

A. M. CLERKE.

[If the gases which absorb the light of the sun's photosphere formed an atmosphere about the sun, it would be impossible to conceive of two kinds of vapour at different temperatures existing in the same region. But we may feel sure that the vapours present in the chromosphere and corona of the sun do not form an atmosphere in which the gases rest in equilibrium or in layers upon one another. With solar gravity equal to $27\frac{1}{4}$ times terrestrial gravity, such an atmosphere, even if composed of hydrogen, could not extend to a height of a few hundred miles without being reduced in density so as to be quite negligible. Thus it may be demonstrated that at a temperature of 2457° Cent. hydrogen would be reduced to a millionth of a millionth of its density at the lower level on rising through a height of 270 miles. We must therefore conclude that the molecules of the gases above the photosphere are moving in long free paths, having been evaporated from solid or liquid particles falling from a cooler region, or that they are derived from prominence streams rushing upward from a lower level; in either case we may have molecules at the same level at very different temperatures, because they are derived from different sources.

I admit that there is an appearance of stratification in the lower and hotter regions of the sun immediately above the photosphere, but I would urge that this can only be an apparent stratification due to the effect of temperature in modifying the general physical condition and the spectrum given out, and that in the stars as well as in the sun there must be a complete mixture of materials; though as we approach the heated centre there will be regions where some of the materials condense into the liquid or solid state, while the rest remain in a state of vapour.

It seems highly probable that similar molecules will always give out or absorb the same wave-lengths under similar conditions, and that they will always condense and vaporize at the same temperature, and at first sight it might seem necessarily to follow that the driving into vapour of different materials would always succeed one another in the same order as we approach a highly-heated body; but there are at least two possible ways in which a variation of the order may be accounted for.

1. Differences in the mass of stars would cause matter condensed in the coronas surrounding the stellar photospheres to approach the heated centre with different velocities, and before complete evaporation falling particles would be carried to different depths or isothermal regions.

2. In stars at different temperatures we may have very different intensities of the explosive action which, in the sun, is continually driving the matter of which the prominences and the corona are composed away from the centre, to cool in the outer regions and fall again. It seems probable that the mass of the star remaining unaltered, the greater the heat the greater would be the velocity of the up-rushes, and incandescent material would be carried into colder regions before it ceased to shine.

In addition to these two causes of variation, stars may not all consist of similar materials, or of materials mixed in the same proportion; but it is evident that this last possible cause of variation will not account for the difference between the spectra of Mira and the sun.

I entirely agree with Mr. Maunder as to the comparative shallowness of the layer about the sun which causes general absorption, as compared with that which causes selective absorption. It seems probable that the layer causing general absorption is not a gaseous layer, but is a stratum above the photosphere which is rendered partially opaque by the presence of small solid or liquid particles.—A. C. RAYMOND.

THE FACE OF THE SKY FOR SEPTEMBER.

By HERBERT SADLER, F.R.A.S.

SOME magnificent spots have lately appeared on the Sun's disc. Conveniently observable minima of Algol occur at 10h. 11m. p.m. on the 3rd; 7h. 0m. p.m. on the 6th; 11h. 52m. p.m. on the 23rd; and 8h. 41m. p.m. on the 26th. About the end of the month the Zodiacal light is visible in the east before sunrise.

Mercury is a morning star, and is well situated for observation during the first portion of the month. He rises on the 1st at 3h. 40m. a.m., or 1h. 33m. before the Sun, with a northern declination of $11^{\circ} 46'$, and an apparent diameter of $6''$, $\frac{7}{10}$ ths of the disc being illuminated. On the 3rd he rises at 3h. 48m. a.m., or 1h. 30m. before the Sun, with a northern declination of $13^{\circ} 57'$, and an apparent diameter of $5\frac{1}{4}''$, $\frac{7}{10}$ ths of the disc being illuminated. The planet is now at about its greatest brightness. On the 9th he rises at 4h. 25m. a.m., or 1h. 1m. before the Sun, with a northern declination of $10^{\circ} 30'$, and an apparent diameter of $5\frac{1}{4}''$, $\frac{2}{10}$ ths of the disc being illuminated. After this he gets too near the Sun to be readily observed. He is in superior conjunction on the 20th. While visible, Mercury describes a direct path through Leo, without approaching any conspicuous star very closely.

Venus is an evening star, but her proximity to the Sun and her increasing southern declination render her rather difficult to observe. She sets on the 1st at 7h. 43m. p.m., or 57m. after the Sun, with a southern declination of $4^{\circ} 3'$, and an apparent diameter of $12\frac{1}{2}''$, $\frac{4}{10}$ ths of the disc being illuminated. On the 17th she sets at 7h. 9m. p.m., or 1h. after the Sun, with a southern declination of $12^{\circ} 0'$, and an apparent diameter of $13''$, $\frac{9}{10}$ ths of the disc being illuminated. On the 30th she sets at 6h. 46m. p.m., or 1h. 5m. after the Sun, with a southern declination of $17^{\circ} 11'$, and an apparent diameter of $14\frac{1}{2}''$, about $\frac{3}{10}$ ths of the disc being illuminated. At this time her brightness is about $\frac{25}{100}$ ths of what it will be about the middle of January, 1899. Venus is in conjunction with Saturn at 3h. a.m. on the 2nd, Venus being nearly 2° south of Saturn. During the month Venus passes through part of Virgo into Libra, but does not approach any bright star. She will be occulted by the Moon on the 13th, but the phenomenon will not be visible in England.

Mars, Saturn, and Uranus are, for the observer's purposes, invisible.

Jupiter is getting every night more favourably situated for observation. He rises on the 1st at 9h. 21m. p.m., or 2h. 35m. after sunset, with a northern declination of $19^{\circ} 19'$, and an apparent equatorial diameter of $11.0''$, the phase on the p limb amounting to $0.4''$. On the 18th he rises at 8h. 16m. p.m., or 2h. 9m. after sunset, with a northern declination of $19^{\circ} 24'$, and an apparent equatorial diameter of $13\frac{1}{4}''$. On the 30th he rises at 7h. 28m. p.m., or 1h. 47m. after sunset, with a northern declination of $19^{\circ} 20'$, and an apparent equatorial diameter of $11\frac{3}{4}''$, the phase being still perceptible. During the month he

describes a very short looped path in Taurus. The following phenomena of the satellites occur while Jupiter is more than 8° above and the Sun 8° below the horizon:—A transit ingress of the shadow of the first satellite at 10h. 23m. p.m., on the 2nd; a transit egress of the shadow of the second satellite at 0h. 43m. a.m., on the 3rd; a transit ingress of the satellite itself at 1h. 8m. a.m., and its transit egress at 3h. 25m. a.m. On the 4th a transit ingress of the third satellite at 0h. 51m. a.m. and its transit egress at 2h. 14m. a.m.; an occultation reappearance of the second satellite at 10h. 31m. p.m. On the 5th a transit ingress of the shadow of the first satellite at 4h. 29m. a.m. On the 6th an eclipse disappearance of the first satellite at 1h. 39m. 18s. a.m.; an occultation reappearance of the satellite at 5h. 9m. a.m.; a transit ingress of the shadow of the first satellite at 10h. 58m. p.m. On the 7th a transit ingress of the first satellite at 0h. 18m. a.m.; a transit egress of its shadow at 1h. 10m. a.m.; a transit egress of the satellite at 2h. 29m. a.m., and an occultation reappearance of the same satellite at 11h. 37m. p.m. On the 10th a transit ingress of the shadow of the first satellite at 0h. 58m. a.m.; its transit egress at 3h. 19m. a.m.; a transit ingress of the satellite itself at 3h. 39m. a.m.; and a transit ingress of the shadow of the third satellite at 11h. 13m. p.m. On the 11th a transit egress of the shadow of the third satellite at 0h. 57m. a.m.; an eclipse reappearance of the second satellite at 10h. 23m. 15s. p.m., and its occultation disappearance at 10h. 45m. p.m. On the 12th an occultation reappearance of the second satellite at 1h. 1m. a.m. On the 13th an eclipse disappearance of the first satellite at 3h. 33m. 11s. a.m. On the 14th a transit ingress of the shadow of the first satellite at 0h. 52m. a.m.; a transit ingress of the satellite itself at 2h. 9m. a.m.; a transit egress of the shadow at 3h. 1m. a.m.; of the satellite at 4h. 20m. a.m.; and an eclipse disappearance of the satellite at 10h. 1m. 41s. p.m. On the 15th an occultation reappearance of the first satellite at 1h. 28m. a.m.; a transit egress of its shadow at 9h. 32m. p.m.; and a transit egress of the satellite itself at 10h. 48m. p.m. On the 17th a transit ingress of the shadow of the second satellite at 3h. 34m. a.m. On the 18th a transit ingress of the shadow of the third satellite at 3h. 13m. a.m., and an eclipse disappearance of the second satellite at 10h. 44m. 43s. p.m. On the 19th an eclipse reappearance of the second satellite at 0h. 58m. 39s. a.m.; an occultation disappearance of the satellite at 1h. 13m. a.m.; and its reappearance from occultation at 3h. 28m. a.m. On the 20th a transit egress of the second satellite at 9h. 36m. p.m. On the 21st a transit ingress of the shadow of the first satellite at 2h. 15m. a.m.; a transit ingress of the satellite itself at 3h. 59m. a.m.; a transit egress of its shadow at 4h. 58m. a.m.; an occultation disappearance of the third satellite at 10h. 6m. p.m., and its reappearance from occultation at 11h. 23m. p.m.; and an eclipse disappearance of the first satellite at 11h. 55m. 43s. p.m. On the 22nd an occultation reappearance of the first satellite at 3h. 17m. a.m.; a transit ingress of its shadow at 9h. 14m. p.m.; a transit ingress of the satellite itself at 10h. 26m. p.m.; and a transit egress of its shadow at 11h. 26m. p.m. On the 23rd a transit egress of the first satellite at 0h. 37m. a.m., and its reappearance from occultation at 9h. 45m. p.m. On the 26th an eclipse disappearance of the second satellite at 1h. 20m. 4s. p.m.; its reappearance at 3h. 33m. 57s. a.m.; and its occultation disappearance at 3h. 38m. a.m. On the 27th a transit ingress of the second satellite at 9h. 46m. p.m.; a transit egress of its shadow two minutes later. On the 28th a transit egress of the second satellite at 0h. 1m. a.m.; a transit ingress of the shadow of the first satellite at

4h. 39m. A.M.; an eclipse disappearance of the third satellite at 9h. 7m. 17s. P.M.; and its reappearance from eclipse at 10h. 36m. 27s. P.M. On the 29th an occultation disappearance of the third satellite at 1h. 45m. A.M.; an eclipse disappearance of the first satellite at 1h. 19m. 42s. A.M.; an occultation reappearance of the third satellite at 3h. 0m. A.M.; an occultation reappearance of the first satellite at 5h. 6m. A.M.; and a transit ingress of the shadow of the first satellite at 11h. 8m. P.M. On the 30th a transit ingress of the first satellite at 0h. 15m. A.M.; a transit egress of its shadow at 1h. 20m. A.M.; a transit egress of the satellite at 2h. 26m. A.M.; and its reappearance from occultation at 11h. 33m. P.M. The following are the times of superior and inferior conjunctions of the fourth satellite:—Superior, September 2nd, 9h. 11.9m. A.M., 19th, 2h. 16.2m. A.M.; Inferior, September 10th, 7h. 9.5m. P.M., 27th, 11h. 11.5m. A.M.

Neptune is beginning to be visible, as he rises on the 1st at 10h. 6m. P.M., with a northern declination of 20° 55', and an apparent diameter of 2.6'. On the 30th he rises at 8h. 8m. P.M., with a northern declination of 20° 54'. He is in quadrature with the Sun on the 5th. He is almost stationary in Taurus during the month.

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

The Moon enters her last quarter at 9h. 42m. A.M. on the 3rd; is new at 7h. 5m. A.M. on the 10th; enters her first quarter at 1h. 19m. A.M. on the 18th, and is full at 8h. 23m. P.M. on the 25th. She is in perigee at 10h. A.M. on the 4th (distance from the earth 229,650 miles); in apogee at 2h. P.M. on the 17th (distance from the earth 251,240 miles); and in perigee again at 4h. P.M. on the 29th (distance from the earth 228,430 miles).

The following ephemerides of comets 1892 VI. and 1893 I. may be useful:—

1892 VI.				
	R.A.	Decl. South.	Br.	
September 1.	17h. 7m. 30s.	18° 21' P	...	0.159
" 5.	9m. 36s.	17.9'	...	0.146
" 9.	11m. 51s.	15.3'	...	0.134
" 13.	14m. 17s.	12.6'	...	0.124
" 17.	16m. 53s.	10.4'	...	0.115
" 21.	19m. 37s.	8.6'	...	0.106
" 25.	22m. 29s.	6.8'	...	0.098
" 29.	25m. 30s.	5.2'	...	0.081
1893 I.				
	R.A.	Decl. South.	Br.	
September 1.	0h. 22m. 42s.	8° 52' S'	...	0.079
" 13.	0h. 0m. 52s.	12° 37' 3"	...	0.069
" 21.	23h. 46m. 38s.	11° 49' 3"	...	0.061
" 29.	33m. 23s.	16° 42' 2"	...	0.053

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, Knowledge Office," and posted before the 12th of each month.

Solution of August Problem (A. G. Fellows):—

Key-move, 1. B to R3.

If 1. . . . K x R, 2. P to R6, &c.

If 1. . . . K to Q1, 2. B to Kt8, &c.

CORRECT SOLUTION received from R. B. Cooke.

Solution to "Alpha's" Sanscrit Contribution:—

1. R to R7ch, B x R.

2. Q to Kt8ch, B x Q.

3. P to Kt6, &c.

Correctly solved by R. B. Cooke.

Solution to Mr. Rosenbaum's Problem

1. Kt to Kt5, K to Ktsq.

2. R to KSch, K to B2.

3. Kt to Q6ch, &c.

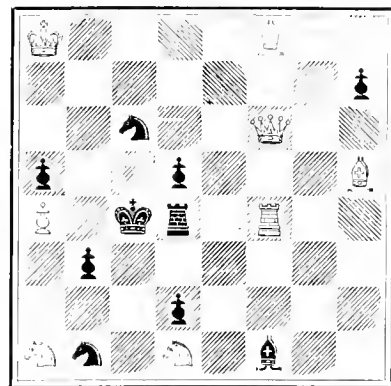
Correctly solved by R. B. Cooke.

W. A. Champion.—A good first attempt, but not quite correct. After 1. B to Kt8, K x B; 2. Kt to Q3, K to Q1 (best), there is no mate. Moreover, Black is not compelled to take the Bishop on his first move.

PROBLEM.

By C. D. LOCOCK.

BLACK.



WHITE.

White to play and mate in two moves.

The following game was played at the meeting of the Counties' Chess Association last month. The score is from the *Daily News*:—

"FIANCHETTO DEFENCE."

WHITE	BLACK
(Mr. J. H. Blake).	(Rev. J. Owen).
1. P to K4	1. P to QKt3
2. P to Q4	2. B to Kt2
3. B to Q3	3. QKt to B3 (a)
4. P to QB3	4. P to K4 (b)
5. P to Q5	5. QKt to K2
6. Kt to K2	6. Kt to Kt3 (c)
7. Castles	7. B to K2
8. Kt to Kt3	8. Kt to B3
9. Kt to B5	9. Castles
10. P to QB4 (d)	10. P to Q3
11. Kt to B3	11. B to Bsq (e)
12. B to K3	12. K to Rsq ?
13. K to Rsq (f)	13. R to KKtsq ?
14. P to KKt4	14. Kt to Ksq
15. Kt to K2	15. B to Kt4
16. Q to Q2!	16. P to Kt3 (g)
17. R to KKtsq	17. B x Kt
18. KtP x B	18. Kt to R5 (h)
19. R to Kt3	19. P to KR3
20. QR to KKtsq	20. Q to Q2 (i)
21. P to B4	21. P x P
22. Kt x P	22. P to Kt3
23. Kt to K6!	23. Kt to Kt2 (j)
24. Kt x B	24. BP x Kt
25. B x P!	25. P x B
26. Q x P	26. Kt to R4 (k)
27. Q x Kt (R4)	27. Q to R2
28. R to R3	28. Resigns (l)

NOTES.

(a) Played by Mr. Owen's side in the last Telephone Match between Liverpool and the British Chess Club.

It tempts White to waste time by 4. P to Q5, Kt to K4 ; 5. B to K2, with a view to P to KB4.

(b) But this is quite contrary to the spirit of the close defence. The Bishop is left out of play, and a weak point is visible at KB4 (*vide* White's 9th and Black's 11th moves).

(c) He might perhaps have tried to free his game a little here by 6. . . P to KB4. On his next move the Knight should come out to B3.

(d) Chiefly to make room for his QKt, which cannot well play to Q2 on account of Kt to B5. But he might play 10. B to K3 and 11. Kt to Q2.

(e) Not much good unless he intends to take off the Knight at once. The usual manoeuvre in these cramped positions is R to Ksq, followed by B to KBsq.

(f) With a view to aggressive measures. Black in the meantime still further cramps his King's position.

(g) A very ugly-looking move. 16. . . B x B, though not quite satisfactory, was probably safer.

(h) The losing move. 18. . . B x B, 19. Q x B, Kt to Bsq would be much better.

(i) Hoping to release his Knight by P to Kt3 and P x P ; but White by manœuvring his Knight to K6 shuts out the Queen. The advanced Black Knight consequently remains a prisoner.

(j) Overlooking White's winning reply. 23. . . Q to R2 has far more point.

(k) If 26. . . Kt (Kt2) x P, 27. P x Kt, Kt x P, B x Kt (or R to R3ch) wins.

(l) The other Knight has no escape after the threatened P x P.

CHESSE INTELLIGENCE.

The Columbian International Chess Tournament is expected to commence on the 25th of this month. Messrs. Blackburne and Mason will be among the English representatives. Mr. Steinitz will not compete.

The return match between Messrs. Loman and Jacobs ended, as before, in a victory for Mr. Loman. Mr. Jacobs made a very good fight, especially in the earlier stages of the contest. Mr. Loman is now engaged in a match with Herr Teichmann.

The Counties' Chess Association held a very successful meeting last month at Woodhall Spa, Lincolnshire. The victory of Mr. E. O. Jones came as a surprise to those who had made no allowance for improvement. Mr. Skipworth, a most inconsistent player, was evidently in his best form, while Prof. Wayte hardly played up to his reputation. The final score was as follows :—

1st Prize.—E. O. Jones	5½
2nd Prize.—Rev. A. B. Skipworth	4½
3rd Prize.	
{ J. H. Blake	4
{ H. W. Trenchard	4
{ Rev. W. Wayte	3½
{ Rev. J. Owen	2½
{ Dr. S. F. Smith	2½
{ C. J. Lambert	4½

Messrs. Gunston and Thorold were among the notable absentees.

"KNOWLEDGE" THREE-MOVE PROBLEM TOURNAMENT.

This will commence in the November number of KNOWLEDGE, and is open to the world

The Proprietors of KNOWLEDGE offer the following prizes :—

- 1st Prize.—A full-sized Set of Staunton Chess-men.
- 2nd Prize.—Fifteen shillings.
- 3rd Prize.—KNOWLEDGE free for twelve months.

The Conditions are as follows :—

1. Each competitor may send not more than one three-move unconditional direct mate problem (diagrammed).
2. Competing positions must be original and unpublished.
3. Each problem must be accompanied by a motto and full solution, with a sealed envelope containing the composer's name and address.
4. Competing positions must reach Mr. C. D. Locock, Burwash, Sussex, England, on or before October 10th, 1898.
5. The Chess Editor reserves the right of excluding manifestly impossible, unsound, or inferior positions.
6. Should more than twenty positions be received, the Chess Editor may, with the assistance of an expert, select the best twenty for competition. In that case the remainder will be returned to their respective composers without delay.
7. The adjudication will be partly by solvers and partly by a recognized expert.

All solvers who solve correctly every problem will be entitled to vote on their merits, the Chess Editor having also one vote. The six or seven problems thus selected will then be submitted to an expert, whose decision on their respective merits will be final.

SOLUTION TOURNEY.

- 1st Prize.—Half-a-guinea.
- 2nd Prize.—Bird's *Chess History and Reminiscences*.

This will commence in the November number, and will run concurrently with the Problem Tourney.

Two or three Problems will be published each month.

Solutions must reach KNOWLEDGE Office on or before the 12th of each month.

Marks will be awarded as follows :—For each correct key-move, three points; for each dual continuation (on the second move), one point. One point will be deducted for every incorrect claim. If a Problem has no solution, "No solution" must be claimed.

Duals will not count in Problems with more than one key.

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THE LIFE-HISTORY OF A SOLAR ECLIPSE.

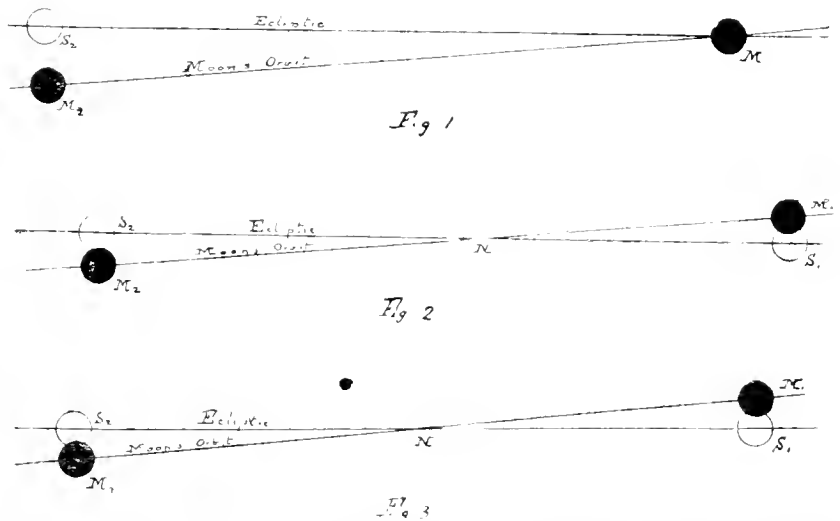
By E. WALTER MAUNDER, *Sec. R.A.S., Superintendent of the Physical Department, Royal Observatory, Greenwich.*

SHORTLY before the recent total eclipse, a paragraph went the round of the papers to the effect that this eclipse would be a repetition of one which occurred some eight hundred and sixty years before our era, and which was made use of to bring about a revolution in the government of Assyria. Seeing, however, that an eclipse of the sun is caused simply by the three bodies—the sun, moon, and earth—coming into the same straight line, the moon being between the other two, it seems at first that it is absurd to speak of one eclipse being a recurrence or repetition of another, unless we go further, and regard every eclipse as a recurrence of any other, the same three bodies being alone concerned in each and all of them.

There is, however, a very real significance attaching to the expression. Certain eclipses do stand in a special relationship to each other, a relationship which they do not hold to the general run. Eclipses have their own special characteristics, and it is easy to see how these arise. The periods of the earth and moon are nearly, but not quite, commensurable, and the conditions which prevail at one eclipse are reproduced very closely, but not precisely, after a considerable interval of time.

To go more into detail. Since the orbit of the moon has a slight tilt, and does not coincide with the plane of the earth's orbit, it follows that, instead of having a solar and a lunar eclipse every month, an eclipse only takes place when the new or full moon falls near one or other of the nodes, the two points where the plane of the orbit of the moon intersects the plane of the orbit of the earth. Next, the time which the moon takes in moving from one of her nodes round to the same node again is not the same as that which she takes in travelling from conjunction to conjunction, that is, from new moon to new moon again. Or, to use the technical terms, a "draconic" month is not the same as the "synodic." The synodic month, or lunation, the "month" in the ordinary sense of the word, is 29 days 12 hours 44 minutes; the draconic month, the return to the node, is accomplished in 27 days 5 hours 6 minutes, or two days and nearly eight hours sooner. If we have a total solar eclipse at one new moon, the moon being in conjunction and at her node at the same moment, then when she reaches the same node the next month she will still be $2\frac{1}{4}$ days from "new," and when "new" will have passed her node by about 30° . Thus in Fig. 1, M represents the moon as new exactly at the node, and therefore as centrally eclipsing the sun. When she is new the following month she will be at M_2 , and as the figure illustrates the descending node, will be below the sun, S_2 , as seen from the earth at conjunction. No eclipse can therefore take place; indeed, if the moon has passed her node by as much as 17° she will in general escape eclipse, and under special circumstances a distance of even $15\frac{1}{2}^\circ$ may leave her clear of the sun.

The next month will see the moon about 60° from her node when "new"; another month the distance will be not quite 90° . The conditions for an eclipse are, therefore, more unfavourable than ever. But in six months' time, when the distance from the first node is a little less than 180° , the moon is necessarily near the opposite node, and an eclipse follows. Then for six months more there is no eclipse, until, at the end of twelve months, we find that once again conjunction occurs nearly at the node. Twelve times the synodic month is 354 days 8 hours 48 minutes 34 seconds, or not quite fifteen hours longer than thirteen times the draconic month, 353 days 18 hours 12 minutes 48 seconds, and the moon is only about 8° from the node at the "new." But since twelve lunar



months equal 354 days, the new eclipse occurs eleven days earlier in the year than its predecessor; and since the mean limit for the distance from the node is 17° , it is

possible to have a set of five eclipses following each other in successive years, but each falling ten or eleven days earlier in the year than the preceding eclipse had done. The first of the five would be a very small partial eclipse, since it would be 16° or 17° from the node; the next would be a much larger eclipse, 8 from the node; the third would be central, and the fourth and fifth would correspond to the second and first respectively. The following little table gives the most recent example of the kind:—

Date.	Greenwich Civil Time. d. h.	Least distance of centre of earth from centre of shadow.	Character of Eclipse.	Greatest Phase.
1884. March 27 7		1.46	Partial	0.149
1885. March 16 18		0.80	Annular	—
1886. March 5 22		0.10	Annular	—
1887. February 22 21		0.60	Annular	—
1888. February 11 23		1.27	Partial	0.506

A set of five is, however, of comparatively infrequent occurrence; the usual number is four.

There is another and much closer correspondence between the draconic and synodic months than that supplied by thirteen of the former to twelve of the latter. For 223 ordinary or synodic months amount to 6585 days 7 hours 12 minutes 39 seconds, whilst 242 returns to the node require 6585 days 8 hours 35 minutes 12 seconds. The difference between the two is less than an hour; only $52\frac{1}{2}$ minutes in fact. If then the moon is sufficiently near its node at a given conjunction to cause an eclipse, then in 6585 $\frac{1}{2}$ days, say 18 years and 11 days, the same conditions will be almost exactly reproduced, and another eclipse will, in general, take place.

This period of 223 months, or a little over 18 years, is the period of the *Saros*, the great astronomical cycle handed down to us from remotest antiquity by the Chaldean astronomers. And it is the almost perfect reproduction, after the interval of 6585 $\frac{1}{2}$ days, of the conditions of the earlier eclipse, which has led astronomers to connect the two eclipses together, and to speak of the later one as the recurrence or repetition of the former.

This reproduction of the conditions of the earlier eclipse is even more perfect than we have stated. Not only is it the case that the moon, when in the same position relative to the node, has only passed conjunction by an hour, but in four hours and a half she will come into exactly the same position relatively to her perigee as she occupied at the first eclipse. For besides the synodic and the draconic months, of which we have already spoken, there are yet others, one of the most important of which is the "anomalistic" month—the time, that is, that the moon takes to pass from her point of nearest approach to the earth round to the point of nearest approach again. The significance of this fact is two-fold. First, the moon is almost precisely at the same distance from the earth as she was at the earlier eclipse; she therefore appears to be of the same angular diameter as before. Next, as the moon moves at a varying speed in her orbit, a speed varying with her distance from the earth, and therefore on her distance from her perigee, it follows that her rate of motion is almost exactly the same as before. When we take into consideration that the *Saros* is only eleven days longer than a complete number of years, we see that the earth also must be not very far from the point of her orbit that she occupied before, so that her distance from the sun, the apparent diameter of the latter, and the earth's rate of motion in her orbit, are but little different from what they were before. The *Saros*, therefore, represents a very close approach to commensurability of the solar year, and the synodic, anomalistic, and draconic months; and reproduces almost precisely the relation of the moon to the node of its orbit,

and to conjunction with the sun, the apparent diameters of the sun and moon, and their apparent rates of motion in the heavens. It is a singularly close approximation to a perfect cycle.

And there is a yet further correspondence between the eclipses which follow each other at the *Saros* interval. Not only does the second eclipse occur almost exactly in the same position with regard to the node as the first, and in the same position with regard to the lunar perigee; not only are sun and moon of nearly the same apparent diameter at the one occurrence as they were at the previous one; not only are their rates of apparent motion nearly the same, but the track of the shadow cast by the moon on the earth lies almost in the same latitude. For as the *Saros* is only eleven days longer than a complete number of years, the position of the earth's axis with regard to the sun is very nearly the same. The sun is in the zenith over very nearly the same latitude as it was before: or, if we look at it from a different standpoint, the apparent centre of the earth's disc, as seen from the sun, has nearly the same latitude as on the earlier occasion. But it has not the same longitude, for the period of the *Saros* being 6585 days and nearly 8 hours, the earth would have exceeded an integral number of rotations by nearly a third; or, since the earth rotates from west to east, the longitude of the centre of the disc would be nearly 120° further west. Three *Saros*s would, however, bring us very nearly to an integral number of days, and the position in longitude would be pretty nearly reproduced, whilst the position in latitude would have not greatly changed. Some writers on astronomy have therefore thought that the original Chaldean period was not 18 years, but 54 years, as with the limited means of communication in the ancient world it must have often been impossible for astronomers to have known by observation of the occurrence of the eclipses falling 18 and 36 years after a given one, whilst that falling 54 years later would reproduce its conditions pretty faithfully. However this may have been, the knowledge of the actual *Saros* of 18 years 11 days clearly goes back to great antiquity, though whether it was first arrived at from observation or from induction we cannot now decide.

This shift in terrestrial longitude of 120° has its point of interest; for the average length of the shadow track in an eclipse is about 130° , moving from west to east, from the point where the sun rises just as the eclipse is over, to that where the sun sets just as it is beginning. It follows, therefore, that the shadow track in a given eclipse ends very nearly in the same longitude as its predecessor began, and begins very nearly in the same longitude as its successor will end. The tracks of three successive eclipses, therefore, together nearly belt the globe; not in a circle, however, but in a gentle spiral, a spiral continued in the eclipses which follow.

It is no wonder, then, that by a very natural and permissible idealization the eclipses following each other at the interval of a *Saros* have been considered to be the same, and their successive returns chronicled in relation to each other, just as we might record the successive appearances of a short period comet.

If we regard, then, the successive eclipses following each other at the *Saros* interval as constituting one single entity, we shall soon see that an eclipse—using the word in this wider sense—has a very definite history. It has its birth, infancy, full vigour, old age and death. For slight and insignificant as is the failure of the *Saros* to precisely harmonize the different months and the year together, the outstanding differences—the hour late in reaching the node, the five hours and a half late in reaching perigee, the 10° difference in the solar longitude—all

combine to make the eclipse at one return a little different from what it was the time before. And since these differences continually increase, there is a steady and progressive change in the character of the eclipse.

To take one point alone—the fact that the moon arrives at conjunction about an hour sooner than she arrives at the node. The maximum distance from the node at which an eclipse can take place is 18° ; $18'$ on either side of the node gives a range of 36° , or one-tenth of the circle, for the extent of the region wherein an eclipse is possible. One-tenth of 27 days 5 hours is 65 hours. If the lagging in the return to the node were exactly an hour, we should then have the life-time of an eclipse extending to 65 or 66 returns; as it is, it is a little longer than this, and like the life-time of man himself it reaches three-score and ten, sometimes a little more, but no eclipse “by reason of strength” can attain to four-score returns. The usual duration is seventy or seventy-one,* and curiously enough the total number of eclipses in a particular *Saros* is also seventy or seventy-one; solar and lunar eclipses being both included. During this time the eclipse will have travelled down the year, eleven days at a time, twice and a little over; the last occurrence falling some thirty-six days later in the year than the first.

As has been already mentioned, an eclipse will generally take place if the moon when “new” is not more than $17'$ from the node. Let us suppose that a time comes in the history of a decaying eclipse when the moon is $13'$ from the node at conjunction, as in Fig. 2, where N represents the node, and S and M the positions of sun and moon at mid-eclipse. What will follow? At conjunction next month the moon will be some $30'$ further on in her orbit, and will be about 17° from the node on the other side, as at M_1 , and in the general way we shall have a grazing eclipse. We shall have, therefore, two partial eclipses only a month apart. The next *Saros* will bring about a repetition of the same state of affairs, only that the earlier eclipse of the pair will take place further from the node, whilst the second eclipse, the new one, which had been a mere grazing eclipse at the previous *Saros*, would fall nearer the node, and hence will give a somewhat larger phase than before. This state of things is represented in Fig. 3, where the new eclipse at $M_2 S_2$ has manifestly more body than in Fig. 2. This process would be repeated several times, the old eclipse continually receding from the node and becoming smaller, the new one approaching it and growing larger, until at last the moon would have drifted too far from the node in the earlier month to cause an eclipse. Henceforward there would be only one eclipse, that of the later month. This would increase in phase time after time; would become annular or total; would at length fall close to the node; would pass it; and then, receding from it on the further side, would begin to diminish in phase. Lastly, as the seventy returns began to run out, a time would come when this eclipse would fall a full day or more before the node was reached. Then the next month we should have the moon at conjunction just near enough to the node to cause a very small partial eclipse, and once again a pair of eclipses would be formed. As before, the earlier eclipse would grow smaller and smaller, waning as the new eclipse waxed, and ere long it, too, would in its turn cease to exist, like the eclipse which it had superseded.

This is the law, then, of eclipse life. Each is born as the second member of a pair of eclipses; each dies as the

first member of such a pair. The solar eclipse cycle is the true Phoenix of the ancients—the Arabian bird which sprang from the ashes of its dying parent, and which will, in like manner, give birth to its solitary offspring in its own dying moments. It lives for 1262 or 1280 years, forty generations of men, seventy of its own returns, and passes away as the new existence, to which its decay has given being, attains its first strength and vigour.

As an instance of the life-history of an eclipse, we may take the one which fell on New Year's Day, 1889. This eclipse goes back to May 27th, 933, when it was the second of a pair of eclipses. The other member of the pair only lasted for two *Saros*s later, and on June 28th, 987, our eclipse appeared for the first time alone. All this time it was a small partial eclipse, but the phase increased in magnitude at every return; and at its eighth appearance, August 11th, 1059, it was an annular eclipse. It continued as an annular eclipse until June 8th, 1564, the thirty-sixth appearance, but at the three previous occurrences it had been partly total and partly annular; the thirty-fourth eclipse, that of May 18th, 1528, being the occasion when the moon was closest to the node at conjunction. The thirty-seventh eclipse fell on June 20th, 1582, and was the last eclipse before the Gregorian reform of the calendar; the calendar date of the thirty-eighth, therefore, is July 10th, 1600, that being the New Style date corresponding to June 30th, 1600, Old Style. The eclipse has been a total one ever since; its fifty-third occurrence being the Algerian eclipse of December 22nd, 1870, and its fifty-fourth the Californian eclipse of January 1st, 1889. It will still continue to be a total eclipse for one hundred and forty years, and will be last seen as such at the sixty-second appearance, March 30th, 2033. It is a very large partial eclipse at the next return, April 11th, 2051, and at the following return, April 21st, 2069, the dying Phoenix gives birth to its successor, for it is followed on May 20th, 2069, by the first occurrence of a new series of eclipses. The two series run on side by side for eight returns, until the old eclipse reaches its end, as a very small partial eclipse, on July 7th, 2195—its seventy-first occurrence.

If we trace the shadow-tracks of the eclipse from its first occurrence as an annular eclipse in 1059, we find that it began in the southern hemisphere close to the pole; indeed the shadow-track intersected the earth's axis beyond the pole, so that there was no place where central eclipse took place at noon. The centre of the eclipse on the next occasion lay in south latitude 76° ; that is to say, the place where central eclipse took place at noon, or the place where the shadow-track cut the earth's axis as seen from the moon, was in that latitude. The centre then moved swiftly north. In 1095 it was in south latitude 61° ; in 1113 in south latitude 60° . Then for one hundred and sixty-two years it practically remained stationary, the reason being that the 1113 eclipse occurred near the autumnal equinox, and the *Saros* bringing the following eclipses a little further on in the year every time, the south pole was turned more and more towards the sun almost exactly at the same pace as the central shadow moved north. Directly the winter solstice was passed, however—the winter solstice of the northern hemisphere, that is—and the south pole began to turn away from the sun, the northward movement of the central shadow began to be felt; indeed the change in the presentation of the earth's axis exaggerated its effect, and every successive return of the eclipse showed a rapid rise in latitude, until the date of the eclipse had travelled on past the summer solstice. This fell in 1564, by which time north latitude 31° had been reached, the equator having been crossed before the

* The paragraph referred to at the beginning of the paper was therefore wholly wrong. No eclipse lasts 2755 years. The usual duration is 1262 years.

eclipse of 1192. The northward pace was now notably slackened. In 1651 north latitude 18° was reached, and the eclipse was total in England—the last one total in this country except the celebrated pair of eclipses of 1715 and 1724. Three returns later, in 1708, north latitude 53° was reached: but shortly after this, the turning of the north pole from the sun caused the shadow to appear to turn southwards, and when it had reached the winter solstice the latitude had fallen to north latitude 36° . This was the celebrated eclipse of December 22nd, 1870, to observe which M. Janssen escaped from besieged Paris in a balloon. But now that the eclipse has passed the solstice, and the north pole is beginning once again to turn towards the sun, the latitude of the central shadow will move northwards with great rapidity, and by 2015 will have reached north latitude 85° . At the next return the shadow-track, though not yet quite clear of the earth, will pass above the north pole, and the eclipse will be total for the last time.

The effect of the triple *Saros* in reproducing, not only the general conditions of an eclipse, but also the very hour and locality, is very strikingly seen in the two eclipses of 1708 and 1762. Here the shadow track is nearly the same in both cases, and the central point has only shifted a few miles, lying in both instances near the boundary line between Europe and Asia, between the towns of Samara and Orenburg. Curiously enough—but this must be looked upon as a mere chance coincidence—the same eclipse will have its centre a third time in the same place, viz., in 1961; but the general direction of the shadow-track will then be very different.

The shadow-track at the third return after 1762, viz., in 1816, again runs in a similar direction though the central point has shifted, and for the third time Norway is the seat of a total eclipse. The next triple *Saros* brings us to the 1870 eclipse, when the track had shifted southward for a time.

Such are a few of the relations produced by the incommensurability of lunar and terrestrial movements, combined with a curiously close approach to a precise commensurability. These are only a few of them, for I have entirely ignored the eclipses of the moon, or the solar eclipses at the opposite node, which of course have both a very definite relation to the series I have been considering. Still less have I included the numerous luni-solar cycles which, though useful for other purposes, have no relation to eclipses. The paper has, however, already proved very long, and may have been sufficient to have called attention to a subject in which less interest is taken at present than used formerly to be the case.

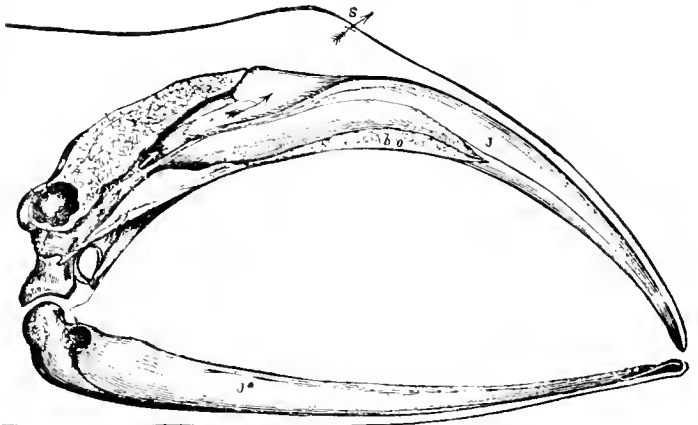
WHALEBONE AND WHALEBONE WHALES.

By R. LYDEKKER, B.A. Cantab.

SEEING that the substance so-called has nothing in common with true bone, many zoological writers object to the use of the term "whalebone"; and they have accordingly proposed the substitution of the word "baleen," which has been specially coined for the purpose. To our thinking, there is, however, no necessity for this substitution of a word of foreign origin for such a well-known English name, any more than there is for replacing the native term "black lead" by its foreign equivalent "graphite." Everybody knows what is meant by whalebone or black lead, while comparatively few are familiar with the terms "baleen" and "graphite"; and as the two former are every bit as good as their foreign substitutes, we prefer to employ them. If, indeed, there should exist any persons so misguided as to imagine either

that whalebone is equivalent to the bone of whales, or that black lead has any sort of affinity with lead, we fear that the substitution of the terms "baleen" and "graphite" would not much aid in removing their ignorance.

The substance which we accordingly take leave to call whalebone is one of the chief essential characteristics by which the whalebone whales are distinguished from the toothed whales forming the subject of our article in the preceding number of KNOWLEDGE. As all our readers are probably aware, this substance is attached to the upper surface of the mouth of the whale, from which it depends in the form of a series of parallel, narrow, elongated,



Section through the skull of the Greenland Whale, with the outline of the soft parts. *s* indicates the position of the nasal aperture.

triangular plates, placed transversely to the long axis of the mouth, with their external edges firm and straight, but the inner ones frayed out into a kind of fringe. The longest plates of whalebone are situated near the middle of the jaw, from which point the length of the plates gradually diminishes towards the two extremities, where they become very short. There is, however, whalebone and whalebone, and whereas in the Greenland whale the length of the longest plates varies from some ten to twelve feet, while the total number of plates in the series is about 380, in the great rorquals or tin-whales, the length is only a few inches, while the number of plates is considerably less. To accommodate the enormous whalebone plates of the Greenland whale, the bones of the upper jaw are greatly arched upwards, while the slender lower jaw is bowed outwards, thus leaving a large space both in the vertical and horizontal directions, the transverse diameter of the space being much wider below than above. When the mouth is closed, the plates of whalebone are folded obliquely backwards, with the front ones lying beneath those behind them; but directly the jaws are opened, the elastic nature of this wonderful substance causes it to spring at once into a vertical position, and thus form a sieve-like wall on both sides of the mouth, the thin ends of the plates being prevented from pushing outwards by the stiff lower lip which overlaps them. By elevating its enormous fleshy tongue within the cavity thus formed, the whale causes the enclosed water to rush out between the plates, leaving such small creatures as it contained lying high and dry on the surface of the tongue ready for swallowing.

In structure, whalebone (which, by the way, although black in the Greenland whale, is white in some of the other species) is of a horny nature, and grows from transverse ridges on the mucous membrane of the roof of the mouth; being, in fact, nothing more than an ultra-development of the ridges on the palate of a cow, hardened and lengthened by an excessive growth of a horny super-

ficial or epithelial layer. The whole of this stupendous horny growth takes place, however, after birth, young whales having smooth palates, with no trace of the horny plates. Although at birth young whalebone whales show no traces of the substance from which the group derives its name, they equally exhibit no evidence of the presence of teeth. If, however, their jaws be examined at a still earlier stage of development, it will be found that there are a number of small teeth lying within a groove beneath the gum on each side of both the upper and the lower jaws. Previous to birth these teeth become absorbed, and thus never cut the gum. Their presence in this transitory stage is, however, of the deepest interest to the evolutionist, since they unmistakably indicate the derivation of the whalebone whales from ancestors provided with a full series of functional teeth. This, however, is not the whole of the story these rudimentary structures have to tell. From the recent investigations of Dr. Kükenthal, it appears that in addition to the above-mentioned tooth-germs, the jaws of very young whales likewise exhibit traces of a still earlier deciduous series of milk-teeth; thus showing that the former correspond to the permanent series of other mammals. Accordingly, these tooth-germs do not represent the functional teeth of the toothed whales, which, as we have seen in the article on that group, correspond to the milk-teeth of ordinary mammals. Even more remarkable are certain observations relating to the structure of these tooth-germs. It has been shown, indeed, that the teeth in the latter part of the series, when first formed, consist of a number of adjacent cusps, and that as development proceeds these cusps become completely separated from each other so as to constitute distinct individual teeth of a simple conical form.

This discovery is of the very highest import, since it serves to indicate how the numerous simple conical teeth of the dolphins and other toothed whales have probably been derived by the splitting and subdivision of originally complex cusped teeth more or less closely resembling those of the extinct Zeuglodonts referred to in our article in the last number.

Being primarily distinguished from the toothed whales by their total absence of teeth after birth and the presence of whalebone in the adult condition, the whalebone whales present certain other distinctive characters to which we may now briefly allude.

In the first place, the whales of this group differ externally from all those furnished with teeth in that their nostrils open externally by two distinct longitudinal slit-like apertures; while, if we cut into the head, we shall find that there is a distinct organ of smell, of which all traces have disappeared among the toothed whales. Moreover, instead of the skull being invariably unsymmetrical in the region of the nose, as it is in the latter group, it retains the normal symmetry; while, instead of the mere nodules which in the toothed whales represent the nasals of other mammals, in the whalebone whales these bones are fairly well developed. Moreover, the lower jaw of any member of the present group may always be distinguished from that of a toothed whale not only by the absence of teeth, but likewise by the circumstance that each of its branches is much bowed outwards in the middle, while their anterior extremities are connected together only by ligamentous tissue, instead of by a bony symphysis of greater or lesser length. Many other points of difference between the two groups might be cited, but we have especially referred to those mentioned above, for the reason that while the presence of whalebone indicates that in one respect the members of this group are more specialized than their

toothed cousins, in regard to the structure of the skull in the region of the nose and the retention of an organ of smell, as well as in the double apertures of the nostrils, they depart less widely from the ordinary mammalian type. And it is from this evidence that zoologists regard the two main groups of whales as being widely divergent branches from a common ancestral stock, if, indeed, they do not go so far as to consider that each has had a totally independent origin.

With regard to the number of forms by which they are represented, the whalebone whales are far less numerous than the toothed group, while the whole of them are included within a single family. What the group lacks in number is, however, amply made up by the great bodily size of its various representatives. Among the toothed whales, the sperm-whale alone attains gigantic dimensions; whereas in the present group there are several species, such as the Greenland whale, which nearly equal that enormous creature in bulk, while two of the rorquals far surpass it. This, however, is by no means all, for whereas the great majority of the dolphins and porpoises are relatively small cetaceans of less than twenty feet in length, the smallest member of the present group is the New Zealand pigmy whale, which attains a length of twenty feet, while next to this comes the lesser rorqual, whose length is frequently close on thirty feet.

Of the various genera of this group, the most specialized are the typical or right whales (*Balaena*), in which the black whalebone is far larger and more elastic than in any of the others, except the pigmy whale; while, in order to accommodate it in the mouth, the skull has the palate narrower and much more highly arched, and the two branches of the lower jaw more outwardly bowed than in the other members of the group. Externally, these whales—which are commercially of far greater value than the undermentioned rorquals—are characterized by the inordinately large dimensions of the head, by the smooth throat, the moderate length of the flippers, and the total want of a back-fin. So gigantic, indeed, is the size of the mouth in these whales that its capacity actually exceeds that of the whole of the other cavities of the body; and yet the size of the throat is so small as almost to justify the common nautical saying that a herring will choke a whale. There are but two well-defined species of right whales, viz., the Greenland or Arctic whale (*B. mysticetus*), and the southern right whale (*B. australis*), the latter of which was nearly exterminated some centuries ago in the Atlantic by the Basque whalers, while the former is only too likely to share the same fate at the hands of their modern successors in the Arctic seas. Of the two, the Greenland whale is decidedly the more specialized, having a much larger head and longer whalebone, and is in this respect *facile princeps* among its tribe; although, as it only measures from forty-five to fifty feet in length, it is inferior in point of size to the rorquals. The skeletons of both these whales are characterized by the whole of the vertebrae of the neck being welded together into a solid mass; and the same feature is exhibited by that of the pigmy whale (*Neobalaena*) of the Australasian seas, which, as already mentioned, is a mere dwarf among giants, as it does not exceed some twenty feet in total length. Agreeing also with the right whales in its smooth throat, the pigmy whale differs by having a small hook-like fin on the back, while its long and elastic whalebone is white instead of black. Far larger than the last, the great grey whale of the Pacific (*Rhachianectes*) forms a kind of connecting link between the right whales and the rorquals, having the smooth throat and finless back of the former, while its whalebone is even shorter

and coarser than in the latter; the palate consequently is but little vaulted, and the entire head smaller in proportion to the body.

The remaining whales of this group are divided into hump-backs (*Megaptera*) and rorquals or finners (*Balaenoptera*): both of which are characterized by the presence of a number of parallel groovings or flutings in the skin of the throat, by the presence of a back-fin (whence their name of finners or fin-whales), and also by the shortness and coarseness of their whalebone, which is generally of a yellowish colour. Their flukes are, moreover, less expanded than are those of the right whales: while, as already said, their heads are relatively smaller and lower, with the cavity of the mouth much less vaulted. In their skeletons, the vertebrae of the neck differ from those of the right whales in being longer and completely disconnected from one another; and in this respect the Pacific grey whale holds a position intermediate between the two groups. Hump-backs, of which there is but a single species, are specially characterized by the shortness and depth of the body, which behind the shoulder rises above the level of the back fin, and by the exceeding elongation and slenderness of the flippers, which are about equal to one-fourth the total length of the animal. The female hump-back, which somewhat exceeds her partner in size, attains a length of from forty-five to fifty feet, or about the same as that of the Greenland whale. An enormous whale, believed to belong to this species, became some years ago entangled in the telegraph cable line off the coast of Baluchistan with three turns of the cable round its body. On the other hand, in the rorquals, the body is long and slender, while the flippers are small and pointed. Of the four well-established species of this genus, the blue or Sibbald's whale (*B. sibbaldi*)—the "sulphur-bottom" of the American whalers—enjoys the proud distinction of being the largest of all known animals, whether living or extinct, attaining the enormous length of from eighty to eighty-five feet; while the common rorqual (*B. musculus*) comes in a good second with a length of from sixty-five to seventy feet. Both the others are, however, considerably smaller.

As regards their distribution in time, right whalebone whales have left their remains commonly enough in the pliocene strata of all parts of the world, and they probably also occur in those of the miocene period; but, although a single vertebra from the eocene beds of Hampshire has been assigned to a member of this group, there is at present no decisive evidence that they had come into existence at such an early date. Since most of the pliocene species are of smaller dimensions than their living representatives, it appears that these marvellous creatures had only attained their maximum size shortly before the time when their very existence was to be threatened by the relentless hand of man.

Formerly the only members of this group of whales which were thought worthy of general pursuit were the right whales; the shortness of their whalebone, coupled with their relatively small yield of oil, and their tremendous speed, rendering the rorquals scarcely worth the trouble and risk of hunting. Of the two right whales, the Greenland species, as being the more abundant, received the greatest share of attention; and so relentless has been its pursuit, that it is now either well-nigh exterminated from many of its ancient haunts, or has retreated still farther north to regions almost impossible of access. As showing how the constant persecution in the Greenland seas has told upon the size of the comparatively few remaining individuals of this species, it may be mentioned that the eleven specimens killed there during the season

1890-91 yielded an average of less than 8 cwt. of whalebone, whereas in five taken during the same season in Davis Strait the average yield was more than double this amount. In consequence of this diminution in the number and size of the Greenland whale, the price of whalebone has of late years gone up enormously; and whereas some time ago whalebone of over six feet in length sold at £1000 per ton, in 1892 it had reached the enormous price of upwards of £2500 per ton. The southern right whale yields a smaller quantity of less valuable whalebone, now selling at from £1600 to £1800 per ton; the quantity obtained from a well-grown example varying from 800 to 1200 pounds. The amount of oil produced by a whale of the same species averages from eight to fourteen tons, of which the present market value is about £28 per ton. If the unfortunate animals are not allowed some respite, it is only too probable that the supply will before long cease altogether.

As another result of this growing scarcity of the Greenland whale, attention has been directed to the previously despised rorquals and hump-backs; the employment of steam whaling vessels, and the use of explosive harpoons, having enabled the whalers easily to cope with the greater speed of these cetaceans. At Hammerfest, a special "fishery" has, indeed, been established for the capture of rorquals, where the capture of these animals is now large. The products of these whales are, however, nothing like the value of those of the Greenland species; and if the latter, together with the southern right whale, be so nearly exterminated as to render pursuit no longer profitable, the supply of long whalebone will absolutely come to an end.

Cannot, we ask, something be done to check this shortsighted greed, before the opportunity is for ever lost?

GALLS AND THEIR OCCUPANTS.—IV.

By E. A. BUTLER.

FOR our next illustrations of gall formation we must look to a type of insect very different from those we have already examined. The aphides, or plant-lice, from the very nature of their food, the juices of plants, which they obtain by puncturing the twigs or leaves, necessarily more or less modify plant growth and produce shrivellings and distortions of various kinds. Such a result may be expected to follow the attacks of all species, but some go farther than this and produce actual galls, which externally closely resemble those caused by other kinds of insects. The natural history of this group is so peculiar that it will be necessary to sketch the plan of their development before the connection of the galls with the insects can be properly understood. There are many different kinds of aphides, and everyone is probably familiar with their general appearance. The soft green bodies, commonly called "green fly," which cluster in sticky crowds round the softest and tenderest shoots of rose trees, and the black ones which crowd equally thickly round the tops of broad-bean plants, are, perhaps, two of the most familiar examples. They form a well-marked division of the order Homoptera, which are distinguished from other insects by having four wings of a more or less similar appearance, and a pointed beak containing four fine piercing needles, and by passing through an incomplete metamorphosis—that is, never becoming a limbless, resting chrysalis, but having legs and remaining more or less active all through their life.

Assuming, then, that we know what sort of insects we are speaking about, let us take, to illustrate the group, the

species called *Schizoneura ulmi*, which makes galls on the leaves of elm trees. The eggs of this creature are exceedingly minute yellowish or brownish bodies, which are to be found, if diligently sought for at the approach of winter, in the crevices of the barks of trees which have borne the insect during the preceding summer. Each of these eggs represents the entire family of a single pair of insects. The mother was but little larger than the egg she produced, and she died immediately upon its laying. Sometimes, indeed, she dies before her solitary egg is laid, in which case the egg would be found in such situations as above described, but enclosed within the dried skin of its parent. Of course one would naturally expect that when these eggs hatch they would give rise to insects similar to those which produced them, or at least to creatures which by a process of development and growth would gradually become like them. But when we are dealing with aphides, such ideas must be put aside altogether, for here we find developed to a wonderful extent the phenomenon called "alternation of generations," a phrase by which is meant that forms, more or less different from one another, regularly succeed one another in a cycle by some process of multiplication, so that a number of "generations," so to speak, intervene before we arrive again at the same sort of thing that we started with. In the present instance, no less than seven such generations constitute the cycle, and these must successively appear, each being the viviparous parent of the next in the scale, before we arrive again at the egg with which we commenced. Some of these seven are pretty much alike, but the rest differ greatly.

It is obvious that if we are to speak intelligently of these different stages in the life-history of a single insect, we shall require distinctive names for the entire seven. No one of them, to the exclusion of the others, can be described as the insect itself; nothing short of the whole series can fairly be considered as representing this. Nor are they stages like the larva and pupa of other insects, the differences between which are no more than what are caused by a mere change of skin, so that the insect remains one indivisible creature throughout its life. On the contrary, in each one of these stages the insect may be represented by an indefinite number of separate and independent beings, which in fairness ought all to be taken into account in estimating the produce of a single egg, up to the time when the next egg appears. Of course these stages might be distinguished numerically, but names descriptive of their functions are preferable. Such a system of names was devised by Lichtenstein. They were expressed in French, and no thoroughly satisfactory English equivalents seem to be available. Not to worry our readers, however, with these rather complicated foreign expressions, we will render into English the most characteristic portion of the names, and thus we speak of the creature which issues from the above-mentioned egg as the "stem-mother" or "foundress." Buckton, the historian of the British aphides, gives this stage the name of "queen aphid," in consequence of certain resemblances between her functions and those of queen bees or wasps. If this name be used, however, it must be borne in mind that while queen bees and wasps are fully developed females which mate with male partners and produce eggs in the usual way, nothing of this sort takes place in connection with the queen aphid. On the whole, it will probably be productive of less confusion to use the term "stem-mother," implying by this that the form so designated is the first active six-legged member of the series, and that she is, as it were, the mother of the stock, the progenitor from whom the whole pedigree is derived.

The egg hatches in springtime, and the stem-mother,

who has no wings and is therefore not likely to wander far, at once begins to attack the young leaves on the tree on which she was hatched, piercing them with the fine needles in her beak as soon as they unfold from the bud. The damage done to the tissues by the punctures induces an abnormal growth, and little cavities appear on the leaf, within one of which the stem-mother nestles. The leaves that have been attacked in this way now curl downwards and change colour, becoming pale and sickly-looking. Meanwhile the stem-mother continues to suck out their juices, grows, changes her skin two or three times, and after a few days begins to produce a family, with which she stocks the cavities of the curled leaves. They are little green things and are produced alive, so that no time is wasted in getting them set to work at the task of tapping the leaves of their juices. Some of these members of the second generation remain on the leaf which was their birthplace, but others crawl off to neighbouring leaves; ultimately they produce viviparously another set of offspring, at first similar to themselves, but destined to advance to a higher grade of development. By successive moultings they first acquire the rudiments of wings, and at length become fully equipped with four delicate transparent wings. These winged forms are all of the same sort, and all have the power, like their predecessors, of producing living young. They are known as "emigrants," because they soon make use of the power of flight which they possess, and float away to other trees, thus spreading their ravages over a wider area. By this time, then, we have a large number of creatures as the descendants of a single egg, spread far and wide, and yet no other egg has thus far appeared, nor indeed will do so till the end of the summer.

These winged emigrants do not live long, but each gives birth to about a dozen living young, at intervals of about half-an-hour, and then dies. We are now in the fourth generation, and these new creatures are very different from those that have preceded them, being wingless and very active. When first dropped they look much like eggs, and have to shed a thin skin before they can move their limbs; the casting of this membrane enables a number of minute hairs to shoot rapidly out from the surface of the body, and thus we have a kind of transformation scene going on, a little shining yellow stationary object changing in about half a minute to a hairy six-legged creature, which runs about quickly and soon covers itself with a kind of cottony down. Another generation of wingless creatures is again produced from these, and then we come in the sixth generation to something like the emigrants again, *i.e.* the members of this grade gradually acquire wings; but their function is quite different from that of the emigrants aforesaid, for they are to become the parents of the true males and females which, in the next generation, will appear for the first time. These winged creatures are smaller than the previous set, and are called by the rather inappropriate name of "pupa-bearers." They get their wings in July, and quickly make good use of them to wander in search of suitable places for the deposition of their brood. They settle on the bark of the selected elm trees, and there give birth to two sorts of beings, both exceedingly minute, and yellowish or orange in colour. These, which constitute the seventh generation, are the true sexes. Their sole function is that of reproduction, and hence all their energies are bent to this purpose. They take no food, and in fact the female has neither beak nor mouth, and her partner is almost in a similar predicament, for though he is born with a beak, he soon loses it and becomes as mouthless as his mate.

After having paired, the female establishes herself in a

erevice of the bark, and there lays her single egg, which is large enough to occupy the whole of the cavity of her body. Having done this, she, or rather all that is left of her, at once dies, though she may, as we have said above, die even without depositing her burden, leaving it enshrouded in her withered skin. Thus, after having passed through a pedigree of seven successive generations of beings, we find ourselves back again at the stage with which the cycle commenced. The eggs lie on the trees throughout the winter, and next season the same series is gone through again. From a history such as this, it follows of course that by far the greater number of aphides seen during any particular summer do not originate from eggs at all, and that indeed, when compared with the number of living beings produced altogether, the total number of eggs is ridiculously small.

Now it is evident from the above that galls which are produced by insects of this sort differ in many respects from those which have previously occupied our attention. In the first place they are not associated with their fabricators throughout the whole cycle of their varied existence, but only during certain stages. Again, it is not the true female of the species, but the stem-mother, that originates these aphid-galls, and they are used by her and her immediate progeny till the migrating stage is reached. Moreover, the original puncture which started the gall is not made, as has always been the case hitherto, for the lodgment of an egg, but simply for the obtaining of food. In fact, no egg is ever associated with the gall at all. The galls produced by the different species are of various shapes and sizes, and as they shelter communities, not individuals, their size bears no relation to that of the individual aphides; some are as large as hazel nuts, and some occasionally reach the size of a ripe fig. They are found frequently on the stalks of leaves, as in Fig. 12,



FIG. 12.—Aphid-gall on stalk of poplar leaf. c. Hole for exit of aphides.

which shows one commonly found on the stalks of poplar leaves; sometimes they rise from the blade of the leaf itself. They are hollow, and have an opening at the end, out of which the winged "emigrants" escape. If opened they are found to contain not only a company of aphides, but a globule of sweetish liquid as well, and a quantity of a white mealy powder, with which also the bodies of the insects are dusted. The nature of the liquid and its exact relation to the inhabitants of the gall is doubtful; it is often too large in amount for there to be a possibility of its being entirely a secretion by the insects, and some naturalists suppose it to be in part at least exuded sap, which has escaped through the many punctures inflicted by the aphides upon the walls of the gall. The mealy powder clings to the surface of the globule, and thus prevents it from injuring the delicate insects amongst which it lies. According to Dr. M. C. Cooke, liquid of this sort found in large elm-galls is collected in France and used, under the name of "elm-water," as a lotion for sore eyes.

Nothing more beautiful can be imagined in the way of galls than those made on the spruce, fir, and larch by aphides belonging to the genus *Chermes* (Fig. 13). They closely mimic fir-cones, so closely in fact that a section needs to be made before one can be convinced that they are not a legitimate fruit of the trees. They are, of course, smaller than the actual cones, and this would help to distinguish them, were it not that they are so strongly suggestive of young cones. The life-history of the creatures is less intricate than that detailed above, and only a few points need be noticed. The mother of the tribe starts the gall, but she does not produce living young. She lays a



FIG. 13.—Gall of *Chermes abietis*, mimicking fir-cones. Magnified two diameters.

number of eggs, which are attached to the tree immediately around her body, each by a thread-like stalk. The larvae hatched from these by their punctures increase the growth of the gall, and cause the adjacent leaves to swell so much as to meet one another at certain spots and enclose the insects within cavities. In this way a many-celled structure is built up, which externally resembles a miniature fir-cone. As time advances, the cone dries up, and its component scales then open out so as to leave free exit for the contained insects.

Only one other instance of gall-growth need now be referred to, and with it we revert to the type which formed our earlier illustrations, viz., gall-formation on the insertion of an egg. But though the type of gall is similar to those formerly described, the insect cause is totally different, belonging to an order we have not yet had occasion to mention, viz., the Coleoptera, or beetles. It is an agricultural pest, known as the cabbage gall weevil. This insect is a stumpy, hard-skinned, black-bodied beetle, with a long, slender, curved beak, half-way down which are inserted the elbowed antennae. The mouth is at the tip of the beak, and here are situated a minute pair of jaws, with which the little pest can pierce the skin of a cabbage-stalk. The beetle is by no means a large one, being only about one-eighth of an inch long from tip of beak to end of body. When it is alarmed it tucks its beak under its body, which is slightly grooved for its reception, and folds its legs up closely, so that its size seems much reduced, and it resembles a little lump of dirt.

The female insect with her beak pierces that part of the cabbage stem which is below ground, and lays an egg in the hole. Many such holes may be formed by the same beetle near together on the same stem. A gall soon forms round each puncture, and sometimes quite a cluster of rounded knobs may be seen on the stem. The egg hatching produces a footless maggot, which lives on the material of the gall. When it is full grown it gnaws its way through the rind of the gall and works itself into the earth, where it fashions a little cell in which it turns to a chrysalis; this becomes a perfect beetle the next season. In all its stages it is a very hardy insect, being able to endure a good deal of interference with its comfort without evil consequences. It will even survive being frozen stiff when in the pupal condition. Though these galls are small, they may become harmful by exhausting the plant, when present in great numbers. Not only the cabbage crop, but turnips also are subject to their attacks, though they seem less injurious in this case. This little beetle, which, if allowed to multiply too greatly might become a serious pest, has had bestowed upon it a name by no means commensurate with its diminutive size, for in our cabinets it stands ticketed *Ceuthorrhynchus subcollis*.

WHAT IS THE SUN'S PHOTOSPHERE ?

By A. C. RANYARD.

PERHAPS it may be well to explain, for the sake of readers who are not familiar with the long names which have been given to various regions of the sun, that the photosphere is the shining sphere we generally speak of as the sun. It is in fact only a part of the sun, but it is the part with which we are most familiar, because it can be seen with the naked eye, and can be examined with the telescope under ordinary conditions.

Immediately outside the photosphere is a region in which coloured prominences can be detected with the spectroscope under ordinary conditions. This region immediately above the photosphere is called the chromosphere; it has no definite outer limit, though it has a comparatively sharply defined lower limit, marked out by the upper surface of the photosphere. During a total solar eclipse the chromosphere, or the upper portions of the chromosphere which are not hidden by the moon, can be seen with the naked eye and with an ordinary telescope, extending to a greater height above the sun's limb than they can be traced with the spectroscope under ordinary daylight conditions; and towering to a vast height above the chromosphere are still fainter structures and rays, extending sometimes to a distance of more than a solar diameter from the moon's limb. The faint structures extending into the outer region are collectively spoken of as the corona, but there is no defined limit separating the corona from the chromosphere. Bright lines, indicating the presence of hot vapour, can be detected with the spectroscope extending to a great height in the corona, and the structures of the corona can be traced down through the region of the photosphere in a manner which would lead us to conclude that the coronal structures, as well as the prominence structures of the chromosphere, have their origin in a region below the bright surface of the sun.

To define the photosphere as the highly luminous spherical surface which surrounds the nucleus of the solar nebula is not to explain what it is. The beautiful photographs of parts of the solar photosphere which, by the kindness of Dr. Janssen, I am able to lay before readers of KNOWLEDGE, show that the shining surface is broken up into a series of masses arranged with a certain degree of parallelism in adjacent parts, like the cirrus clouds in a mackerel sky; and in Plate I., which represents the photosphere on a larger scale than Plate II., it will be seen that the elongated bright masses are striated across their length, and that in many cases they break up into a series of rounded cloud masses arranged in rows.

I have had two classes of plates printed—one in a chocolate-brown ink, which has been over-exposed in preparing the plate for printing so that it only shows the brightest parts of the photosphere, and another in a dark platinotype tinted ink with less exposure, so that the details of the brightest regions are sacrificed in order to show fainter and more nebulous parts. Those who take an interest in the matter will be repaid by comparing the two classes of plates. About half of the edition of KNOWLEDGE has been issued with the chocolate-brown plates, and the remainder with the dark platinotype tinted plates.

It was long ago pointed out by Dr. Janssen that a reticulated pattern is traceable in the arrangement of the cloud masses of the photosphere. In the regions corresponding to the strings of the netting the cloud masses are clearly defined. They are separated by numerous dark interspaces, and the elongated masses appear to stand up

or to be arranged more or less radially to the sun's centre; whereas in the areas corresponding to the meshes of the net the structure appears to be hazy or blurred, and the elongated cloud masses lie more or less parallel to one another as if raked out in a plain at right angles to the solar radius. The phenomena presented by solar spots and the dark interspaces between the clouds of the photosphere would lead us to conclude that the photosphere is a comparatively thin layer of brilliantly shining clouds, which is torn and churned by innumerable currents, as indeed we might expect if all the uprushing streams of the chromosphere and corona pass through it.

In the very interesting lecture on "Flame," delivered before the recent meeting of the British Association at Nottingham, Prof. Smithells concluded his address by asking his audience to consider what must have been the condition of the earth in past ages.

"The earth," he said, "is known to be a cooling body, and also an oxidized body. At one time it must have been too hot for the oceans to have existed upon it in a liquid state, and at a still more remote period all the waters of the earth probably existed as an enormous gaseous envelope of uncombined hydrogen and oxygen. Chemistry forces us to imagine an intervening time at which this oxygen and hydrogen would begin to combine. During that period, huge cosmical flames would rend the atmosphere. The steam formed would descend to the hotter strata of the pre-geologic atmosphere, would be dissociated and sent forth again to combine in the upper atmosphere, causing an incessant celestial pyrotechny," which the lecturer concluded must have caused the earth—as seen from a distance—to resemble the sun as known to solar physicists at the present time.

I am not able to adopt Prof. Smithells' theory as to the constitution of the solar photosphere, but it seems to me that too little attention has been devoted to the explosive combinations which Prof. Smithells points out must take place in some region of a highly-heated atmosphere of mixed gases. Since the day when Sir John Herschel calculated the heat which would be given out during the burning of a globe of coal as large as the sun, and compared it with the heat which is given out by the sun in six thousand years, it has been too frequently assumed in popular astronomy books that no chemical combinations can be taking place upon the sun; but without chemical combination and explosions it is very difficult to conceive of an adequate cause for the swift uprushes of matter we observe in the chromosphere, and the still more gigantic uprushes whose existence is evidenced by the structures observed in the corona.

The great deviation from the radial of many of the streams of matter projected into the chromosphere, as well as the tangential rays of the corona, point to the conclusion that the region of these explosions cannot be situated at any very great distance below the photosphere. It is possible that such explosions may take place in the region of the photosphere, but it does not seem probable that the intense light of the photosphere can be due to burning or chemical combination, for we know of no flames comparable in brightness with the brilliant incandescence of the electric arc light, and the incandescent carbon candle of an electric light is not as bright as the solar photosphere. The most brilliant lights we know of are produced by the intense incandescence of solid substances. Thus a mass of lime in the dull oxy-hydrogen flame is brighter than any gas flame we can produce, but, according to the measures of Foucault and Fizeau in 1844, the solar surface was found to be one hundred and forty-six times more brilliant than the calcium light; and Prof. Langley

in 1878 found the surface of the sun to be five thousand three hundred times brighter than the molten metal in a Bessemer "converter." There is evidently a great range in the light-giving capacity of incandescent bodies, but the brilliance of the solar surface does not greatly exceed the brightest incandescence of the most refractory bodies, obtainable by means of the electric current; and it should be remembered that in laboratory experiments the intensely heated part of a glowing rod of carbon, or other refractory substance, is being cooled by adjacent cold parts, and it is therefore probably not as hot as if the experiment were made on the solar scale.

Such considerations would lead us to conclude that the light of the photosphere must be due to the brilliant incandescence of the most refractory substances present in the sun, at a level when they are just on the point of being driven into vapour.

To those who would urge that we do not know what would be the brightness of an explosive flame two thousand miles thick, I would reply that such explosions could not go on continuously over a wide area—there must be room for the descent of the associated products of combustion, and an interval of time for the ascent and cooling to the temperature of explosive combination of the ascending elements; also, that in such a mixed mass of vapours as must exist in the well-churned region of the solar photosphere, the brightness of the explosive flame would probably be considerably less than the brightness of the flame where pure gases combine; and further, that a flame containing metallic vapours, such as we know are present in the region immediately above the photosphere, would give a spectrum showing many bright lines, which it seems probable would not all be similarly reduced by absorption, so as to give the appearance of a comparatively uniform continuous spectrum, crossed by dark lines, such as we see when the spectrum of the light of the photosphere is examined.

It has recently been suggested by more than one physicist that it is possible that gases only give out their characteristic bright-line spectra when some chemical or electrical change is going on in their molecules; but it seems to me that this suggestion (and it is nothing more than a speculative suggestion) is sufficiently negatived by facts already in our possession. Prof. Smithells has himself shown that iodine vapour may be rendered incandescent by merely heating it in a glass tube, warmed to a red glow in a Bunsen burner; and following the analogy offered by the radiation of solid bodies, we should expect that a gas which absorbs as freely as iodine vapour would also radiate freely, and that other vapours which absorb radiations less greedily than iodine vapour would only commence to radiate when raised to temperatures higher than can be conveniently obtained for laboratory experiments.

The phenomena of the sun itself also seem to indicate that the incandescence of vapours in the chromosphere is not due to chemical changes, but is more probably a mere heat effect. If the incandescence were due to chemical change, we should expect all the bright lines corresponding to any particular element to extend to the same height above the photosphere, namely, to the height at which the chemical change affecting the element was taking place; but the lines in the spectra of the same element extend to very different heights, and that not always in the order of their brightness.

Hitherto solar physicists have generally attempted to account for the spectral phenomena presented by the sun as mere heat effects caused by radiation from hot matter, and absorption by cooler gases; and it is no doubt profit-

able to pursue this method without making assumptions as to unknown electrical effects, and the chemistry of temperatures with which we are not familiar in terrestrial laboratories. But it must be remembered that more than half of the lines of the known solar spectrum remain unaccounted for, and that no lines corresponding to whole groups of chemical elements have as yet been recognized in the solar spectrum.

In the last number of KNOWLEDGE I endeavoured to show that the vapours present in the chromosphere and corona cannot form a solar atmosphere in which gases rest in equilibrium stratified into absorbing layers, as is so frequently assumed. The proof turns upon what we know of the intensity of solar gravity at the level of the photosphere, and upon the assumptions which it seems safe to make with regard to the temperature of the region immediately above the photosphere. If the photosphere consists of incandescent clouds of liquid or solid particles of matter similar to the matter of which the earth is composed, the general temperature of the region cannot be much above the temperature at which similar matter would be driven into vapour in terrestrial laboratories. It may be a little above such a temperature, because the matter of which the photospheric clouds are composed may be continually falling from a cooler outer region towards the hot solar nucleus.

Two classes of observations made during total solar eclipses tend to support the theory that the photosphere is composed of incandescent solid or liquid particles, for they show that it is highly probable that minute particles, many of which have diameters that are small compared with the wave-length of light, exist in the corona and extend down into its lower regions. When the corona is examined with a suitable polariscope, strong polarization colours, which extend down to close to the moon's limb, are observed, indicating a condition of radial polarization of the coronal light such as can be accounted for by dust polarization in the region of the corona. Secondly, the solar absorption lines have been observed in the coronal light down to the brilliant region near to the moon's limb, indicating that the corona chiefly shines with light which has been received from the sun and has been dispersed by liquid or solid matter in the coronal region. Most chemists and physicists will therefore, no doubt, agree that we are reasonably safe in assuming that the temperature of the coronal region cannot exceed 10,000° Cent.

The narrow character of the lines in the spectrum of the chromosphere seems to indicate that the gaseous pressure in the region where they exist must be very small compared with the pressure of the earth's atmosphere at the sea-level; but assuming that the gaseous pressure at the level of the photosphere is equal to the pressure of our atmosphere at the sea-level, and assuming the height of the solar atmosphere to be the height at which the pressure is reduced to a millionth of a millionth of the pressure at the level of the photosphere, we can calculate the height of a hydrogen atmosphere at any temperature with solar gravity equal to 27½ times terrestrial gravity. Thus, at a temperature of 2457° Cent., the height of a hydrogen atmosphere about the photosphere would be only 270 miles, and at a temperature of 27,027° Cent. its height would be 2700 miles.

It will then, no doubt, be asked, can we, with such a rapid decrease of densities as is indicated by the above results, retain the old idea that the photosphere is a layer of clouds floating in the solar atmosphere? We know nothing of the temperatures within the photosphere, and without a knowledge of such temperatures we cannot determine the depth at which the density of the solar



Plate I.—PHOTOGRAPH OF SUNSPOTS AND THE SOLAR PHOTOSPHERE.

Taken by Dr. J. C. G. at Meudon, on the 10th of June, 1887, with a refractor of 5 inches aperture. Diameter of the Sun's image, if on the same scale as in the Plate, one and a half metres.



Plate II.—PHOTOGRAPH OF THE SUN'S SURFACE, SHOWING THE STRUCTURE OF THE PHOTOSPHERE.

On a scale of three-quarters of a metre to the Sun's diameter. From a Photograph by Dr. JANSEN, taken at Meudon in 1892.

atmosphere would double. No doubt the photosphere would act as a screen, preventing radiation from the solar nucleus, and the temperatures within the photosphere would probably be much higher than in the coronal region.

The volume of a gas varies as $\frac{1}{\tau^{1.5}}$ where τ is the absolute temperature in degrees Centigrade, and if the solar atmosphere extends as high as the level of the photosphere, the average temperature of the material within the photosphere will need to be enormously great, for the average density of the sun is only about a quarter as great as that of the earth, viz., 1.414 times the density of water.

Some vague idea as to such temperatures may be gathered from the consideration that with a gas obeying Boyle's law, and with gravity remaining uniform as at the level of the photosphere, an atmosphere of hydrogen (at a temperature of two million seven hundred and thirty thousand degrees Centigrade, measured from the zero of temperature -273° Cent.) would increase in density a million million million times in descending from the photosphere to a depth of 105,000 miles; for other gases, or a mixture of vapours, the rate of increase of density would be still more rapid. But the assumption that gases above their critical temperature when greatly compressed continue to obey Boyle's law is probably not permissible, for at low temperatures Boyle's law only approximates to the truth when the free paths of gaseous molecules are long compared with the molecular diameter.

It is not, however, necessary to assume that the incandescent clouds of the photosphere are floating in an atmosphere, as clouds of water vapour float in our atmosphere. In the case of terrestrial clouds, each little globule of water is no doubt continually falling, but it falls very slowly because of its small weight and the relatively large surface which is exposed to the resistance of the atmosphere. The weight of a small particle decreases as the cube of its diameter, while the surface which it exposes to a resisting atmosphere only decreases as the square of its diameter; consequently, the smaller the particle, the slower will be its rate of falling through a resisting atmosphere.

A minute particle in the photosphere would be retarded in its fall under the action of solar gravity by the backward kicks of molecules evaporated from its under surface exposed to the radiation from the heated centre. We should expect to find such falling particles checked in their downward course most rapidly just before they were finally evaporated, for two reasons: (1) because the weight of the falling particle would have already been greatly sweated away, and the total weight of the particle would bear a smaller proportion to the weight of the molecules evaporated towards the heated centre in a unit of time, and (2) because we should expect the force and number of the backward kicks to increase very rapidly when the particle enters a region where the heat is such that it will rapidly be completely evaporated.

We should therefore expect small particles, falling towards a very hot body, to accumulate at a level where their falling motion was thus rapidly checked, and if the particles consist of matter which cannot be driven into vapour until it has attained a white heat, we should expect a layer of such particles to shine like a brilliantly incan-

descent cloud. It is therefore conceivable that the photosphere might lie far above the summit of the solar atmosphere. But the great inclination to the radial of many of the prominence structures thrown upwards into the region of the chromosphere and corona seems to point to the conclusion that the region from which the explosions take place cannot be situated at a great depth below the photosphere, and one can hardly conceive of explosions taking place which result in driving matter outwards unless there is some fulcrum to drive from, as there would be if explosions took place within a solar atmosphere in which the resistance to motion is greater in a downward than in an upward direction.

The great tenuity of the gaseous matter outside the photosphere is, it seems to me, evidenced by the narrow character and want of absolute blackness of the dark lines in the Fraunhofer spectrum, as well as by the narrowness of most of the bright lines, of the incandescent gases of the chromosphere. These come from a lower region, probably of greater pressure and temperature, and in the ease of great outrushes the chromosphere lines are sometimes broadened and reversed in a complicated manner, implying pressure and overlapping streams of gas at different temperatures; but as a general rule the lines of the chromosphere spectrum are narrow, indicating long free paths and uniform vibration of the radiating gaseous molecules, such as only can be conceived of in a gas of extreme tenuity.

The dark lines of the Fraunhofer spectrum are, as a general rule, far from being absolutely black, proving that only a portion of the light of the wave-length radiated by the photosphere has been lost in its passage through the absorbing region; whereas the old experiment of Kirchhoff with the flames containing sodium and lithium vapour, proves that a few inches, or decimal parts of an inch, of vapour in which the molecules are comparatively close together, is sufficient to give an amount of absorption which materially darkens the absorption lines produced in the whole thickness of the solar envelope. With absorbing molecules very widely and sparsely scattered, only a small portion of the wave front corresponding to a ray of light would be interfered with in its passage through the absorbing region.

Science Notes.

The microscopic hairs on the leaf of the hop would appear to partake in a small degree of the properties of those of the closely-related stinging nettle. The peculiar form of eye trouble spoken of as hop-picker's ophthalmia, seems at any rate to be ascribable to these hairs, which adhere to the hands and subsequently get rubbed into the eyes.

The fastest mechanism, artificial or natural, made to penetrate water for any considerable distance, is according to Mr. Jeremiah Head, Thornycroft's torpedo boat, "Ariete," which on trial made 30.16 miles per hour.

M. Lionel Declé, in an account of the marriage customs of the Matabeles, mentions one feature which is, we believe, quite singular. The husband does not buy his wife, and although there is a suggestion of a memory of marriage by capture in the details of courting and in the avoidance of the parents-in-law, she would appear to remain her father's property. When children are born, the father has to buy them of his father-in-law, or, failing this, they revert to the mother's family.

* The mean velocity of hydrogen molecules at a temperature of 2184° Cent. is 3.18 miles per second, and the mean velocity of hydrogen molecules evaporated from a surface heated to 2184° Cent. must be much greater than the mean velocity of molecules of hydrogen gas at a temperature of 2184° Cent., for the swiftest molecules are the first to separate themselves from the attracting molecules of a heated surface. Hence evaporation, by lowering the average velocity of the molecules left behind, cools an evaporating surface.

Aerial mechanisms are capable of very much greater speed. Canon Tristram told the biological section of the British Association in his address—which, through his unfortunate illness, was read by Sir William Flower—that Herr Gütke holds that godwits and plovers can do their 240 miles an hour, and the spine-tailed swift, according to Dr. Jerdon, can breakfast in Ceylon and sup in the Himalayas on the same day.

A very interesting topic, which is winning its way to attention, is the periodic and secular variation of the latitude of places on the earth's surface. Prof. Chandler has been laboriously investigating these movements for some time. He has examined records extending over the last half century, and including 33,000 observations of latitude, and has come to the conclusion that the observed value of latitude is the resultant arising from the superposition of two periodic fluctuations. These are—(a) one of 427 days due to a separation of the axis of rotation from the chief axis of inertia, and (b) an annual one due to the periodic shifting of the earth's centre of gravity in connection with seasonal redistributions of moisture.

Herr Alfred Moller has been conducting a series of observations at Blumenau, upon the economy of those leaf-cutting ants described in "The Naturalist in Nicaragua," and he finds that they not only cultivate fungi, but also that they have by judicious selection evolved a specially suitable variety, with peculiar swollen lateral branches. The fungus garden is an enclosure, protected of course from the light, and thither the strips of leaf are taken, and crushed up by the jaws of the ants, to supply their crop with organic food. So efficient is the weeding out of unsuitable material by these little horticulturists, that some of the earth of the garden, grown in a nutritive solution, gave a perfectly pure culture, free even from bacteria. The ants appear to subsist entirely on their specialized fungus knobs.

The Rev. J. Mathew has been studying various Australian rock and cave drawings. Many of these, it has long been known, are of a character far above the possibilities of existing aboriginal work, and indicative of an altogether higher level of civilization in the artists. One he describes is in red, blue, yellow, black, and white, and represents a figure dressed in a long robe and with the head surrounded by a kind of many-coloured halo. Mr. Mathew has found on one such halo certain marks which he interprets as the name of the chief god of Sumatra, and he also finds many other facts, the frequent presence of a sacred crocodile for example, which incline him to give these interesting markings a Sumatran origin. The natives can tell nothing about them, simply regarding them as bories. He thinks, however, the crude religious notions of the aborigines may have been derived from the forgotten predecessors of the Anglo-Saxon colonist, to whom he ascribes these drawings.

Letters.

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

To the Editor of KNOWLEDGE.

THE SUN AS A BRIGHT-LINE STAR

DEAR SIR:—I have been greatly interested in reading Miss Clerke's valuable and suggestive paper on "The Sun as a Bright-line Star," and the discussion to which it has

given rise in the August and September numbers of KNOWLEDGE. May I be allowed, however, to point out that an important matter seems to have been overlooked by those who have taken part in the discussion. I refer to the *double reversal* of the H and K lines of the facula. A positive enlargement from a photograph taken at the Kenwood Observatory is sent herewith to the Editor. It clearly shows the bright H and K lines, with a central dark line, not only in a facula, but also on the disc as far as the slit extended. We here have evidence that a large area of the sun's surface was uniformly covered with a layer of calcium vapour hotter than the photosphere below it, and this again was capped by cooler calcium vapour which exercised sufficient absorptive power to cause a dark line to appear in the centre of the bright line originating in the hotter layer. Instances of double reversals of H and K extending without interruption for great distances are very common. Sometimes the lines can be traced entirely across the solar disc. The two bright components of the doubly-reversed lines are about equal in width to the central dark component. In certain cases portions of one of the bright components seem to be missing, while the other bright component is unbroken. Where the slit lies across a facula the two bright components widen and increase in brilliancy. Their form is then spindle-shaped, and the central dark line has become fainter and narrower. The accompanying photograph perfectly illustrates this point. Two causes may be involved in bringing this about. In the first place the increased thickness of the radiating calcium vapour (assuming a facula to be an elevation in the photospheric calcium stratum) tends to increase the brightness of the lines and also to widen them, on account of the increased radiation on both sides of the centres of maximum brilliancy. Again, if we assume the cooler calcium to overlie the hot calcium in a layer of uniform depth (a depth necessarily greater than the height of the facula), then the absorption should be least in the facula, where the overlying stratum of cool vapour is thinnest.* I am inclined to think that the actual appearance of the lines is such as to indicate the simultaneous existence of both these conditions.

Now let us consider the case of Mira Ceti. Suppose the thickness of the layer of cool calcium to be increased to such an extent that not only the centre but the whole of the bright line is blotted out. This might occur even if the H and K radiations of the facula were abnormally bright. In the sun it is extremely uncommon for the more refrangible hydrogen lines to be radiated by facula. Nevertheless, it is not difficult to imagine conditions favourable to this result. Under these circumstances, if there were insufficient cool hydrogen in the atmosphere of Mira to absorb the radiations of the lower regions, we should have a spectrum showing H and K broad and dark, and the series of hydrogen lines bright, with the exception of that near H, where the absorption of the calcium would have blotted it out.

Miss Clerke's explanation of the absence of the hydrogen H line in Mira, therefore, seems to me a plausible one. But the apparent similarity between this star and the sun appears to be increased rather than diminished by such a conclusion. Spectroscopists would do well to heed Miss Clerke's suggestion as to the collection of further data for the elucidation of this important subject.

Very truly yours,

GEORGE E. HALE.

Should these ideas be confirmed by the results of future investigation, it might become possible to roughly estimate the height of a facula by the character of the double reversal of the H or K line in it.

[Prof. Hale's letter was received just as KNOWLEDGE was going to press, and I have consequently not been able to reproduce for readers of KNOWLEDGE the interesting photograph forwarded by him, but I hope to do so on a future occasion.—A. C. RANYARD.]

THE ABSENCE OF A LUNAR ATMOSPHERE.

To the Editor of KNOWLEDGE.

DEAR SIR,—There seems to me so simple an answer to this question—what has become of the lunar atmosphere? that it is probable the suggestion has been made many times before. However, I have not seen the idea suggested, and therefore submit it to your readers. I would suggest that the atmosphere has not been drawn away from the moon, but that it is merely *frozen*.

It is well known that oxygen and nitrogen condense to a liquid at something under -140° . At a lower temperature they solidify. The moon is a cold body. Let it be granted that the temperature is below -140° , and what would become of the atmosphere? It would only exist in the liquid or solid state.

Possibly, in the absence of any pressure a much lower temperature than -140° would be required; but that is immaterial. In the protracted lunar night—a fortnight long—the degree of cold might be so great, and the atmosphere therefore frozen so hard, that the heat of the lunar day would be utterly unable to volatilize it.

Yours faithfully,

C. W. SWEETING.

[Profs. Langley's and Very's observations seem to point to a temperature near to the freezing point of water during the lunar day in the neighbourhood of the moon's equator.—A. C. RANYARD.]

To the Editor of KNOWLEDGE.

DEAR SIR.—A method of readily comparing two photographs for the purpose of detecting new stars (or missing stars) has occurred to me, which would obviate the necessity of tedious comparisons and measurements.

My method depends upon the fact that if a negative and its positive are correctly adjusted, face to face, then no image is transmitted, the field is neutral; but if the negative or positive is not identical, then the difference is apparent on inspection.

To apply this in practice, I propose to take an *old* star negative, not too dense, and compare it with a positive film, also wanting in density, which has been printed from a *recent* negative; when these two are exactly superposed, any new stars will at once become conspicuous to the eye as white spots, and any stars which have disappeared will be evident as black spots; or a print may be taken, thus showing all differences between the two photographs.

I think this method of examination would show very slight changes in nebulae, &c., which might otherwise escape the eye.

If the two pictures are allowed to be slightly out of adjustment, then all objects are thrown up in relief, giving nebulae, &c., a very substantial appearance.

I am sending a negative and positive, taken from one of the collotypes in KNOWLEDGE, to make the matter clear, and you will see that I have put a few extra stars on the back of the negative.

Yours faithfully,

F. H. GLEW.

[The method proposed by Mr. Glew seems to me likely to be very useful.—A. C. RANYARD.]

LIGHTNING PHOTOGRAPHS AND SOME PHOTOGRAPHIC DEFECTS.

By A. C. RANYARD.

THE *Graphic* of 19th August contained a picture made from the photograph reproduced in Fig. 1, together with the following paragraph:—

"A PHOTOGRAPH OF A STORM.—Dr. W. D. Hemphill, of Kingstown, to whom we are indebted for the photograph we reproduce, informs us that the negative was taken on Wednesday, August 9th, at 11 p.m. The lightning on the left of the picture is



FIG. 1.—Supposed photograph of ball lightning, taken by Dr. W. D. Hemphill, August 9th, 1893, at 11 p.m.

the ordinary stream coming from the clouds above; but that on the right is what appeared to be a ball of fire, which fell direct into the sea, and like potassium when thrown into water, darted about on the surface. The ball of fire carried with it a trail of light, leaving smaller balls here and there, and one of these passing a gas-lamp, illuminated the glass as shown in the photograph. The display was one of the most brilliant and vivid ever beheld, and fortunately the camera happened to be pointed in the direction, as the knotting and twisting of the threads of light resembled the course of a ball of wool played with by a kitten more than anything else."

Upon seeing this paragraph I wrote a letter, addressed to Dr. Hemphill, inquiring whether the camera was fixed or held in the hand during the exposure, and whether he had himself seen the ball of fire wandering to and fro upon the sea. In reply to which he courteously sent me a silver print from his negative and the following letter:—

"6, Windsor Terrace, Kingstown.

"August 30th, 1893.

"DEAR SIR.—In answer to your letter I beg to give you the following particulars. I was sitting in my window opposite the sea, and, anxious to take a photo of lightning, I placed my camera—a small 1/2 plate hand camera—on a table; my daughter was sitting with me watching the storm. When I opened the shutter to take the stream of lightning on the left of the picture, my daughter called out 'A ball of fire has fallen near Sandycove!' I at once moved the camera in my hand towards Sandycove, the tower of which you see on the right of the bay. The light from the heavens on sea, land, &c., was almost blinding, otherwise the night was quite dark about 11 o'clock p.m.; but unfortunately, just as I had the plate exposed, a man lit the lamp shown in the picture. I kept the camera pointed in the position of the balls for some seconds, and my daughter tells me that she distinctly saw three balls fall into the sea at short intervals. I examined the negative with a high power pocket glass, and am of opinion that the connecting lines between the balls were caused by reflections from the gas-lamp, which was brilliantly illuminated by the electric discharges, and probably caused the lines during the moving of the camera (still open). I may tell you I showed the negative to Sir Howard Grubb, who examined it with me, and also to Prof. Tielborne. The explanation about the gas-lamp causing the lines was

suggested by Sir H. Grubb, and indeed the true lightning lines are easily distinguished under the magnifying power, as they have a central line with distinct penumbra, which the lamp lines have not.

"Believe me, dear sir, yours faithfully,

"W. D. HEMPHILL"

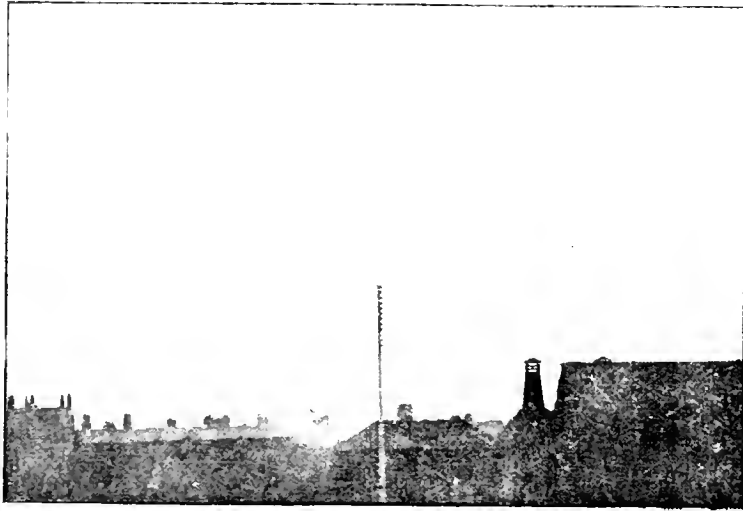


FIG. 2.—Photograph of setting sun taken by Mr. Glover in the month of May, 1893.

A close examination of the photograph shows that the bright spots upon the sea are joined by lines which, after following a very irregular course, lead to the gas-lamp. The circular halo round the gas-lamp is evidently caused by reflection of light from the back of the plate, and shows that the flame of the gas must have been very bright. It seems to have been sufficiently bright to trace a line on the sensitive plate as the camera was moved, producing a larger over-exposed patch wherever the camera momentarily stopped. The camera seems to have been stopped and held steady for a considerable time in the position where the image of the lamp is brightest—probably one of the lightning flashes occurred during this interval—but there is a double image of the horizon and of other distant objects which it seems probable were produced at the instant when the landscape was lit up by the two flashes of lightning shown on the left hand of the picture, the camera being pointed in slightly different directions at the instant of each flash.

The circular halo which frequently appears round the photographic image of small bright objects has caused much speculation to observant photographers, and has been a fruitful source of theories with

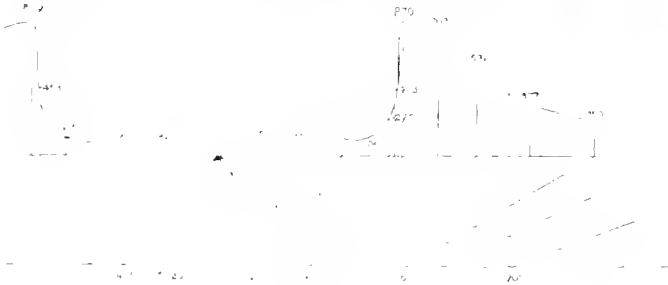


FIG. 4.—Diagram showing the intensity of light reflected from the back of a photographic plate.

regard to photographic action. Some years ago, when studying eclipse-photographs, I made a series of experiments to de-

termine the cause of similar halos which are sometimes seen round the bright images of prominences, and found that the diameter of the halo varied with the thickness of the glass plate on which the photograph is taken. When a brilliant point of light is photographed, and the image is over-exposed, its photographic image is surrounded by a brilliant halo, the inner edge of which is comparatively sharp while the outer edge is very soft and nebulous. On measuring the thickness of the plates used, and the diameter of the circle corresponding to the inner sharp edge of the halo, I found that the inner edge of the halo corresponded to the place where light from the luminous image was reflected at the critical angle from the back of the plate. During the exposure the parts of the photographic film which are being acted upon are brilliantly illuminated, and light must be dispersed from the illuminated parts of the film in all directions within the thickness of the plate. The light which falls nearly perpendicularly upon the back surface of the plate in great part emerges and is lost in the space behind the plate, but a part is reflected, and on reaching the film on the front surface produces, if it is sufficiently intense, a photographic effect. Of the dispersed light which falls more obliquely on the back of the plate, a larger proportion is reflected, but it is distributed over an area which increases with the distance

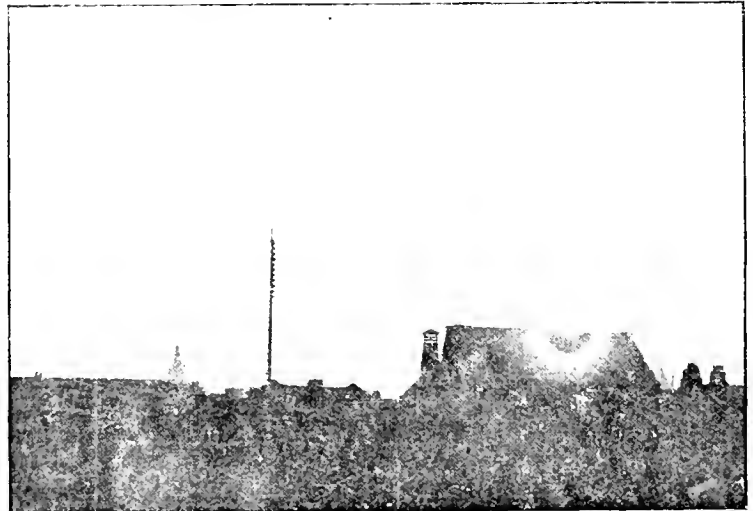


FIG. 3.—Photograph of setting sun taken by Mr. Glover, 13th June, 1893.

from the illuminated part of the film, so that the intensity of the photographic action of the reflected light on the film at first decreases till the angle of total reflection at the back of the plate is approached, when the intensity of the reflected light rapidly increases.

In order to further verify this theory, I calculated according to Fresnel's law the intensity of the light which would be reflected from the back of the plate, and would reach the film on the front surface at various distances from the luminous point, on the assumption that the photographic plate was made of crown glass, with an index $\mu = 1.54$, and that light would be uniformly dispersed in all directions within the plate from the luminous part of the film during the exposure. Fig. 4 is a curve, the height of which corresponds to the intensity of the light, on the above suppositions, reaching the front surface of the plate after reflection at various angles from the back

surface of the plate. It will be seen that the height of the curve seems to correspond with the intensity of the photographic action, and to confirm the theory with which we set out. In one total solar eclipse photograph taken during the American eclipse of 1869 there was a curious spot of light upon the dark body of the moon, which was spoken of by one writer as probably due to a comet between us and the moon. It was situated immediately beneath a bright prominence on the sun's limb, and was evidently due to the reflection of the light of the prominence from the inner surface of a drop of water on the back of the plate during the exposure. The wet collodion process was used in those days. Now that dry plates are used, comets on the moon are less likely to be discovered.

Figs. 2 and 3 have been made from photographs kindly sent me by Mr. M. Glover, of Stephen's Green, Dublin. They represent the image of the sun setting over the roofs in the neighbourhood of his studio, and show the ring of light reflected from the back of the photographic plate encroaching upon the dark objects on the horizon. Owing to the size of the sun's disc the inner edge of the nebulous ring is not quite as sharply defined as in the case of nebulous rings about the over-exposed images of stars and artificial points of light.

THE CONSTITUTION OF GASES.

By J. J. STEWART, B.A. Cantab.

(Continued from page 55.)

WHEN a solid is raised to such a temperature that it becomes luminous, and the light which it gives out is viewed through a spectroscope, a continuous spectrum is observed which consists of an uninterrupted band of light, and which extends, if the luminous body is hot enough, from the dark red rays at one end to the violet at the other. When a gas, on the other hand, is raised to a high temperature it gives a very different sort of spectrum. This consists of a series of bright lines, or sometimes bands, separated by intervals of darkness, the position of the lines being characteristic of the particular gas. In some cases the luminous bands are very numerous, as in the spectrum of nitrogen; in others the spectrum is of a very simple character, as that of sodium vapour, which, under certain conditions, consists of only two narrow yellow lines close together.

The spectra of hot gases are explained by the vibrations set up in the free gaseous molecules. When the temperature of a gas is raised the velocity of its particles increases, and the encounters between them become more numerous and energetic. After a collision two molecules may be imagined rebounding from each other in a state of vibration due to the shock. The molecules of each gas are capable of vibrating in certain definite modes, which are characteristic of the particular gas, and these vibrations, being communicated to the luminiferous ether, give rise to the definite rays in the spectrum of the gas.

It is a remarkable fact that when the rays from a bright source of light, such as incandescent lime, are made to pass through a layer of cooler gas, the spectrum produced has dark lines occupying the same places as would be filled by the bright lines occurring in the spectrum of the gas in question when heated. The dark lines in the solar spectrum are an example of this, the layer of

cooler gas here being found in the region outside the sun's photosphere. The occurrence of these dark lines is due to the absorption by the cold gas of a part of the energy in the luminous waves passing through it. The molecules of the gas are capable of absorbing those vibrations which they are able to give out when they themselves are heated. An analogous phenomenon is the resonance of a musical string. The stretched string can be made to vibrate when the note which it is capable of giving is sounded in its neighbourhood, and a set of such strings can take up from a mixture of notes those vibrations which they themselves would yield, and thus they absorb a portion of the energy of the vibrating air. Even when the layer of gas is sufficiently hot to give out light, the dark lines are seen when the source behind it is hotter than the gas, as the rays given out from the gas, being less intense than the neighbouring rays which are not affected by it and pass through it, appear dark in comparison.

On the fact of the possession by each gas of a characteristic spectrum the methods of spectrum analysis depend. When a compound under investigation can be vaporized, the presence of various elements in it may be detected by observing the position of the lines in the spectrum and comparing these with the known position of the lines in the spectra of the different elements. Such methods are being increasingly used in astronomical investigations, as giving an insight into the constitution of the fixed stars and nebulae.

The molecules of a gas during the greater part of their course move freely and independently of neighbouring molecules, but in the case of liquids a molecule never gets beyond the influence of its neighbours so long as it remains part of the liquid. The particles of the liquid move with various velocities, and when the liquid has a free surface it may happen that some of the molecules on or near that surface have such a high velocity that they are shot right out of the liquid and move about freely in the space above it. This is what takes place when *evaporation* is going on. When the temperature of the liquid is raised the rapidity of movement of its molecules is increased, and there are a greater number in the surface layer which have a high enough velocity to get outside the sphere of influence of their neighbours—that is, evaporation takes place more rapidly. Amongst the molecules of the vapour thus produced above the liquid, some in the course of their movements approach so near the liquid surface that they become entangled amongst the liquid particles and are re-absorbed into the liquid. This entering and leaving of the molecules is constantly going on at every exposed liquid surface, and evaporation only takes place when the number of molecules which escape from the liquid is greater than that of those which re-enter it. When the number absorbed is in excess, condensation occurs. But even when the mass of the liquid remains unaltered and neither evaporation nor condensation seems to be taking place, this movement of molecules outward and inward is still going on, only now as many molecules re-enter as leave the liquid; what has been called a state of movable equilibrium has been set up.

The solution of a gas in a liquid is a similar phenomenon. When the gas-molecules reach the surface of the liquid, they are retained there, on account of the attraction of the molecules of the liquid on those of the gas. Some of the molecules which have thus entered the liquid, on returning to its surface with a high velocity are able to leave it, and, as before, equilibrium ensues when the number entering and leaving is the same. When the pressure of the gas alters, the number of molecules striking the liquid surface will change in the same proportion, and

* A further account of these experiments will be found in the *Memoirs of the Royal Astronomical Society*, Vol. XLVI., pp. 230—233.

for equilibrium to be maintained, the number leaving the liquid, and therefore the number of dissolved molecules, must change in this same proportion—*i.e.*, the quantity of gas dissolved is proportional to the pressure, which is known experimentally to be the case.

An interesting example of the behaviour of gaseous molecules is furnished by the radiometer invented by Mr. Crookes. This consists of a set of light fans or vanes made of aluminium, and mounted so as to be able to rotate easily, the whole being enclosed in a globe of glass, in which the air is highly rarefied. One side of each vane is of polished aluminium, the other is covered with lamp-black. When the arrangement is exposed to radiation, the lamp-black surface absorbs more heat, and is thus at a higher temperature than the bright surface of the vane. Therefore, the particles of gas, when they strike the black surface, rebound with a higher velocity, and produce a greater reaction than when they meet the bright and cooler surface. In this way the metal vanes are caused to revolve, the bright polished faces foremost, and when the radiation on them is strong they spin rapidly round. The gas surrounding the vanes must be rarefied, and not at the ordinary pressure, in order that the time when a particle is on its free path may be great compared with that taken up by collisions. The gaseous molecules move backwards and forwards between the glass sides of the globe and the vanes, rebounding at a relatively low velocity from the glass, which is transparent to the rays falling upon it, and is not heated.

In some remarkable experiments in 1822 Cagniard de la Tour heated various liquids, such as alcohol and ether, in strong glass tubes in which the vapour formed was confined within a limited space and was not allowed to occupy more than from two to five times its original volume. Thus the contents of the tube existed under a high pressure, and as the temperature was raised at a certain point the liquid seemed suddenly to become completely changed into vapour.

In an extended series of experiments on carbonic acid gas, Dr. Andrews showed that above a temperature of 30.92 C. no amount of pressure was able to liquefy it. At high pressures above this temperature the substance may be considered to be in an intermediate condition, and to be neither a liquid nor a gas. The temperature above which a gas cannot be liquefied by means of pressure is called the *critical temperature* of the gas.

A gas can continuously be changed into a liquid, without any abrupt alteration in its state, by compressing it while above its critical temperature to the volume it would occupy when liquid; then on lowering the temperature below the critical point, while maintaining the pressure, the substance is found to be in the liquid state.

From these phenomena Dr. Andrews concluded that the liquid and gaseous states are merely widely separated forms of the same condition of matter.

There is a mutual attraction between the molecules of a gas, which acts so as to assist the external pressure to which the gas is exposed. As the volume of the gas decreases, the molecules may come so near together that their attraction towards each other may hold them together or vibrating about a common centre; then the kinetic energy of the molecules will not separate them, and no external pressure is necessary to maintain the volume the same. The gas has become a liquid. When the gas is above the critical temperature, the kinetic energy of the molecules is so great that no diminution of volume will enable the attraction of neighbouring molecules to hulk them together and so balance the pressure due to the energy of their motion; the gas cannot then be liquefied.

THE EARTH IN SPACE.

By WILLIAM SCHOOLING, F.R.A.S.

THESE is a curious fascination in putting side by side the myth and science of astronomy. The old legends of the sun and moon, of earth and sky, of heaven and the stars, tell us of the self-same objects whose place and size, whose weight and nature astronomers are chronicling to-day.

The difference is great indeed between the guesses of early times and the methods of modern science; nowhere else, perhaps, is the contrast seen so well between the infancy and the maturity of the mind of man, and no part of astronomy shows it so clearly as that which tells of the earth's place in the universe.

To the Greeks eight centuries before Christ the earth was flat, surrounded by the sea, and covered by the canopy of sky, which is the floor of heaven, the abode of the Olympian gods.

Greece was at the centre of the earth, and Delphi at the central point of Greece, for Jupiter sent forth two eagles from the east and west that met upon the spot where stood the Delphian temple, thus proved to be the centre of the world. The sun and stars climb up the crystal dome of sky, and daily descend again through the water into the shadow land beneath—the realm of forgetfulness and the region of death. The Ethiopians in the east and west were closer to the sun than were the Greeks, and by its nearness, as it rose and set, the Ethiopians were scorched.

The sun plunged in the ocean as it set, and the Greeks record the hissing heard by the Iberians at sunset when the burning sun fell into the sea. Tacitus tells the same story of our northern ancestors, and in Polynesia the notion lingers still that the natives of the western isles have heard the hissing of the sunset; while in Peru, the legend was that the sun rushed to the sea and by its heat dried up the greater part, then dived below the earth that was upon the water, and daily rose again by the gateways of the east.

These seem curious fancies to us who have learnt that the volume of the sun is more than a million times greater than the earth; who know that though the ocean stretches for thousands of miles, yet the sun is so remote that while a flash of light could pass more than seven times round the earth in a single second, it would take eight minutes to reach us from the sun; who know also that if, not once a day, but once a minute for fifteen centuries, the whole sea could be poured into an abyss the size of the sun, it would not fill it up. Yet the thought is natural that the ocean stretches so far that the sun must fall into it when it sets, and is so vast that it can easily contain the sun. Had we no teachers to tell us of their own or other men's discoveries, there are not many of ourselves but would be satisfied with thinking of things as they appear at first sight to be, and the heavens would appear to us, as to others, near at hand, and readily accessible. To us, as to the Greeks, the rainbow would stretch down from heaven a sign of war and tempest, or the pathway of a messenger from gods to men; just as to the South Sea Islander it is the heaven-ladder that the heroes climb. To the Scandinavians it was *Bifrost*, the trembling bridge, timbered of three hues, and stretched from sky to earth. In German folk-lore the souls of the just are led by guardian angels along the rainbow into paradise, and it is the bridge of souls with Arabs and Chinese.

But not alone by the rainbow do we pass to heaven: a legend from Samoa tells of a mountain reaching to the sky, and of a tree that when it fell was sixty miles in length,

but up which men used to climb; and everywhere we come across legends of trees rooted in the earth with branches reaching to the sky, or of trees rooted in the sky with branches stretching downwards to the earth.

In the sky are land and sea, with people, houses and plantations, but most often it is the dwelling-place of heroes and deities alone.

In Paraguay the souls of the dead go up to heaven by the tree *Itagidigu*, which joins the earth and sky, and there are myths that tell of a rope let down to earth whereby intercourse is kept up with the sky. Such a story is told in Vancouver's Island; and in the White Nile district it is said that God made all men good and they lived with Him in heaven, but as some of them turned bad He let them down by a rope to the earth. The good could climb up again by this rope to the sky, where there was dancing and beer and all was joyous, but the rope broke (or a bird bit it through), so there is no going up to heaven now; it is closed to men.

But if we turn to science, how different is the story that we have to tell! It is like the old myths of heaven-raising that tell how once the sky fell down so low that men could not stand upright, and then a hero came, who, for a drink of water, raised the sky and pushed it up and up to the place where we see it now.

For us science is the hero who has raised the heaven, that has examined far-off worlds, that has explored the sky depths, and has stories to tell more marvellous and more romantic than the myths of old.

It has to tell us that the earth is far larger than men used to think, though the true size of the earth has been approximately known for centuries, and yet it has to tell us also that the place of the earth in space and time is one of inconceivable insignificance. But first think of the greatness of our world. It is a globe nearly eight thousand miles in diameter, but only by putting figures into other shapes and forms do we begin to see their meaning.

This globe contains two hundred and sixty thousand million cubic miles, and could we load a train with it the length of the train (if the inside of the trucks were six feet wide and six feet high) would be over two hundred thousand billion miles, and travelling at the rate of sixty miles an hour it would take over three thousand eight hundred and thirty-eight million centuries to pass a given point, while if the engine-driver could communicate with the rear-guard by means of flashes of light it would be thirty-four thousand years before the guard saw the signal; while if we form the earth into a square column reaching to the sun, a distance of ninety-three million miles, each side of the column would be over fifty miles in length. Yet vast as these figures seem, they fade into insignificance by comparison with the sun, for if it were formed into a square column reaching to the earth each side of the column would measure sixty thousand miles, or eleven hundred times as much as the earth column; put in other words, the sun would provide one million three hundred thousand such columns as the earth would make.

Even if we keep within the limits of our solar system, we have distances much more vast than that from sun to earth.

If we stretch our columns until they reach from the sun to Jupiter, the earth-column shrinks to twenty-three miles square, the sun-column to twenty-six and a half thousand; while reaching out to Neptune, the most distant of the planets, the column formed by the earth

would be less than ten miles square and the sun eleven thousand, while their length has grown to twenty-eight million centuries of miles.

How curious a contrast even this affords to more primitive conceptions of the sky, such as that of the Samoans, who think the heavens are at the horizon, or that strangers that come to them, as the white men did, come from beyond the sky and are therefore *Papalangi*, or heaven-bursters.

The heaven for them has windows or holes where the rain comes through, and if you climb high enough you can look through and see the sky folk living much as men do on the earth. And the Warans say that there was once a rope by which people used to climb down to the earth through a hole in the sky, until one day a fat man stuck in the hole and people now can neither get up nor down.

Of men beyond the arch of heaven science knows nothing, but it can say something in regard to the possibility or otherwise of life such as we know it here on other planets, because it can tell something of their temperature, atmosphere and other conditions; but as to life in other suns or stars, science for the most part has no word to say and leaves us to guess, like Samoans and more primitive folk.

As to other worlds scattered through the sky depths, science has lately been learning much; something of their nature, their number, their distance is constantly being learnt, while the way is being prepared for gaining some real insight into the relations of the stars among themselves, and for fixing our own position in regard to other suns and systems than our own.

To Epicurus the stars were little concave mirrors fixed in the firmament and reflecting sunlight: to the Venerable Bede they were faintly luminous, needing reinforcement from the sun to make them visible. Even to Tycho Brahe there was no great distance between the planets and the stars, and he calculates their distance at fifty to sixty thousand miles.

But we have to invent a new measure for talking of their distance, since, finding miles too small, we talk of "light years," which means the distance that a ray of light travelling some hundred and eighty-six thousand miles a second would traverse in a year.

Before we get too used to talking of light years it may be well to try to get a notion what a light year really is. It means a journey that would take an express train more than eleven million years. It means a velocity that the periphery of a gigantic fly-wheel one hundred miles in diameter could not keep up with, though it made five hundred revolutions in a second. It means a distance traversed in one second that sound will not pass over in ten days.

And this is the unit for the quantities that modern astronomy deals with when treating of the distribution of stars in space. Sometimes one hears a cubic light year spoken of—that is, an imaginary cube with each side a light year long.

It was long after men saw how to measure the distance of the stars before they succeeded so as to feel much confidence in the results obtained; but now the distances of a few stars are known with comparative accuracy and certainty, many measures having been made that probably come within twenty or thirty per cent. of the truth.

The nearest star that has been found is Alpha Centauri, with a distance of $4\frac{1}{3}$ light years. Probably next in order is a small star, numbered 21,185 in Lalande's catalogue. It is about $6\frac{1}{2}$ light years off, while 61 Cygni, the most

* The earth is about four times as dense as the sun, and if the columns of matter were of the same density the sun would only make three hundred and thirty-two thousand columns such as the earth would make.

frequently measured of any star, is about 7 to $7\frac{1}{2}$ light years off. But let us take our nearest neighbour and try to see something of the isolation of our solar system in space. Let us try to conceive of a sphere of which the sun is centre with a radius of 4.35 light years, so placing our nearest stellar neighbour on its circumference—translated into the more familiar unit its diameter is over fifty billion miles and its cubic contents nearly three hundred and fifty cubic light years, or seventy thousand sextillions (7 with 40 ciphers) of cubic miles, for a cubic light year is rather more than two hundred sextillions cubic miles. Here is isolation indeed! The sun, with all its vastness, does not fill one two hundred thousand trillionth (2 with 23 ciphers) part of the sphere that has our nearest stellar neighbour on its surface: the gigantic volume of the sun in such a space is like an isolated shot containing but one half of a cubic inch immersed in the whole water of the sea,* while a little speck less than the two millionth of a cubic inch suspended in the three hundred and seventy-three trillion gallons of the sea would represent the earth suspended in the sphere, the radius of which reaches only to the nearest star.

Did we set the Pole star at the limits of our space sphere, the volume of the sphere would be three thousand times as great; and the sun must be thought of as occupying the six thousandth part of an inch in the four hundred million cubic miles of sea.

Were Vega, at a distance of ninety-six light years, on the boundary of our sphere, the space that reaches to our nearest neighbour must be increased ten thousand times in volume, and the earth becomes a difficult microscopic object in the vast abyss of sea. These are all stars whose distance has been measured with more or less accuracy, but there are other objects more remote that have defied all attempts to measure them—in literal fact, they are *immeasurably* remote distances.

Whether we are to reckon the number of their light years by centuries only, by thousands or by millions, it is premature to guess. One thing at least is clear; the figures given here to show the position of the earth in space are wholly paltry and inadequate compared with the (as yet) unknown reality. Much has been learnt and the way prepared for yet greater advances. Man has dethroned himself from the chief position in the universe; has seen his world cease to be the centre round which all else revolves; has recognized his abode as the tiniest imaginable speck in space; man—

"Who sounds with a tiny plummet, who scans with a purblind eye,
The depths of that fathomless ocean, the wastes of that limitless sky"

—yet has a longing to penetrate still farther through the star depths to win yet other secrets from the mysteries of space.

Though thus enlarging his horizon, he sees the earth sink into insignificance more and more, yet relatively to himself it becomes more important; it is part of a larger whole, and it must supply him with the key to unlock the secrets of the universe elsewhere. It is the starting-point for the survey that has revealed so much, that will reveal still more, but ever as the boundary of the known extends, it is encompassed by an unknown that is extended too. However vast in space or time the knowable becomes, the unknowable is vaster still; the man whose horizon is widest, whose knowledge is most profound, knows best and feels most reverently that, however much we learn, there remains a mystery beyond, surrounding all.

* I have shown, in an article published in *Lougan's Magazine* for June, 1894 that all the water of the sea, collected into a sphere, would fill a space about one hundred miles in diameter.

THE FACE OF THE SKY FOR OCTOBER.

By HERBERT SADLER, F.R.A.S.

AT the time of writing, a very fine group of spots is visible on the Sun. There is an annular eclipse of the Sun on the 9th, but it is invisible at Greenwich, and the path of the annulus lies almost wholly across the Pacific Ocean; it therefore needs no further notice. Conveniently observable minima of Algol occur at 10h. 23m. P.M. on the 16th, and 7h. 12m. P.M. on the 19th.

Mercury is too near the Sun during the month to be visible. Venus is an evening star, but, owing to her great southern declination, is very badly situated for observation. On the 1st she sets at 6h. 44m. P.M., or 1h. 4m. after the Sun, with a southern declination of $18^{\circ} 5'$, and an apparent diameter of $14\frac{1}{3}''$, about $\frac{3}{4}$ ths of the disc being illuminated. On the 15th she sets at 6h. 27m. P.M., or 1h. 22m. after the Sun, with a southern declination of $22^{\circ} 47'$, and an apparent diameter of $16''$, $\frac{71}{100}$ ths of the disc being illuminated. On the 31st she sets at 6h. 23m. P.M., or 1h. 49m. after the Sun, with a southern declination of $25^{\circ} 49'$, and an apparent diameter of $17\frac{1}{2}''$, $\frac{6}{100}$ ths of the disc being illuminated. During the month she passes from Libra through Scorpio into Ophiuchus, being very near δ Scorpil on the evening of the 12th.

Mars is, for the purposes of the amateur observer, invisible.

Jupiter is an evening star, and is admirably situated for observation. He rises on the 1st at 7h. 24m. P.M., or 1h. 14m. after sunset, with a northern declination of $19^{\circ} 20'$, and an apparent equatorial diameter of $45''$. On the 15th he rises at 6h. 26m. P.M., or 1h. 21m. after sunset, with a northern declination of $19^{\circ} 8'$, and an apparent equatorial diameter of $46\frac{1}{2}''$. On the 31st he rises at 5h. 20m. P.M., or three-quarters of an hour after sunset, with a northern declination of $18^{\circ} 17'$, and an apparent equatorial diameter of $48''$. During the month he describes a short retrograde path in Taurus, to the south-west of the Pleiades. 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 first satellite at 3h. 53m. P.M. On the 4th a transit ingress of the shadow of the second satellite at 10h. 4m. P.M. On the 5th a transit ingress of the first satellite at 0h. 9m. A.M.; a transit egress of the shadow of the satellite at 0h. 24m. A.M.; and a transit egress of the satellite itself at 2h. 24m. A.M. On the 6th an eclipse disappearance of the third satellite at 1h. 7m. 15s. A.M.; its reappearance at 2h. 36m. 48s. A.M.; an eclipse disappearance of the first satellite at 3h. 43m. 50s. A.M.; an occultation disappearance of the third satellite at 5h. 20m. A.M.; an occultation reappearance of the second satellite at 9h. 26m. P.M. On the 7th a transit ingress of the shadow of the first satellite at 1h. 2m. A.M.; a transit ingress of the satellite itself at 2h. 2m. A.M.; a transit egress of its shadow at 3h. 14m. A.M., and of the satellite itself at 4h. 13m. A.M.; an eclipse disappearance of the first satellite at 10h. 12m. 20s. P.M. On the 8th an occultation reappearance of the first satellite at 1h. 20m. P.M.; a transit ingress of the first satellite at 8h. 28m. P.M.; a transit egress of its shadow at 9h. 42m. P.M., and a transit egress of the satellite at 10h. 39m. P.M. On the 9th a transit egress of the third satellite at 8h. 30m. P.M. On the 12th a transit ingress of the shadow of the second satellite at 0h. 10m. A.M.; a transit ingress of the satellite itself at 2h. 30m. A.M.; a transit egress of its shadow at 3h. 0m. A.M., and of the satellite at 4h. 45m. A.M. On the 13th an eclipse disappearance of the third satellite at 5h. 7m. 10s. A.M.; an eclipse disappearance of the second

satellite at 7h. 47m. 58s. P.M.; an occultation reappearance of the second satellite at 11h. 45m. P.M. On the 14th a transit ingress of the shadow of the first satellite at 2h. 56m. A.M.; a transit ingress of the satellite itself at 3h. 48m. A.M.; a transit egress of the shadow at 5h. 8m. A.M. On the 15th an eclipse disappearance of the first satellite at 0h. 6m. 37s. A.M.; its reappearance from occultation at 3h. 6m. A.M.; a transit ingress of the shadow of the first satellite at 9h. 24m. P.M.; of the satellite itself at 10h. 14m. P.M.; a transit egress of its shadow at 11h. 36m. P.M. On the 16th a transit egress of the first satellite at 0h. 25m. A.M.; a transit egress of the shadow of the third satellite at 8h. 59m. P.M.; an occultation reappearance of the first satellite at 9h. 33m. P.M.; a transit ingress of the third satellite at 10h. 45m. P.M., and its egress at 11h. 57m. P.M. On the 19th a transit ingress of the shadow of the second satellite at 3h. 17m. A.M.; a transit ingress of the satellite itself at 4h. 49m. A.M.; a transit egress of its shadow at 5h. 37m. A.M. On the 20th an eclipse disappearance of the second satellite at 10h. 23m. 3s. P.M. On the 21st an occultation reappearance of the second satellite at 2h. 2m. A.M.; a transit ingress of the shadow of the first satellite at 4h. 50m. A.M., and of the satellite itself at 5h. 33m. A.M. On the 22nd an eclipse disappearance of the first satellite at 2h. 1m. 1s. A.M., and its reappearance from occultation at 4h. 52m. A.M.; a transit egress of the second satellite at 8h. 13m. P.M.; a transit ingress of the shadow of the first satellite at 11h. 18m. P.M., and of the satellite itself at 11h. 59m. P.M. On the 23rd a transit egress of the shadow of the first satellite at 1h. 30m. A.M.; a transit egress of the satellite itself at 2h. 10m. A.M.; an eclipse disappearance of the first satellite at 8h. 29m. 16s. P.M.; a transit ingress of the shadow of the third satellite at 11h. 14m. P.M.; an occultation reappearance of the first satellite at 11h. 18m. A.M. On the 24th a transit egress of the shadow of the third satellite at 1h. 0m. A.M.; a transit ingress of the satellite itself at 2h. 8m. A.M., and its transit egress at 3h. 19m. A.M. On the 25th a transit egress of the shadow of the first satellite at 7h. 59m. P.M., and of the satellite itself at 8h. 36m. P.M. On the 26th a transit ingress of the shadow of the second satellite at 5h. 53m. A.M. On the 28th an eclipse disappearance of the second satellite at 0h. 58m. 6s. A.M.; an occultation reappearance of the second satellite at 4h. 18m. A.M. On the 29th an eclipse disappearance of the first satellite at 3h. 55m. 32s. P.M.; a transit ingress of the shadow of the second satellite at 7h. 12m. P.M.; of the satellite itself at 8h. 16m. P.M.; a transit egress of the shadow at 9h. 33m. P.M., and of the satellite itself at 10h. 30m. P.M. On the 30th a transit ingress of the shadow of the first satellite at 1h. 12m. A.M.; of the satellite itself at 1h. 43m. A.M.; a transit egress of the shadow at 3h. 25m. A.M., and of the satellite at 3h. 54m. A.M.; an eclipse disappearance of the first satellite at 10h. 24m. 15s. P.M. On the 31st an occultation reappearance of the first satellite at 1h. 2m. A.M.; a transit ingress of the shadow of the third satellite at 3h. 11m. A.M., and its egress at 5h. 1m. A.M.; a transit ingress of the satellite itself at 5h. 27m. A.M.; a transit ingress of the shadow of the first satellite at 7h. 41m. P.M.; of the satellite itself at 8h. 9m. P.M.; a transit egress of the shadow at 9h. 53m. P.M., and of the satellite itself at 10h. 20m. P.M. The following are the times of superior and inferior geocentric conjunctions of the fourth satellite with the centre of the planet:—Superior, October 5th, 6h. 18½m. P.M., October 22nd, 9h. 23m. A.M.; Inferior, October 14th, 3h. 13m. A.M., October 30th, 5h. 52½m. P.M.

Saturn is in conjunction with the Sun on the 8th, and Uranus is invisible.

Neptune is well situated for observation, rising on the 1st at 8h. 8m. P.M., with a northern declination of 20° 54', and an apparent diameter of 2.6". On the 31st he rises at 6h. 6m. P.M., with a northern declination of 20° 50'. During the month he describes a short retrograde path in Taurus, in a region barren of conspicuous stars.

October is a fairly favourable month for shooting stars, the most marked display being that of the Orionids on the 18th, the radiant point being in v.l.h. 8m. R.A., and 15' northern declination.

The Moon enters her last quarter at 3h. 19m. P.M. on the 2nd; is new at 8h. 27m. P.M. on the 9th; enters her first quarter at 11h. 20m. P.M. on the 17th; is full at 7h. 28m. A.M. on the 25th; and enters her last quarter at 10h. 42m. P.M. on the 31st. She is in apogee at 10h. A.M. on the 15th (distance from the earth 251,626 miles); and in perigee at 7h. A.M. on the 27th (distance from the earth 225,010 miles).

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 12th of each month.

Solution of September Problem (C. D. Locock):—

1. R to R1, and mates next move.

CORRECT SOLUTIONS received from Alpha, H. S. Brandreth, Poppy, R. B. Cooke, and F. Glanville.

Additional Solutions of August Problem received from Alpha and H. S. Brandreth.

Alpha.—Your original letter containing the above must have miscarried.

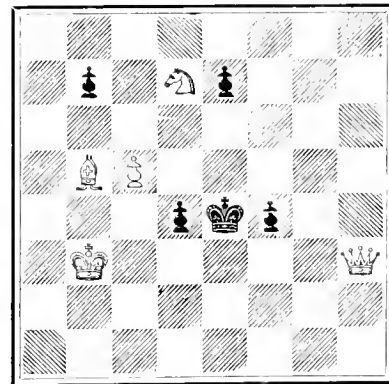
Poppy.—The Problem ("Sweetness, &c.") arrived safely.

W. A. Champion.—The move 1. R to B3 in the September Problem is what is technically known as a good "try." As you rightly observe, there is no mate if Black replies 1. . . . Kt to K2. R to B3 cannot, therefore, be the correct key; you will find the latter given above.

PROBLEM.

By G. K. ANSELL.

BLACK



WHITE.

White to play and mate in two moves.

"KNOWLEDGE" THREE-MOVE PROBLEM TOURNEY.

The Chess Monthly, Nuova Rivista degli Scacchi, British Chess Magazine, Hackney Mercury, Southern Counties' Chess Journal, &c., are thanked for notices of this Tourney,

entries for which close on October 10th. The full conditions will be found in the August and September numbers of KNOWLEDGE, and may be had on application to the Chess Editor.

SOLUTION TOURNEY.

1st Prize.—Half-a-guinea.

2nd Prize.—Bird's *Chess History and Reminiscences*.

This will commence in the November number, and will run concurrently with the Problem Tourney.

Two or three Problems will be published each month.

Solutions must reach KNOWLEDGE Office on or before the 12th of each month.

Marks will be awarded as follows:—For each correct key-move, three points; for each dual continuation (on the second move), one point. One point will be deducted for every incorrect claim. If a Problem has no solution, "No solution" must be claimed. If a Problem has more than one solution, duals will not score.

The following game was recently played at Simpson's Divan:—

ROY LOPEZ.

WHITE (H. E. Bird).	BLACK (Van Vliet and Schwann).
1. P to K4	1. P to K4
2. KKt to B3	2. QKt to B3
3. B to Kt5	3. P to Q3
4. P to QB3 (a)	4. P to KB4
5. P to Q4	5. P x KP
6. Kt x P (b)	6. P x Kt
7. Q to R5ch	7. K to K2
8. B to Kt5ch	8. Kt to B3
9. B x QKt	9. P x B
10. P x P	10. Q to Q4
11. B to R4	11. B to R3! (c)
12. P to QB4 (d)	12. Q to R4ch!
13. Kt to B3? (e)	13. K to K3!
14. B x Kt (f)	14. P x B
15. Q to R3ch	15. P to B1
16. Castles (KR)	16. B x P
17. KR to Ksq	17. B to Q6
18. Kt x P	18. B x Kt
19. R x B	19. Q to Q4 (g)
20. QR to Ksq (h)	20. B to Kt2
21. KR to K3?	21. QR to Qsq
22. R to KB3	22. Q to K5!
23. R to QBsq? (i)	23. Q to B7
24. R to KBsq	24. R to Q8
25. P to KKt1	25. R x Reh
26. K x R	26. Q to B5ch

Resigns.

NOTES.

(a) Steinitz was the first to discover and condemn this move on account of Black's reply.

(b) With very bad judgment White enters on a counter attack, which originally occurred in the Steinitz-Blackburne match. Mr. Bird, who must have been well acquainted with the whole variation, fails to perceive that, though a move ahead as compared to the game referred to, this circumstance is actually a disadvantage—*vide* note (c).

(c) Better now than 11. . . K to K3 as played by Steinitz, because White, owing to his 1th move, cannot attack the Queen with Knight.

(d) In order to bring out the Knight at B3. 12. P x Ktch, followed by the exchange of Queens, would leave Black a great superiority, while 12. Kt to Q2, K to K3 would leave Black a piece ahead.

(e) A blunder. The *Nuova Rivista*, from which the score of this game is taken, gives the following continuation:— 13. P to QKt4, Q x Pch; 14. Kt to Q2, R to Qsq; 15. P x Ktch, P x P; 16. Castles (!). But 16. B x Pch instead would win the exchange, showing that Black's 14th move was incorrect.

(f) If the Queen moves, Black takes the KP with Queen.

(g) 19. . . R to Qsq seems even stronger.

(h) An attempt to draw by 20. R to B4, Q x KP; 21. R x P, Q x R; 22. R to Ksqch, proves futile. His next move is waste of time, but there is no chance anyhow.

(i) 23. R to KBsq at once was clearly better. But the Black allies never gave Mr. Bird a chance after his 13th move.

CHESS INTELLIGENCE.

The great Columbian Chess Congress appears after all to have been indefinitely postponed owing to lack of the necessary funds. Several European players had already crossed the Atlantic in order to take part in the tournament when the announcement was made.

Mr. Lasker has at length definitely challenged Mr. Steinitz to a match of ten games up. The other conditions proposed are of a kind with which Mr. Steinitz will not be able to find fault, being in fact those on which he ordinarily insists. The match, if it takes place, is to commence before January 1st, a date which would allow Mr. Steinitz ample time to collect his backers.

Herr Albin, the solitary conqueror of Dr. Tarrasch in the Dresden Tourney, has taken advantage of his visit to the States to play a match with Mr. A. B. Hodges. After each player had won four games the prize was divided.

The National Tournament of the German Chess Association took place at Kiel last month, the result being a victory for Herr Walbrodt. Herr von Bardeleben was second, a great improvement on his recent form, and Herr von Gottshall third.

A very fine series of three-move problems by Mr. Blackburne is now appearing in the weekly chess column of the *Daily News*. Mr. Blackburne adheres to the old school of problem-composition; in other words, each problem has a fine key leading to one main idea, the minor variations (if any) being strictly subordinate. Personally, we much prefer this to the modern style of problem, in which the Black King is chased over the whole board, "a foiled circuitous wanderer."

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THE TALLEST MAMMAL.

By R. LYDEKKER, B.A.Cantab.

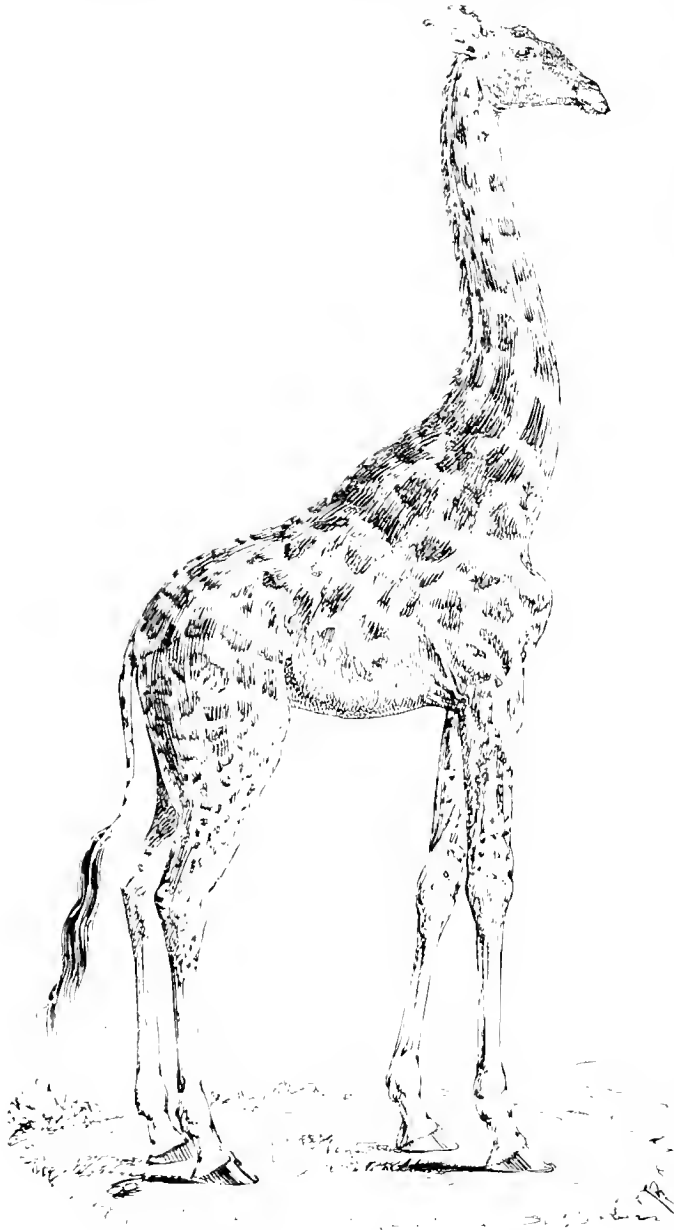
COMPARED with their extinct allies of earlier periods of the earth's history, it may be laid down as a general rule that the large animals of the present day are decidedly inferior in point of size. During the later portion of the Tertiary period, for instance, before the incoming of the glacial epoch, when mammals appear to have attained their maximum development, there lived elephants alongside of which ordinary individuals of the existing species would have looked almost dwarfs, while the cave bear and the cave hyena attained considerably larger dimensions than their living representatives, and some of the sabre-toothed tigers must have been considerably larger than the biggest African lion or Bengal lion. Again, the remains of red deer, bison, and wild oxen, disinterred from the cavern and other superficial deposits of this country, indicate animals far superior in size to their degenerate descendants of the present day; while some of the extinct pigs from the Siwalik Hills of northern India might be compared in stature to a tapir rather than to an ordinary wild boar. The same story is told by reptiles, the giant tortoise of the Siwalik Hills, in spite of its dimensions having been considerably exaggerated, greatly exceeding in size the largest living giant tortoises of either the Mascarene or the Galapagos Islands. The latter rocks have also yielded the remains of a long-snouted crocodile, allied to the garial of the Ganges, which probably measured from fifty to sixty feet in length, whereas it is very doubtful if any existing member of the

order exceeds half the smaller of these dimensions. If, moreover, we took into account totally extinct types, such as the megatheres and mylodons of South America, and contrasted them with their nearest living allies—in this instance the sloths and anteaters—the discrepancy in size would be still more marked, but such a comparison would scarcely be analogous to the above.

To every rule there is, however, an exception, and there are a few groups of living large mammals whose existing members appear never to have been surpassed in size by their fossil relatives. Foremost among these are the whales, which, as we have seen in a previous article, now appear to include the largest members of the order which have ever existed. The so-called white, or square-mouthed, rhinoceros of South Africa seems also to be fully equal in size to any of its extinct ancestors; and the same is certainly true of the giraffe, which may even exceed all its predecessors in this respect. Whether, however, the fossil giraffes, of which more anon, were or were not the equals in height of the largest individuals of the living species, there is no question but that the latter is by far the tallest of all living mammals, and that it was only rivalled in this respect among extinct forms by its aforesaid ancestors. Moreover, if we exclude creatures like some of the gigantic dinosaurian reptiles of the Secondary epoch, which, so to speak, gained an unfair advantage as regards height by sitting up on their hind legs in a kangaroo-like manner, and limit our comparison to such as walk on all four feet in the good old-fashioned way, we shall find that giraffes are not only the tallest mammals, but likewise the tallest of all animals that have ever existed.

In the great majority of animals that have managed to exceed all their kin in height, the increment in stature has been arrived at by lengthening the hind limbs alone, and thus making them the sole or chief support of the body. In some of these cases, as among the living kangaroos and the extinct dinosaurs, the body was raised into a more or less nearly vertical position, and the required height attained without any marked elongation of the neck. In birds, on the other hand, like the ostrich, the body is carried in nearly the same horizontal position as in a quadruped, but both the hind legs and the neck have been elongated. The giraffe, however, has attained its towering stature without any such important departure from the general structure characterizing its nearest allies, and thus preserves all the essential features of an ordinary quadruped. Belonging, as we have had occasion to mention in an earlier article, to the great group of ruminant ungulates, among which it is the sole living representative of a separate family, the giraffe owes its height mainly to the enormous elongation of two of the bones of the legs, coupled with a corresponding lengthening of the vertebrae of the neck. As in all its kindred, the lower segment of each leg of this animal forms a cannon-bone, the nature of which has been explained in the article referred to; and in the fore limb it is the bone below the wrist (commonly termed the knee), and the radius above the latter, which have undergone an elongation so extraordinary as to make them quite unlike, as regards proportion, the corresponding elements in the skeleton of a ruminant, such as an ox, although retaining precisely the same structure. Similarly, in the hinder limb, it is the cannon-bone below the ankle joint or hock, and the tibia or shin-bone above, which have been thus elongated. To anyone unacquainted with their anatomy, it might well appear that a giraffe and a hippopotamus would differ greatly in regard to the number of vertebrae in their necks; but, nevertheless, both conform in this respect to the ordinary mammalian type, possessing only seven of such segments,

Whereas, however, those of the latter animal are very broad and short, in the giraffe they are extremely long and slender, attaining in full-grown individuals a length of some ten inches. This remarkable adherence to one numerical type in the neck vertebrae is, indeed, a very



The Giraffe.

curious feature among mammals: the extreme contrasts in respect of form being exhibited by those of the Greenland whale, in which each vertebra is shortened to a broad disc-like shape, and the giraffe, where it is equally narrow and elongated.

As regards the height attained by the male of the tallest of quadrupeds, there is, unfortunately, a lack of accurate information, and since it is probable that the majority of those now living are inferior in size to the largest individuals which existed when the species was far more numerous than at present, it is to be feared that this deficiency in our knowledge is not very likely to be remedied. By some writers the height of the male giraffe

is given at sixteen feet, and that of the female at fourteen feet, but this is certainly below the reality. For instance, Mr. H. A. Bryden states that a female he shot in southern Africa measured seventeen feet to the summits of the horns: while Sir S. Baker, whose experiences are derived from the north-eastern portion of the continent, asserts that a male will reach as much as nineteen feet, although, most unfortunately, it is not mentioned whether the latter height is merely an estimate, or is based upon actual measurement. From the evidence of a very large, though badly preserved specimen in the Natural History Museum, it may, however, be inferred that fine males certainly reach the imposing height of eighteen feet.

Although this towering stature is the most obvious external feature of the giraffe, it is not one which would of itself justify the naturalist in classing the animal as the representative of a family apart from other ruminants; and we must accordingly inquire on what grounds such separation is made. On the whole, the most distinctive structural peculiarity of the giraffe is to be found in the nature of its horns. These, as mentioned in our article on "Horns and Antlers," are quite unlike those of any other living ruminant, and take the form of a pair of upright bony projections arising from the summit of the head in both sexes, and completely covered during life with skin. In the immature condition separate from the skull, these horns become in the adult firmly attached to the latter: and below them, in the middle of the forehead, is another lower and broader protuberance, sometimes spoken of as a third horn. Obviously, these horns—for want of a better name—are quite unlike the true horns of the oxen and antelopes, or the antlers of the deer; and this essential difference in their structure is alone quite sufficient to justify the reference of the giraffe to a family all by itself. When, however, we come to inquire whether the creature is more nearly akin to the deer or to the hollow-horned ruminants (as the oxen, antelopes, and their allies are termed), we have a task of considerable difficulty. Relying mainly on the structure of its skull, and its low-crowned grinding teeth, which are invested with a peculiar rugose enamel having much the appearance of the skin of the common black slug, some naturalists speak of the giraffe as a greatly modified deer. A certain justification for this view is, indeed, to be found in the circumstance that the liver of the giraffe, like that of the deer, is usually devoid of a gall-bladder. Occasionally, however, that appendage, which is so characteristic of the hollow-horned ruminants, makes its appearance in the giraffe, thus showing that no great importance can be attached to it one way or another. On the other hand, in certain parts of its soft anatomy, the creature under consideration comes very much closer to the antelopes and their kin than to the deer. It would appear, therefore, on the whole, that the giraffe occupies a position midway between the deer on the one hand and the antelopes on the other: while as neither of these three groups can be regarded as the direct descendant of either of the other two, it is clear that we must regard all three as divergent branches from some ancient common stock.

As regards general appearance, the giraffe is too well known to require description, but attention may be directed to a few of its more striking external peculiarities. One remarkable feature is the total lack of the small lateral or spurious hoofs, which are present in the great majority of ruminants, and attain relatively large dimensions in the reindeer and musk-deer. Indeed, the only be taken as an indication of any affinity between the are absent are certain antelopes; but this absence cannot other members of the whole group in which these hoofs

latter and the giraffe, since it is most probably the result of independent development. Equally noticeable are the large size and prominence of the liquid eyes, and the great length of the extensile tongue; the former being obviously designed to give the creature the greatest possible range of vision, while the extensibility of the latter enhances the capability of reaching the foliage of tall trees afforded by the lengthened limbs and neck. In comparison with the slenderness of the neck, the head of the giraffe appears of relatively large size; but this bulk, which is probably necessary to the proper working of the long tongue, is compensated by the extreme lightness and porous structure of the bones of the skull. Lastly, we may note that the long tail, terminating in a large tuft of black hairs, is a feature unlike any of the deer, although recalling certain of the antelopes.

Somewhat stiff and ungainly in its motions—the small number of vertebrae not admitting of the graceful arching of the neck characterizing the swan and ostrich—the giraffe is in all parts of its organization admirably adapted to a life on open plains dotted over with tall trees, upon which it can browse without fear of competition by any other living creature. Its wide range of vision affords it timely warning of the approach of foes; from the effect of sand-storms it is protected by the power of automatically closing its nostrils; while its capacity of existing for months at a time without drinking renders it suited to inhabit waterless districts like the northern part of the great Kalahari desert. And here we may mention in passing that the camel has gained a reputation for being adapted for a desert-life above all its allies which is not altogether deserved. It is true, indeed, that a camel can and does make long desert journeys, but these can only be maintained during such time as the supply of water in its specially constructed stomach holds out, and when this fails there is not an animal that sooner knocks up altogether than the so-called “ship of the desert.” Did their bodily conformation and general habits admit of their being so employed, there can indeed be little doubt that the giraffe and some of the larger African antelopes, which are likewise independent of water, would form far more useful and satisfactory beasts of burden for desert travelling than the, to our mind, somewhat over-rated camel. Returning from this digression, it must be mentioned that when we speak of the giraffe being independent of water, we by no means intend to imply that it never drinks. On the contrary, during the summer this ruminant, when opportunity offers, will drink long and frequently; but it is certain that for more than half the year, in many parts of southern Africa at least, it never takes water at all. In certain districts, as in the northern Kalahari, this abstinence is, from the nature of the country, involuntary; but according to Mr. Bryden, the giraffes living in the neighbourhood of the Botletli river—their only source of water—never drink therefrom throughout the spring and winter months. When a giraffe does drink, unless it wades into the stream, it is compelled to straddle its fore legs far apart in order to bring down its lips to the required level, and the same ungainly attitude is performed on the rare occasions when it grazes.

There is yet one other point to be mentioned in connection with the adaptation of the giraffe to its surroundings before passing on, and this relates to its coloration. When seen within the enclosures of a menagerie—where, by the way, their pallid hue gives but a faint idea of the deep chestnut tinge of the dark blotches on the coat of a wild male—the dappled hide of a giraffe appears conspicuous in the extreme. We are told, however, that among the tall *kameel-dhorn* trees, or giraffe-mimosas,

on which they almost exclusively feed, giraffes are the most inconspicuous of all animals; their mottled coats harmonizing so exactly with the weather-beaten stems and with the splashes of light and shade thrown on the ground by the sun shining through the leaves, that at a comparatively short distance even the Bushman or Kaffir is frequently at a total loss to distinguish trees from giraffes, or giraffes from trees.

At the present day, it is hardly necessary to mention, the single species of giraffe is exclusively confined to Africa, not even ranging into Syria, where so many other species of animals otherwise characteristic of that continent are found. This restricted distribution was, however, by no means always characteristic of the genus; for during the Pliocene period extinct species of these beautiful animals roamed over certain parts of southern Europe and Asia. The first of these extinct giraffes was discovered by Falconer and Cautley many years ago in that marvellous mausoleum of fossil animals, the Siwalik Hills of north-eastern India; remains of the same species being subsequently brought to light in the equivalent deposits of Perim Island, in the Gulf of Cambay, and likewise in the Punjab. A second species has also left its remains in the newer Tertiary rocks of Pikermi, near Athens; while those of a third have been disinterred in China. It was, indeed, believed for a long time that France also was once the home of a member of the genus, but the specimen on which the determination was based is now known to be a jaw-bone belonging to the existing species. Although we are, unfortunately, unacquainted with the geology of the greater part of Africa, the foregoing evidence points strongly to the conclusion that giraffes (together with ostriches, hippopotami, and certain peculiar antelopes) are comparatively recent emigrants into that continent from the north-east; but, as we have elsewhere had occasion to mention, the reason why all these animals have totally died out in their ancient homes is still one of the darkest of enigmas.

Unknown in the countries to the north of the Sahara, as well as in the great forest regions of the west, which are unsuitable to its habits, the giraffe at the present day ranges from the north Kalahari and northern Bechuanaland in the south, through such portions of eastern and central Africa as are suited to its mode of life, to the southern Sudan in the north. Unhappily, however, this noble animal is almost daily diminishing in numbers throughout a large area of southern and eastern Africa, and its distributional area is steadily shrinking. Whether it was ever found to the south of the Orange river and in the Cape Colony may be a moot point, although, according to Mr. Bryden, there are traditions that it once occurred there. Apart from this, it is definitely known that about the year 1813 these animals were met with only a little to the north of the last-named river; while as late as 1836 they were still common throughout the Transvaal, and more especially near the junction of the Marico with the Limpopo river. Now their last refuges in these districts are the extreme eastern border of the Transvaal (where only a few remain), and the district lying to the north of Bechuanaland and known as Khama's country, or Bawangwato, together with the northern Kalahari. Even here, however, their existence is threatened, as there is a proposal to put down tube-wells in the waterless Kalahari, which, if successfully accomplished, will open up the one great remaining stronghold of the animal to the merciless hunter. Unless, therefore, efficient and prompt measures are taken for its protection, there is but too much reason to fear that the giraffe will ere long be practically exterminated from this part of Africa;

although, fortunately, it has a prospect of surviving for many years to come in the Sudan and Kordofan. The great majority of the giraffes killed at the present day in southern Africa are shot solely for the sake of their skins, which are now, owing to the practical extermination of rhinoceroses south of the Zambesi, and the ever-increasing scarcity of the hippopotamus, used in the manufacture of the formidable South African whips known as *pamboks*. The value of a skin usually varies, according to size and quality, from £2 10s. to £4, although they have been known to fetch £5 apiece; and it is for the sake of such paltry sums that one of the noblest and most strange of mammals stands in imminent danger of extermination!

We may conclude this notice by mentioning that although the giraffe was familiar to the Romans of the time of the empire, by whom it was known as the camelopard, it appears to have been almost completely lost sight of in Europe in later times till the closing decades of the eighteenth century, although a single example is stated to have been exhibited alive in Florence some four centuries ago. With that exception, it seems to have been generally regarded as a fabulous animal until one was shot near the Orange River in 1777 by an Englishman, and another by the French naturalist, Le Vaillant, in 1784. From that time onwards our knowledge of the animal and its habits gradually increased, although it was not till the spring of 1836 that four living specimens from the Sudan were brought alive to London, where some of their descendants lived continuously till 1892, since which date the species has been unrepresented in the Regent's Park.

THE MAKING OF MOUNTAIN CHAINS.

By H. G. WELLS, B.Sc.

WITHIN the past decade, speculation upon the process of mountain formation has attracted a considerable amount of attention from geologists. With increased stratigraphical knowledge, it has been possible to trace the successive stages in the life of an elevated region with increased certainty, and a great and growing quantity of collateral information has been collected upon volcanic phenomena, earthquakes, the microscopic structure of rocks, and the behaviour of viscous bodies under pressure.

The history of every mountain range seems to resolve itself into the story of an incessant struggle between hypogene and solar energy. From the moment the land emerges from the sea the forces of denudation begin to act upon it: as the upheaving powers win for a time, and the land gradients increase, erosive action becomes more and more efficient, the wedges of the frost come to aid the wear of the rain as the snow-line is approached, and at last the Titanic forces of elevation, the strength of the caryatid giant, old Seismos, becomes exhausted, and the record of his efforts is slowly erased by the at last triumphant forces of the air. This, in brief, is the life-history of every mountain chain, the common plot of all the stories at which we are now to glance.

Somewhere in Swedenborg's writings there is an account of the examination by angels of one of the risen dead. They did not ask the man questions, or subject him to cross-examination. They simply took his body, and methodically from that infallible document read out to him all the things he had done. If I remember rightly, they began by "unrolling his fingers." Whatever act his fingers had performed had left its record in their structure, and whatever thought had passed through his brain had made its infinitesimal difference there. This is precisely the way

the scientific man hopes at last to build up the history of the past. Every hill, every pebble, every microscopic patch in a weathered felspar, every cleavage crack in a needle of hornblende, rightly interpreted, bears its witness to the cosmic forces that have been at work upon them; and at present we must read the story of the mountains in this way, so far as our light permits. We may best begin by remarking upon a few of the most significant features of existing mountain masses.

Perhaps, in the order of their importance, one should first notice the fact that almost all our great mountain chains have, high up upon their flanks, rocks of comparatively recent origin, and that we often find great thicknesses of such rocks. The very summit of Mont Blanc, for instance, was once surmounted by Jurassic rocks. Cretaceous rocks crown the Rocky Mountains, and Tertiary masses lie at great elevations upon their sides. Nummulitic limestone, a foraminiferal rock of early Tertiary age, is found at heights of nineteen and twenty thousand feet on the Himalayas, and still younger Pliocene formations lie high on their slopes. The elevated *molasse* of the Alps is a middle Tertiary rock. Not one of the really great mountain chains of the globe appears to have been elevated, or indeed above water, during the Mesozoic period. At that time each was an area of deposition, and further, of subsidence, as the accumulated thickness of Mesozoic strata witnesses. So that we must figure for the beginning of our story a sea, near land indeed, or strata would not accumulate, and with a sinking bottom, or its silting up must have occurred in the place of continuous deposition.

Of course, when we state that the early Tertiary and upper Mesozoic rocks are *recent*, the non-geological reader must understand we mean recent relatively to the length of geological periods. The date of accumulation of these sediments is certainly a matter of hundreds of thousands if not of millions of years.

Mr. Mellard Reade has insisted particularly upon the importance of this fact of the comparatively modern sedimentary structure of mountain masses. He has, indeed, propounded a theory of the origin of mountain elevation largely based upon this. As everybody knows, there is within the earth an enormous store of heat; for instance, near the surface for every fifty feet or so we go down the temperature rises 1°. The temperature of the surface—disregarding solar radiation—is the net result of two processes; heat must be continually arriving from the hotter interior by conduction, and heat must be continually escaping by radiation into space. Mr. Reade asks us to consider the result of a continually increasing thickness of strata over any part of the earth's surface. It will act, just as a blanket does, by preventing the escape of heat. The rocks below will in time grow warmer, since they are no longer superficial, and the growing accumulation of strata will also be heated. The whole mass will expand horizontally and vertically, the movement of subsidence will finally cease, and at last, as a consequence of the lateral strain, the horizontal strata will bulge and be ridged upward into the form of mountain masses.

More striking, perhaps, than the recent age of their constituent strata, and almost equally significant, is the folding that mountainous regions have undergone. We cannot do better than call attention here to the accompanying figure of that classical example, Mont Blanc. The strata the reader will see here have been folded and folded again, and their ridges have been denuded. If one takes the edges of a sufficiently flexible book and approximates the ends, one may imitate these foldings roughly, but they may be imitated still better by compressing layers of cloth laterally beneath a weight.

Now, unless all the elementary presumptions of geology are wrong, these folded strata must originally have been deposited horizontally. Since their deposition, therefore, their extremes have been brought nearer together. This puckering points unmistakably to a squeezing in from the sides. It has been calculated, in the case of the Alps, that



Fig. 1

Section of Mont Blanc.

points on either side of this mountain mass have been brought closer to one another by as much as seventy-two miles. In the case of the Appalachian Mountains the estimate is eighty-eight miles. We seem to have here, then, the clear record of the successive stages in such a process as is indicated in a simplified fashion by our Fig. 2 (A, B, C, D), in which A, B and C represent phases in a steady lateral compression, and D repeats C, with some allowance for the action of sub-aerial denudation.

It is upon this aspect of mountain structure that Prof. Lapworth laid particular stress in his memorable address to the Geological Section of the British Association. He insisted upon the horizontal pressure and upon the strata giving to this strain at their weakest points, bulging up into ridges and furrows, and with further compression folding over, so that we get at last "over folds" (Fig. 1), with an upthrust or *arch limb*, a *middle portion*, and a downthrust or *trough limb*. The middle portion must especially be under great pressure, and it may undergo crushing, or the fold may rupture and the arch slide forward over the fault to form a reversed fault or over-fault or thrust plane as in Fig. 5. The final result of this folding will be to strengthen the crust at the original weak point by more

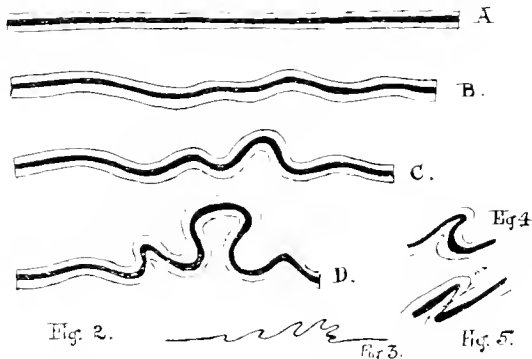


Fig. 2.

Fig. 3.

Fig. 5.

than doubling its thickness, and adjacent portions of the strata will then begin to pucker. So that in the flanks of the original fold fresh folding will arise until we get either a fan-like series (as in Mont Blanc), or a one-sided arrangement (Fig. 3) such as is displayed in the Appalachian and Jura Mountains.

The causes of these mountain foldings may possibly be the lateral stress due to local horizontal expansion, if the theory of Mr. Mellard Reade is correct. But a great number of geologists consider that the prime cause of these foldings, and indeed of mountain upheavals, is the contraction of the earth due to its secular cooling. As this

contraction goes on, the cold crust has to accommodate itself to the shrinking interior, and in doing this it is necessarily crumpled and wrinkled. The great land masses and the great oceanic troughs of our earth, moreover, lie along lines of longitude. Winchell has attributed this north and south trend of the chief lines of crumpling to the directive influence of the tidal stress.

Prof. Lapworth, in his address, stated the case for the contraction theory of mountain origin in a remarkably vivid way. He called attention to the manner in which trough and ridge everywhere corresponded. For the upthrust of America, with its Mississippi valley and its unilateral ridges of the Rockies and Appalachians, we have the Atlantic with its division by the Dolphin ridge into two parallel troughs; and corresponding to the broad uprise of the older continents we have the great depression of the Pacific. Coming to the shorter transverse foldings, the Alpine mass had for its trough the Mediterranean; and Central Asia the southward deep of the Indian Ocean. This "undulation" of the surface of the solid earth is far more in agreement with the theory of secular cooling than the theory of Mr. Mellard Reade.

On the other hand, there are those who consider the amount of folding we find in mountain masses, which must amount altogether to a diminution of the earth's circumference by many hundred miles, too great for their conception of the amount of contraction the world has undergone since the rocks in question were solidified. Moreover, in certain localities in Sweden and elsewhere, *crumpled rocks are found lying on an undisturbed base*. Prof. Reyer has recently propounded some novel and remarkably suggestive views in this matter.

He has conducted a series of experiments upon the behaviour of artificial strata made of muddy material or plaster of Paris mixed with glue and variously tinted. These before complete consolidation were placed on boards slightly tilted (5° to 15°), and the arrangement was occasionally tapped to imitate earthquake shocks. There was a general sliding down and crumpling of the mass, such as might conceivably happen in the case of sedimentary rocks, and sections taken after hardening showed, in consequence of this gliding, beautiful imitations of folding, contortion

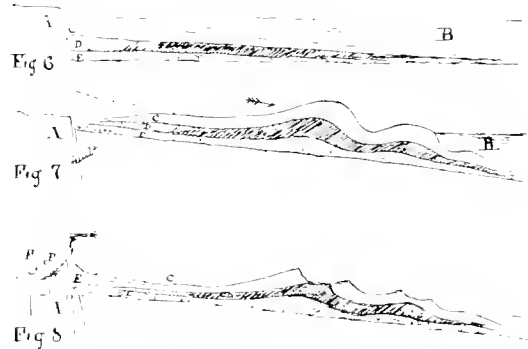


Fig. 3

Fig. 7

Fig. 5

and faulting such as are seen in mountain chains. Such experiments as this might very easily be repeated by teachers of geology or physiography. They certainly aid the imagination very greatly in thinking out these physiographic problems.

Prof. Reyer's conception of the development of a series of mountain folds, based on experiments of this kind, may be illustrated by the three figures above. While it harmonizes with Mr. Mellard Reade's hypothesis, it seems perhaps a little better adapted to explain complex crumpling of strata than does that supposition. A represents a continental mass, from which the sediments C, D,

E, accumulating in the sea, B, are derived. For manifest reasons, these will be thickest and coarsest near land, where the carrying power of water is at its greatest. Now, on the reasoning already given, this accumulation will finally lead to upheaval, the uprise of strata being greatest in the region where the "blanket" is thickest. That is to say, the base is tilted. The strata consequently glide seaward and pucker up upon the tilted base (Fig. 7). Meanwhile the continental mass (A) is continually undergoing denudation, and the rocks immediately beneath, therefore, are cooling. We may say that the young land to the right is pulling the blanket off its older neighbour, the area A. The cooling of A causes a subsidence and faulting, and the faulting, weakened, and sinking crust is there least able to resist eruptive material, so that at last (Fig. 8) a volcanic chain, F F F, may grow up behind the fold chain.

This, briefly, is the story suggested by Prof. Reyer, a story also fairly consistent with existing mountain structures. But it need not be regarded as a theory absolutely opposed to that so clearly propounded to the English student by Prof. Lapworth. The heating effect of deposition suggested by Mr. Mellard Reade, the crust contraction to which Prof. Lapworth gives prominence, the "gliding" of Prof. Reyer, are all causes that must operate. Prof. Reyer's theory may explain many cases of folding, Mr. Mellard Reade's many cases of upheaval, and yet the great wrinkles on the face of Mother Earth may be due to her withering as the warmth of her youth departs from her.

Clearly, from what has been said, volcanic phenomena are a mere incident in the growth of a mountain chain. They do not, for instance, appear to have played a leading part in Alpine history, and the Rocky Mountains were already elevated before the great trachytic and basaltic outflows of that region occurred. Volcanic forces cannot, therefore, for one moment be regarded as standing in a causative relation to mountain building. Nevertheless, in the Andes and the Himalayas the abundant presence of volcanoes is food for thought. However, the question of the causes of volcanic action scarcely belongs to this paper.

Here we may allude to a third feature of mountain structure. It emphasizes the enormous pressures to which the folded rocks were subjected. It is the alteration of the microscopic structure of these rocks.

We find, for instance, clays, with all their once higgledy-piggledy particles, twisted round into a direction at right angles to the force of compression, so that they can be split up into laminae, and are no longer clays but slates. Limestones lose the traces of their organic relics, and become recrystallized as marble. Some rocks are seen with their constituent minerals literally crushed and rolled over and into one another, as though they had been through a colossal crushing mill (Mylonitic structure). The quartz of granite, for instance, is powdered, the felspar cracked and reduced to cloudy particles, the mica twisted and shredded. The rock has also been, as it were, *masticated* in the presence of in-soaking water. Old minerals have been dissolved out, fresh ones formed.

In some cases a parallel order of the minerals has been induced. It is as if the rock had become plastic under these stupendous stresses, and that we had here its lines of flow. Nothing could be more eloquent of the irresistible nature of the mountain-making forces. It is interesting, too, to notice how we have thus repeated, in a thin flake of rock that would scarcely weigh a grain, the same story of enormous lateral pressure that we find in considering the stratigraphical structure of an Alpine *massif*.

To summarize our deductions, we have in the history of

every great mountain chain the following phases. We can do without any appeal to "old Seismos" now to account for the elevation. A long period of quiet subsidence and deposition of sediment is followed by upheaval. There is a process of lateral compression relieved by a bulging, the formation of a ridge or ridges, with troughs on either side. Probably there are no great paroxysms: the steady squeezing and upward creep goes on day by day, year by year, age by age. Strata are imperceptibly thrown into bends, into loops, the foldings are heaped up one above the other, overfolds are formed. The rising mass slowly becomes a prominent terrestrial feature. Stresses, culminating day by day, are at last relieved by the formation of faults and thrust planes, and as the ruptured strata slip there are earthquakes. Rocks are crushed and metamorphosed, softened, moulded, possibly even liquefied. There may be volcanic outbursts along the axis or upon the margins of the rising area.

The emerging mass becomes subjected to denudation. In the main troughs which will be sinking beside the rising ridge, forming seas or lakes, sediments will accumulate. Presently these areas cease to subside and become involved in a greater movement of elevation, as is shown by the Swiss *molasse* and the Siwalik rocks on the Himalaya flanks. So the vast growth continues. Strata tilted on its rising shoulders slide and are crumpled. Above, the snow and glacier are soon at work—unequal heating by day and frost by night, rain and wind, splinter the metamorphosed upturned rock masses into peak and pinnacle, cirque and precipice. Thus in the course of ages the mountain chain attains its prime, and a brief equilibrium follows.

But the forces of lateral pressure and upheaval are dying away or they have found a weaker area elsewhere. The volcanoes become extinct, the earthquakes less violent and less frequent. Every moment a hundred streams carry away their quota of material suspended or dissolved. So the period of decay sets in. From the still eruptive Himalayas we may turn to the more quiescent Alps, from there again to the worn-down masses of Scandinavia and Scotland, from there to the still more ancient mountain range half buried beneath the strata of Wales and Central England; and so the story ends at last as it began, in sedimentation in the sea.

In conclusion, attention may be called to the rather remarkable fact that in the moon no great meridional mountain ridges, such as one might expect from the analogy of the earth, are to be traced. Neither have the mountains of the moon so distinctly the linear ridge-like arrangement characteristic of terrestrial mountain axes. One might have anticipated, on the contrary, in the absence of an atmosphere and atmospheric denudation and with feebler gravitational attraction, that broad regions of crust folding would have been more conspicuous than on the earth. It may be that these features have been masked by the subsequent precipitation of the lunar atmosphere; but the volcanic character of lunar scenery is hardly consistent with this hypothesis. This, however, is a question for the astronomer to consider.

Letters.

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

To the Editor of KNOWLEDGE.

DEAR SIR, The arguments which you have brought to bear upon the significant question, "What is the Sun's

Photosphere?" are of wide import; for if they be valid for the sun, they must be equally so for the great majority of the stars. It seems impossible to stop short at the conclusion that "the light of the solar photosphere is due to the brilliant incandescence of the most refractory substances present in the sun, at a level where they are just on the point of being driven into vapour." The further inference presses itself upon us that "the most refractory substances" in the stars behave similarly; and these substances are likely to be, if not identical, at any rate closely analogous in sun and stars. Hence, if photospheric temperatures be determined by their boiling-points, a very narrow range of diversity can be allowed to stellar emissive power. All stars of normal constitution must radiate a nearly equal amount of light and heat per unit of superficial area. Binaries with known orbits afford, however, a measure of what has been called their "density-brightness." Supposing, in other words, their mean density to be the same, the intrinsic lustre of their photospheres can be determined. It is found to vary enormously; but if the condensation theory of photospheric formation be true, there can be but little difference in this respect between one star and another. If we admit the theory, then, the observed variations must be laid to the score of density, not of brilliancy. This, however, involves somewhat improbable consequences. The whole bulk of the stars of γ Leonis, for instance, should, on the supposition in question, be composed of matter fully seven thousand times more rarefied than the average solar materials; and these stars being of the same spectral type with the sun, no differences of absorption could help to explain away any part of this vast discrepancy. Again, δ Cygni sends us one hundred times more light than we should receive from the sun if it were so situated as to form with a satellite-sun a system with the same period, and of the same apparent dimensions as the system of that binary. The surface of δ Cygni, if of solar brilliancy, should accordingly, in order to enclose an equal quantity of matter with that constituting the sun, be one hundred times more extensive than the solar surface: that is to say, the star must be one thousand times less dense than the sun. If these results be inadmissible, then nothing remains but to revert to photospheric diversities of lustre.

From certain of the Algor-stars, however, a direct measure of brilliancy may in time be derived. Thus, spectroscopic determinations of relative velocities in the system of γ Cygni will give, apart from any hypothesis, the joint mass of its two equal components; their bulk can be inferred from the duration of their phases, once the size of their orbits is known; and should it prove possible to ascertain their distance from the earth, their total light—consequently, their photospheric brilliancy—will follow at once.

Faithfully yours,

AGNES M. CLERKE.

[I do not feel that we can safely assume that all stars are composed of similar materials. The uniform difference in the colour of the larger and smaller components of binary stars seems to point to a difference of composition rather than to a difference in the temperatures of the large and small stars (see *Old and New Astronomy*, p. 784). And the densities of the planets of the solar system seem to point to the conclusion that the different planets must be composed of different materials; otherwise it is difficult to conceive why Mercury, which is smaller than the earth and larger than the moon, and presumably hotter than either of them, should be denser than either the earth or the moon. The earth is about 5.66 times as heavy as water, or about twice as dense as the average density of the rocks which compose its surface—a fact which might

be accounted for on the assumption of uniform composition, by assuming that the matter composing the central parts of the earth is materially compressed by the enormous weight of the overlying strata. The moon is about 3.16 times as heavy as water, and though presumably colder than the earth owing to its larger surface compared with its mass, it is conceivable that the moon might be composed of similar materials less closely compressed under the more feeble action of lunar gravity. But Mercury, which has a diameter of about 3000 miles, is about 6.85 times as heavy as a similar sized globe of water—a density which could hardly be accounted for, on the above assumption as to uniform composition, even if it were assumed that Mercury is much colder than the earth.

If we were able to assert that all stars must be composed of similar materials, and that the brightness of their photospheres corresponds to the boiling temperatures of the same substance, there might still be a difference in the apparent brightness of the photospheres of stars, caused by differences of absorption above the photosphere due to differences in the density and mass of the stars, as well as to differences in the explosive energy which carries matter into the regions of the chromosphere and corona above the photosphere. Possibly we are not even warranted in assuming that such differences must give rise to a difference in the type of stellar spectrum emitted.

While generally concurring with Miss Clerke, it seems to me that we cannot safely assume that it is *improbable* that one star is a thousand times as dense as another star—in fact, the evidence afforded by the disposition of the stars on the nebulous streams of the Hercules cluster seems to me to point to the conclusion that these stars are very little denser than the nebulous matter surrounding them, and consequently that their average density is probably less than a thousand millionth of the density of our sun.—A. C. RANYARD.]

EXPLOSIONS IN THE SUN.

To the Editor of KNOWLEDGE.

DEAR SIR,—I have read your most interesting and suggestive article on the solar photosphere in the October number of KNOWLEDGE, and in reference to this will you permit me to draw your attention to a point which I should much like to see discussed in your valuable periodical? I refer to the supposed explosive combinations of gases at the solar surface.

It appears to be generally assumed that when two (mixed) gases, having a strong chemical affinity, are cooled from a very high temperature to the point of dissociation, a violent explosion will be the result. Now I understand by the term "explosion" a sudden, almost instantaneous, increase of volume, accompanied (or caused) by a great rise of temperature, the potential energy due to the chemical affinity having been suddenly converted into kinetic molecular energy, or heat. But this can only occur when the molecules of the combining gases are in unstable equilibrium previous to the explosion. Thus when hydrogen is mixed with an equivalent of oxygen at ordinary temperatures the mixture is unstable, and on applying a relatively minute force the gases explode, an enormous amount of heat being evolved, so that the resulting water vapour, which otherwise would only occupy two-thirds the original volume, expands to many times that volume.

But suppose the two mixed gases to be at their dissociation temperature, then the force which we call chemical affinity is exactly balanced by the molecular repulsion due to the extremely high velocity of the molecules, and when this velocity is slightly reduced by cooling, combination

will take place without violence and without producing any heat, for it is obviously paradoxical to suppose the temperature to rise: if it did, dissociation would again take place. Consequently there will be no expansion, but, on the contrary, a contraction, as the compound molecule will require less space than its constituents.

My view, therefore, is that chemical combinations taking place under the solar conditions, namely, the cooling of gaseous mixtures from temperatures above their dissociation points, will simply result in contractions of volume, and I cannot see that these will be of the nature of explosions.

Of course it may be said that explosive combinations might occur when the component gases are not mixed, but cool separately to a temperature considerably below the dissociation point. A subsequent accidental mixing would then, no doubt, set free the energy due to their chemical union. But in this case also true explosion would not occur, as the gases could not be diffused into each other and then ignited as in terrestrial explosions. Under solar conditions ignition would always occur immediately the gases came into contact, and would continue, only in the region of contact, as a surface flame until one or other element was entirely consumed.

When, on the other hand, the combined elements are re-heated in the lower strata of the solar photosphere and re-dissociated, expansions will occur, which possibly, if confined by some means, would be sufficiently violent to account for the observed outbursts. But that these expansions would not necessarily be of a violent character seems probable, if we may compare the dissociation of compounds in the sun with the change in vapour density of certain substances which can be experimented upon in our laboratories. Thus nitric peroxide at low temperatures has a vapour density approximating to the formula N_2O_4 , but on heating a change takes place independently of the law of Charles, the double molecule ($\begin{smallmatrix} NO_2 \\ NO_2 \end{smallmatrix}$) being dissociated into $NO_2 + NO_2$; that is, at a given temperature and pressure (above the dissociation temperature) the vapour will occupy twice the volume it would have done in the former condition. But this expansion is by no means sudden and violent, occurring at the moment the dissociation temperature is reached; for according to the accepted kinetic theory of gases, at any temperature, individual molecules are regarded as moving with widely different velocities, the temperature indicating the mean velocity, and therefore dissociation begins at a far lower temperature than the theoretical dissociation point, and it will not be completed until a much higher temperature has been attained. It follows from this, that as the vapour or gas cannot augment its temperature through the required range instantaneously, the dissociation and consequent expansion will take time, and not therefore be explosive.

A serious objection, however, to the theory of chemical combinations and dissociations in the sun appears to me to be the absence of spectroscopic evidence either of the compounds formed or of the combining elements. Under the conditions I have explained above, one would expect to find in the outrushing gases a mixture of dissociated elements. What we actually do find is a mixture of calcium and hydrogen and helium. Of the last-named element of course nothing is known, but the other two at any rate are both positive elements, and therefore unlikely to form combinations or to possess any strong affinity for each other. It is true that in the comparatively rare metallic eruptions other elements (metals) are present, but these are usually seen at the base of an ascending column of heated gas, and seem to be merely thrown up from below

by the violence of the outrushing calcium and hydrogen—these latter elements, with helium, being the only invariable constituents of all classes of prominences.

Thus it appears to me that chemical forces such as we are acquainted with fail to account in a satisfactory manner for these extraordinary explosions and outrushes from the solar photosphere, of which I have on several occasions had the good fortune to be an eye-witness.

J. EVERSHEED.

To the Editor of KNOWLEDGE.

DEAR SIR,—The few words with which I concluded my lecture to the British Association at Nottingham were, I need scarcely say, not meant to herald a theory of the sun, and it would be unbecoming on my part to enter into a detailed discussion of solar physics. But, as you wish it, I will just say in respect to Mr. Evershed's letter that in reflecting on the past condition of the earth I never pictured a homogeneous mixture of hydrogen and oxygen developing by cooling into explosive or even flame-like combustion. All the probabilities seem to be against such a distribution of the gases. In a heterogeneous distribution, flames would, on Mr. Evershed's own showing, become possible at a certain temperature. The steam might be dissociated in hotter layers and the gases carried again into heterogeneous circulation, just as steam mixed with an inert gas is partly dissociated on passing through a hot tube. These two points were all I contended for.

As to the other matters raised in Mr. Evershed's letter, I will only say that whilst not presuming to argue in favour of chemical explosions as a source of solar eruptions, I would advise caution to those who argue their impossibility. Such reasoning as that offered by Mr. Evershed would never allow us to admit (apart from our experimental knowledge) of such phenomena as the super-heating or super-cooling of water or steam, or the existence of any false equilibria. Iron changes its molecular condition at a certain temperature. When cooled down from higher temperatures the reverse change, which is attended with evolution of heat, should set in gradually. As a matter of fact it does not—we have the phenomenon of "recalescence"—the iron suddenly glows again. This is Mr. Evershed's paradox realized. False equilibria abound in chemistry; what is called chemical affinity seems with our present knowledge most capricious, and I think he would be a rash man who would deny the possibility of super-cooled chemical systems. There is reason to believe that chemical affinity varies periodically with temperature. Ozone which is formed at ordinary temperatures is destroyed at a moderate heat, and, it appears, formed again at much higher temperatures. Chemical phenomena, in short, cannot be predicted, as has been shown again and again, by *a priori* thermochemical reasoning. This being so, I feel, as I expressed myself at Nottingham, that one must not rashly exclude chemical action as a factor in solar phenomena.

ARTHUR SMITHELLS.

I agree with Prof. Smithells that Mr. Evershed's *a priori* method of reasoning is dangerous and must not be relied upon for the prediction of phenomena which cannot be verified by experiment. The appearances observable on the sun seem to point to the existence of rapid disturbances very like explosions. I notice that Mr. Evershed, who is a practical observer, speaks of the solar disturbances as *explosions*, a word which implies rapid change of volume, if not chemical action. There are great difficulties in accounting for the rapid motions observed on any other supposition. Our terrestrial winds are produced by differences of temperature causing unequal expansions of

the air. Where the surface of the earth is warmed the air rises, and the winds rush in from all sides. But though it is possible to conceive of unequal heating of the rare gaseous matter in the region just below the photosphere, where the photospheric clouds might be conceived of as shielding certain portions of gas from radiation into space, and in the region just above the photosphere where the clouds may shield certain portions from the radiation of the solar nucleus, it is much more difficult to conceive of such unequal cooling in the region far below the photospheric cloud layer, or of velocities being generated by slight differences of weight sufficient to carry the rising matter far above the level of the solar atmosphere.—A. C. RANFORD.]

THE COMPARISON OF PHOTOGRAPHS.

To the Editor of KNOWLEDGE.

DEAR SIR,—The method proposed by Mr. F. H. Glew in *KNOWLEDGE* for October also occurred to me some months ago. It may interest him to know that I have put it to a practical test. Mr. Downing kindly sent me from the *Nautical Almanac* office the positions of some asteroids, which would be in a suitable position near the meridian in the month of August. I took a photograph of the region round the planet Arethusa on the 22nd, and the following night took another photograph of the same region. I then took a positive by contact printing off the negative of the 22nd, and superposed it on the negative taken on the 23rd. The black *star images* of the negative then exactly fill up the clear white images in the positive, and the *star images* then completely vanish. The image of the *asteroid*, being in different positions on the two plates, will not blot itself out, and it can then be seen at once on inspection. I have had a frame made to hold the two photographs in superposition, and provided with screws acting on slides, so that the one photograph can be adjusted with the greatest precision over the other. The frame slides into an optical lantern, and the image of the photograph when thrown on a screen can be quickly examined for a planet. Yours very truly,

W. E. WILSON.

Daramona House, Street, Co. Westmeath.

October 9th, 1893.

LUNAR CRATERS SEEN IN RELIEF.

To the Editor of KNOWLEDGE.

DEAR SIR,—I have repeatedly observed that when photographs of lunar craters, like the beautiful ones we have lately had in *KNOWLEDGE*, are viewed so that the light from a window or lamp shines upon them from the same direction as that of the sunlight when the photographs were taken, the craters appear as craters; but if the photographs be turned round so that the light from a window or a lamp comes from the opposite direction, there is immediately an appearance of false relief and the craters seem to be raised up like mounds. The effect is curious, and seems to show that the same drawing and the same arrangement of light and shade can represent indifferently a hollow or an elevation. What is the explanation? I have seen the same effect in looking at the moon with a telescope; the craters seem suddenly to stand up like mounds.

Alderbury Vicarage, Salisbury. R. S. HURCHES.

Oct. 5th, 1893.

It is evident that suitable shading, as well as perspective drawing, influences our minds in the compound mental process gone through when we translate a picture drawn in two dimensions into objects existing in three dimensions. A little consideration will show that exactly

similar outlines might correspond to a hollow or an elevation—a crater or a hill; but with a side illumination the disposition of light and shade would be reversed in passing from the one to the other. And it would be equally reversed if the objects were illuminated from the other side. Consequently, before we can make up our minds whether a drawing represents a bas-relief or an intaglio, we involuntarily consider from which side the light is falling; and a mistake made as to the direction may cause us to interpret the drawing or photograph of a crater as representing a mound with similar outlines, or *vice versa*.—A. C. R.]

THE SPECTRA AND MOTIONS OF STARS.

To the Editor of KNOWLEDGE.

SIR,—I had intended making some remarks on the letters of Prof. Kapteyn and Mr. Boraston, which have appeared in your columns, on the subject of the spectra and proper motions of the stars and their distribution in space. I have, however, but little to write, and as I hope the new volume of the *Draper Catalogue*, dealing with the southern stars, will shortly be available, it seems desirable to wait for further data. Prof. Pickering's paper, recently read at Chicago, is a very suggestive one. It confirms one result which I had derived from an examination of the proper motions of the stars, *viz.*, that stars of the Orion type (B) are not to be regarded as intermediate between the Sirian and Solar stars, but that, on the contrary, the ordinary Sirians (A) are to be regarded as intermediate between the Orion stars and those of the Solar type. He does not, however, place the Capellan stars (F) at the end of the list as the dullest and consequently the nearest to us (on the average) for their magnitude, as I hold them to be; and, considering the brightness of Canopus, as well as its small proper motion and parallax (according to Dr. Gill), it is rather startling to find it referred to this type. Perhaps the reference may turn out to be a mistake, like that of Rigel, which is now referred to the Orion type (B). I find also that Prof. Pickering refers the sun to the Areturian, not the Capellan type. The Galactic type he regards as A. I am rejoiced to see that he contemplates deducing the apex of the sun's way from a separate examination of stars with different types of spectra. If the Sirians of the type A, or the Galactic stars, form a separate system, the fact will probably be revealed by finding a different apex for the sun's way from that derived from stars with other spectra. But the proper motions of stars of type A, and still more of type B, are usually very small, and their true motions are therefore liable to be overlaid by errors of observation and computation. Determinations based on Solar stars will, at all events, be more reliable for some time to come.

Dublin, October 17th.

Sincerely yours,

W. H. S. MONCK.

THE TINTS OF THE LUNAR PLAINS.

By A. C. RANFORD.

THE full moon, which appears so silvery white as it shines in the evening sky, reflects, according to Zöllner, only about one-sixth of the light which falls upon it, and when its dazzling brightness is partly quenched by daylight it still appears white, and might easily be mistaken for a small white cloud. But as seen beside a vast ball of snow similarly illuminated by the sun's rays, the moon would appear a dull grey, for fresh-fallen snow reflects only 0.783, or rather more than three-quarters of the light which falls upon it; while the

moon as we see it in the daylight reflects less than one-sixth of the light which falls upon it, for the crescent or gibbous moon which is seen in the daytime is never as white as the full moon, because, except when the moon is opposite to the sun, we, in looking from the earth, see some part of the black shadows thrown by the lunar mountains, and the admixture of dark shadows tends to dull the general whiteness of the lunar surface.

It needs only a very cursory glance at the moon to see that it is not all equally white. The rustic and the child, without any optical aid, see dark patches on its surface, in which they recognize the features of a laughing face, or, with the aid of a little imagination, detect the figure of an old man carrying a bundle of sticks. As seen with an opera glass or telescope, the difference in brightness of different parts of the moon's face becomes much more noticeable. It is immediately recognized that the lunar plains are, as a general rule, much darker than the mountainous regions and high ground, and that the moon's limb or smooth outer edge is whiter than the rest of the lunar disc; but at the moon's limb only mountain-tops are visible, the valleys and low-lying land being hidden by intervening hills. We thus learn that on the moon the mountain-tops are whiter than the low-lying land, and from terrestrial analogies we conclude that this is more probably due to some white substance covering the high ground than to a difference between the tint of the soil of which the lunar plains are composed and the rocks of which the mountains are built.

We may, I think, venture to speak of the lunar mountains as being composed of rock, for many of them have very steep sides; and if they were composed of sand, or any very friable rock, we should not expect to find the lofty precipices which are recognizable in many parts of the moon.

See, for example, the north-eastern flank of the lunar Apennines (Fig. 2) and the steep conical hills which rise from the Mare Imbrium, such as Piton (Fig. 5), and Pico and Teneriffe Mountains to the south-east of Plato (Fig. 4).

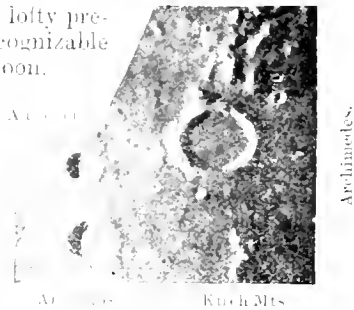


FIG. 1. Archimedes.

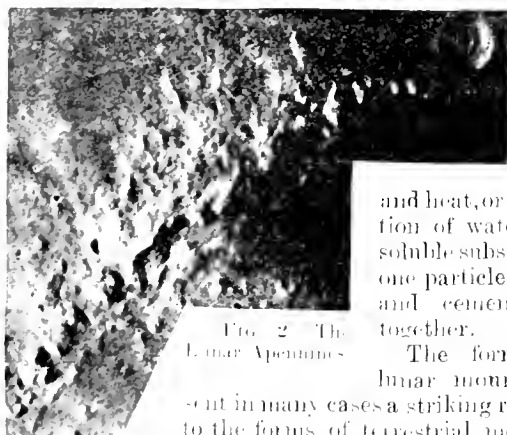


FIG. 2. The Lunar Apennines.

mountain chains and ridges which seem rather to suggest

that they have been buried and have undergone changes due to pressure and heat, or the infiltration of water carrying soluble substances from one particle to another and cementing them together.

The forms of the lunar mountains present in many cases a striking resemblance to the forms of terrestrial mountains of volcanic origin, but there are some lunar mountain chains and ridges which seem rather to suggest

the crumpling of horizontal strata. See, for example, the Riphæan Mountains (Fig. 3), shown in the photographic plates in the September number, and the ridges to the south of Archimedes, well shown in the plates in this number, as well as the curious stag's horn form, called the Kirch Mountains, to the north of Archimedes and to the east of Aristillus (see Fig. 1).

But there are no long mountain chains trending north and south upon the moon as on the earth; and if we may accept the theory which attributes the northerly and southerly trend of the chief lines of crumpling of terrestrial strata to the directive influence of the tidal stress, it would follow that the lunar features we now see have come into existence since the epoch when



FIG. 3. Riphæan Mountains.

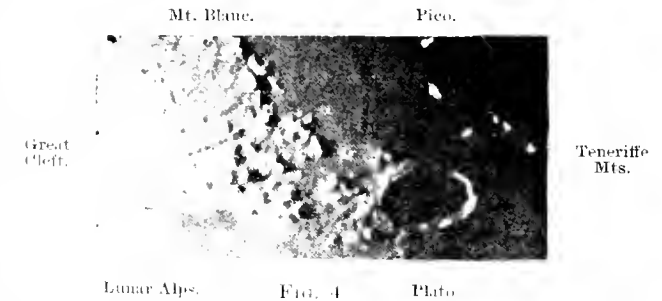


FIG. 4. Mt. Blanc, Pico, Great Cleft, Lunar Alps, Plato, Teneriffe Mts.

the moon's period of rotation about her axis came into coincidence with her period of revolution about the earth; for before that epoch the tide which swept round the moon

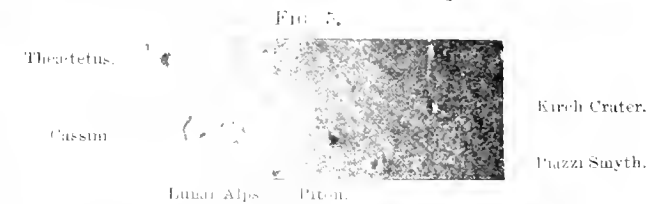


FIG. 5. Theatetus, Cassini, Lunar Alps, Piton, Kirch Crater, Piazzi Smyth.

must have been much larger and more effective in influencing the direction of the ridges of crumpling on the moon than the terrestrial tide now is upon the earth, not only because the earth has more than eighty-one times the mass of the moon, but also because the moon was then probably nearer to the earth than it is at present.

Leaving out of account the great lunar mountain chains which surround the Mare Imbrium, and which seem to be the dilapidated relics of a vast crater ring that once surrounded the plain, it is worthy of

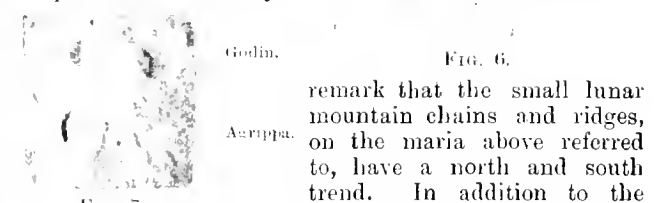


FIG. 6. Endoxus, Aristoteles, Godin, Acrippa.

remark that the small lunar mountain chains and ridges, on the maria above referred to, have a north and south trend. In addition to the Riphæan Mountains, the Kirch Mountains, and the ranges of hills to the south of Archimedes, I would refer the reader to the ridges shown in the

FIG. 7.

SOUTH

WEST

EAST



1. PHOTOGRAPH OF THE NORTH POLE OF THE MOON WHEN 242 HOURS OLD.

Taken by MM. PAILL and PROSPER HENRY with their 13-inch refractor, at the Paris Observatory, on the 28th May, 1890.
Enlarged 15 diameters from the image in the principal focus.

SOUTH

WEST

EAST



II.—PHOTOGRAPH OF THE NORTH POLE OF THE MOON WHEN 216 HOURS OLD.

Taken by MM. PAUL and PROSPER HENRY with their 13-inch refractor, at the Paris Observatory, on the 29th March, 1890
Enlarged 15 diameters from the image in the principal focus

photograph in the July number, the long ridge on the Mare Tranquillitatis stretching from near Ross (62) to near Sabine (65), and the ridge on the Mare Nectaris stretching northward from Beaumont (322); but it should be remembered that low-lying ridges on maria are more likely to be detected if they have a north and south trend than if they run east and west, because the shadows thrown by them as the sun rises will be more conspicuous if the ridge lies nearly parallel to the terminator or division between dawn and darkness upon the moon's surface.

Probably few readers will be inclined to consider that these inconspicuous ridges are the weathered relics of ancient mountain chains, which mark the lines of crumpling of the lunar crust, before the moon commenced to turn the same hemisphere constantly towards the earth. But they are worthy of close study, as they seem to differ

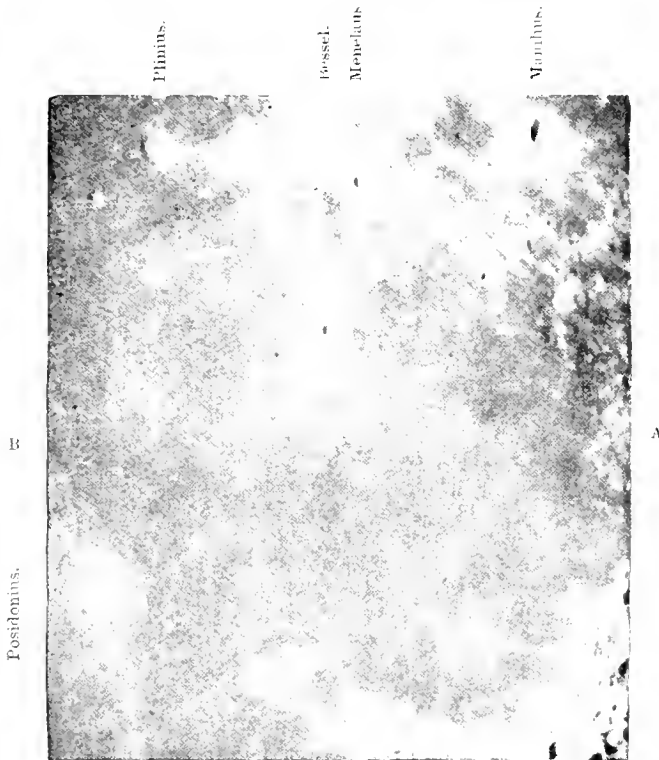


FIG. 8. The Mare Serenitatis.

in character from the more conspicuous volcanic features to which attention has hitherto been chiefly directed.

If, as seems probable, these mountain ridges were formed at a later period than the plains on which they stand, and if we may safely follow terrestrial analogies, these lunar ridges afford evidence that the moon has sensibly cooled and shrunk since the maria were formed; and they would lead us to conclude that the maria are probably composed of horizontally stratified rocks capable of being pressed or pushed into folds and ridges.

Such horizontal stratification does not necessarily imply the deposition of sediment on an ocean bottom, or water action. Horizontal strata might be composed of volcanic products, such as alternating beds of harder and softer lavas, volcanic mud and scoriae, but we should expect such beds to be thicker near to the volcanic vents from which they issued, forming a more or less steep or gently inclined cone, with possibly a crater and lake of lava over the throat of the volcano. If we conceive of the Mare Imbrium as representing the solidified surface

of such a vast lake of lava, we must be prepared to conceive of the existence of a lunar crater some 600 miles in diameter. But the Mare Nubium and Oceanus Procellarum are still more difficult to account for on such a theory, for they have no surrounding walls, and the one plain merges into the other without any line of demarcation. Volcanic mud might possibly have overflowed such an area, but it is difficult to conceive of a flood of lava hot enough and liquid enough to flow evenly over such an immense region; and in order to account for horizontal stratification we must conceive of more than one ebbing and flowing of the flood, without leaving a trace of a wall around its margin, or an indication of the position of the vent from which the flood issued.

Some may feel inclined to assume that these vast plains correspond to the lunar surface which was formed when the moon first solidified from the liquid state, but the circular form of most of the smaller maria, and the fact that some of them are surrounded or partly surrounded by walls, would lead to the conclusion that these level areas are due to some levelling action which has spread from a centre and levelled surrounding inequalities.

If the lunar rocks are similar to terrestrial rocks and lavas, it seems probable that the original lunar surface would not have solidified in horizontal strata, for, as Prof. G. F. Becker, of the United States Geological Survey, has shown, most lavas and terrestrial rocks expand on melting and contract on solidifying; so that if a crust formed on a liquid ocean of such material it would soon break up by its own weight and sink, bringing other hot material to the surface, which would again solidify and sink, causing a complete mixture until the whole was solidified, and thus, unless subsequent changes took place by water action or otherwise, the original surface would not be stratified.

The various tints of the lunar plains would lead us to conclude that they are not uniformly composed of the same material, or that some white or dark material has been distributed over their surface

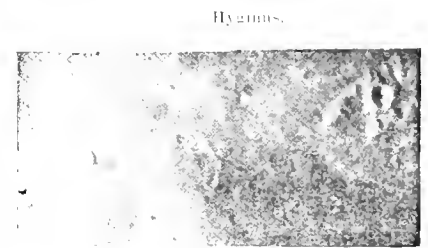


FIG. 9.

in patches. A careful study of the forms of these patches may possibly give us some clue to the action which has been going on. The darker parts of the maria probably correspond in tint to very dark terrestrial rocks, for the moon as a whole reflects less than a quarter (more accurately two-ninths) of the light which would be reflected to us by a sphere of snow. The maria correspond in area to nearly half the area of the visible lunar hemisphere, and the mountainous regions of the moon are not by any means all completely white. So that, assuming the whitest parts of the moon to correspond in their light-reflecting power (or albedo) to snow, the whole mountainous area probably reflects about a third of the light which would be reflected by snow, and the darker parts of the maria would probably reflect considerably less than a tenth of the light which would be

* Prof. Becker accounts for the apparently solid character of the material composing the body of the earth by supposing that it is solidified by pressure. Water, which expands on freezing, can by pressure be kept from solidifying, and similarly he concludes that lavas and slags, which expand in melting, can by pressure opposing their expansion be kept in their solid condition though at a temperature above their fusing point when not under pressure.

reflected by an equal area of snow. According to the measurements of Zollner, clay marl reflects 0.156 of the total light, and dark grey syenite 0.078, or about one-tenth of the light which is reflected by a surface of clean snow. Consequently, we may probably assume that the darkest parts of the maria correspond in tint to very dark lavas.

I would, in the first place, invite the reader's attention to the very curious dark stream which stretches southward from Piton (Fig. 5) on the Mare Imbrium. It is best seen on Plate II., but will be recognized on Plate I., and on both the plates in the December number of KNOWLEDGE for 1890. It stretches up towards the Crater Aristillus (Fig. 1), and branches into two streams about halfway between Piton and Aristillus. Judging from its appearance, it would seem to be a stream of dark material which has flowed from Piton. There can be no doubt about its existence. It is well shown on a photograph taken at the Lick Observatory, now in the Astronomical Society's Library, and on one taken by Dr. Henry Draper, as well as on a photograph taken by Mr. De la Rue.

Another curious dark marking springs from a broad base on the edge of the Mare Imbrium near to Plato, and stretches in a south-westerly direction towards the crater Piazzi Smyth (Fig. 5). This dark marking is best seen on Plate I., but it is also recognizable on Plate II., and on the plates in the December number for 1890, as well as on other photographs. It appears to be connected with other stream-like dark markings more to the eastward, which are traceable on Plate I. and also in the two photographs in the December number for 1890.

I would also invite the reader to study the dark parallel lines on the crater floor of Archimedes (Fig. 1) as shown in the plates, and the curiously contorted dark structure in the region between Archimedes and the lunar Apennines. The darkest part of this structure is near to the foothills of the Apennines. Its curiously contorted form, and especially its darkest portion near to the foothills, is visible in a great many otherwise inferior photographs.

It will be noticed that the upper or southern half of the Mare Serenitatis is brighter than the lower half, and in Plate II. it will be seen that the darker region has a fringe-like border dividing it from the brighter upper half (see A. B. Fig. 8). This might at first be taken for a photographic defect, but certainly some portions of the serrated division may be detected in other photographs. The bright streak which runs through the Mare Serenitatis in a northerly and southerly direction is recognizable in all photographs. It passes through the crater Bessel (Fig. 8), and seems to be a ray from the distant crater Tycho. The dark regions fringing the southern border of the Mare Serenitatis are also striking features—they seem to have sharply defined hard edges; there are also some curious very dark regions to the north of Hyginus (Fig. 9) which are well worthy of study.

Notices of Books.

Popular Astronomy.—We gladly welcome this new astronomical monthly periodical, edited by Prof. W. W. Payne and C. R. Willard, of the Goodsell Observatory, Northfield, Minnesota. The first number contains an excellent selection of short astronomical articles, brightly written in popular language, but nearly all of them containing something that will interest the advanced student of astronomy as well as the beginner. Prof. Daniel Kirkwood gives a most interesting article on "The Asteroids and their relation to the Planetary System," and Prof. Willow Upton an excellent introductory article

on "The Constellations and their History." But perhaps the most interesting of the contents of this first number is an article by Prof. Payne on "Jupiter's Comet Family," illustrated by a diagram showing the orbits of the nineteen members of the Jovian family, from Encke's comet down to Holmes' comet of 1892. The grouping of the aphelia in longitude about the autumnal equinox where Jupiter is moving most quickly through space, because he is then moving in his orbit approximately in the same direction as the sun and his family are moving through space, comes out very strikingly. If subsequent numbers keep up to the standard of the first, "Popular Astronomy" will form a very valuable addition to astronomical literature.

On Hail, by the Hon. Rollo Russell. (Stanford and Company, 1893.) A most valuable and interesting book, which brings together a mass of information with regard to hailstorms and hail. It is illustrated by two full-page photographs of enormous hailstones which fell at Richmond, Yorkshire, after the terrific hailstorm of the 8th July, 1893. It seems that hailstorms have always a cyclonic character. Raindrops, or aggregations of snow, seem to be carried into the central ascending current, which carries them upward, and at the same time the air is rarefied by the centrifugal action of the storm till it is reduced below the freezing temperature. As the frozen snow or drop increases in size, its gravity tends more and more to overcome the rising current, and it is carried upwards with slower and slower velocity, so that smaller drops are carried past it, and when nearly stationary it increases in diameter very rapidly by blending with smaller drops which come in contact with it. Ultimately it is carried out of the central parts of the tornado, and generally falls in the south-east quadrant of the cyclonic storm.

Science Notes.

Natural Science criticizes the language of the American biologist. The disease of speculation is growing in biology, but on this side of the Atlantic, though we may have *idioplasms* and *ids*, things really as unsubstantial as the gnomes who formerly presided over the segregation of minerals, we at any rate have nothing like "bioplastology," "phyloneponic," "paragerontic," and "metaneonic," in which to clothe our ignorance and dazzle the common man. Biology certainly displays a very unhealthy tendency just at present to accumulate theories and theoretical names in the place of recording and systematizing facts.

That familiar friend of the geological beginner, *Eozoon Canadense*, has at last received its *quies* and must figure nevermore in the category of once living things. Drs. Johnston Lavis and J. W. Gregory have found eozoon to perfection, stolon tubes and everything complete, in ejected blocks of metamorphosed limestone from Monte Somma, and so the last link in the chain of evidence to prove eozoon a merely mineral structure is completed. However, the Archæans were not lifeless, for Dr. Charles Barrois described Archæan Radiolaria as long ago as last year in the *Comptes Rendus*.

A red-hot wire of platinum has for many years past been used for cutting various organic substances, but it is stated in the *London Chemical News* that Mr. Warren has discovered a new use for this method and employs a wire heated by an electric current to saw the hardest kinds of wood. At first the wire would break, but he remedied this by using a steel core platinum-plated by a solution of platonic chloride in ether.

A remarkable increase (1200) in the number of cattle killed by wild beasts in India is noted in the recent report of the Chief Commissioner. This is due, according to Sir Anthony Macdonnell, to the increasing scarcity of deer in the jungle. The native huntsman, in bringing the increasing resources of civilization against the deer, is driving the tiger to trust to domesticated meat, whether he prefers it or not.

Dr. Crochley Clapham, with the help of statistics, would revolutionize our ideas of the "intellectual brow" altogether. The smaller your head, and the more prominent your occiput, the greater your sanity—at least the mad have, as a rule, good heavy frontal lobes. Insane heads, he also showed—and his statistics covered 1000 skulls—have a larger average size than sane.

The question of the systematic abstracting and indexing of scientific papers, to which we called attention in our August issue, is under consideration by a committee of the Royal Society. The need of the index is exemplified in the current issue of the *Philosophical Magazine*, where Lord Kelvin notes too late that his communication upon a piezo-electric pile repeats matter already published by the brothers Curie in the *Comptes Rendus* in 1881. But it will be very difficult to go behind the titles of papers, which frequently do not indicate a title of the matters referred to.

A remarkable mass of error, according to Dr. Hurst, has grown out of an incorrect figure of the Berlin specimen of that most ancient of all birds, the *Archæopteryx*. Apparently three claws are shown in the position occupied by the *ala spuria* and *manus* of a bird's wing, but it has not been noticed that the wing feathers could not have been attached to these, but must have been fastened to another digit, corresponding to the huge "ring finger" of a Pterosaur, and which is still buried in the rock upon which the cast lies. Yet, says Dr. Hurst, it is mainly upon this fact that the tracing of the ancestry of birds, not to the Pterosaurs but to the Deimosaur, rests.

LEXELL'S COMET AND THE QUESTION OF ITS POSSIBLE IDENTITY WITH COMET V, 1889.

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

THE first comet whose return was predicted did not fail to appear about the time at which it was expected. Not so, however, the second, which was discovered by Messier in Paris on the 11th of June, 1770, and calculated by Lexell to be moving in an elliptic orbit of small eccentricity, which it would require only about five and a half years to complete. About a fortnight after its discovery it approached the earth within a distance of only about six or seven times that of the moon, and it was visible for a few weeks to the naked eye. Its position at the return due in the winter of 1775 was calculated to be such that it could not on that occasion be visible; but it was expected that another return would take place in the summer of 1781, and that the comet would then again be conspicuous. This expectation failed of fulfilment, and the erring body was long known by the name of "Lexell's lost comet." Later investigations, however, particularly those of Le Verrier, have fully accounted for the failure, which was caused by the powerful perturbing influence of Jupiter. To that body we owe the comet's visibility in 1770, its orbit having been altered by an approach to the giant planet of our system in 1767. But a much closer approach in 1779 (which brought the comet within a distance from the

planet smaller than that of its fourth satellite) must have so changed the orbit again that the comet would not be visible to us at future returns, unless another approach to Jupiter should reverse the effect of this, and bring the wanderer once more within the reach of our vision, telescopic or otherwise. For more than a century at any rate this did not take place; but in 1889, on the 7th of July, Mr. Brooks, of the Smith Observatory, Geneva, New York, discovered a faint comet, which appeared to be revolving round the sun in an elliptic orbit, with a period of about seven years. Dr. Chandler's investigations showed that this body must have made a very near approach to Jupiter in 1886, so much so indeed as to be nearer that body than any of its satellites, excepting, perhaps, the new tiny one discovered by Prof. Barnard in 1892, which is distant from Jupiter's surface by less than the planet's diameter. The probability seemed on several accounts to be great that Brooks's comet of 1889 was identical with Lexell's of 1770, and that Jupiter in 1886 had reversed his work of 1779, and restored to us a sight of the long-lost wanderer. Such a view appeared probable, but it would seem that it must after all be abandoned. Dr. Poor, of the Johns Hopkins University, Baltimore, United States, has made a re-investigation of its motions, availing himself of the principle formulated by M. Tisserand, who succeeded the late Admiral Mouchez as Director of the Paris Observatory last year. This is, that whatever be the nature of the perturbations produced in the elements of the orbit of a comet by the attraction of a planet when the comet passes through the sphere of its activity, one function will remain practically unaltered. It is represented by the formula

$$n = \frac{1}{a} + \frac{2\sqrt{A}}{R} \sqrt{\rho \cos i},$$

where n is the function in question, a , ρ , and i are respectively the semi-axis major, the parameter, and the inclination of the comet's orbit, and A and R are the semi-axis major of the orbit of the disturbing planet, and its radius vector at the point of the comet's closest approach. Now, Dr. Poor has computed the value of n with those elements of Brooks's comet which correspond to the following four points of its path: 1st. March, 1884, the action of Jupiter insensible; 2nd. March 24.5, 1886, entrance into the sphere of activity; 3rd. October 26.5, 1886, exit from that sphere; 4th. September 30, 1889, the action of Jupiter again insensible. These values of n , thus computed, are respectively 0.5289, 0.5212, 0.5233, and 0.5291, showing the very small change produced by so close an approach to the planet as that which occurred in 1886. But the value of n for Lexell's comet amounts to only 0.4852. This seems to render its identity with Brooks's comet of 1889 exceedingly improbable, unless some considerable perturbation had been produced by proximity to another planet besides Jupiter, since the approach to that body in 1779. Saturn is the only other planet which could come into consideration in this respect, and Dr. Poor shows that the nearest approach made by the comet to it took place between 1881 and 1884, and that even then the two bodies did not come within five astronomical units of each other, so that the resulting perturbations were quite inappreciable. With the caution, however, of the true scientific mind, he forbears to express himself decidedly against the conjectured identity of Lexell's and Brooks's comets, but points out that the question may be definitely settled at the expected return of the latter in 1896. Meantime, he promises in another paper (those here referred to, I should remark, are contained in Nos. 302 and 303 of the *Astronomical Journal*) to give the results of an investigation of the path of

Brooks's comet (V., 1889), whilst it was in the immediate vicinity of Jupiter. This will include a discussion of the questions of the probability of the disruption of the comet, and of the possibility that a portion of it was drawn permanently into the Jovian system, becoming a species of satellite of that planet.

DUST AND ATMOSPHERIC PHENOMENA.

By Dr. J. G. McPHERSON, F.R.S.E.

(Lecturer on Meteorology in the University of St. Andrews.)

AT a recent meeting of the Royal Society of Edinburgh, Mr. John Aitken read a most interesting and important paper on "Dust and Atmospheric Phenomena." It was a continuation of the investigations made in 1889, which I abridged in these columns in October, 1890. During 1890 he went over the same ground under different atmospheric conditions. He first visited Hyeres, where by his famous instrument he counted 250,000 dust-particles in a cubic inch of the air, whereas on the former visit he counted only 12,000. He observed, however, that where there was least dust the air was very clear, whereas with the maximum of dust there was a very thick haze.

At Mentone, the number of dust-particles in the cubic inch was 13,000 when the wind was blowing from the mountains, but increased to 130,000 when the wind was blowing from the populous town, where the air was more polluted. At Bellagio the result was similar. With the smaller number the air was clear and brilliant, with scarcely any perceptible haze on the hills; but with the larger number there was a thick haze, the distant hills being quite invisible. After a series of observations there, with careful examination of the temperature by wet bulb as well as dry bulb thermometer, he came to the conclusion that the increase in the number of dust-particles accompanied by constant humidity is accompanied by a decrease in transparency; and that the increase in humidity is also accompanied by decrease in transparency if the number of dust-particles remains constant.

When Mr. Aitken first visited the Rigi Kulm, in Switzerland, the air was remarkably clear and brilliant, and the number of dust-particles per cubic inch never exceeded 33,000. On his second visit, in May, 1890, he counted no less than 166,000—about five times the number; this was accompanied by a thick haze, which rendered the lower Alps scarcely visible. The thickness was not due to humidity, for the wet bulb was depressed 10°, therefore the air was very dry; but it was due to the number of dust-particles suspended in the atmosphere. On looking down from the mountain to the valleys, the air was, some time before sunset, so thick that the lower slopes of Pilatus were scarcely to be detected. This was due to a thick haze between the observer and the mountains, as if a veil were hung between him and the distant scenery. The upper limit of the haze was well defined, and though the sky was cloudless, the sun looked like a harvest moon, and required no eagle's eye to keep fixed on it.

Next day there was a violent thunderstorm, which gave an opportunity of making observations at its different stages. At noon, when it was clear, the number of particles to the cubic inch was 66,000. At 6 p.m. the storm commenced, and 60,000 to the inch were registered; but in the middle of the storm he counted only 13,000. There was a heavy fall of hail at this time, and Mr. Aitken accounts for the diminution of dust-particles by the downrush of purer upper air, which displaced the contaminated lower air. For the year before, he observed

the same change during a heavy fall of rain on the Eiffel Tower, when the number per cubic inch was as low as 3000.

He next showed, from a reference to the general circulation of the wind over Switzerland during the periods of observation, that when the number of particles was small during his first visit the general air circulation was from the Alps; and, on the second visit, when the number was great, the movement of the air was from the inhabited parts. He also found that on the day of the storm the diminution of the number of particles was concurrent with a change in the direction of circulation, which brought pure air from the Alpine region, and it was when the pure air and the foul air began to mix that the storm broke.

But the most remarkable set of observations was made on the Lake of Lucerne. In the course of an hour there was an exceptional diminution in the number, which made him think that something had gone wrong with his instrument. At 3 p.m. he counted 171,000 in a cubic inch, at 3.45 the number was reduced to 28,000. During the interval the thermometer had risen from 71° to 75°, and the wet bulb depression varied from 11° to 19°. On looking about, he found that the direction of the wind had changed, bringing down the purer upper air to the place of observation. The rapid change in the direction of the lower current of air was caused by a south-west wind striking the face of the mountain, which was there nearly vertical. The bending downwards of the trees by the strong wind showed that it was coming from the upper air. At 4 p.m. the thermometer fell to 68°, and the wet bulb depression was 10°; he counted 204,000 particles in the cubic inch—a most remarkable result—but the old conditions were restored by the reversal of the wind.

Returning to Scotland, Mr. Aitken continued his observations at Ben Nevis and at Kingairloch, opposite Appin, Mr. Rankin using the instrument at the top of the mountain. These observations showed in general that on the Ben southerly, south-easterly, and easterly winds were more impregnated with dust-particles, sometimes containing 133,000 per cubic inch. Northerly winds brought pure air. The observations at Kingairloch showed a certain parallelism to those on the summit of the mountain. With a north-westerly wind the particles reached the low number of 300 per cubic inch, the lowest recorded at any low-level station.

The general deductions made by Mr. Aitken from his numerous observations during the two years are that air coming from inhabited districts is always impure; dust is carried by the wind to enormous distances; dust rises to the tops of mountains during the day; with much dust there is much haze; high humidity causes great thickness of the atmosphere if accompanied by a great amount of dust, whereas there is no evidence that humidity alone has any effect in producing thickness; there is generally a high amount of dust with high temperature, and a low amount of dust with low temperature, and a high amount of dust reduces the transparency of the air.

CURIOUS COCOONS.—I.

By E. A. BUTLER.

THOSE insects which, just before assuming their final form, pass into a limbless, inactive condition, or, in other words, become a chrysalis and undergo a complete metamorphosis, evidently need some special protection during this period of rest, when they are unable to look after their own interests. And the need is intensified by the fact that the period of pupation often lasts throughout the winter, so that the insect spends a larger proportion of its life in this helpless and

passive state than in a condition of activity. The means adopted to meet the need are varied, but the majority of cases may be grouped under two heads: either the insect buries itself in the ground, or, remaining above ground, envelopes itself in a silken covering or cocoon. While the former method, from the nature of the case, presents few peculiarities and calls for little remark, the latter is full of interest in consequence of the variety of form and the remarkable adaptations and contrivances which the cocoons exhibit; we therefore propose briefly to discuss the most interesting of these specimens of insect architecture which are to be met with in the woods, fields, and hedges of our own country. We naturally look to the Lepidoptera for our chief, though not for our only, examples; the most notably cocoon-constructing section of this order is the group called Bombyces, including the moths known in popular phraseology as "tigers," "ermine," "eggers," and "emperors."

But before referring to specific instances in detail, a few words are necessary as to the organ by which the material used in these constructions is produced. There is a pair of glands which are found only in the larvæ, and disappear in the adult insect, and in these the silk is secreted as a gummy substance. They are bent and coiled tubes, lying at the sides of the body, and they sometimes extend for a considerable distance from the head towards the tail. Their structure is similar to that of salivary glands, but they do not communicate with the mouth, and consequently the silk does not, as at first sight it appears to do, issue from the mouth. The ducts from the glands unite into a common canal, which opens upon a minute papilla a little below the mouth, and from this the secretion exudes. Though glutinous at first, it has the property of drying and hardening as soon as exposed to the air, thus losing its stickiness. In this, as well as in other respects, it differs from the silk of spiders, which is secreted by glands at the opposite end of the body, and which, as serving the purpose of a snare, remains more or less sticky after exposure.

The cocoons of different species vary in colour from white, through shades of yellow, brown, and grey, to almost black; but this is probably not entirely due to differences in the natural tint of the silk, but to processes it undergoes after having been spun, or to the admixture of foreign matter. The larva always forms its cocoon round itself, so that it is usually an entirely closed covering, with no indication of a way of entrance or exit. As it is most commonly constructed amongst twigs, dead leaves, etc., or in crevices and corners, and under ledges, a few threads are first run promiscuously among surrounding objects to serve as a sort of scaffolding or mooring, and then a much more compact structure is fashioned in the centre of these, so as closely to envelope the body of the spinner.

It is difficult to say what have been the influences that have determined the shape of the cocoon in each species; certainly neither the shape of the caterpillar nor that of the chrysalis is the factor of prime influence, since we find that caterpillars of similar shape make very different cocoons, while there are caterpillars of very dissimilar appearance which make cocoons more or less alike; and there seems no particular reason why a shape that suits one would not equally well suit another. Moreover, it sometimes happens, as with the emperor moth to be presently described, that the small end of the chrysalis lies in the big end of the cocoon, so that no attempt is made to secure what tailors would call a "good fit." The protection afforded by the enclosure of the pupa in a cocoon is not necessarily entirely in the direction of the

disappointment of insectivorous enemies—in fact, as to the extent to which this sort of protection may be necessary there is great lack of definite information, and whatever opinion may be formed will be more or less conjectural; we are not in a position to say exactly, from actual observation or experiment, what insectivorous animals would be glad to feed upon these pupæ, but are hauled in their desire by the presence of the cocoon. Besides this somewhat hypothetical advantage, however, there are the obvious benefits of the degree of fixity the cocoon gives to a body which, if lying free and loose on the ground, would be at the mercy of any disturbance in its surroundings, and of the shelter afforded by enclosure in a non-conducting and probably damp-proof medium amidst changing climatic conditions, especially when its use is required during the winter season. But there is abundant scope for inquiry in all these directions, and if any of our readers feel inclined to investigate the subject for themselves, they will doubtless be rewarded with discoveries.

Amongst the numerous cocoons formed by British insects none is more remarkable than that of the emperor moth (*Saturnia carpinii*) (Fig. 1). As a rule, cocoons are more or less oval in outline and of similar shape at each end, but in the present instance we have a pear-shaped or flask-shaped body, rounded and swollen at one end, and with a large circular opening at the other. A little distance below the opening a set of stout threads, almost like bristles, pass from the inner wall of the cocoon all round in an upward direction towards the centre of the opening, where they meet, thus closing the cocoon by a hollow, conical, brush-like partition, which effectually bars entrance from without, but admits of easy egress from within by merely pushing the threads on one side. Thus, by this very simple but exquisite contrivance, no obstacle is placed in the way of the exit of the moth when matured, although the precious contents of the chamber are during the long continuance of pupahood securely shut off from any would-be robber in the outer world.

The colour of these cocoons is variable; usually they are some shade of deep brown, but sometimes they become of a pale creamy white. It has been supposed by some naturalists that this difference is intentional, and that its object is to enable the cocoon to harmonize more completely with its surroundings, and so more effectually to elude notice. Many careful experiments have been made to determine this point, since if established it would be a more remarkable physiological fact than the change of colour in the surface layers of a caterpillar's skin, under the influence of external colours, to which we alluded some time ago. For we are not here dealing with a case of concealment brought about by the attachment of foreign objects of suitable colour selected from the surroundings, a case which would imply no more than a certain degree of intelligence and ingenuity on the part of the fabricator of the cocoon; nor is it an instance of the colour of the caterpillar itself being so modified as to correspond more closely to its surroundings; but it would be an instance of a living being retaining its own colour unchanged, but possessing the power of modifying the colour of its deep-seated secretions at will, or at any rate in response to external optical stimulus merely, notwithstanding that usually the act of secretion is one of the most unconscious



FIG. 1.—Cocoon of Emperor Moth, part of outer wall being removed at the top to show conical barrier of fibres.

and involuntary which take place in the life of an organism. The experiments did not lend much support to the hypothesis of protective coloration, but pointed strongly towards a different reason for the presence or absence of the dark brown colour.

By first enclosing single caterpillars which were about to spin in pockets made of various materials, some dark, others light, and, secondly, enclosing families of caterpillars in white and black muslin bags, abundantly supplied within with crumpled pieces of white and brown paper respectively, so as to make the surroundings as uniformly light or dark as possible, Mr. W. Bateson has shown that the colour of the cocoon is independent of that of the material on which it is built, for dark cocoons were attached both to dark and light substances indifferently, and *vice versa*. But it was observed that the more natural were the surroundings of the caterpillar, and the less it was interfered with at the close of its larval career, the greater was the tendency to form a dark cocoon, the light ones being made specially by those which had been removed from their food-plant. Continued association with the food-plant up to the time of transformation thus seemed necessary for the construction of cocoons of full colour. It was further observed that the caterpillars had the power of ejecting from the mouth a green liquid, which, apparently by a process of oxidation, became brown on exposure to the air: and that in all probability a similar fluid was voided from the hinder extremity of the alimentary canal. There were many indications, which we have not space here to detail, that it was this fluid, derived from the partially digested food, and ejected from the alimentary canal, which stained the cocoons and gave them their brown colour, and that when light cocoons were made, the caterpillars had probably already voided this fluid before their isolation, and therefore possessed no further store to stain the cocoon as soon as it should be made; or, by being removed too early from their food, failed to make the fluid, and were therefore unable to give the cocoon the usual layer of colouring. Thus the colour of the cocoon would seem to be dependent, not upon the predominant tint of the surroundings, but upon the condition of the caterpillar at the time it is made.

Of course it still remains an open question why this liquid should be poured out upon the cocoon at all, and in what way it may conduce to the well-being of the insect that its abode during its time of quiescence should be thus varnished. The colouring substance, though soluble in water at first, becomes incapable of being washed out when once the cocoon is stained, thus proving itself a fast colour. It is an obvious suggestion that this dyeing of the cocoon may have something to do with rendering it impervious to the rains of winter; but it is hardly safe to hazard such a conjecture, since other equally plausible suppositions might no doubt be made, which yet experiment might show to be untenable; it is better therefore to wait for the results of further experiments before coming to any definite conclusion. It should be remarked that there seems no particular need of further protection to the chrysalis than that which it already possesses in being enclosed within the very tough skin of the cocoon. Any insectivorous animals which might otherwise feel disposed to prey upon it would apparently be sufficiently kept at bay by this very unmanageable material, so that special efforts for the concealment of the besieged after the acquisition of so excellent a breastwork would seem to be only wasted energy.

The egger moths are so called because of the very compact, egg-like cocoons they make. The two species best known in this country are the oak-egger, a fine large

yellowish-brown moth which appears in summer time, and the small egger, a much smaller species of a reddish-brown colour tinged with ashy grey, which makes its *début* in mid-winter. The cocoons of both of these are very similar—parallel sided, and equally rounded at each end (Fig. 2). The silk is close and compact, and forms a parchment-like shell, thin but hard, and extremely smooth within: in each case it is an exceedingly close-fitting cell, which is not more than half the length of the caterpillar that makes it; hence it follows that, as the artificer is accommodated within during the whole of the time of construction, it finds itself very cramped for room as it turns about and carries its thread from side to side. The small egger, in some unaccountable way, always leaves a minute perforation in one side of its cocoon, an arrangement which its larger relative does not imitate. From this hard and compact shell the moth makes its escape



FIG. 2.—Cocoon of Oak Egger Moth.

by pushing off from one end an irregular piece, which looks as if it had been bitten round. When we remember, however, that the moth is entirely destitute of biting jaws of any kind, the real method of escape is seen to be a great puzzle, for the separation of this portion of the cocoon clearly implies the severance round its edges of the crossing and recrossing threads of which the cocoon is composed, and it is difficult to understand how that should be done without a biting or cutting instrument. Careful watching of the emerging moth is here of little use, for the cocoon is opaque, and the attack is made from within, and when we catch the first glimpse of the head of the newly-fledged insect issuing from the cocoon the deed is already done, and the escaping prisoner has kept its secret as effectually as Messrs. Maskelyne and Cooke in their escape from within their closely-corded box.

The problem has, however, recently been somewhat satisfactorily attacked in the case of a different insect, and one imprisoned, it might be imagined, more entirely beyond hope of escape than either of the above. The moth in question is the puss moth (*Dicranura rivula*), of whose extraordinary caterpillar we gave our readers a description some time ago (KNOWLEDGE, February, 1893). This creature selects a crevice in the bark of a tree, and excavating it into an oval hollow, roofs itself over on a level with the surrounding bark, with a layer of mixed silk and chewed bark, which closely imitates the colour and roughness of the true bark, so that often nothing less than the closest and most minute scrutiny avails for the discovery of the cocoon. This roof of mingled silk and sawdust does not reveal distinct threads, as has been the case with the other cocoons, but seems to be composed of one continuous mass: it becomes so hard and unyielding that the blade of a knife, unless very firmly pressed, slides off and makes no impression on it. This intensely hard roof completely covers in the dumpy brown chrysalis into which the brilliant caterpillar changes, and from this at the end of the following spring issues the large fluffy soft-bodied moth, with its whitish wings prettily pencilled with grey streaks, in a manner which recalls the markings of a tabby cat. In this case, as before, a portion of the hard shell is burst off just above the anterior end of the chrysalis, making a hole just large enough for the moth to squeeze itself out. Thus the problem is repeated, and with an added intensity: how can a soft-bodied creature, with no jaws or claws, work its way through a partition almost as hard as if it had been made of metal?

For the solution of the problem the analytical chemist

had to be appealed to, for the moth, not having sufficiently strong mechanical means to free itself from its prison, invokes the aid of chemistry. Mr. Oswald Lattier removed some pupæ from their cocoons shortly before their emergence, and wrapped each up in a piece of the thin blotting paper used by chemists for filtering solutions. Each, therefore, on becoming a moth, had to pierce the paper instead of its cocoon. As this took place, it was found that the paper was wetted at the spot of emergence, a stain being left behind when it dried. By using a number of these stained papers, enough of the material which composed the stains was procured to enable an analysis to be made. It was then found that the liquid, which was evidently poured out by the moth at the time of its emergence, was none other than that very well-known substance, caustic potash, renowned and widely used for its solvent powers. This was a very interesting discovery, for it had not previously been known that any animal secreted a caustic alkali; moreover, it was doubly interesting from the fact, to which we have previously referred, that the caterpillar of the same moth secretes a liquid of a chemically opposite character, viz., formic acid. The next step was to try whether the material of the cocoons was soluble in caustic potash. A few drops were placed on the inside of some cocoons, and in three minutes they were reduced to a pulp. Here, then, stood revealed the means by which the creature was able to effect a breach in its strong prison walls; it actually dissolved its way out by means of a caustic alkali.

But the explanation was not yet quite complete, for if the alkali were the only means of egress used, it seemed likely that there would result a general softening of a part of the wall of the cocoon, and a bursting out through that, rather than, as was really the case, the neat separation of a portion of the wall, the severed piece remaining as hard as the rest. The moth was found to make its exit wearing a sort of cap, consisting of the front part of the chrysalis shell, which fitted on to its head by means of little projections and sockets, and served as a shield, protecting the underlying parts from damage during the passage out. Close examination revealed just beneath this shield a couple of hard sharp points projecting from above the moth's mouth, and usually concealed by the fluff down around. These are the instruments by which the section is made, though they would be quite powerless if the silk were not first moistened and softened by the secretion. Thus the moth is most wonderfully armed for burrowing its way out; with a shield on its head, two diggers beneath, and a supply of alkali to overcome the resistance of the wall it has to penetrate.

When cocoons are attached to grass stems, they naturally tend to become shuttle-shaped; the stem runs up one side, and the ends of the cocoon taper away till they are reduced to the thickness of their support. Two very good instances of this are to be seen in the "drinker" moth and the family of burnet moths. The caterpillar of the "drinker" (*Obanestis potatoria*) is a hairy creature, with two extra long and close tufts of black hairs like horns, one at each end, and also with a number of short snow-white and deep yellow or orange tufts along the sides. It feeds on grasses, and has the habit, when disturbed, of dropping to the ground and rolling into a



FIG. 3.—Cocoon of Drinker Moth, on grass stem.

very compact ring. The moth is coloured something like the oak egger, but is not so large; nevertheless, the cocoon (Fig. 3) is a good deal larger. It is of a pale yellowish colour, leathery and flexible, and thus quite unlike those we have just been considering. It has a slightly irregular and crumpled appearance outside, but inside is smoother, although the individual silken threads can be much more distinctly traced here than outside, where the texture looks more irregular and matted. Some of the caterpillar's hairs are worked into the structure outside.

The burnet moths are extremely brilliant insects, which frequent grassy hill-sides and meadows, and delight to fly in the brightest sunshine. There are several kinds, but they are all narrow-winged moths, with long stout bodies; the forewings are of a brilliant metallic greenish-black, adorned with crimson spots, and the hind wings are rich crimson with a black border. The commonest species (*Zygana ulipendula*) has six crimson spots on the fore-wings, and is an abundant and well-known insect in suitable localities. The cocoons of these creatures are of a shining golden colour, thin and papery in consistence, but nevertheless harder and more unyielding than that of the "drinker," as well as much smaller. They are usually attached to grass stems, and three or four are sometimes placed on the same stem (Fig. 1), either one above the other or clustering round at the same level, and therefore more or less overlapping one another. Their bright colour and elevated position makes them very conspicuous objects. Occasionally the cocoons are constructed in other places, such as on fern fronds, thistle stems, or even stones, but the grass stem is the general rule—a rather curious association, since grass is not, as it is with the "drinker," the food-plant.

There is no difficulty in telling whether the insect is within or not, for when it escapes it leaves the front half of the empty chrysalis case sticking out of a hole in the cocoon, and the contrast between the black shell and the golden vase which supports it is very striking. This position is assumed by the chrysalis before the emergence of the moth, whence it is evident that, though limbless, it has the power of climbing; the means of doing this consist of rows of minute hooks on the segments of the abdomen, just as with the leaf-rollers we described on a former occasion. In this habit the burnets are quite unlike the other insects we have referred to, which, as they have no hooks and cannot climb, all leave their empty shell wholly inside the cocoon. Another difference is that the cocoon is simply burst open at the end, and no part of it is actually separated from the rest. But here again we find a resemblance to the "drinker," which does the same; and since in this case the chrysalis skin does not project, and the cocoon is scarcely damaged by the escaping moth, it is not an easy matter, except by the touch, to decide whether the cocoon is empty or full. Neither "drinker" nor burnets require the accommodation of the cocoon for more than a few weeks at the outside, and when once they are broken open and deserted, the weather soon makes them more and more dilapidated, and they are not long in going to ruin.

(To be continued.)



FIG. 4.—Four Cocoons of Burnet Moth, on grass stem, the empty chrysalis cases projecting.

THE FACE OF THE SKY FOR NOVEMBER.

By HERBERT SADLER, F.R.A.S.

SOLAR spots show but little diminution in number. Conveniently observable minima of Algol occur at 0h. 4m. A.M. on the 6th, 8h. 53m. P.M. on the 8th, 5h. 12m. P.M. on the 11th, and 9h. 35m. P.M. on the 25th.

Mercury is an evening star during the greater portion of the month in the technical sense of the term, but, owing to his proximity to the Sun and great southern declination, he is very badly placed for observation. On the 1st he sets at 5h. 8m. P.M., 36m. after sunset, with a southern declination of $23^{\circ} 10'$, and an apparent diameter of $6.0''$, $\frac{1}{10}$ ths of the disc being illuminated. On the 12th he sets at 4h. 57m. P.M., 11m. after sunset, with a southern declination of $24^{\circ} 13'$, and an apparent diameter of $7\frac{1}{2}''$, $\frac{1}{10}$ ths of the disc being illuminated. He is at his greatest eastern elongation (23°) on the 5th, and in inferior conjunction with the Sun on the 26th. After this he becomes a morning star, rising on the last day of the month at 6h. 58m. A.M., 16m. before sunrise, with a southern declination of $18^{\circ} 2'$, and an apparent diameter of $8\frac{1}{4}''$. During the month the planet describes a looped path in Libra and Scorpio.

Venus is an evening star, but, owing to her great southern declination, is also very badly placed for observation. She sets on the 1st at 6h. 21m. P.M., or 1h. 52m. after the Sun, with a southern declination of $25^{\circ} 55'$, and an apparent diameter of $17\frac{3}{4}''$, $\frac{3}{8}$ ths of the disc being illuminated, and her theoretical brightness being about one half of what it will be at the beginning of January, 1891. On the 16th she sets at 6h. 38m. P.M., or 2h. 28m. after the Sun, with a southern declination of $25^{\circ} 56'$, and an apparent diameter of $20''$, $\frac{1}{10}$ ths of the disc being illuminated. On the 30th she sets at 7h. 5m. P.M., or 3h. 11m. after the Sun, with a southern declination of $23^{\circ} 14'$, and an apparent diameter of $23\frac{1}{4}''$, $\frac{3}{10}$ ths of the disc being illuminated, and the theoretical brightness of the planet being about two-thirds of what it will be at the beginning of next January. During October Venus describes a direct path through the whole of Sagittarius on to the confines of Capricornus, being near λ Sagittarii on the evening of the 11th, σ Sagittarii on the 18th, and the wide pair, $h^1 h^2$, on the 25th.

Mars is, for the purposes of the amateur, invisible.

Jupiter is now a magnificent object in the evening sky, being visible all night long. He rises on the 1st at 5h. 16m. P.M., or three-quarters of an hour after sunset, with a northern declination of $18^{\circ} 15'$, and an apparent equatorial diameter of $17.9''$. On the 16th he rises at 1h. 10m. P.M., or about sunset, with a northern declination of $18^{\circ} 20'$, and an apparent equatorial diameter of $48.1''$. He is in opposition to the Sun on the 18th, at a distance from the earth of just 374 millions of miles. On the 30th he rises at 3h. 10m. P.M., with a northern declination of $17^{\circ} 55'$, and an apparent equatorial diameter of $48.0''$. During the month he describes a retrograde path in Taurus, to the south-west of the Pleiades. At about 7h. P.M. on the 29th a $9\frac{1}{2}$ magnitude star will be at about $20''$ distance from the planet's northern limb. 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 occultation reappearance of the first satellite at 7h. 28m. P.M. On the 3rd an eclipse reappearance of the third satellite at 6h. 46m. 21s. P.M.; an occultation disappearance of the same satellite at 6h. 52m. P.M., and its occultation reappearance at 8h. 1m. P.M. On the 4th an eclipse disappearance of the second satellite at 3h. 33m. 8s.

A.M. On the 5th an eclipse disappearance of the first satellite at 5h. 50m. 12s. A.M.; a transit ingress of the shadow of the second satellite at 9h. 50m. P.M., and of the satellite itself at 10h. 31m. P.M. On the 6th a transit egress of the shadow of the second satellite at 0h. 10m. A.M., and of the satellite itself at 0h. 46m. A.M.; a transit ingress of the first satellite at 3h. 7m. A.M.; a transit ingress of the satellite at 3h. 27m. A.M.; a transit egress of the shadow at 5h. 19m. A.M., and of the satellite at 5h. 38m. A.M. On the 7th an eclipse disappearance of the first satellite at 0h. 18m. 57s. A.M., and its reappearance from occultation at 2h. 46m. A.M.; an occultation reappearance of the second satellite at 7h. 48m. P.M.; a transit ingress of the shadow of the first satellite at 9h. 35m. P.M.; of the satellite at 9h. 52m. P.M.; a transit egress of the shadow at 11h. 47m. P.M. On the 8th a transit egress of the first satellite at 0h. 3m. A.M., an eclipse disappearance of the same satellite at 6h. 47m. 36s. P.M., and an occultation reappearance of the satellite at 9h. 12m. P.M. On the 9th a transit egress of the shadow of the first satellite at 6h. 16m. P.M., and of the satellite itself at 6h. 29m. P.M. On the 10th an eclipse disappearance of the third satellite at 9h. 9m. 30s. P.M.; an occultation reappearance of the same satellite at 11h. 21m. P.M. On the 11th an eclipse disappearance of the first satellite at 6h. 8m. 10s. A.M. On the 13th a transit ingress of the shadow of the second satellite at 0h. 27m. A.M.; of the satellite itself at 0h. 47m. A.M.; a transit egress of the shadow of the second satellite at 2h. 48m. A.M.; of the satellite itself at 3h. 2m. A.M.; a transit ingress of the shadow of the first satellite at 5h. 1m. A.M., and of the satellite itself nine minutes later. On the 14th an eclipse disappearance of the first satellite at 2h. 13m. 47s. A.M.; an occultation reappearance of the satellite at 1h. 30m. A.M.; an eclipse disappearance of the second satellite at 7h. 25m. 42s. P.M.; its reappearance from occultation at 9h. 52m. P.M.; a transit ingress of the shadow of the first satellite at 11h. 30m. P.M., and of the satellite itself at 11h. 36m. P.M. On the 15th a transit egress of the shadow of the first satellite at 1h. 42m. A.M.; of the satellite itself five minutes later; an eclipse disappearance of the first satellite at 8h. 42m. 29s. P.M., and its reappearance from occultation at 10h. 56m. P.M. On the 16th a transit ingress of the shadow of the first satellite at 5h. 58m. P.M.; of the satellite at 6h. 2m. P.M.; a transit egress of the shadow at 8h. 11m. P.M., and of the satellite at 8h. 13m. P.M. On the 18th an eclipse disappearance of the third satellite at 1h. 10m. 30s. A.M., and its reappearance at 2h. 43m. 21s. P.M. On the 20th a transit ingress of the second satellite at 3h. 2m. A.M.; of its shadow at 3h. 5m. A.M.; a transit egress of the satellite at 5h. 17m. A.M., and of its shadow at 5h. 25m. A.M. On the 21st an occultation disappearance of the first satellite at 4h. 3m. A.M., and its eclipse reappearance at 6h. 16m. 19s. A.M.; a transit egress of the shadow of the third satellite at 5h. 3m. P.M.; an occultation disappearance of the second satellite at 9h. 49m. P.M. On the 22nd an eclipse reappearance of the second satellite at 0h. 14m. 17s. A.M.; a transit ingress of the first satellite at 1h. 19m. A.M.; of its shadow at 1h. 24m. P.M.; a transit egress of the first satellite at 3h. 30m. A.M., and of its shadow at 3h. 37m. A.M.; an occultation disappearance of the first satellite at 10h. 29m. P.M. On the 23rd an eclipse reappearance of the first satellite at 0h. 15m. 32s. A.M.; a transit egress of the third satellite at 6h. 25m. P.M.; of its shadow at 6h. 44m. P.M.; a transit ingress of the first satellite at 7h. 15m. P.M.; of its shadow at 7h. 53m. P.M.; a transit egress of the first satellite at 9h. 56m. P.M., and of its shadow at 10h. 5m. P.M. On the 24th an occultation disappearance of the first satellite at

4h. 55m. p.m., and its eclipse reappearance at 7h. 14m. 22s. p.m. On the 25th an occultation disappearance of the third satellite at 1h. 34m. p.m. On the 27th a transit ingress of the second satellite at 5h. 17m. a.m., and of its shadow at 5h. 42m. a.m. On the 28th a transit ingress of the third satellite at 6h. 23m. p.m.; of its shadow at 7h. 16m. p.m.; a transit egress of the third satellite at 7h. 47m. p.m., and of its shadow at 9h. 5m. p.m. On the 29th an occultation disappearance of the second satellite at 0h. 2m. a.m.; its reappearance from eclipse at 2h. 50m. a.m.; a transit ingress of the first satellite at 3h. 2m. a.m., and of its shadow at 3h. 19m. a.m.; a transit egress of the satellite at 5h. 14m. a.m., and of its shadow at 5h. 31m. a.m. On the 30th an occultation disappearance of the first satellite at 0h. 13m. a.m., and its reappearance from eclipse at 2h. 40m. 45s. a.m.; a transit ingress of the second satellite at 6h. 25m. p.m.; of its shadow at 7h. 1m. p.m.; a transit egress of the satellite at 8h. 41m. p.m., and of its shadow at 9h. 22m. p.m.; a transit ingress of the first satellite at 9h. 28m. p.m., and of its shadow at 9h. 47m. p.m.; a transit egress of the satellite at 11h. 39m. p.m., and of its shadow at midnight. The following are the times of superior and inferior geocentric conjunctions of the fourth satellite with the centre of the planet:—Superior, November 7th, 11h. 42m. p.m., 24th, 1h. 14m. p.m.; Inferior, November 16th, 8h. 1m. a.m.

Saturn does not rise till 3h. 16m. a.m. on the last day of the month, and Uranus is in conjunction with the Sun on the 3rd.

Neptune is very well situated for observation, rising as he does on the 1st at 6h. 2m. p.m., with a northern declination of 20° 49'. On the 30th he rises at 4h. 5m. p.m., with a northern declination of 20° 43', and an apparent diameter of 2.7'. During the month he pursues a short retrograde path in Taurus, in a region barren of conspicuous stars.

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. p.m. The Andromedes occur on the 27th, the radiant point being in R.A. 1h. 40m., northern declination 43°.

The Moon is new at 0h. 57m. p.m. on the 8th; enters her first quarter at 5h. 45m. p.m. on the 16th; is full at 6h. 8m. p.m. on the 23rd; and enters her last quarter at 9h. 8m. a.m. on the 30th. She is in apogee at 1h. a.m. on the 12th (distance from the earth 252,330 miles); and in perigee at 2h. p.m. on the 24th (distance from the earth 222,310 miles).

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 12th of each month.

Solution of October Problem (G. K. Ansell):—

1. B to K2, and mates next move.

CORRECT SOLUTIONS received from Alpha, W. A. Champion, F. O. Lane, J. E. Gore, W. A. J. Pennett, H. S. Brandreth, W. Willby, A. E. Whitehouse, J. M. Robert, R. F. Arden, P. Henri, F. Glanville, and R. B. Cooke.

Humilis.—Pseudonym for Tomney duly recorded.

Alpha.—We shall regret the temporary loss of our most constant solver.

W. A. Champion.—Perfectly correct this time.

P. Edwards.—Mortimer's *Pocket Guide* is the best small

book on the openings (price 1s.). If you require a larger book, we should advise either Gossip's *Theory of the Chess Openings*, or Freeborough and Ranken's *Chess Openings*. We believe that the new edition of the latter work contains a treatise on "Odds."

Crossjar. The two mover "Ballymore," has no apparent solution. On the other hand, "Wood Green" has at least *three*, if that is any compensation. The enclosure mentioned was omitted, but the problems shall be kept in case you want them again.

Posuit ultimum lapidem.—Tu quoque turriculo lapidem extremum posuisti.

"KNOWLEDGE" PROBLEM TOURNEY.

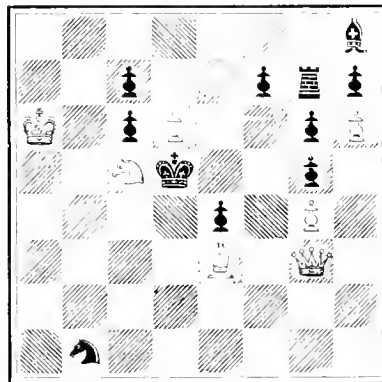
The following problems have been entered for this tourney:—"Sweetness and Purity, &c.," "Stella," "Bonne bouche," "Fortes fortuna juvat," "Cave coquum," "Pro virtute," "Lieblich sind uberstandene Muehen," "Invicta," "Morceau," "Nulli secundus," "I can't help your troubles," "Slender," "East Harling," "A Norseman's a Chess-piece," "Enrichetta," "La Retraite," "The Circle," "Posuit ultimum lapidem."

Three other positions have been reluctantly excluded in accordance with Rule 5, and have been returned to their respective composers. The order of publication—a not unimportant matter where solvers take part in the judging—will be decided by ballot. Three problems, as a rule, will be published in each number.

POSITION No. 1.

"Pro virtute."

BLACK (11).



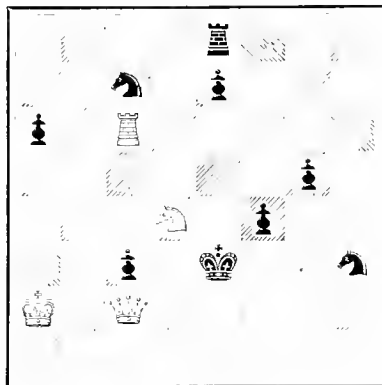
WHITE (7).

White mates in three moves.

POSITION No. 2.

"I can't help your troubles."

BLACK (9).



WHITE (6).

White mates in three moves.

SOLUTION TOURNEY.

Solutions, to be in time, must bear a post-mark not later than the 12th of the month in which the problems appear. They should be addressed to C. D. LOOCK, Burwash, Sussex. Key-moves and dual continuations (if any) alone need be given. It will obviously be unfair to publish any criticisms of problems during the progress of the tourney, but the Chess-Editor will be interested to receive them.

Marks will be awarded as follows:—For each correct key-move, three points; for each dual continuation (on the second move), one point. One point will be deducted for every incorrect claim. If a problem has no solution, "No solution" must be claimed. If a problem has more than one solution, duals will not score. "Short mates" take precedence of all others.

Should any problem be incorrectly printed it will be cancelled and republished.

Information as to the correctness of any diagram cannot be given. All diagrams must be assumed to be correct unless the number of pieces on any diagram disagrees with the number stated. In that case no notice need be taken of it.

Those solvers who intend to qualify for the "Coroner's Jury" (*vide* Rule 7), by solving every problem correctly, are particularly requested to keep a record of their impressions of each problem as it is published. Merits or defects, clearly visible at the time, are otherwise liable to be forgotten after an interval of six months. This hint is, of course, only necessary in the case of our less experienced solvers.

The following prettily played game is taken from the *Liverpool Mercury*. It was played in a recent match between Liverpool and Dublin.

ZUCKERTORT'S OPENING.

WHITE (A. Rutherford).	BLACK (A. S. Peaker).
1. Kt to KB3	1. P to Q4
2. P to Q4	2. Kt to KB3
3. P to K3	3. P to K3
4. P to QB4	4. P × P
5. B × P	5. P to QB4
6. Castles	6. B to K2
7. B to Q2	7. Castles
8. B to B3	8. Kt to K5
9. Q to QB2	9. Kt × B
10. Kt × Kt	10. P to QR3
11. QR to Qsq	11. Q to B2
12. B to Q3	12. P to KR3
13. Kt to Kt	13. Kt to Q2
14. P × P	14. P to KB1
15. Kt to Kt3	15. Q × P
16. B to Bt	16. K to Rsq
17. Q to Kt3	17. Q to Kt3
18. Kt to K5!	18. Q × Q
19. Kt to Kt6ch	19. K to Ktsq
20. B × Q	20. K to B2
21. Kt × B!	21. Kt to B1
22. Kt (B5) × B and wins	

CHESS INTELLIGENCE.

Mr. Lasker, after defeating Mr. Ettlinger of the Manhattan Chess Club by 5 games to 0, has entered for a tournament arranged in New York, for the benefit of those players who had intended to take part in the Columbian Chess Congress. The other competitors are M. Taubenhaus of Paris, Dr. Schmidt of Dresden, Herr Albin of Vienna,

Messrs. Jasnogrodsky, Lee, and Gossip of London, and Messrs. Delmar, Pollock, Showalter, Pillsbury, Olly, Ryan, and Major Hanham of the United States. Mr. Lasker won his first three games in fine style, and should be certain of the first prize. Mr. Lee also made a good start. The performance of Mr. Pillsbury, the winner of a brilliant consultation game against Steinitz, published in this column a few months ago, will be watched with great interest.

A match by correspondence is announced between Mr. Steinitz and the Liverpool Chess Club. Two games will be played, the time limit being one move a week.

Mr. C. E. Biaggini, the hon. sec. of the North London Chess Club, informs us that the club has recently changed its quarters. It now meets at the Amhurst Club, Amhurst Road, N., on Thursdays at 7.30.

The *Hackney Mercury* announces its eleventh Problem Tourney, for two-move and three-move direct mates. Composers are limited to one problem in each section. Entries to be made before March 1st, 1894.

The announcement of the match now in progress at St. Petersburg between Dr. Tarrasch of Nuremberg, and M. Tschigorin of Russia, came as a surprise to most chess-players. The negotiations were conducted in secret and the match commenced without delay early last month. Dr. Tarrasch won the first game, a *Ruy Lopez*, with the greatest ease in twenty-nine moves, his opponent going all to pieces in the middle game. In the second game Tschigorin met the French Defence in the strangest fashion, and had to remain strictly on the defensive for some thirty moves, while the German master pressed the attack on the Queen's side with great skill, and eventually won a Pawn. Tschigorin then obtained a counter-attack on the King's side, which his opponent treated with greater contempt than it deserved, the result being that the Russian, playing with great ingenuity, and aided by his adversary's neglect, succeeded in forcing a mating position on the forty-second move. M. Tschigorin won the third game in sixty-two moves, and lost the fourth in the same number. Dr. Tarrasch also won the fifth game in twenty-six moves. Probably few expected the Russian player to win two out of the first three games; and though Dr. Tarrasch certainly threw away the second game by over-confidence, it looks as if the match may be closer than was expected. The present score is: Tarrasch, 4; Tschigorin, 2; Drawn, 0.

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TERMS OF SUBSCRIPTION.

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ANTARCTIC SEALS.

By WILLIAM S. BRUCE,

Naturalist to the Antarctic Expedition, 1892—3.

AFTER a period of dormancy extending over more than half a century, the Antarctic is again being opened up to scientific investigation and to commerce. Scotland and Norway sent out five vessels last year, and Norway is again to the fore this year; New Zealand also is said to be eager to join the chase. It seems also likely that work of a more purely scientific nature will be undertaken in the Antarctic during the coming year. Some readers may, therefore, be interested to hear something about the southern seals, which differ very considerably from those of the north.

In the Antarctic only two of the great families of seals are represented: they are the sea-lions and sea-bears, or eared seals (*Otariidæ*), and the more specialized true seals (*Phocidæ*); the intermediate family of walruses (*Trichechidæ*) being entirely absent. In recognizing nine different species of *Otariidæ*, Mr. J. A. Allen divides the family into five species of sea-lions and four species of sea-bears, and three of these five sea-lions and three of the four sea-bears belong to southern seas. The true seals he divides into sixteen species, and five out of these sixteen species of true seals belong to southern seas. It is from the sea-bears of the *Otariidæ* family that ladies' sealskin jackets are made: the under skin, to which the long, rigid hairs are attached, is shaved off, and the long hairs fall out, leaving the upper skin with the soft under fur alone. The Falkland Islands'

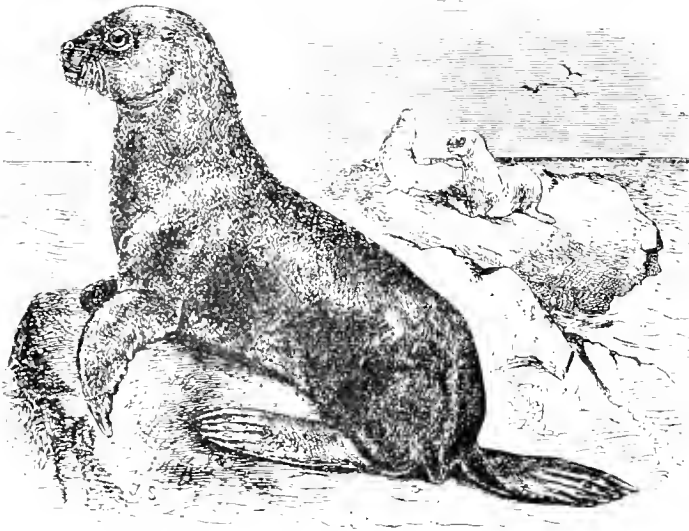
fur seal (*Arctocephalus falklandicus*) is noted, however, for the evenness, shortness and elasticity of the fur. The fur is soft enough to wear as a rich fur without the removal of the longer hairs, which are always removed in the other fur-seals. The skins of all other seals, whether sea lions or true seals, are used for making leather. The tens of thousands of seals that are slaughtered annually off Newfoundland and Greenland supply us with patent leather, and similarly the twenty to thirty thousand seals' hides that the Dundee whalers brought home from the Antarctic last spring will eventually be used for the same purpose. Crocodile leather, which we see in such vast quantities nowadays, is also said to be largely made from seals' skins. Besides skins, seals provide a great quantity of oil. During the recent trip to the south, the Dundee vessels secured from seven hundred to one thousand tons of seal oil; this is largely used in the jute manufactory for moistening the fibres, and this fact possibly accounts for Dundee not only being "Juteopolis" but also practically our only remaining sealing and whaling port. But now mineral oils, which are so cheap, are taking the place of animal oils in the jute factory as they have in other branches of industry, and the masters and owners of sealers and whalers are beginning to think it hardly worth while fishing seals and whales for oil alone.

Concerning the sea-bears, or fur-seals, and the sea-lions, or hair-seals, of the Antarctic very little is known. The former have an abundant soft, silky under fur, are black when young, and ultimately yellowish or whitish-grey colour; and the latter, the sea-lions, have no under fur, but only coarse, hard, stiff hair; they are yellowish or reddish-brown, dark when young, but become lighter as age advances. The groups generally live apart, but have the same geographical distribution. They are gregarious, polygamous, and the males are from three to five times as large as the females. They differ very markedly from true seals in having the power to turn their hind limbs forward, and thus use them for locomotion on land: the presence of a small external ear is another characteristic. Of the Alaskan seal herd, Mr. H. W. Elliott gives the following graphic description, which may be extended to the southern herds: "The fighting between the old males for the cows is mostly—or, rather, entirely—done with the mouth. The opponents seize one another with their teeth, and then, clenching their jaws, nothing but the sheer strength of the one, and the other tugging to escape, can shake them loose, and that effort invariably leaves an ugly wound, the sharp canines tearing out deep gutters in the skin and furrows in the blubber, or shredding the flippers into ribbon-strips.

"The bulls generally approach each other with comically averted heads, just as though they were ashamed of the rumpus which they are determined to precipitate. When they get near enough to reach one another, they enter upon the repetition of many feints or passes before either the one or the other takes the initiative by gripping. The heads are darted out and back as quick as a flash; their hoarse roaring and shrill piping whistle never cease, while their fat bodies writhe and swell with exertion and rage; furious lights gleam in their eyes; their hair flies off into the air, and their blood streams down. All this combined makes a picture so fierce and so strange that, from its unexpected position and its novelty, this is one of the most extraordinary brutal contests man can witness."

Mr. J. A. Allen has done much to simplify the classification, but the utmost confusion exists in most of the attempts made to classify them. Many attempt to divide them into a great many genera, but Mr. Beddard considers that if "the genus be split up at all it should be divided

into *Otaria*, containing only the Patagonian sea-lion (with its various synonyms) and *Arctoccephalus*, comprising all the other species." The latter have narrower and more pointed noses and longer ears, besides other anatomical differences. The most notable is the Patagonian sea-lion (*Otaria jubata*), which is represented by a living specimen in the gardens of the Zoological Society. Besides inhabiting Patagonia and the coasts of South America, this remarkable animal is also found in the Falklands. As is well known to frequenters of the Zoological Gardens, this animal in captivity becomes remarkably tame, and even shows great affection to those who attend to its wants. The Cape sea-lion (*Otaria pusilla*) inhabits the islands south of Africa. A living representative of this species is also to be seen at the



† The Patagonian Sea-Lion (*Otaria jubata*). From Selater, *Proc. Zool. Soc.*, 1866, p. 80.

Society's gardens, its pond being close to that of the public favourite; it is smaller than the Patagonian sea-lion, and is less familiar to the public. The Australian seas have also a representative. Strictly speaking, perhaps one should exclude most of the *Otariidae* from Antarctic fauna, but in a wide sense most of the localities above mentioned are spoken of as being within the sphere of the Antarctic regions. In places such as South Georgia, the South Shetlands, and the island of Mas-a-fuero, near Juan Fernandez, and other localities where these animals abounded, they now no longer exist, on account of the excessively greedy ravages of man.

Formerly there was an extensive fur-seal trade in South America and the Falkland Islands, in Australia, and in South Africa; but now there are so few seals in these localities that they are not worth hunting. In the Falkland Islands, however, it is pleasing to hear that the fur-seals are now increasing in numbers, the most rigid protection being enforced; but with no telegraphic communication, and with no railways in the islands, poachers are said often to be able to secure a considerable amount of booty and make off before the authorities are able to enforce the law. In islands lying within New Zealand or Tasmanian waters a close season has also recently been proclaimed.

The true seal-are represented by five species and two genera (*Albu*); they are the white Antarctic seal (*Stenohymenus carnophaga*), sometimes called the "crab-eater seal" (for what reason it is difficult to say); the sea-leopard seal (*Stenohymenus leptomyx*); Weddell's false sea-leopard

seal (*Stenohymenus Weddellii*); Ross's large-eyed seal (*Stenohymenus Rossii*); and, lastly, the monster seal known as the "sea-elephant seal" (*Cystophora elephantina*). Skulls, and in some cases complete skeletons, of most of these seals are exhibited in the British Museum, South Kensington, and the College of Surgeons' museum, as well as in some of the provincial museums; one or two stuffed specimens also occur.

Of these five species the first two, the white Antarctic seal and the large sea-leopard, are most abundant, being found in great numbers on the pack ice. The beautiful white Antarctic seal must surely be a descendant of Rudyard Kipling's great white seal, which roamed the world around to escape cruel and relentless man. Its coat is of a beautiful creamy white, resembling that of the polar bear, but short-haired, the colour becoming somewhat more intense along the back. Looking at the animal face to face, its coat appears silvery, and the dorsal stripe almost vanishes; but when looked at from behind it assumes a deeper cream colour, and the broad stripe along the back becomes quite prominent. The full-grown animal may attain a length of about seven feet. The sea-leopard is a very striking animal, and, with the exception of the sea-elephant, is the largest of all seals. In the recent Antarctic expedition (1892-3) some were met with that measured over thirteen feet in length. Their coat is a dark brown-grey and mottled, becoming paler grey below, and in some cases almost black on the back. A rather striking and not altogether inappropriate name was given to these seals by the sailors in the recent cruise; they called them "serpents," and they do really often look very serpent-like with their long necks and green eyes. Weddell's false sea-leopard is more rarely met with, and is nearly as large as the sea-leopard, but less shapely and more thickly blubbered; its head is smaller, fore flippers very small, coat more woolly and of a dark brown-grey. Ross's large-eyed seal is a beautiful creature, with bright and affectionate eyes; in form and size it is very like the white seal, but its coat is of a beautiful mottled grey, darker towards the back. The sea-elephant is the largest of all seals, attaining the enormous length of twenty feet. It is a near relative of the crested seal of the north, and is also found along the Californian coast. The male has a somewhat elongated snout, hence the origin of its name. The females are about one-third less in size. The males are said to come ashore on the Shetlands about the end of August and beginning of September, and in the first part of October are followed by the females. The males are very fat when they first arrive, but get lean towards the end of December, when they leave the islands. Another herd was said to visit the islands about the middle of January—when they renew their hair—and still another in March; by the end of April all returning to the sea. They are very difficult to kill, but, like the other species, allow themselves to be approached even with a club. This seal used to be highly valued for its blubber; in 1821 and 1822 alone as much as nine hundred and forty tons of sea-elephant oil was taken from the South Shetlands; and it may here be mentioned that during these same two years at least three hundred and twenty thousand fur-seals were also taken from these islands.

It was with the skins and blubber of the first two species of these true seals that the Scottish and Norwegian crafts loaded themselves last season. The slaughter was revolting to one unused to it: within two minutes the seal is brained, deprived of its skin, and its gory corpse left writhing on the snow. Early in the morning, when the sun is beginning to make more or less impression by his rays, and the seals are coming out of the water on to the

pack, all hands are ready to take part in the fray. The sails are stowed; the skipper sits in the crow's nest from early in the morning till late in the evening; the two



Sea-Leopards on pack ice.

engineers, relieving one another, take charge of the engines; the cook or the steward is on the look-out; some non-combatant takes the helm; all the rest are away after plunder in the boats. Now a full boat is making its way to the ship. She steams towards it. As she nears, the engines are stopped and the boat glides alongside. The cook or the steward rushes from the look-out, the helmsman from the wheel, one working the steam winch and the other unswitching the skins, while the boat's crew swallow a hasty meal. Their boat being unloaded, they are off again for another fill. Another boat is seen approaching, and away the ship goes again, dodging this piece of ice, charging that piece with her sturdy bows, boring away where the ice lies closely packed, rounding this berg, and on to the next, until she reaches the boat, which is down to the gunwale in the water, with its crew cautious, plying their oars as they lie crouched upon their bloody load. So it goes on from day to day; "hay is made while the sun shines," and the pile of skins and blubber rises high upon the ship's deck. Then comes a gale of wind, accompanied by fog, sleet and snow, and the ship "lays to" under lee of a stream of pack ice or a berg. The deck becomes busy with life; the blubber is "made off," and put into the tanks, and the skins are salted. During such inclement weather the seals do not seek the ice, but may be seen swimming about in the water. When the gale is over, at the end of two or three days, the next few days of calm weather are again taken advantage of to continue the slaughter. Thus the periods of gales and calms, which alternate in this part of the world, come in conveniently for sealing: the produce obtained in the calm weather being "made off" during the gales.

Concerning the habits and anatomy of these seals much remains to be investigated. During the summer months (December, January, February), as has already been stated above, the first four are to be found on the pack ice, where, during the day, they bask in the sun, digesting the meal of the previous night. Their food consists of fish or shrimp-like crustaceans, and sometimes of penguins. Stones, which were probably first swallowed by the penguins, may also be found in their stomachs. They become so lazy with sleep that a man may dig them in the ribs with the muzzle of his gun, and wondering what it is disturbing their slumbers they raise their head, which quickly falls pierced with a bullet. There may only be one seal on a piece of ice, which is usually the case with the sea-leopard seals, but the smaller kinds lie in half-dozens and tens, and as many as forty-seven were seen on one piece during the recent cruise. On one occasion several seals were found upon a tilted berg; so high was the lowest edge above the surface of the water that the boat's crew with difficulty clambered up and secured their prey. Yet the seals must

have made a leap from the water on to this their last resting place. December seems to be their mating season: about that time they are in very poor condition, and very much scarred. The females appear to be as freely scarred as the males. It was also noted that the seals were most numerous where the water was bluest and clearest: this in all probability, meaning that they were more numerous on the outside of the pack, since the muddy olive brown colour of the water, due to *corallion diatoms*, seen so frequently in the south polar seas, seems to indicate proximity to the main pack. The males appear to be as numerous as the females, and, in the case of the sea-leopard seal and Weddell's seal at least, the males are perhaps rather smaller than the females.

They move swiftly through the water, and can throw themselves eight or nine feet above the surface, covering distances of fully twenty feet. Their moaning in the gloaming of a calm grey day comes as a weird sound through the haze, and makes the icy solitude more lonely, adding awe to a scene already full of fascination! They seem to wonder at man, and not recognizing him as an enemy they allow him to approach, only to be laid low with club or bullet. It is a matter of great regret that they should be so indiscriminately massacred; there is no regard for sex or age, and even females heavy with young do not escape. If fleets of sealers continue to visit the south, there should be some law of protection, otherwise there is no doubt that, like the southern fur-seals at the beginning of the century, these Antarctic seals will be exterminated.

THE COFFIN OF THE BUILDER OF THE THIRD PYRAMID.

By F. W. READ.

THE coffin and bones of Menkaura, which stand near the entrance to the First Egyptian Room in the British Museum, have been for upwards of half a century exhibits of the greatest interest to students of the ancient world. They have recently, however, been invested with a new interest of quite another kind, by the supposed discovery of one of the younger generation of German Egyptologists. We are invited, in fact, to transfer the date of the coffin from the fourth to the twenty-sixth dynasty, a difference of from two thousand to three thousand years. But before entering upon an explanation of the new view, it may be well to give some slight account of the finding of these famous remains, and the opinions hitherto held in regard to them.

The three principal pyramids, which were built on a rocky plateau to the west of Memphis, are assigned by Herodotus to three successive monarchs named Cheops, Chephren, and Mykerinos. This is one of the few instances in which "the Father of History" seems to have lighted upon a genuine tradition. The building of those three gigantic pyramids marked an epoch in the history of the country, and must have profoundly impressed the imagination of the people; and this may perhaps account for the truth having reached the ignorant temple attendants from whom Herodotus appears to have derived his information. The three monarchs in question bore the native names of Khufu, Khafra, and Menkaura; and their succession is proved beyond doubt by the Egyptian monuments. First, by the inscriptions in certain tombs, which give us the names of the successive monarchs in whose reigns the occupants of the tombs lived. Secondly, by the lists of kings which the sovereigns of the new empire set up to the honour of their ancestors. The connection

of the monarchs with the pyramids is not very fully evidenced, as the walls of the chambers were left absolutely bare of inscriptions. But though there are no inscriptions, as ordinarily understood, the name of Khufu is found roughly scrawled on the walls of the so-called King's Chamber in the first pyramid. These, with various other scrawls, are supposed to be masons' marks, and may be accepted as sufficient evidence that the stones were hewn for the king whose name they bear. The third pyramid is connected with Menkaura by the coffin to be more particularly described later. It must also be remembered that the period during which the fourth, fifth, and sixth dynasties ruled was an age of pyramid building. This is amply evidenced by the fact that it was customary to write after the king's name that of his pyramid; and in this way it is established that Khufu, Khafra, and Menkaura did at least each build a pyramid, whether those ascribed to them by Herodotus or some others. Taking, then, all these facts together, each slight in itself, but the whole pointing to the same conclusion, we can hardly resist the inference that the story of Herodotus is a genuine Egyptian tradition.

But if we ask the date of the "Pyramid Kings," Herodotus is no longer a safe guide. He places the reigns of these monarchs almost immediately before that of Sabakos. This king, known to the monuments as Shabaka, was the founder of the twenty-fifth or Ethiopian dynasty, and the commencement of his reign may be fixed with a close approximation to the truth at *b.c.* 700. The whole of the available evidence, however, goes to show that the three chief pyramids were built during the fourth dynasty, the first of which any contemporary monuments exist. The date to be assigned to it has long been a matter of dispute. The chronology of Brugsch, which is accepted among Egyptologists generally as a convenient provisional scheme, fixes the reign of Khufu at *b.c.* 3733-3700. But there are many circumstances which render it excessively difficult to construct any satisfactory Egyptian chronology for the period prior to the expulsion of the Hyksos. The materials available are of three kinds: (1) the fragments of the historical work of Manetho; (2) certain lists of the old kings set up under the new empire; (3) contemporary monuments. A few words under each of these heads will enable the reader to understand generally the position of the question.

1. Manetho, who was a priest of Sebenmytus in the Delta, wrote his history under the Ptolemies. It was written in Greek, and presumably for the information of the conquerors. This work, having been written while the hieroglyphics were still intelligible to educated Egyptians, and being doubtless based chiefly on authentic temple records, must have been a most valuable guide to the main current of Egyptian history. Unfortunately for us, the original work has perished; there remain only distorted and mutilated fragments, a mere skeleton of names and figures from which the flesh has been ruthlessly torn. These bare catalogues of kings were drawn up by Africanus in the second, and by Eusebius in the fourth, century of our era. They also were destined to disappear, their only representatives at the present time being an Armenian version of Eusebius and the "Chronography" of George the Syncellus (about *A.D.* 800), which embodies the lists of both Africanus and Eusebius. A solitary quotation in Josephus, describing the Hyksos invasion, alone survives to tell us that the original Manetho was very different from that handed down by the epitomists. The lists, moreover, are hopelessly at variance in the lengths of the reigns assigned to the kings, and in several cases the evidence of the monuments shows them to be

false. To a very large extent, however, Manetho has been vindicated. In particular, the rule of the Hyksos conquerors, once doubted by Egyptologists, has been established by the gradual accumulation of a number of small fragments of evidence, the combined force of which is too great to be resisted. Still, the correctness of the lists is so far doubtful that no satisfactory chronology can be founded upon them.

2. Under the eighteenth and nineteenth dynasties (about *b.c.* 1700-1200) various lists of kings were set up in the temples and elsewhere. Their object was not historical but devotional; they belonged to that ancestor worship which was so important a part of the Egyptian religion. Hence it was not considered necessary to mention *every* king who had reigned, and no dates or lengths of reigns were inserted. The result is that the various lists differ greatly among themselves. The longest one, that of Seti I., at Abydos, shows seventy-five kings as having preceded him on the throne of Egypt. Yet even this list omits many whose reigns have been fully established by the monuments. Besides a number of others, it passes over all the kings between the twelfth and eighteenth dynasties, *i.e.*, not only the whole of the Hyksos rulers, who would certainly not be reckoned as ancestors by the race that had driven them from the throne, but at least one dynasty of native kings. So that these lists, useful as they are, can no more than Manetho give us an exact chronology.

3. Contemporary records are necessarily our most valuable material, and it is from them that modern Egyptologists have chiefly written the history of Ancient Egypt; but they are not sufficient for the construction of a chronology. They are mainly of two kinds: inscriptions made by order of the kings in commemoration of their exploits (these being chiefly found on the walls of temples), and those inscribed in the tombs of private persons. These latter are of special value in indicating the successive monarchs under whom the deceased and sometimes his ancestors served. They also frequently tell us of the great works, whether of peace or of war, in which he was engaged. These two classes of monuments taken together would afford a nearly perfect chronological system, had we a complete series of them. But in early Egyptian history there are several "dark periods," for which no contemporary monuments whatever have been found. Such portions of the history we only know from the Manethonian and monumental lists. But even if we had a series of contemporary monuments embracing every portion of the history, this would not make our chronology exact. If we find the thirtieth year of a king mentioned, we know that he must have reigned *at least* twenty-nine years, but we have no means of knowing how much longer he may have reigned. It so happens, however, that for the latest period of Egyptian history we have a series of monuments which not only fix the succession of the kings but the exact lengths of their reigns. These are the well-known Apis tablets. The bull Apis or Hapi was worshipped at Memphis from very early times as an incarnation of the god Ptah, the principal deity of the city. When one of the bulls died he was buried in a most magnificent manner in a specially-constructed vault, and tablets were set up to his memory. These tablets stated the date of his birth, of his enthronement at Memphis, and of his death; and, as all dates in Egypt were expressed in the regnal years of the monarch, it is plain that we have here a means of determining the lengths of the reigns of the kings mentioned. These tablets extend from the reign of Taharka (of the twenty-fifth dynasty) to the time of the Ptolemies, so that from about *b.c.* 700 we have a chronology which cannot vary more than four or five years from the truth.

Briefly, then, these are the materials from which Brugsch constructed his chronology. He accepted the great tablet of Abydos as affording the best list of kings for the period prior to Seti I.; assumed that on the average three kings would reign one hundred years; and allowed some five hundred years for the period between the twelfth and eighteenth dynasties, which the tablet of Abydos ignores. For the next period, *i.e.*, from Seti I. to the twenty-fifth dynasty, he gathered the succession from contemporary monuments, still counting three kings to the century; and thenceforward he adopted the absolute dates fixed by the Apis tablets. It is obvious, therefore, that the dates given by Brugsch for the earliest period (to which the "Pyramid Kings" belong) leave room for some error. This, however, could hardly amount to more than five hundred years, and even if we allow one thousand years, the "Pyramid Kings" may still claim an antiquity in comparison with which the earliest periods of Greek and Roman history appear modern.

Having now established, as far as the materials will allow, the kings to whose reigns the pyramids are to be assigned, and the place of those monarchs in the history of Egypt, we may pass to an account of the discovery of the coffin and sarcophagus of Menkaura, and finally to a consideration of the recent attack upon the authenticity of the former. In the year 1837 Colonel Howard Vyse made a thorough examination of the pyramids, and was fortunate enough to discover in the third a very beautiful basalt sarcophagus, a wooden coffin, and portions of a human body. If these latter are the remains of the original occupant of the coffin, they are of surpassing interest, as the oldest historical remnant of the body of a human being extant. There have not been wanting those who have denied their title to this description, and have supposed them to belong to some prowling Arab. There are two circumstances, however, which render such a view wholly untenable. Portions of the coffin and mummy were found together in a chamber adjoining that which contained the sarcophagus. It would appear that the Arabs had at some unknown period broken into the pyramid for purposes of plunder (as is their habit), and that, having taken the coffin and its contents out of the sarcophagus, they removed them to a larger chamber for more convenient examination. Here they broke open the coffin, and tore the mummy to pieces in their search for valuables. It does not seem otherwise possible to account for the fragments of the body and the coffin being so intimately associated. Another circumstance, apparently very little known, which was brought to the notice of the writer by a medical man, points in the same direction. The person whose remains were found in the pyramid suffered from ankylosis of the knee, and it is in the last degree unlikely that anyone with such a complaint would attempt to clamber about in a pyramid.

The sarcophagus, coffin, and mummy were shipped for conveyance to England, but the vessel was unfortunately wrecked off Gibraltar. The sarcophagus, owing to its weight, was lost beyond all hope of recovery; but a considerable portion of the mummy, and nearly the whole of the lid of the coffin were saved, and ultimately deposited in the British Museum. It is on this lid that the inscription occurs which leads us to assign the third pyramid to the reign of Menkaura. It runs as follows:—"Osiris, King of the North and South, Menkaura, living for ever! Heaven has produced thee; thou wast conceived by Nut; thou comest of the race of the god Seb. Thy mother Nut spreads herself over thee in her form of heavenly mystery. She grants that thou shalt be a god; never more shalt thou have enemies, O Menkaura, King of North and South.

living for ever!" (*Guide to the British Museum*, p. 102.) On the faith of this inscription, the coffin has been hitherto almost universally accepted as that in which the bones of Menkaura originally reposed. Egyptology, however, is no more than other sciences exempt from destructive criticism; and at last a man has arisen bold enough to dispute the antiquity of this cherished relic. In the *Zeitschrift für Ägyptische Sprache* of Leipzig there has recently appeared an article by Herr Kurt Sethe, in which he contends, chiefly on philological grounds, that the coffin must be assigned to the twenty-sixth dynasty. The argument cannot be fully explained without the use of hieroglyphics, but an attempt may be made to indicate its general character.

Let us take, for example, the first word of the inscription, "Osiris." This word, as written here, and commonly elsewhere, consists of three characters—a seat, an eye, and a bearded human figure. The seat and eye are phonetic, being pronounced respectively *uas* and *ar*, making together Usar, which the Greeks converted into Osiris. The bearded human figure is ideographic, and shows that the preceding signs constitute the name of a god. Now it is a singular fact, and quite contrary to what one would expect, that the early texts are very deficient in these ideographic signs, and this is markedly the case in the name of Osiris. Herr Sethe states that it cannot be found with such a sign till the middle of the fifth dynasty. This will serve as a sample of the argument, similar reasoning being applied to nearly every word in the inscription. Herr Sethe, however, does not deny that the third pyramid was built for Menkaura, or that he was buried in it. Taking his stand on the admitted fact that under the twenty-sixth dynasty there was a perfect rage for everything belonging to the fourth dynasty, he suggests that it was thought right to examine the tombs of those early kings and "restore" whatever was defective. Finding the coffin of Menkaura sadly decayed they made him a new one, putting on it the old inscription. This they wrote, not in the archaic manner, but as it was customarily written at the time. The conclusion is not so startling as if the coffin had been declared to be an out-and-out forgery; still, it is sufficiently striking to arouse the interest of all lovers of antiquity. A difference of from two thousand to three thousand years is not one to be lightly passed over.

The object of this article being simply to state a curious Egyptological problem in such a form that the non-Egyptologist can readily grasp the point at issue, it is beyond its scope to enter upon either an attack or defence of the new view. This will be an easier task when the "heresy" has been examined by the leaders of Egyptological thought.

CURIOUS COCOONS.—II.

By E. A. BUTLER.

WHEN once a moth has escaped from its cocoon there is generally no further use for the deserted shelter, and it is left to take its chance of wind and weather. But in one or two instances, at least, this rule does not hold good, and the vacated cocoon still serves a useful purpose in the economy of the insect. The vapourer moth (*Orania antiqua*), whose

* In his recently-published work on "The Mummy," Dr. Budge seems to rest the case for the antiquity of the coffin on the appearance of the wood, p. 298. It would be interesting to know how he distinguishes wood 5500 years old from that which is 3000 years younger. It is right to state that Dr. Budge is here replying to some obscure French writer, having been apparently unacquainted with Herr Sethe's more formidable attack. In a later portion of his work (p. 306), he mentions the latter's article, but without offering an opinion on the question at issue.

curiously tufted and tussocked caterpillar we alluded to on a former occasion, employs its old cocoon as a receptacle, or rather support, for its eggs. In every part of its economy this insect is an odd creature. It is one of those few Lepidoptera the females of which are practically wingless. The male insect is a lover of bright sunshine, and flies in search of its apterous and stay-at-home mate during the hottest parts of summer days. As it is an exceedingly common insect, and the caterpillar feeds upon a variety of shrubs which are amongst those cultivated by man, it makes itself quite at home in the gardens and squares of our large towns, and may often be observed gaily fluttering along the streets in the neighbourhood of its home. It is a modest little broad-winged, russet-coloured insect, with a crescent-shaped spot of white towards the outer and lower corner of each fore-wing, and with beautiful comb-like antennae. Its partner does not rely upon beauty as a recommendation, for she is one of the plainest-looking creatures imaginable, and it requires a stretch of charity to refrain from calling her positively ugly. She possesses the merest rudiments of wings, though, as she never uses them, she might as well have none at all. Her figure exhibits an excess of obesity which, to the human eye at least, is sufficiently repulsive, but apparently it has its attractions for her own kind, for the males will come long distances for the honour of becoming the possessors of her unwieldy frame. Her body is clothed with a thick covering of pale greyish hairs. She never leaves the cocoon which was the home of her pupahood, but waits upon it till the arrival of her accepted swain, after which she lays her eggs, scattering them over the surface of the cocoon, the greater part of which they are generally numerous enough to cover. This done, she dies.

The cocoon is loosely constructed; the silk is fine and glossy, but as many of the caterpillar's hairs are intermingled with it, the texture appears coarse and irregular, and the black brush-like hairs that belonged to the tufts at the sides of the neck and at the tail are sometimes conspicuous objects amongst the otherwise pale yellowish mass (Fig. 5). The cocoon is not a complete one, like

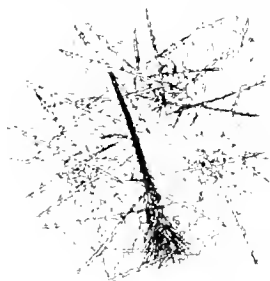


FIG. 5. Part of Cocoon of Vapourer Moth, showing one of the black brush-like hairs. Magnified six diameters.

most of those described in our last paper, but should rather be described as simply a web forming a roof arching over the chrysalis, the surface of a tree trunk or wall constituting the base of support, and occupying the whole of the other side. The chrysalis is of a deep brown colour, and, strange to say, is ornamented with tufts of hairs on its different segments, a feature which is, however, characteristic of the family. The scattering of the eggs over the web may, perhaps, in some way be connected with the unusual circumstance that the eggs do not

all hatch at the same time, but the young caterpillars continue to issue from them during a period of ten weeks, so that eggs, caterpillars, pupae, and perfect insects may all be met with at the same time during the summer. Another species, called the scarce vapourer moth (*Orgyia ynostigma*), a much less common insect, has similar habits.

It may be taken for granted that hairy caterpillars will, as a rule, intermix their hairs with their silk, thereby effecting a considerable saving of material; but this is not very different from saying that cocoons may generally be

expected to contain hairs, for it is chiefly, though not exclusively, hairy caterpillars that make cocoons, and the longer and more numerous the hairs with which the caterpillar is clothed, the larger will be the proportion they will bear to the silk in the construction of the cocoon. This is very manifest in the slight web formed by the garden tiger moth (*Arctia Caja*), whose caterpillar, popularly known as the "woolly bear," is the hairiest of a hairy family. The web is thin, and the dark hairs are extremely conspicuous. This is also true of the rest of the "tigers," belonging to the same genus, and of the "ermine," belonging to the genus *Spilosoma*, and the colour of the cocoon is, therefore, obviously determined largely by that of the caterpillar's hairs. Now it is clear that if an attempt were made to utilize the silk of such cocoons, the numerous hairs scattered amongst and clinging to the threads would become a serious inconvenience in the unwinding of the silk, even should the threads of the latter be sufficiently continuous to make such a procedure possible. It is fortunate, therefore, that the silkworm of commerce is not a hairy insect, for if it were, it would assuredly mingle its hairs with its silk, and thus render its cocoon useless for manufacturing purposes. The fact that it is hairy when first hatched, though it loses its hairs almost entirely at the first moult, seems to point either to an original adult hairiness when in a wild condition, or at least to its descent from hairy ancestors. As the present excellence of the silk is, no doubt, due to long domestication and careful selection, it is quite possible that a reversion to hairiness of body in the adult condition would be accompanied by a deterioration in the quality of the silk itself, quite apart from what would result from the admixture of hairs.

Amongst other curious lepidopterous cocoons may be mentioned that of the lackey moth (*Cistiocampa neustria*), yellowish white, and supplied, when first formed, with abundance of a pale yellow powder like flowers of sulphur; this is at first scattered through the silk, but gradually collects into the lowest corner, and soon after falls out altogether through the meshes.

The two beautiful moths called "green silver lines" (*Haliax*), whose fore-wings are of a delicate pale green with two or three white or yellowish lines drawn across them, make cocoons which are like an inverted boat. Passing to exotic insects, we find some very curious cocoons amongst the silk-producing Bombyces; one of the most extraordinary is that of the tusser silk moth. This is a large moth of a pale fawn colour, with transparent circular windows in the centre of its wings; it is a good deal reared in India for the sake of the silk obtained from its cocoon. The cocoon is oval, hard, and compact, without loose outlying threads, seeing that it is not anchored as usual, but is suspended at the end of a stout stalk, the further end of which forms a circular loop tightly fastened round some twig of the food-plant, so that the cocoon hangs from the bough like a kind of fruit (Fig. 6).

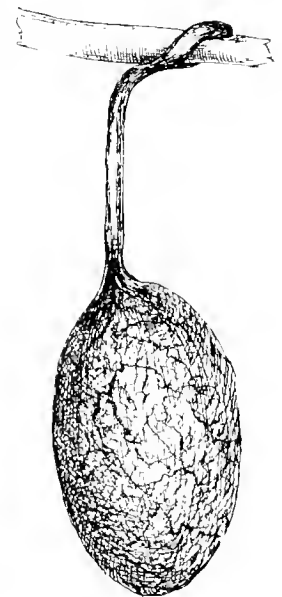


FIG. 6.—Cocoon of Tusser Silk Moth.

Our next illustrations will be taken from the order

Coleoptera, or beetles. Many of these insects feed upon plants, and amongst these vegetarian groups are several species that construct cocoons. Two of the most interesting instances may be mentioned, both taken from the beetles called weevils. A weevil may be easily recognized by the peculiar structure of its face; this is prolonged into a longer or shorter beak or snout, sometimes reminding one of an elephant's trunk, and carrying the mouth organs at the tip. *Hypera variabilis* is the name given to a brownish species which feeds upon various leguminous plants, and, while generally common, is sometimes found in absolute profusion. The grub of this creature, a short caterpillar-like being, covers its body with a sticky substance secreted by a gland placed at the tail. When it has eaten its destined amount of lucerne or other leguminous food, and reached its full size, it retires to the underside of a leaf, and begins to construct there, with this same sticky substance, a kind of oval cage consisting of a thin and open network of threads. Within this the little creature enters upon its pupal experience, remaining, of course, still visible from the outside through the meshes of the network. Few natural objects are more graceful and delicate than these little cages, which may often be seen attached to leaves. The construction of the cage is rather a slow business, occupying, although it is not a large structure and the network is but one layer thick, about twenty-four hours in completion. So delicate a structure would, no doubt, stand but little wear and tear, and would be a most imperfect shelter against climatic changes; but fortunately its durability is not greatly put to the test, for the perfect beetle is rapidly developed within, and issues after only a few days of captivity. The genus *Hypera* is a large one, containing sixteen British species, the habits of all of which are similar to those detailed above.

The other instance of beetle cocoons is that of the genus *Cionus*. Here we have half a dozen species of extremely pretty weevils, with large globular bodies, variously coloured, and always adorned with raised velvety patches, some of which are rectangular streaks and others circular discs. These beetles are specially attached to one order of plants, the *Scrophulariaceæ*, and particularly to those members of it called figworts (*Scrophularia*). The figworts grow in damp places in tall clusters; they may be known by their disagreeable odour, their succulent stems carrying opposite pairs of smooth, broad, rounded leaves with notched edges, and their bunches of small, deep red, cup-shaped flowers at the top. The flowers do not all open at the same time, so that often there may be seen on the same cluster buds, flowers, and seed-vessels. Sometimes the leaves of these plants are seen to be riddled with holes, as though someone had been making them a target for the discharge of small shot; the leaves are then more or less dry and brown. This damage is wrought by the larvæ of weevils belonging to the genus *Cionus*, and a little close inspection will usually reveal the beetles crouching down on the leaves; or failing this, if the eye be carried to the bunch of flowers, buds, and seed-vessels at the top of the stem, a still more careful scrutiny will probably detect a number of oval olive-brown bodies amongst the rounded buds and seed-vessels, and very closely resembling them in appearance (Fig. 7). These are the cocoons of the beetles, and though perfectly exposed, they are yet beautifully concealed by their resemblance to the fruitage of the plant. In many respects the economy of these insects is like that of the genus *Hypera*: there is the same sticky secretion on the larvæ, furnished by a gland at the tail, and as before it is worked up into an oval cocoon to enclose the pupa. But there is this difference: whereas the cocoon of *Hypera* is a network, that of *Cionus* is a continuous papery

layer without openings, so that the chrysalis is entirely hidden. The structure, in fact, reminds one of a child's air ball, and within it the chrysalis lies free, rattling against the sides when shaken. Within its balloon-like

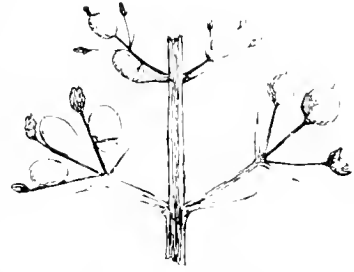


FIG. 7.—Part of Figwort Flower-head, with seed-vessels and cocoons of *Cionus scrophularia*.

covering the insect lies for about a week, when it casts its last skin, cuts nearly off a neat segment from the bottom of the cocoon, and crawls out through the hole. From the above it will be seen that these beetle cocoons are not strictly comparable with those of moths, inasmuch as the material of which they are composed is secreted, not by a gland opening beneath the mouth, but by one which opens upon the upper surface of the last segment of the body.

A third order of insects, the Hymenoptera, now claims our attention, for the habit of cocoon-forming is widely extended, and occurs amongst most of the groups of insects whose metamorphosis is complete. Our illustrations will be taken from the parasitic members of this extensive order, which go by the general name of ichneumon flies. They are long-legged, thin-bodied, four-winged insects, with long antennæ and very often with the body terminating in a longer or shorter stick-like ovipositor. Most of them are during their larvalhood internal parasites of other insects, their footless maggots living inside the bodies of caterpillars and other larvæ, and subsisting at the expense of the tissues of their hosts, whose ruin they thus achieve. Of these creatures, two extensive and well-defined families are recognized—the *Ichneumonidae* and the *Braconidae*. These two groups are very similar in general appearance, and certain members of the one family closely mimic certain of the other, so that a novice who did not know exactly what points to look for in endeavouring to distinguish them, would probably consider as identical two insects that would be in reality widely different, as would at once become evident if their whole life-histories could be simultaneously passed in review. But they may very easily be distinguished by paying attention to the arrangement of the nervures of the fore-wings. A comparison of the two wings in Fig. 8 will at once make this plain. In

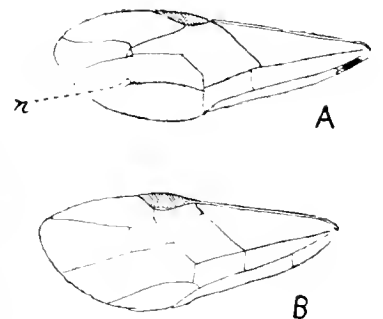


FIG. 8.—Fore-wings of (A) Ichneumonid, (B) Braconid.

both there is a dark spot, called the "stigma," more than half-way along the upper margin of the wing; in the Ichneumonid the space immediately beneath this forms a large cell of a more or less distinctly five-sided outline and with its lower and outer edge concave; in the Braconid the same space is occupied by three cells, each roughly four-sided. The little nervure marked *n* also is present in the one and absent in the other. There is endless diversity in the actual forms of these cells in the different genera, but the general plan remains much the

same, and will usually serve to distinguish a Braconid from an Ichneumonid pretty readily.

Both of these groups of parasites make cocoons, many of which closely resemble those of the Lepidoptera, except that they are, most of them, smaller. But as the larvae are naked maggots instead of hairy caterpillars, of course the cocoons are always composed purely of silk, and contain no hairs. As might be expected from the shape of the perfect insects, the cocoons are of a long, narrow form, equally rounded at each end; they are of all shades of colour, from the purest white to the deepest black. A large reddish-yellow Ichneumonid, *Paniscus testaceus* by name, which is very destructive to the puss moth, makes a thick, rough, dull blackish-brown cocoon. Except by those who rear the hosts, these cocoons are not likely to be seen, as they are to be found only inside the cocoon of the moth; for the parasite does not reach maturity till after its host has immured itself. Another ichneumon, strikingly like the last, and easily mistaken for it, though belonging to a different genus (*Ophion*), makes a totally different cocoon; it is much like those of the egger moths, only narrower—oval, yellowish-brown, and covered with a network of black threads. A species of Braconid (*Zele testaceator*), exceedingly like this again, though much less common, provides for itself a most elegant envelope of a satiny white appearance. Thus we have three species which superficially bear a close resemblance to one another, but which construct totally different cocoons. Some of the smaller kinds make very pretty cocoons; a little Ichneumonid parasitic on the weevil (*Hypera variabilis*), above described, makes a minute reddish-brown one with a neat white band round the middle (Fig. 9), and many others are similarly adorned.



FIG. 9. Banded and tailed Cocoons of Ichneumon Flies.

Many of these cocoons may be found amongst the herbage in woods, hedges, &c., though their small size of course necessitates a careful search; after the disclosure of the flies, they appear to last for some months, and may be found lying about amongst dead leaves and other rubbish.

Amongst Braconids, there is a large number of small species which are great scourges to the caterpillars of moths and butterflies; they live gregariously in their hosts, and when full fed they eat their way out, and construct their neat little white, buff, or yellow cocoons in clusters round and over the shrivelled remains of their victim. The caterpillar of the common white butterfly (*Pieris rapae*) may often be seen on walls, treated in this way, its crumpled and distorted carcass being almost hidden under a cluster of little oval silken spindles. One curious genus makes glossy brown cocoons, from one end of which a long, stout, and much-twisted anchoring thread proceeds, to the extent of some three or four times the length of the cocoon (Fig. 9); the method of its formation is not easy to understand. Some gregarious Braconids unite their cocoons together, deeply imbedding them in a common mass of silk which entirely conceals their outlines, and makes the whole look more like a single cocoon of a moderate-sized moth than a cluster of small ones. The possibility of such an association, of course, depends upon their all reaching the pupating stage at the same time; but there is no difficulty about this, for the eggs are all deposited in the host's body on the same occasion, and as the maggots are always completely surrounded by their food, the juices and tissues of their host, they all have equal chances of development, and therefore reach maturity together. The flies also emerge in company.

Science Notes.

Plate II. in the October number of KNOWLEDGE was made from a photograph of the photosphere taken by Dr. J. Janssen on the 10th of June, 1890. The sun's disc would have a diameter of 90 centimetres, or rather more than 35 inches on the scale of the plate.

De Morgan, in an interesting article in the *Philosophical Magazine* for April, 1848, on Thos. Wright "of Durham," attempts to show that Wright, whose theories of the Milky Way and Saturn's ring have recently attracted fresh attention, passed the greater part of his life in London, and not in the north of England. Amongst other proofs that Wright lived in London, De Morgan points out that he illustrated the dimensions of the solar system by comparisons with distances in the metropolis. Mr. R. A. Gregory has recently made a much more extended comparison of the same kind. He says: "If the dome of St. Paul's Cathedral is taken to represent the sun, Mercury is proportionately represented by a skittle-ball at Chancery Lane; Venus, by a globe rather less than one foot in diameter revolving at the distance of Charing Cross from the Cathedral dome; the earth, by a one-foot globe situated at Buckingham Palace; and the moon, a cricket ball circling round her at a distance of thirty feet. The radius of the orbit of Mars is represented by the distance from St. Paul's to South Kensington Museum, the planet itself being about the size of a small football. The minor planets are exemplified by small shot revolving at the distance of Hammersmith; Jupiter, by a globe eleven feet in diameter just beyond Richmond; Saturn, a nine-foot globe at Staines; Uranus, a four-foot globe at Reading; and Neptune, by a globe four and a half feet in diameter at Oxford. On this scale the nearest star has a distance of five hundred thousand miles.

Prof. Michelson's "Interference Refractometer," described in a recent number of *Astronomy and Astro-Physics*, is likely to prove of great use to spectroscopists. Among some twenty lines in the solar spectrum examined by it (though all appear to be simple lines when examined by the eye), the great majority proved to be highly complex. Thus, the red hydrogen line is a double, whose components have the intensity ratio seven to ten, and whose distance is about one-fiftieth of the interval between the sodium lines. Each component of the yellow sodium lines is a double, whose components have also the intensity ratio seven to ten, and whose distance apart is about one-hundredth of the distance between the principal components. Thallium gives a double line, whose components are in the ratio one to two, at a distance of about one-fiftieth of that of the sodium lines; while each component has a small companion, whose intensity is about one-fifth of that of the principal lines, at a distance of about one three-hundredth of that of the sodium lines. The green mercury line is made up of a group of five or six lines, the strongest of which is itself double (or perhaps triple), the distance of the components being less than one five-hundredth part of that between the sodium lines. These distances, small as they are, says Prof. Michelson, can be measured within about one-twentieth part, so that by this means it is possible to detect a change of wave-length corresponding to the ten-thousandth part of that between the two sodium lines.

SHOOTING STARS AND THEIR TRAILS.

By A. C. RANFORD.

ON any clear moonless night one never need wait many minutes to observe a meteor darting across the sky. Those most frequently seen appear and disappear almost before the eye has had time to note their colour and the direction of their motion; but occasionally larger meteors are observed which generally move more slowly across the heavens, and sometimes leave a luminous streak in their wake.

Prof. Max Wolf, of Heidelberg, has on several occasions succeeded in obtaining photographic traces of meteors which have appeared to the eye as large as stars of the first or second magnitude. The photograph which he has kindly sent for reproduction in this month's number of KNOWLEDGE shows two of such meteor tracks. They cannot both belong to the same meteor family, for their paths cross, and they therefore cannot have diverged from a common radiant area, as all meteors travelling parallel to one another in space appear to do.

The rich groups of meteors which the earth encounters at various times in the year do not appear to diverge accurately from a point in the heavens. Eye observations have shown that they diverge from a radiant region of sensible area: for though the meteors are, no doubt, moving absolutely parallel to one another before they meet the earth, they are slightly deflected from their original course after entering the earth's atmosphere, probably by reason of the irregular shapes of many of the meteoric masses, which causes them to skid on one side, as a stone or shell thrown into the sea is deflected by the resistance of the water. Sometimes meteor paths show a very sensible curvature, but in the case of eye observations there is always some difficulty in accurately noting small deviations from straightness.

Prof. Max Wolf's photographs enable us to detect the curvature of meteor paths with great precision. If a straight-edge be put against the smaller meteor track on our plate, viz., that which passes horizontally across the page, it will be seen that the path is decidedly convex towards the north, an effect which cannot be due to the distortion of the lens with which the photograph was taken; for, as will be seen by the distorted images of the stars which lie on the southern and eastern sides of our plate, it is an enlargement from only a part of the original negative, and the centre of the original negative was somewhere towards the top right-hand corner of our plate, where the images of the stars are round. Consequently, any distortion caused by the short-focussed photographic lens, with which the original negative was taken, would have given a still greater curvature to the other meteor track which passes diagonally across the page. The lenses which have been used for enlarging the picture had much longer foci, and the distortion caused by them may be neglected.

The meteor which has passed horizontally across the plate has drawn a clear sharp line of even thickness from side to side of the picture: but the larger meteor, which transited the field diagonally, has left a photographic trace which is decidedly thicker in some parts than in others, an appearance which was probably caused by differences of brightness at different parts of its path. The track of this larger meteor, when examined by a lens, is seen to break up, in some parts of its course, into knots or nuclei, separated by small intervals, as if the variations of brightness were very rapid.

It is difficult to conceive of such rapid alterations in the brightness in an ordinary incandescent solid such as

we are able to experiment upon in the laboratory, but in the case of a meteorite we have a cold body with an incandescent skin or film of boiling material on its surface, for the meteor has just arrived from the cold of space and is being heated by the vigorous bombardment of its surface. The sudden expansion of the surface material, or of the skin beneath the boiling film, must give rise to fierce strains, which, in the case of a large bolide, sometimes rend it with a fearful noise like loud thunder, which has been heard for a distance of fifty miles, although the explosion or rending of the stone has taken place in the thin upper air.

Probably under no other conditions is a stone subjected to such fierce strains as when it plunges with planetary velocity into an atmosphere and is rapidly heated from its outside. No doubt, a soft stone would quickly crumble to pieces on being subjected to such an ordeal, and with every fragment detached the surface of the moving mass would be increased, and the area of incandescent surface, and consequently the brightness of the meteor would be proportionately increased.

The uneven photographic trail of this little meteor tells an eloquent tale as to the rapidity with which the crumbling fragments from the moving mass are driven into vapour and lost to sight. In the case of larger meteors the moving body is sometimes surrounded by an envelope of incandescent vapour, many hundred yards, and sometimes several miles, in diameter. Thus a remarkable fire-ball, which was well observed in the south-west of England on the 6th of November, 1869, was during its passage through the air surrounded by a luminous cloud more than four miles in diameter. It first became visible in the air at a point about ninety miles vertically above Frome, in Somersetshire, and disappeared at a height of about twenty-seven miles above the sea near St. Ives, in Cornwall, having travelled a distance of one hundred and seventy miles in about five seconds, with an average velocity of about thirty-four miles a second. This meteor was entirely driven into vapour, and after the fire-ball had disappeared a luminous streak or cloud about fifty miles long and four miles in breadth remained visible against the sky for some fifty minutes.

The heat developed at the surface of a body moving through a gas is proportional to the square of the velocity of motion. A body moving with a velocity of about a mile a second would have its surface raised to a temperature of about red heat, and with a velocity of only ten miles a second the surface of the moving body would be raised to a temperature of white incandescence far above that necessary to melt and vaporize all known substances. As Prof. Young has remarked, the temperature of the surface of a moving body is independent of the density of the air through which it is moving: but the velocity lost and the quantity of heat developed in a given time is, of course, greater where the air is dense, and the quantity of air which strikes the surface of the moving body, and is rendered incandescent by the motion imparted to it, evidently increases with the density of the air through which the moving body is rushing.

It follows from this reasoning that the surface of a meteorite must be raised to its highest incandescence immediately it plunges into the thinnest layers of the upper atmosphere; but certainly, as a general rule, meteors increase in brightness the deeper they plunge into the earth's atmosphere. We are therefore forced to conclude that the light given by meteors is chiefly derived from the incandescent air and vapours surrounding them, and not from the incandescent surface of the solid mass, or the liquid film surrounding it, which is so rapidly boiling

away or being driven into vapour. A similar conclusion is also forced upon us by the fact that the larger meteors, though seen from a distance of eighty or one hundred miles, present a sensible diameter. They are frequently described as presenting a pear-shaped disc of half the diameter of the moon, and indeed many of the small meteoric masses which have been seen to fall have been described by observers at a distance as presenting a disc of greater diameter than the moon, though the meteorite itself would have appeared as a hardly visible speck, without sensible diameter, at the distances from which the fall has been observed.

How, then, can the breaking up of a meteorite, and the sudden exposure of a larger surface to molecular bombardment, cause it suddenly to increase in brightness? It is evident that the rate at which the energy of the moving mass is dissipated in the form of heat and light will depend on the amount of surface exposed to bombardment, and the smaller the fragments which are broken away the larger proportion of surface relatively to their mass will they present for bombardment; so that the smaller the fragments the more rapidly will they lose their energy of translation, and the more rapidly will they be driven into vapour, and the greater will be the intensity of the light radiated at a given instant.

Our photograph seems to prove that the vapour generated only retains its brilliant incandescence for a small fraction of a second, for by the blow of the meteor, the incandescent air, as well as the vapour generated, must have attained a rapid velocity in the same direction as the meteor; and if it remained incandescent for an appreciable fraction of a second, its photographic trace would be reduced to a uniform streak.

The facts disclosed by meteors seem sufficient answer to the query whether gaseous incandescence can be produced by the application of heat, though it is probable that electrical energy is developed during the rapid evaporation of the liquefied material of meteors. It is evident that the greater part of the light radiated is due to gaseous radiation which is consequent upon the rapid transformation of molar energy, that is, the energy of translation of the meteor, into the forms of molecular energy which are usually described as heat and heat effects.

Our second plate shows the interior of Dr. Max Wolf's Observatory at Heidelberg, with the little equatorial telescope and attached cameras with which he has obtained such valuable results.

THE SOLAR FACULÆ.

By MONSIEUR H. DESLANDRES, of the Paris Observatory.

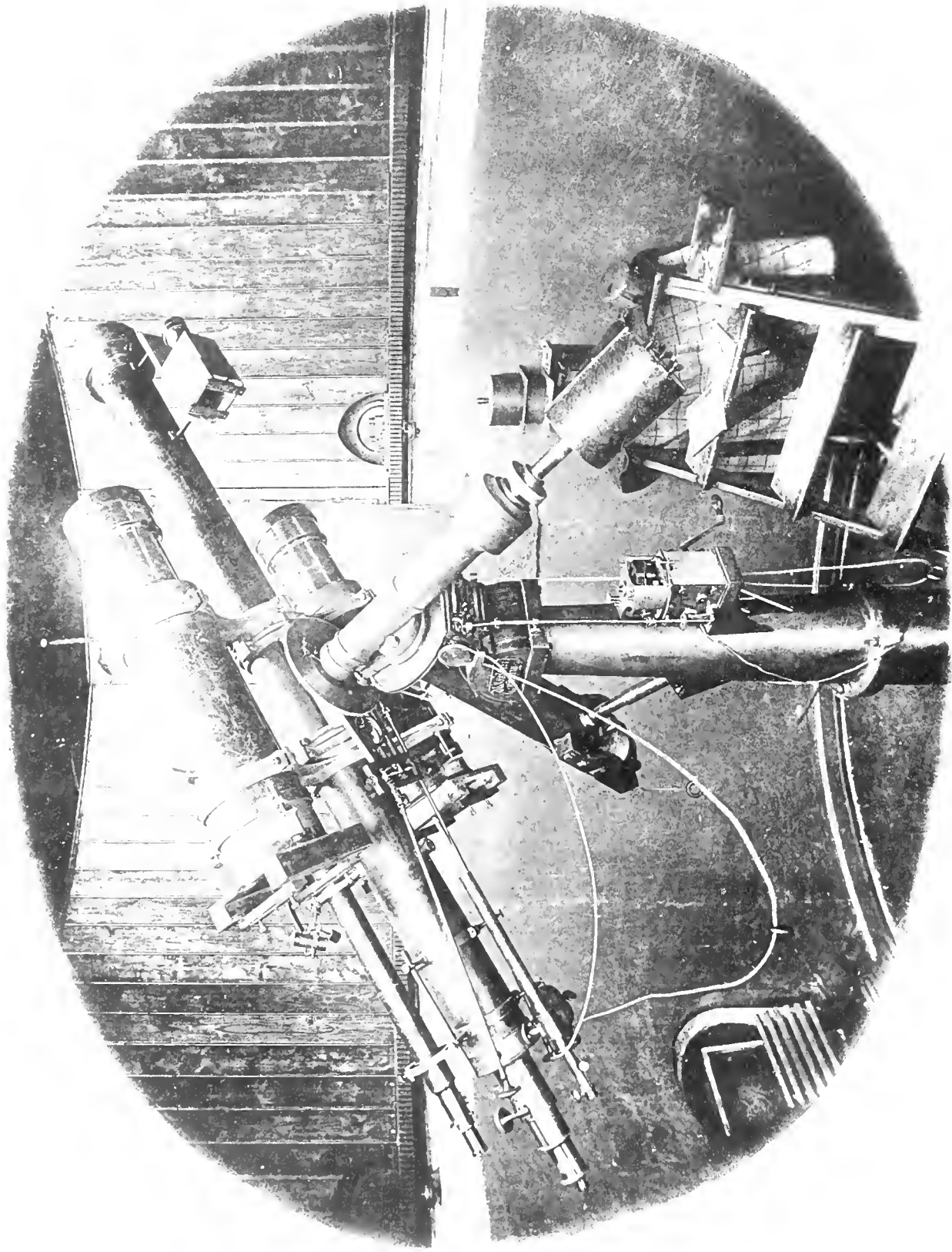
J'AI lu récemment et avec le plus vif intérêt l'article de Miss Clerke, "The Sun as a bright-line Star," publié dans votre numéro du mois d'août. Les nombreux ouvrages de Miss Clerke sont très appréciés en France, et j'ai admiré une fois de plus cet esprit philosophique qui saisit si bien les grandes lignes des questions et les liens généraux des phénomènes. J'ai suivi avec un intérêt égal la discussion ultérieure, à laquelle ont pris part MM. Ranyard, Maunder, Hale, Evershed, qui tous ont une grande autorité dans les questions spectroscopiques.

J'accepte volontiers l'offre que vous me faites de donner à mon tour, dans la discussion pendante, mon opinion personnelle, d'autant plus qu'elle paraît différer sur certains points des opinions déjà émises. En premier lieu, je désire appeler l'attention sur une confusion des faits et des mots

qui a jété un trouble réel dans la discussion, et qui consiste à considérer comme une seule et même chose les facules et les flammes gazeuses au-dessus de ces facules. Pour éclaircir ce point, je dois donner d'abord un aperçu rapide de mes propres recherches sur la question.

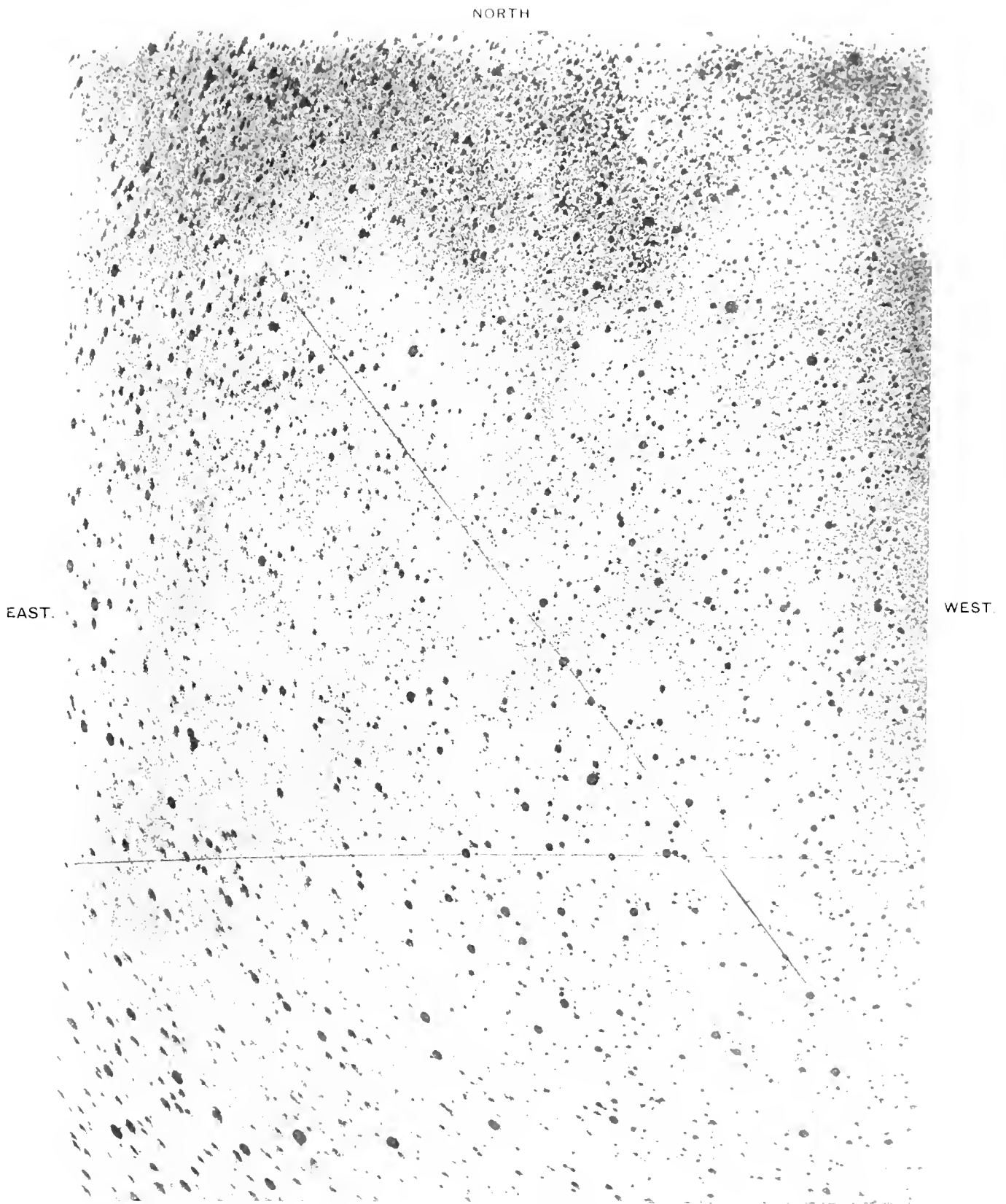
Dans le courant de 1891, j'ai étudié le spectre photographique des facules et taches solaires avec les spectroscopes les plus divers; j'ai employé le simple spectroscopie à un prisme aussi bien que les grands réseaux de Rowland. Or, dans le spectre des facules et des taches voilées de rose, on aperçoit au milieu des larges raies noires H et K une raie brillante de renversement, qui est simple avec une faible dispersion, mais se dédouble avec un instrument plus puissant, en montrant elle-même un renversement par une raie noire centrale. La raie brillante correspond à une flamme de calcium au-dessus de la facule. J'ai présenté ce résultat et cette interprétation le 8 Février 1892 à l'Académie de Paris, en annonçant qu'il assure la recherche des flammes se projetant sur le disque même du soleil, et en indiquant les spectroscopes enregistreurs à deux fentes pour l'étude des formes et des mouvements de ces flammes. A peu près au même moment, Monsieur Hale, dont les recherches sur ce sujet ont été parallèles, présentait les mêmes faits, mais sans leur donner la même interprétation et sans annoncer la raie noire de renversement.

A cette époque j'étudiais la distribution de ces flammes sur le disque solaire par des moyens bien simples. Mon châssis photographique était fixé à la chambre par une coulisse en bois, ainsi que dans les chambres polyposes ou à répétition de la photographie ordinaire. Je déplaçais à la main le soleil sur la fente fine du collimateur de quantités égales, et en même temps aussi la plaque, également à la main, le spectre étant limité à la raie K du calcium et à son voisinage immédiat. Ce dispositif simple donne à la fois la position et la forme générale des flammes et aussi leurs vitesses radiales, et les détails des renversements. Il m'a permis d'annoncer (le 14 Mars 1892) que les flammes formaient en avant et en arrière de la grande tache de Février une série continue, et constituaient un véritable anneau dans l'atmosphère solaire. Ce résultat est le premier fourni par la nouvelle méthode, qui ait été publié. De son côté, Monsieur Hale faisait mieux encore pour l'étude des formes en réalisant un spectroscopie enregistreur à deux fentes et à mouvement continu, appelé par lui spectro-héliographe, et qui donne en une seule épreuve les flammes du disque avec leurs formes exactes, sinon avec leurs intensités relatives. Il a reconnu plus nettement encore l'accord des formes données par l'ensemble des raies renversées avec les formes des facules, et a entrepris plusieurs travaux fort intéressants, auxquels je rends un juste hommage. Mais Monsieur Hale a présenté les images de son appareil comme fournies par les facules elles-mêmes, et il les appelle photographies de facules. Or je dois rappeler et maintenir ma première interprétation, qui est la seule admissible d'après les expériences bien connues sur le renversement. 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 au-dessus d'elles. Il n'y a pas d'ailleurs, comme l'écrit Monsieur Hale, identité entre les formes données par le spectro-héliographe et les formes des facules, mais seulement accord général des formes; et cela est tellement vrai que les flammes apparaissent souvent au-dessus des taches, qui sont justement le contraire des facules. D'après mes recherches, il est plus juste de dire que les facules sont comme un squelette sur



THE INTERIOR OF DR. MAX WOLFS OBSERVATORY AT HEIDELBERG.

Showing the guiding Telescope with three photographic Cameras attached



METEOR TRACES ON A PHOTOGRAPHIC PLATE OF THE REGION OF THE MILKY WAY ABOUT ξ CYGNI.

The photograph was taken by Dr. MAX WOLF, of Heidelberg, on the 7th September, 1891. It shows that one of the meteors varied irregularly in brightness in its passage through the air. The stars and nebulous matter of the Milky Way are shown as photographed, with an exposure of one hour, in the focus of a portrait lens of 2 $\frac{1}{2}$ inches aperture and 7.8 inches focal length. The plate is an enlargement from a part of the original negative.



lequel les flammes se fixent en le recouvrant. Je propose à Monsieur Hale et à toutes les personnes qui étudient ces questions, d'appeler ces renversements du calcium *flammes faculaires*, nom qui est en accord avec les faits, et évite toute ambiguïté.

Cette confusion a conduit en effet Miss Clerke à conclure que les facules sont beaucoup plus chaudes que la photosphère; mais, après les explications précédentes, cette conclusion de Miss Clerke ne s'applique plus aux facules, mais aux flammes faculaires. En fait, je pense, comme Monsieur Maunder, que la température des facules doit être plutôt un peu moindre que celle de la photosphère, ou tout au moins que celle des parties basses de la photosphère. Sur la terre, le sol dans la montagne est plus froid que dans la vallée voisine.

Mais qu'est-ce donc que la photosphère? La constitution indiquée par Monsieur Ranyard répond à tout, d'après moi, et explique toutes les particularités spectrales et autres. La photosphère est un nuage lumineux formé par des particules de métal fondu qui flottent dans un mélange de vapeurs. Le métal liquide a un grand pouvoir émissif et donne le spectre continu; la vapeur, dont le pouvoir émissif est faible mais le pouvoir absorbant considérable, donne les raies noires de Fraunhofer. La similitude du spectre au centre et au bord se conçoit aisément, de même aussi le réseau photosphérique de Monsieur Janssen, par de petites différences de condensation. La température du nuage solaire, ainsi que dans les nuages terrestres, est comprise entre le point de solidification du liquide et le point d'ébullition, qui varie beaucoup avec la pression, et donc doit dépendre de la masse et du volume de l'astre. Les différences d'éclat entre les étoiles sont ainsi explicables. (1)

Mais je reviens aux facules et à leur triple renversement, qui comprend une grosse raie noire, une raie brillante moins large, et une raie noire fine. Ce triple renversement, suivant l'expression même de Miss Clerke, indique une triple origine; il annonce trois états successifs différents de la vapeur dans le sens de la hauteur. Mais tout d'abord, la raie brillante est d'origine électrique. Elle se présente en effet avec les raies de l'hydrogène, qui sont brillantes dans les taches voilées de rose, et partiellement renversées dans les facules. Or, plusieurs observateurs, et Monsieur Fizeau en particulier, ont remarqué que les raies de l'hydrogène ne peuvent être obtenues que par l'intervention électrique. De même aussi, d'après les recherches de Monsieur Loekyer, confirmées récemment par Monsieur Hale, les raies H et K du calcium ne se montrent brillantes et fortes, ainsi que dans le soleil, que par l'illumination électrique.

Les deux autres raies noires du renversement triple peuvent avoir la même origine, mais les expériences du laboratoire ne permettent pas de conclure à cet égard. Les grandes différences de largeur de ces raies s'expliquent aisément. Ces raies du calcium et de l'hydrogène sont connues en effet comme ayant la propriété de s'élargir lorsque la pression et l'intensité électrique augmentent; à ce point de vue même, elles sont précieuses par les indications spéciales qu'elles fournissent sur l'état de la vapeur.

Cependant les flammes faculaires sont formées de calcium et d'hydrogène; elles ont la même composition que les protubérances; ce sont des protubérances se projetant sur le disque. Cette identité des protubérances et des facules, que conteste Monsieur Hale, n'est pas douteuse; toutes les observations oculaires et photographiques concourent à cette conclusion. Même l'analyse de la raie du calcium dans une protubérance permet de prévoir le renversement de la raie brillante dans la flamme faculaire.

(1) Ces différences dans l'absorption par l'atmosphère jouent aussi évidemment un rôle important.

La raie du calcium dans la protubérance a la forme en fer de lance; elle est large et intense à la base, mince et faible à la partie supérieure. Lorsque, par le fait de la rotation solaire, elle est vue dans le sens de sa hauteur, la partie basse de la raie, qui est la plus intense, donne la première impression, et la partie supérieure arrête la lumière du centre de la raie et donne la raie noire centrale. Et, en fait, le même temps de pose est nécessaire pour obtenir la base de la protubérance et la raie faculaire.

De plus, la base de la protubérance offre, quoique rarement, un déplacement dû à la vitesse dans le sens du rayon visuel; de même aussi la raie des flammes faculaires. La raie faculaire présente parfois seulement un très léger déplacement, ou une légère dissymétrie des deux parties brillantes. Ces déplacements, en particulier, sont une preuve nouvelle de la distinction réelle entre les facules et les flammes faculaires. En fin, l'observation journalière des bords est et ouest du soleil montre les facules succédant aux protubérances et les protubérances succédant aux facules.

La photographie de ces raies brillantes de renversement donne donc la base des protubérances. Mais les épreuves nombreuses du spectre de régions diverses du soleil faites avec une fente étroite du collimateur à Stonyhurst, Chicago, et Paris, indiquent que les raies du calcium, très nettes sur les belles facules, se montrent souvent aussi sur le disque presque entier, mais faibles, ou à peine perceptibles. Ces petits renversements correspondent aux petites protubérances et à la chromosphère elle-même. La photographie des flammes faite avec un appareil capable d'intégrer même les petits renversements donne l'image de la chromosphère telle que la verrait un œil sensible seulement au violet extrême, la photosphère étant enlevée. Tel est le résultat auquel conduit l'analyse exacte des faits. D'ailleurs une pose plus longue donne les parties hautes de la chromosphère et des protubérances qui dépassent les bords du soleil; et une pose encore plus longue donnerait les formes coronales, mais avec des dispositions spéciales (*Comptes Rendus*, Août 1891 et Mai 1893), si bien que la conclusion précédente s'applique d'une manière générale à l'atmosphère solaire toute entière. (2)

L'application de ces résultats aux étoiles, que j'ai indiquée avec ses conséquences (*Comptes Rendus*, Juillet 1892, Février 1893), et que Miss Clerke a développée dans son article, ouvre une voie d'investigation nouvelle et mérite une mention spéciale. Lorsque l'on étudie le soleil, comme une étoile, en recevant dans l'appareil la lumière de tous les points à la fois, on a parfois, au milieu des larges raies noires H et K, une très petite raie brillante renversée. Cette raie, dont l'existence a été vérifiée à Stonyhurst, représente l'intensité moyenne des flammes faculaires, et ses déplacements par rapport aux autres raies sont liés aux mouvements généraux des flammes par rapport à la terre. Elle apparaît bien avec un spectroscopie puissant et surtout une pose un peu longue. La recherche de raies similaires dans les étoiles serait à coup sûr longue et difficile, mais elle permettrait de reconnaître la nature, les variations, et peut-être aussi les mouvements généraux de la chromosphère dans les étoiles.

Postscriptum.—Je vous donne aussi comme un complément mes premiers résultats sur la photographie des flammes solaires, résultats qui sont à certains égards différents de ceux présentés par Monsieur Hale. J'ai reçu en effet récemment du ministère des crédits spéciaux pour la construction d'enregistreurs des flammes solaires,

(2) Ou tout au moins à la partie gazeuse de cette atmosphère, l'emploi d'une radiation autre que celle du calcium permettrait de distinguer les formes données par l'ensemble des particules qui fournissent le spectre continu de la couronne.

et j'ai fait cet été une série d'essais. Monsieur Hale, dans ses dernières comme dans ses premières publications, emploie pour la photographie des flammes par le système à deux fentes, la plus forte dispersion de son spectroscopie à réseau, soit le spectre de 4e ordre. Or la théorie et l'expérience me conduisent à la conclusion contraire; une dispersion très faible est bien préférable. Théoriquement, la netteté la meilleure et aussi l'intensité réelle des flammes sera obtenue lorsque la fente devant la plaque sera aussi écartée, aussi large que la fente du collimateur, et de plus contiendra toute la raie de la flamme, et nulle autre lumière. Ces conditions sont impossibles à réaliser exactement, mais on s'en approche d'autant mieux que les fentes sont plus fines et que la dispersion est plus faible. (3) Car la raie du calcium est de facile expansion; avec une forte dispersion, une fente fine ne reçoit qu'une partie de la raie qui est trop large ou déplacée, ou même ne reçoit que la raie noire centrale. On est alors obligé d'ouvrir la fente et de compromettre la netteté des images. (4) Les photographies de Monsieur Hale sont très belles; mais pour augmenter encore les détails, Monsieur Hale réclame un objectif plus grand donnant une plus grande image du soleil sur la fente du collimateur; il convient tout d'abord de tirer le meilleur parti possible des appareils existants. Pour ma part, j'ai obtenu cet été des photographies de la chromosphère donnant tous les détails des flammes avec un sidérostat, un miroir de six pouces, et un spectroscopie à un seul prisme donnant un écartement de H et K de 2 millimètres; l'image de la seconde fente était grossie trois fois—un grossissement plus grand aurait été encore meilleur. (5) L'image finale est circulaire, le diamètre étant de 0.06 à 0.07 centimètres.

Mais la photographie des formes des flammes n'est pas suffisante. La solution complète, ainsi que je l'ai réclamé déjà en 1891, comporte l'enregistrement des vitesses radiales et des détails des renversements (6) par des sections successives équidistantes dans l'image du soleil.

Mais, pour ce cas nouveau une grande dispersion est nécessaire. J'emploie donc à la fois deux spectroscopes, l'un de faible dispersion pour l'enregistrement des formes, l'autre de grande dispersion pour les vitesses radiales. Les deux spectroscopes sont côte à côte, et analysent ensemble une même image du soleil, fournie par un seul objectif. Ils marchent ensemble (dans les deux sens) à la même vitesse moyenne, celui des formes avec mouvement continu uniforme, celui des vitesses avec un mouvement uniformément variable. L'appareil résultant enregistre simultanément, et d'une manière continue, les formes et les mouvements des flammes de l'atmosphère solaire.

[Perhaps I may be allowed to follow the example of Monsieur Deslandres, and commence by criticizing the

(3) On est arrêté dans cette direction par les inconvénients des fentes très fines et des poses très longues. Les fentes doivent en effet toujours être plus petites que la grosse raie noire, qui est encore large d'ailleurs avec les petits spectroscopes ordinaires de laboratoire.

(4) Dans le dispositif adopté par Monsieur Hale, le spectroscopie est fixé et les deux fentes mobiles; ce qui exige un élargissement supplémentaire de la fente devant la plaque. Ce dispositif, malgré les avantages qu'il présente au point de vue mécanique, doit donc être écarté.

(5) Ces photographies ont été faites avec le concours de mon assistant, Monsieur Mittau.

(6) La raie noire centrale a une largeur variable, qui dépend en grande partie de la pression et donc de la hauteur à laquelle se produit le renversement. Si, dans ces photographies par sections successives on finit par une courbe les points ayant la même largeur de la raie centrale, on obtient des courbes malogues aux courbes de niveau des cartes topographiques.

use of certain terms which seem to tend to confusion. M. Deslandres uses the words "flammes gazeuses" for the gaseous forms which we in England now generally speak of as solar prominences. Some thirty years ago prominences were very frequently spoken of in England as solar flames, but the term, which seems to imply chemical action, has now dropped out of use with English writers, because it tends to beg the important question whether chemical changes producing light and heat are going on upon the sun.

M. Deslandres also speaks of *l'atmosphère solaire*; but the word "atmosphère" implies a gaseous envelope in which one layer rests upon and compresses the layer immediately below it—a condition of equilibrium which the facts at our disposal, as to solar temperatures and the intensity of solar gravity, preclude us from supposing exists upon the sun above the level of the photosphere.

I cannot concur with M. Deslandres in regarding it as proved that hydrogen can only be made to shine by means of electricity. There is a tendency to take refuge in electrical assumptions whenever we find ourselves confronted by facts we cannot readily explain. Iodine vapour can be made incandescent by the application of heat, and why should we, with our small experience, obtained in terrestrial laboratories, assume that other vapours cannot also be made to shine by the application of sufficient heat?

It seems to me that the differences between the spectra of prominences, as seen at the sun's limb and when looked down upon as facule on the sun's disc, are probably due to the rate at which the temperature increases on entering the gaseous mass. According to the theory of exchanges as ordinarily stated, it is difficult to conceive how any gaseous mass can emit a bright-line spectrum, for the outer envelopes of a gaseous mass will always be cooler than its interior, and the cooler gas ought to absorb the radiations emitted by similar gas at a higher temperature; but as a matter of fact such hot streams of gas do give a brilliant bright-line spectrum. But when the same streams are seen upon the bright background of the photosphere, and the line of sight passes through the cooled vapour which forms the head of the prominence, we, in the case of calcium vapour, see a broad band of absorption, on which are two bright lines, separated by a dark interval. But I had better leave the further discussion of this interesting question to Prof. Hale, who will, I hope, put the facts more clearly than I can in the January number of KNOWLEDGE.—A. C. RANVARD.]

Letters.

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

To the Editor of KNOWLEDGE.

DEAR SIR,—As there seems to have been some misapprehension regarding my use of the word "layer" in a letter published in the October number of KNOWLEDGE, I beg permission to define my meaning more clearly. In referring to a "layer" of comparatively cool calcium vapour which exists above the photospheric level, and causes by its absorption the reversal of the bright H and K lines of the facule, I did not mean it to be inferred that the absorbing vapour is in a condition of static equilibrium, or that it is of uniform depth. I agree with you that it seems much more probable that the vapour is constantly in motion, and is not in the condition of an atmosphere.

It is certain that the bright regions on the sun's disc photographed with the spectro-heliograph do not in all

respects agree with the faculae which are visible to the eye when near the sun's limb. In many cases small spots, which are clearly visible to the eye in direct observation or in photographs taken at the focus of a telescope in the ordinary manner, are completely hidden in spectro-heliograms by bright patches in which H and K are reversed. Hitherto the name "facula" has been applied indifferently to the visible and invisible phenomena, but it seems desirable that a distinction be made. The true faculae give a continuous spectrum in addition to the doubly-reversed H and K lines. In the invisible "faculae" the continuous spectrum is either very faint or altogether lacking.

As you have been kind enough to request me to discuss the nature of faculae more at length in a paper for KNOWLEDGE, I need not pursue the subject further at the present time.

Very truly yours,

GEORGE E. HALE.

EXPLOSIONS IN THE SUN.

To the Editor of KNOWLEDGE.

DEAR SIR,—I am much obliged to Prof. Smithells for his interesting criticism of my letter on the above subject, which was written chiefly to point out that explosive combinations of gases cooling from above their dissociation temperatures would not necessarily take place. I quite agree that it would be absurd for anyone to argue the impossibility of such combinations, seeing that we have no experience to guide us as to the behaviour of the elements under solar temperatures.

At the same time I think it is permissible, by reasoning upon the little we do know, to see how far the observed solar phenomena can be explained; and I must maintain that our chemistry fails at present to account for the fact of solar explosions in the same sense that it accounts for terrestrial explosions. Even if we make the assumption suggested by Prof. Smithells, that the gases become super-cooled before combining, it is still difficult to believe that the explosive force would be anything approaching in intensity that of (say) an explosion of oxygen and hydrogen at ordinary terrestrial temperatures; for if we suppose the dynamical theory of gases to be a fair approximation to the truth under solar conditions, it will follow that the absolute temperature at dissociation would have to be reduced by super-cooling by as much as one-half to produce an expansion which would even double the volume with equal pressures. For whatever assumption we make as to the law of increase of chemical affinity with decrease of temperature, in no case can the temperature of the resulting compound rise above the dissociation point; combination may be incomplete, but the volume (under constant pressure) cannot increase in a greater ratio than the dissociation temperature bears to the combination temperature.

Taking as an example the case of dissociated oxygen and hydrogen cooling uniformly and under constant pressure, for the sake of argument, the sequence of phenomena would be as follows: both temperature and volume of the mixture decrease uniformly until a certain temperature has been reached below the dissociation point (supposing the super-cooling to be a fact). Then, either a portion or the whole mass will suddenly combine, the amount depending on the quantity of heat withdrawn in super-cooling; and, apart from the energy due to chemical affinity, an amount of heat will be evolved (latent heat of dissociation) exactly counteracting the contraction due to the combination, the heat of chemical affinity alone being

effective in producing an expansion, and this, as explained above, cannot be greater than the ratio of the absolute temperature at combination to that at dissociation.

To return, however, from theoretical arguments to a consideration of the phenomena actually observed on the sun. From my own personal acquaintance with the chromosphere, I am inclined to doubt whether the evidence relied on to prove the superficial origin of the "explosions" is conclusive, or even real; and I think that too little attention has been paid to certain phenomena which indicate that these outbursts may often originate at a considerable depth below the photospheric cloud layer, and therefore in a region presumably more or less shielded from the effects of cooling by radiation. Thus, in looking over my own observations, which extend over a period of five years and comprise more than five hundred separate drawings of the chromosphere, I can find no single instance of an eruption, great or small, showing the principal motion inclined more than about 40° from the vertical; in general, these visible motions differ but little from a radial direction. It is true that displacements of the bright lines at the solar limb, indicating tangential motion, are frequently seen in active prominences, but this is often found to be only a fractional component of the real direction of motion. Another fact bearing on this question is the enduring nature of the centres of eruption. Many metallic and eruptive prominences have been seen to reappear alternately east and west after intervals equal to one or more semi-rotations. These are usually associated with spots, and have been found to even outlive a large spot. Thus, the great group of February, 1892, was heralded by an eruptive prominence on February 4th, and subsequently, similar violent eruptions were seen by various observers in the same latitude on February 18th and 19th, March 3rd and 4th, March 18th, May 11th and 12th, and finally, June 5th, all of which can be referred to the same heliographic position, the last-mentioned alone being observed two days before it was theoretically due on the west limb. The recurring nature, or rather longevity, of the quieter high latitude prominences I have found to be still more marked, and from this one is led to believe that many of these supposed transient phenomena are the outcome of forces as deep-seated and of as enduring a nature as the spots themselves.

Yours truly,

J. EVERSLED.

[While concurring with Mr. Evershed in thinking that the long-enduring solar prominences and sunspots probably have a deep-seated origin, it seems to me improbable that structures like the tangential rays of the corona and the numerous prominences which exhibit an inclination to the radial, have their origin at a great depth, and on reaching the level of the photosphere are deflected to continue their course in approximately straight lines.

The differences of rotation period of the photosphere in different latitudes, as well as of the absorbing material which gives rise to the Fraunhofer lines at various distances from the solar equator, seem also to point to a continual radial circulation outward as well as inward from the photosphere. Whether such radial motions in the outer parts of the sun are due to explosions at a high or low level, or to fierce winds due to the rapid fall of cooled material under the powerful influence of solar gravity, is a matter on which I at present keep an open mind; but I should like to point out that the lateral motions observed are not inconsiderable, and that the effect of perspective cannot increase any apparent inclination to the radial. A ray which is inclined to the radial may be seen in projection so that it appears radial, but any apparent inclination to the radial must be real.

Motions in the line of sight at the sun's limb corresponding to three hundred miles a second have been observed, and since we know that a radial velocity of three hundred and eighty-three miles a second at the level of the photosphere would suffice to carry matter permanently away from the sun, it seems probable that prominence matter occasionally moves in directions very considerably inclined to the radial, but such lateral motions can, it seems to me, be as easily accounted for on the wind theory as on the explosion theory of the origin of solar prominences.—A. C. RANYARD.

LIGHTNING PHOTOGRAPHS OR PHOTOGRAPHIC DEFECTS.

Gore Lodge, Glenageary, co. Dublin.
14th October, 1893.

To the Editor of KNOWLEDGE.

SIR,—I enclose two photographic prints, which I am told may interest you; they are from negatives exposed under the following circumstances. During a holiday in Switzerland, at the latter end of August last, on a beautiful moonlight night, I was tempted to expose a plate in a small hand camera, the exposure, which was made from my bedroom window, being one hour, from about 10 to 11 p.m. Next morning I took a snap shot of the same scene: the prints I send are from the resulting negatives. The peculiar marks on the "moonlight" print showed up in the negative soon after placing in the developer, and I was at first inclined to throw the negative aside thinking it had been spoiled: for, owing to my plates getting mixed, I did not at the time know I was developing the moonlight exposure, or I might have treated it in a different manner, with perhaps better results. I can only attribute the zigzag marks to lightning, and thinking they are such I send the prints to you, understanding you would be interested in examining them.

I shall be pleased to have your opinion, or to give you any further particulars in my power.

Yours truly,

ROBERT R. LEVINGSTON.

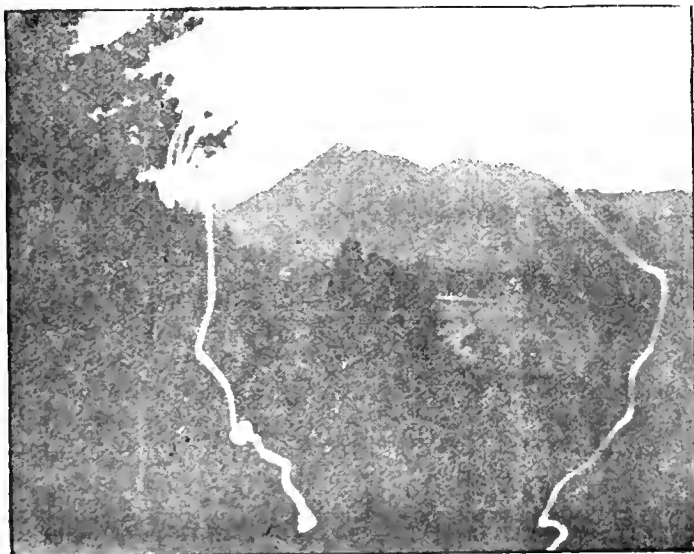


FIG. 1.—Moonlight photograph, exposed during one hour.



FIG. 2.—Photograph of the same view taken the next morning.

[In answer to a letter asking for the focal length of the camera with which the photographs were taken, and inquiring whether Mr. Levingston had seen any lightning or heard the sound of thunder during the moonlight exposure, he replied:—]

Gore Lodge, Glenageary, co. Dublin.
23rd Oct., 1893.

DEAR SIR,—I delayed replying to your kind letter of 19th inst., to procure the particulars you ask for as to "focal length" from a friend who has purchased from me the little camera in which the photographs referred to were taken.

The camera has, I learn, a "focal length" of $4\frac{1}{2}$ inches.

The night on which the "moonlight" picture was taken was an extremely bright moonlight night, and, by way of experiment, I placed the camera on the window-sill, giving just an hour's exposure. I was not aware of any lightning or thunder, but there were no marks on the plate when I put it into the developer, and the "lightning" (?) marks developed out in a most regular manner, the *brighter parts* coming out very quickly after putting into the developer: furthermore, the line mark at the edge of the slide is quite clear in the negative, and no "lightning" marks appear underneath or outside this line, where, of course, the light did not act. I am led to refer to the latter specially, because the Editor of *Photography* hinted that the marks may have been pencil marks.

You are quite at liberty to publish the photos, and if I can help by any further details, I shall be glad to do so.

Yours truly,

A. C. Ranyard, Esq. ROBERT R. LEVINGSTON.

[If the marks on the moonlight photograph were due to lightning the flash must have been very close to the hotel window, for it will be noticed that the band of light seems to run into a complicated knot or tangle in front of the branch of a tree at no great distance in the left hand foreground. Such a flash of ordinary lightning, discharged so close to the hotel, would probably have been accompanied by a clap of thunder which the visitors at the hotel could hardly fail to have heard.

Though the trace upon the plate has a general

resemblance to a lightning photograph, it will be found on closer examination to exhibit important differences. Lightning pursues an irregular jagged course through the air, but here the curves are rounded and the band is uniform in brightness from one side to the other. In the so-called ribbon flashes of lightning one side of the ribbon is much brighter than the other, and a series of bright lines may be traced running parallel to the bright edge; for there are usually several discharges at intervals of a few hundredths of a second, which, as a general rule, follow the same course. The first flash, in finding a path of least resistance through the air, probably jumps from one dust particle to another, and having once heated the air along its jagged path, the succeeding flashes, as a general rule, follow the same course of least resistance, as if they were flowing down a pipe. Ribbon flashes of lightning are usually found to have been photographed with cameras which have been held in the hand, and it may be assumed that the operator has moved with the camera in the interval between the flashes. But, as Mr. Symons has pointed out, it is possible to conceive of a ribbon flash being produced with a stationary camera. Thus, if a wind were blowing at the rate of twenty miles an hour across the line of sight, the moving air would, in the interval between the flashes, which sometimes amounts to as much as the fifth of a second, have carried the dust particles and the pathway of heated air through a distance of nearly six feet. The second flash, therefore, if not very distant from the fixed camera, might occupy an appreciably different position on the photographic plate, and a succession of such flashes might give rise to a ribbon-like flash although the camera was stationary.

But in this case there is no stratification of the ribbon-like band, and the band, though it differs in brightness in different parts, is everywhere of the same breadth, while a ribbon flash of lightning differs in breadth at different parts of its path, being always broadest where the lightning path is at right angles to the direction of motion of the photographic plate or of the wind, and narrowest where the direction of motion is tangential to its curved path, in which latter case the curve is only displaced upon itself.

I would suggest that it is not improbable that Mr. Levingston, after having made his moonlight exposure, took his little camera up from the window-sill, and, forgetting that the direct light of the moon would make a trace upon the plate, turned the camera upwards while he looked about for the cap with which to cover the lens, or while he passed the camera from one hand to the other and closed the shutter over the dry plate. The block (Fig. 1) is about the same size as the original negative, and the white band upon it is about the twentieth of an inch in diameter, which corresponds to the diameter of the moon as photographed in a camera of $4\frac{1}{2}$ inches focus.—
A. C. RANYARD.]

OUR RAINFALL IN RECENT YEARS.

By ALEX. B. MACDOWALL, M.A.

WE are all familiar with the instructive rainfall map, in which the character of different places, as regards wetness, is shown by different shades or colours. And in the case of Great Britain, the wettest places, as everyone knows, are to be found among the mountains of the west, while the driest are in the east.

These maps are constructed from averages of rainfall in a series of years. One naturally asks, How has the rainfall varied from year to year in different parts of these

islands? What is the recent history of its fluctuations? An answer to such questions is to be found in tabulated figures of that excellent annual publication, *British Rainfall*, issued by our chief rainfall authority, Mr. G. J. Symons.

As the true meaning of a column of figures is not always on the surface, I propose to call in the aid of curves, with a view to better comprehension. The curves here used will be smoothed curves, smoothed by means of five-year averages. That is to say, each year-value will

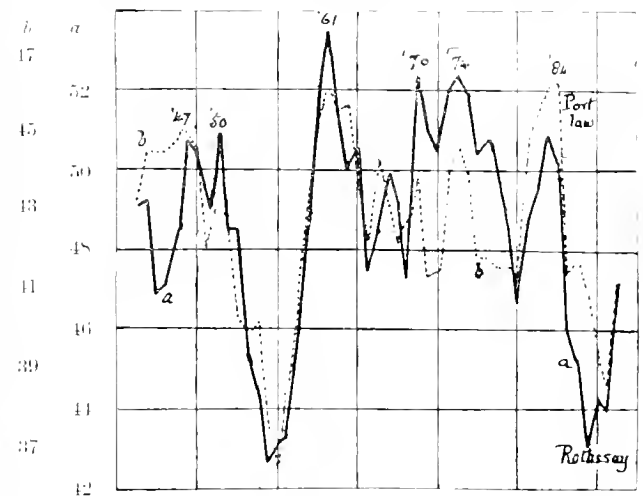
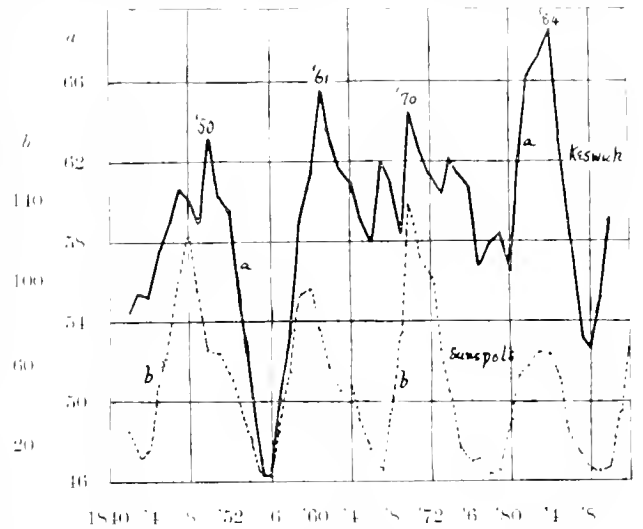


FIG. 1.

be that, not of the actual rainfall, but of an average of five years. In this way the general course and significance of a curve can be better appreciated.

It might perhaps be thought that, a number of such curves for different places in the country having been brought together, we should find them all pretty much alike, though differing slightly in detail. It is not so. While certain groups present a common type, it is possible to find curves which have very little resemblance to each other.

Let us begin by considering a group of curves from the west. Here (Fig. 1) is the smoothed curve for Keswick,

* In these diagrams the rainfall scale is varied at convenience. The figures denote inches. Where two scales are given, the respective curves are indicated by letters a and b.

in the Lake District (from 1810): and further down, that for Rothesay, in Bute. These are distinctly alike, and I find that the curve for Portlaw, in Waterford (added in the lower division), may fairly be ranked with them. The Rothesay curve, from 1856, might be roughly described as forming a long three-crested wave. We are in a position to carry back the curve to the beginning of this century, and the first part here given (*before* 1856) proves to be the third part of another long triple-crested wave, commencing in 1822.

Now there is an interesting correspondence, in these Keswick and Rothesay curves, to the sunspot curve (which is shown in the upper division). The sunspot maxima occurred in 1848, 1860, 1870, and 1883: and, taking the Keswick curve, we have relative maxima in 1850, 1861, 1870, and 1881. The general course of the curves is similar.

This correspondence, at least in the case of Rothesay (which has been previously noticed*), can be traced back to early in the century (in the first decade it seems to fail). Our interest is naturally roused by it; but to affirm a causal relation between the phenomena may be con-

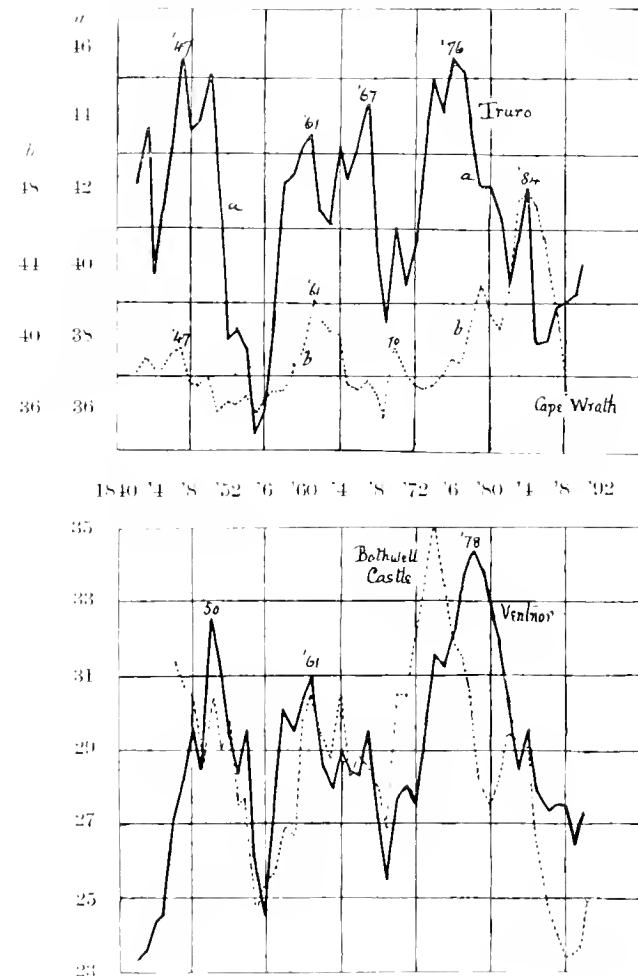


FIG. 2.

sidered at least premature. Certain anomalies met with in the actual values, and pointed out by Mr. Abercromby, call for consideration, though we may not quite accept his view about smoothing processes. It might seem to some

a sufficient condemnation of the sunspot theory, that we have not the same kind of curve everywhere else. But with the meteorological knowledge of to-day, it may fairly, I think, be argued, that opposite weather in two regions (*e.g.*, great wetness in one, and great drought in another) might both be traceable to the condition of the sun, as revealed by spots. On this point, however, I must not linger.

Over what extent of region, precisely, this kind of curve is obtainable, I cannot say. If we go up to Cape Wrath, however, or down to Truro, we find in both cases a different *régime*. The curves for these places are shown in Fig. 2 (upper half).

The curve for Cape Wrath, indeed, culminates about the same years, but in the general relation of different parts of the curve there is considerable change. The Truro curve might perhaps be described as forming three long waves.

Another three-wave curve is that of Ventnor (lower division of Fig. 2), and one meets with several curves of this type in different parts of the country, even widely apart. Speaking generally, there is first a prominent wave-crest in one of the years 1846-50, then a crest about 1861, and the third, most conspicuous of all, somewhere in 1874-80: from which point the curve descends rapidly and with little break to a low point about 1888. With the Ventnor curve I give that for Bothwell Castle, in Lanarkshire, N.B., which has its third crest in 1874, while that of Ventnor is in 1878. The curve for Brechin, east coast of Scotland (Fig. 3), has also three waves, with the third culminating in 1877. Other cases might be given.

The Sheffield curve (Fig. 3) might perhaps be regarded as a kind of transition form to what we find in the east of England (shown below). This East Anglian curve is one for Dickleburgh, in Norfolk, and (last eighteen years) for Norwich. From a high point in 1843 the curve (roughly speaking) takes a long downward sweep, and rises again to a high crest in 1877. (The Oxford curve is very similar, only the earlier culmination is in 1850.) In a curve for Boston, Lincolnshire, the two chief crests are in 1847 and 1881.

In the Greenwich curve (not given) a high point is reached at 1867 (compare Truro and Ventnor), in addition to crests at 1850, 1861 and 1879, which latter is the highest.

In a remarkable work published a few years ago, Prof. Brueckner, of Berne, has traced variations of climate in different parts of the globe since 1700; and from a large induction of facts, he infers the existence of a weather cycle of about thirty-five years in the greater part of the land surface of the earth. It is interesting in this connection to note that Lord Bacon, in one of his essays ("On the Vicissitudes of Things"), refers to such a cycle as being spoken of in the Low Countries.

Taking recent years, Brueckner finds that there was a cold and wet period from about 1841 to 1855, and again from 1871 to 1885, while the period between these (1856-70) was warm and dry. The east of England is included by him among the regions for which this rule holds, and our East Anglian curves are quite in accordance with this view. In certain regions (comprising Ireland, Scotland, West England, the Atlantic islands, &c.) the variations are stated to be exceptional.

The following years, according to Brueckner, are, approximately, centres of cold and wet periods—1700, 1740, 1780, 1815, 1850, and 1880; while the following are centres of warm and dry periods—1720, 1760, 1795, 1830, and 1860.

* See Abercromby's *Weather*, p. 325.

These diagrams deal with weather in the past; do they afford any clue to the future?

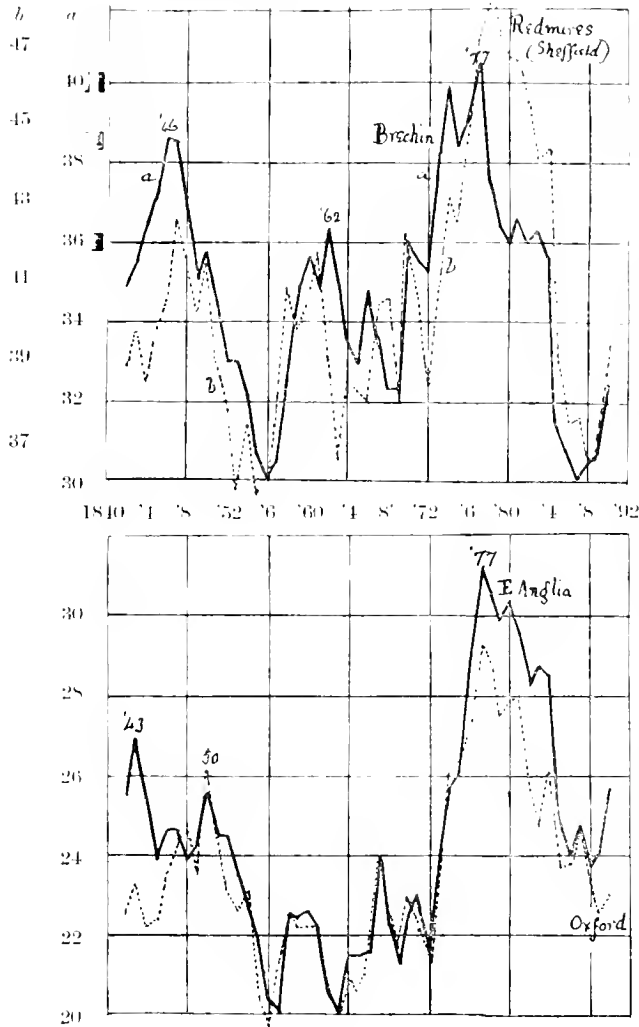


FIG. 3.

In the case of the Rothsay curve and others like it, whatever view we may take of the correspondence with the sunspot curve, the fact of that correspondence having subsisted so many years seems to afford some basis for expecting it to continue; in which case the curves would now be nearing another maximum. On the other hand, there is the thirty-five years' period in the east of England (a period which, by the way, is just about three times that of the solar cycle). Should this cycle of Brueckner's continue to be realized, we might expect those smoothed curves to attain their next conspicuous maximum somewhere about 1912. With regard to the other curves there is not much to be said. They appear to have all lately passed a low minimum, and the rise seems likely to continue. The present crest-interval (reckoning from the last prominent crest) promises to be longer than eleven years. The recent years, 1887, 1888, 1889, 1890, and 1892, have all (according to Symons) shown a deficiency of rainfall in England, and we may reasonably infer that the years now approaching will be wetter, though the wetness might not appear in the summer half of the year, when it would be most noticed. But in all such endeavours to penetrate the future, it is wholesome to bear in mind the plentiful stultification to which over-confident weather prophets have had to submit hitherto.

NITROGEN AS FOOD FOR ANIMALS AND PLANTS.

By VAUGHAN CORNISH, M.Sc., F.C.S.

THE atmospheric fluid, or common air," Lavoisier wrote, "is composed of two gases or aeriform fluids, one of which is capable, by respiration, of supporting animal life, and in it metals are calcinable and combustible bodies may burn; the other, on the contrary, is endowed with directly opposite qualities—it cannot be breathed by animals, neither will it admit of the combustion of inflammable bodies, nor of the calcination of metals.

"We have given to the base of the former, which is the respirable portion of atmospheric air, the name of oxygen. . . . The chemical properties of the noxious portion of atmospheric air being hitherto but little known, we have been satisfied to derive the name of its base from its known qualities of killing such animals as are forced to breathe it, giving it the name of *azot*, from the Greek primitive particle *a* and *ζωη, vita*: hence the name of the noxious part of atmospheric air is *azotic gas*."

Lavoisier, who was the first clearly to state the chemical nature of air as composed of two substances, one chemically active and the other chemically inert, occupied himself for many years in developing the knowledge of the chemistry of oxygen—the active constituent of air. The readiness with which oxygen gas can be made to act upon and combine with other substances enables its chemical functions to be determined with comparative ease, and the mode in which this element is used in the nourishment of the animal body was soon elucidated with tolerable completeness; on the other hand, the inertness of *azot* (or nitrogen, as the substance soon came to be called in England) rendered the chemical study of this constituent of the atmosphere a less attractive as well as a slower and more laborious pursuit. Thus, if we compare the ways in which the oxygen and nitrogen of the air are taken hold of to build up the animal body, we find that one process is direct and in its main features simple, whereas the processes by which the nitrogen of the air becomes a constituent of the flesh and muscle are, on the contrary, indirect and complicated. Even at the present time, a hundred years after the researches of Lavoisier, the mode of "assimilation of nitrogen" is only beginning to be understood. When air enters the hollow cells of the lungs, the blood, flowing round the cells in little veins and capillaries, seizes upon and "fixes" the oxygen, which freely passes through the thin walls of the air-cells, and carries to every part of the body the combined oxygen which it has thus seized upon. Parting in its passage through the body with the oxygen which it has seized from the air, the blood acts as carrier of oxygen from the air to the muscle, flesh, nerve, and other parts of the body. But the blood has no power to seize upon and fix the nitrogen gas which enters the lungs at every breath. The blood has to obtain its nitrogen from the animal and plant food which is taken into the stomach; the throat and not the windpipe is the channel by which the nitrogen of the air is supplied to the body. Animals used by man for food obtain their nitrogen from plants. Plants have to depend ultimately upon the air for their supply of nitrogen.

The plant, however, does not appear to be able to assimilate the free atmospheric nitrogen through its leaves any more than an animal can assimilate the gas through its lungs. Leaves catch the carbonic acid of the air as the lungs of animals catch the oxygen of the air; but the nitrogen, it seems, has to reach the sap through

the roots—it has to be fixed in some way—before the plant can feed upon it. Recent researches seem to have proved that on leguminous or pod-bearing plants there lives a class of bacteria which have the power of feeding directly upon the free nitrogen of the air. They “fix” the nitrogen, which afterwards becomes available for plant food. Perhaps this only happens after the death of the bacteria, when their substance has undergone decomposition and the nitrogen compounds have been converted into a soluble form so that they can enter the sap in the same way as the rest of the food derived by plants from the soil.

The soluble form in which it appears that nitrogen is mostly taken up by the roots of plants is known as the nitrate “form” or state of combination, in which nitrogen is combined with oxygen as it is in nitre and in nitric acid. Besides bacteria associated with leguminous and possibly other orders of plants, there is another agency which brings the nitrogen gas of the atmosphere into combination with oxygen; this agent is electricity. Electric discharges in the atmosphere cause the combination of relatively small quantities of nitrogen, and the soluble oxides of nitrogen thus formed are carried down in solution by the rain, thus adding to the quantities of nitrates in the soil. As far as it is at present known, these two agencies, electricity and bacterial life, are the only carriers of nitrogen from the air to the soil.

Most of the nitrogen at any moment present in the world’s soil is, however, derived from the substance of the preceding generations of plants. The nitrogen required to be supplied to the world’s soil for the crop of any one year is only the difference between what is abstracted from the soil by the plant crop and what is restored to the soil by the death and decay in the vegetable and the animal kingdom.

The difference between the two amounts may be relatively small for the whole of the earth’s surface, and might perhaps be *nil* if large quantities of nitrogen as nitrate were not being constantly carried into the sea by rivers.

The nitrogen in vegetable and animal substances is combined with carbon, and nitrogen in this state of combination may be termed *organic nitrogen*. Nitrogen when in this form is not directly available as a food for plants. By the process termed decay in the case of plants, and putrefaction or decomposition in the case of animals, the nitrogen is set free from its combination with carbon, and ammonia or a compound of ammonia is produced. In ammonia, nitrogen is in combination with hydrogen; and nitrogen, in this state of combination, we will call *ammoniacal nitrogen*. Free ammonia gas, formed in the decomposition of materials containing organic nitrogen, is ultimately brought into the soil in a state of solution by means of rain or dew, owing to the fact that ammonia gas is extremely soluble in water. Much of the ammonia produced by the decomposition of organic matter meets at once either with water or with some material with which it can combine, and thus from the first is retained in the soil. Plants are able to feed directly upon ammoniacal nitrogen; but in the greater part of the nitrogenous food of plants the nitrogen is in combination with oxygen, *i.e.*, in what we have termed the “nitrate” condition. The decomposition of the organic matter of the soil (which is commonly called *humus*) is effected through the agency of the *nitrifying bacteria*. They first split up the organic matter into water, carbonic acid, and ammonia, and then further assist the oxidation of ammonia to nitric acid. The conditions favourable to nitrification are that the oxygen of the air should have free access, that the soil should be sufficiently moist, but

not water-logged, and that the temperature should be fairly high. In the presence of an alkali, or alkaline earth in the soil, the nitric acid forms a salt (termed a nitrate). Where lime or carbonate of lime is present, soluble calcium nitrate is produced, and in this form plants obtain much of their nitrogen. Where potash is present, nitre or saltpetre is formed, *as, e.g.*, in dry districts of India, where nitre is found as an efflorescence on the surface of the soil. Chili nitre, or Chili saltpetre, is the nitrate of sodium, and occurs in large deposits in the rainless districts west of the Andes, in Chili and Peru. In a wet climate such deposits would be speedily washed away, and carried into the rivers and the sea. We have referred before to the loss of the nitrogen which the soil of continents undergoes on account of soluble nitrates finding their way into the sea. The great quantities of nitrates from Chili and Peru which have of late years been applied to the fertilization of the land are a contribution won back from the ocean; the nitrates of the nitrate beds have been formed by the oxidation of guano, the *dejecta* of fish-feeding sea birds. Recently “artificial guano” has been manufactured to a considerable extent from the carcasses of coarse fish, caught for the purpose by fishing from ships specially employed in connection with this manufacture.

Where crops are cut and carried from the place where they were grown, it is necessary to provide for the restoration to the soil of certain materials, particularly nitrogen, which are thus removed instead of being allowed to return to the soil through the death and decay of the plants, as would be the case in a state of nature. This is partially effected by returning to the soil the manure from the animals of the farm which fed upon the crops. When the beasts themselves, however, are sent into the towns, they carry away large quantities of the particularly valuable constituents of a fertile soil, such as nitrogen and phosphorus. In a more primitive condition of agriculture, the beasts would be eaten on the farm itself, and the greater part of the nitrogen, &c., would find its way back to the soil whence it came. Facilities for communication and transport, however, and the concentration of the population in towns all tend to make farming, more particularly manuring or soil-feeding, a more complicated matter. This is especially the case where nitrogenous stuff, *e.g.*, hay, is sold off the farm, instead of being consumed upon it, and oil cake, or other artificial feeding-stuff is purchased in its place. The oil cakes are rich in fat as well as in nitrogen, but the albuminoid ratio is always high, in some cake as high as 5:7. The method of calculating the nutrient or albuminoid ratio was explained in a former article (*vide* KNOWLEDGE, July, 1893). Account has to be taken of this ratio in deciding upon combinations of artificial foods for the use of stock, just as the authorities of prisons, &c., have to consider the nutrient ratio of the diet they supply. Young growing animals retain a larger proportion of the nitrogen supplied to them than the full-grown beasts which are being fatted. In the former case much of the nitrogen goes to build up the muscular flesh, and the manure given by young growing animals is proportionately poorer in nitrogen. On the other hand, full-grown animals which are being fatted for market store up chiefly fatty tissue, which contains no nitrogen, and consequently these animals return a larger proportion of nitrogen to the ground. In feeding different species of animals account has to be taken not only of the albuminoid ratio but of what is called the *digestion co-efficient*, or proportion which the food-stuff taken bears to the amount digested.

This proportion is different in the case of different species of animals. In the case of ruminants a large proportion of indigestible fibre in the food is actually necessary.

Sheep cannot assimilate more than half of the 12 per cent. of nitrogenous matter contained in clover hay. Human beings would be able to assimilate scarcely any of the nutriment in hay, the White King, in "Through the Looking-Glass," who took hay when he was faint, being of course an exception to the rule. By submitting the hay to preliminary treatment by an ox or sheep, man is able to assimilate the nitrogen and other nutrients contained in hay in the form of beef or mutton.

To sum up, we may say that nitrogen exists as—

1. *Atmospheric nitrogen*, in which the atoms of nitrogen are combined with each other. The bacteria associated with leguminous plants feed upon atmospheric nitrogen.

2. *Ammoniacal nitrogen*, on which plants can, and to some extent do feed. Here nitrogen is combined with hydrogen. The source of ammoniacal nitrogen is the decay of animals and plants.

3. *Nitrate nitrogen*, in which nitrogen is combined with oxygen. This is the principal form in which plants obtain their nitrogen. Nitrates, generally speaking, are formed by the oxidation of the ammoniacal compounds produced in the decay of animal and vegetable matter. In the presence of alkalis in the soil, such as lime and potash, soluble nitrates are formed which supply both nitrogen and alkali to plants. Nitrate nitrogen is also brought into the soil by the action of electrical discharges in the atmosphere.

4. *Organic nitrogen*, in which the nitrogen is combined with carbon. This is the form in which nitrogen is taken by animals, either directly from vegetable food—more particularly from green vegetables—or in flesh-feeding animals, partly as above and partly in the form of lean meat. The organic compounds of nitrogen after the death of the animal or plant furnish the food of the nitrifying bacteria, which assist in the work of splitting up these compounds, sending off the carbon as carbonic acid, and leaving the nitrogen, first in combination with hydrogen, and afterwards oxidizing the nitrogen to the form of a nitrate.

Chess Column.

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

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, Knowledge Office," and posted before the 12th of each month.

Solution of Problem No. 1.

Key-move.—1 Q to B2.

If 1. . . . K to K4, or K x P 2. Q to B6ch.

1. . . . R moves, 2. Q x Pch.

1. . . . Kt moves, 2. Q to Q2ch.

1. . . . P x P, or P to B4, 2. Q to QR2ch.

Dual after 1. . . . K to B5, by 2. Q to QR2ch, or Q to QKt2.

Solution of Problem No. 2.

Key-move.—1. R to B5.

If 1. . . . P to B6, 2. Kt to B5ch.

1. . . . Kt to B7, 2. R to B4

1. . . . K x Kt, 2. Q x Pch.

1. . . . P to K1, 2. R x BPch.

1. . . . Kt to Q1, 2. Q to K2ch.

1. . . . Anything else, 2. R to K5ch

Dual after 1. . . . P to Kt5, by 2. R. to K5ch or Kt to B5ch.

CORRECT SOLUTIONS received from the following:—

Eight Points.—Kt. J., F. R. Adcock, Rascal, Buttercup, W. T. Hurley, Semper, A. C. Challenger, A. R., B. G. Laws, Guy.

Seven Points.—R. G. Thomson, W. B. Huggitt, W. N., Mogo, Birkenbaum, R. E. Cooke, G. S. Cummings, A Norseman, Chat.

Six Points.—H. S. Brandreth, W. A. Champion, Alpha, Esculap, Quill, H. Holmes, W. J. Jubb, How's That?, A. E. Whitehouse, J. H. Christie, L. Bourne, Humilis.

Humilis. The rule about the post mark is intended to refer to the district in which the letter is posted.

L. Bourne and H. Holmes. By referring to the solutions of the two problems given above, you will see exactly what is meant by a "dual" continuation.

Mogo.—Chess-Editor, *Hackney Mercury*, 10, The Grove, Hackney, N.

W. B. Huggitt.—In that case it is difficult to believe that the problem can have been up to your enstomary level.

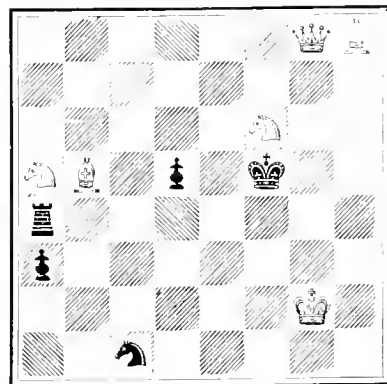
Pearl of the Garden.—The problem has been entered. The post-mark shows that it was posted in time, though it arrived too late to acknowledge last month.

A Norseman.—Could you not avoid some of the misprints which constantly occur in your Chess notation? Unpunctuality condoned for this once only.

POSITION No. 3.

"Sweetness and purity combined—
And man contents his lofty wind."

BLACK (5).



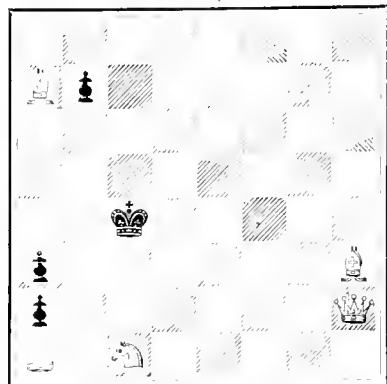
WHITE (6).

White mates in three moves.

POSITION No. 4.

"Stella."

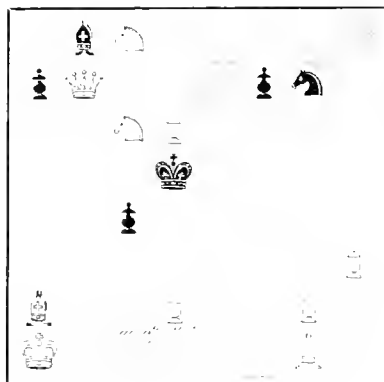
BLACK (1).



WHITE (2).

White mates in three moves.

POSITION No. 5.
"Bonnie bouche."
BLACK (G).



WHITE (G).

White mates in three moves.

NOTE.—In reply to some of our correspondents, the form of solution which we prefer is as follows:—

"No. 1. Q—B2.

Dual after 1. . . . K—B5 by 2. Q—QR2ch.

Remarks." Q—QKt2.

There should be space for three such solutions on a postcard. Solvers' addresses are registered and need not be repeated.

A triple continuation, should any such occur, will not score more than a dual.

The eighth game of the St. Petersburg match is given as an illustration of M. Tschigorin's novel reply to the French Defence. The idea of 2. Q to K2 is to prevent Black from playing P to Q4.

FRENCH DEFENCE.

WHITE (M Tschigorin).	BLACK (Dr. Tarrasch).
1. P to K4	1. P to K3
2. Q to K2	2. P to QB4
3. P to KKt3	3. QKt to B3
4. B to Kt2	4. B to K2
5. QKt to B3	5. Q to B2
6. Kt to R3	6. P to QR3
7. Kt to B4	7. Kt to Q5
8. Q to Qsq	8. Kt to KB3
9. P to Q3	9. P to QKt1
10. Castles	10. B to Kt2
11. B to K3	11. QR to Bsq
12. P to QR4	12. P to Kt5
13. Kt to Ktsq	13. P to K1
14. Kt to Q5	14. B x Kt
15. P x B	15. Q to Q3
16. Kt to Q2	16. Q to B2
17. Kt to B4	17. P to KR4
18. P to B4	18. Kt to B4
19. B to Q2	19. P x P
20. B x BP	20. P to Q3
21. Q to K2	21. R to Qsq
22. QR to Ksq	22. K to Bsq
23. P to B3	23. P to R4
24. B to Q2	24. P x P
25. P x P	25. Kt to R3
26. Kt x RP	26. Kt (R3) to Ktsq
27. Kt to B6	27. R to Ksq
28. P to B4	28. Q to Q2
29. B to B4	29. P to R5
30. P to Kt4	30. Kt x KtP

- | | |
|--------------|---------------------|
| 31. B to R3 | 31. Kt (Ktsq) to B3 |
| 32. B to Kt5 | 32. R to R4 |
| 33. QB x Kt | 33. P x B |
| 34. Q x Kt | 34. Resigns |

CHESS INTELLIGENCE.

The match at St. Petersburg between Dr. Tarrasch and M. Tschigorin was finally given up as drawn after each player had won nine games. Four games only were drawn, the players probably preferring to fight their games out to the bitter end rather than play them over again. The German champion was at one time three clear games to the good, but Tschigorin by three consecutive victories soon equalized matters. The performance of the latter player is all the more creditable considering that he seldom got the best of the opening. Dr. Tarrasch, on the other hand, was at his best in the earlier stages of the games. He seemed to lack the patience necessary for a long encounter, and, for the reasons stated above, most of the games were long. He appears also to have been pressed by the time limit on several occasions. Supposing Dr. Tarrasch to have been in his true form, the result of this match effectually disposes of his claims to be considered the equal of Steinitz, who has clearly shown his superiority to Tschigorin whenever he has been willing to adopt rational lines of play.

Evidently the only player who can now be considered to have a chance with Steinitz is E. Lasker, who has added to his already high reputation by his recent bloodless victory in the New York Tournament. Even if his opponents were not of the very highest rank, to score thirteen wins without a single loss or draw can only be regarded as a magnificent performance. The remaining scores in order of merit were:—Albin, 8½; Delmar, Lee and Showalter, 8; Major Hanham, 7½; Pillsbury, 7; Taubenhaus, 6; Pollock, Ryan, and Schmidt, 5; Jasno-grodsky, 4; Olley, 3½; Mr. Gossip bringing up the rear with 2½. It appears that Mr. Schmidt is not Dr. Schmidt of Dresden, as we stated in error last month, but an American-German of the same name and hailing from the same town.

Negotiations are in progress for a match between Steinitz and Lasker, to be played at Havana. They seem, however, to require an excessively large sum for the privilege of playing in that town.

The return match between the North and South of England is now definitely decided on. It will take place in London, probably on April 7th, 1899, and there will be 110 players a side.

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