SIMPLY WORDED—EXACTLY DESCRIBED.

AN ILLUSTRATED MAGAZINE OF SCIENCE LITERATURE & ART.

"Let Knowledge grow from more to more."
—TENNYSON.

VOLUME XIX.

JANUARY TO DECEMBER, 1896.

London:
KNOWLEDGE OFFICE, 326, HIGH HOLBORN, W.C.

LONDON
PRINTED AT KNOWLEDGE OFFICE, 326, HIGH HOLBORN, W.C.

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GEOGRAPHY AS A SCIENCE IN ENGLAND.

By Hugh Robert Mill, D.Sc.

GEOGRAPHY, as a science, has not flourished in Great Britain. Men may be found in our Universities and learned Societies who sneer at the pretensions of geography to scientific rank; and, when the phrase "Principles of Geography" has been employed, cultured professors have smiled at it as at a paradox. "Geography," remarked a classical scholar to me not long ago, "if a science, is of no educational value; there is only one science which is possibly more barren and profitless to the student—the science of heraldry." The claims of geography as an element in education are, however, being ably urged by powerful voices, and, if not yet fully realised, they are likely to be widely conceded before many years go by. With geography in education I propose to have nothing here to do, except, it may be, incidentally; for in proportion as geography attains recognition in University education will the special subject of this article gain importance and compel attention.

Geography as a science is not respected because it is not understood; and the ground of the misunderstanding, in some cases at least, is that "a science" is not uncommonly looked upon as a department of specialised knowledge. Starting with this idea, it is perfectly logical for an objector to say that the ground claimed for geography is covered by the sciences of astronomy, geodesy, geology, oceanography, meteorology, botany, zoology, history, and anthropology—if, as is not likely, he allows that the last-named are sciences—and to declare that there is no room for the "science of geography." I contend that the departments of natural knowledge cannot be so "clean cut from out and off the illimitable" as to admit of their being arranged side by side to cover the field of nature like a tesselated pavement. Each one is, to a greater or less extent, permeated by those surrounding, and permeates them in turn: the astronomer is not independent of the chemist nor the meteorologist of the astronomer. If sciences are to be viewed as *tesseræ*, the "sciences" as at present familiarly classified must be analysed into units of profound specialism, each of which may be a single and independent study, and may be utilised, differently combined, in neighbouring "sciences."

We may, then, view "a science" as composed of a group of specialisations, a molecule compounded of atoms, so that the same atoms of ultimate specialisation may be combined successively in different molecular generalisations. Another step carries us to the recognition of sciences of higher generalisation, in which the units are the "molecular" sciences themselves, combined and subordinated to a new yet special purpose. It is easy enough to recognise physics as capable of analysis into mathematics and the sciences of matter and energy—heat, light, electricity, and so on; yet he would be accounted a student of little perception who should deny the claim of physics to be a science because the ground is already covered with heat, light, and the rest. It is only in unfamiliar paths that scientific men "cannot see the wood for trees."

My claim is that geography as a science is so far akin to physics that it is a generalisation of the second order, a natural grouping of units which are individually distinct. The physicist looks on nature in the universal aspects of matter and energy; the geographer looks on nature in the limited, but still general, aspect of the surface of the earth.

Geography as a science is the exact and organised knowledge of the distribution of phenomena on the surface of the earth. This involves the human race: and because the human race represents the culmination of organic evolution, the true understanding of the interaction of man with his terrestrial environment is the final object of geography. The materials for building up the final generalising science fit to fulfil such an aim are yet far from complete; but they are already outlined with sufficient clearness to allow of progress being made in the general study. Incompleteness of data is the best incentive to progress and the surest guarantee of substantial advance.

Chemistry was a science even in the days when the professor spoke profoundly of calces and phlogiston; and it was precisely because he generalised his scanty data, and strove to verify his generalisations by renewed observations, that the era of oxygen ushered in the atomic theory with a brilliance that has shrined the fame of chemistry as science *par excellence* in many a humble mind to-day. Yet, before the atomic theory and the periodic law existed to unify the early facts, these had been studied and the principles connecting them groped for. In the time of this groping, chemistry was not the educational machine it has since become, and the products of its study were, for many years, rather amusing experiments than industrial advances. That incomplete data do not retard the growth of theory is proved by modern chemistry, which started from a knowledge of the elements of air; but although argon eluded Cavendish the growth of chemistry was unchecked, and the advancing theory ultimately suggested elements the discovery of which could hardly have been imagined otherwise. In other words, the facts and the theory of a science assist each other, and are best developed simultaneously.

Geography, if properly studied and allowed its natural growth as a science, is now, in the opinion of geographers, as sure to grow and to lead to theoretical generalisations and applications of economic values as chemistry was in the days of Davy.

I have already on several occasions endeavoured to give expression to my views of the content of geography as a science,[*] and need only quote here the opinion that the ultimate aim of geography is "the elucidation of the earth viewed as the present expression of a definite evolution, in which every part is subordinated to the production of a suitable home and sphere of influence for civilised man." The way to attain this end is obviously to proceed toward the completion of our knowledge of all the phenomena the interaction of which is in question, aided by such principles and relationships as can be deduced from what is already known.

The astronomer, geologist, oceanographer, meteorologist, botanist, zoologist, anthropologist, and historian are all laid under contribution in different and varying degree to supply the building material for the geographer to combine, according to his special view-point, into a generalised science, capable of endless application to the sciences which helped to form it, and to the affairs of daily life. A large part may be taken in advancing a science without the individual specialists realising the full import of their contributions, and comparatively few great travellers and explorers were consciously geographers. In considering the position of scientific geography it is convenient to distinguish between detailed exploration and research recorded for convenience by various adaptations of cartographic art, and the discussion and co-ordination of the relations which exist between the various special elements; to distinguish, in fact, between the collection and the interpretation of facts.

It would be absurd in these days of international congresses to speak of any science as being the province of any nation or class, yet there is an influence of race and language upon thought which, however imperfectly it may be understood, is not to be ignored in any science. People of different race work by different methods and pursue different ideals; and it will probably be found that the nation in which any science has developed most rapidly in its adolescent period strongly impresses its particular individuality upon the science, although the impress may subsequently be obscured as contributions accumulate from other sources.

In some languages—German, for instance—it is easier to make and use new terms for new ideas than it is in English. And in its present period of rapid growth geography as a science seems likely to be very largely, if not mainly, advanced by German generalisers, just as chemistry at a similar period in its history was advanced by French specialists. Our chemical terminology was originally a direct transference of the French words, modified according to natural and simple rules. Our geographical terminology may very likely show the German stamp, although it is as yet in an unorganised and rudimentary condition, needing much careful weeding and cultivation to make it a fit medium for conveying the ideas of the science. The terms of mathematical geography are for the most part Latin or Greek in origin, but new terms for descriptive purposes are spreading rapidly from the German into all modern languages. For example, the opposite idea to watershed—itself a Teutonic form—is only expressed by *Thalweg*, which denotes the line of the meeting of waters from converging slopes. *Hinterland* has also been naturalized, directly to express concisely an idea for which the only possible English expression involves several words. Geography suffers from the want of terms, and in America many are being introduced from Greek, Latin, and mongrel sources, some of which will survive. The language which lends itself to self-explanatory terms which every speaker of it understands at the first hearing, such as *Höhlenkunde* and *Seenkunde*, must always have an advantage as a vehicle for rapid interchange of new thought over one which is obliged to fall back on alien origins for *Spelæology* and *Limnology*, which even specialists require to ponder over before they realize that they mean Cave-knowledge and Lake-knowledge.

It will probably be disputed by few that the greatest explorers for the last two hundred years have been British, while the greatest geographers, in the sense of scientific generalisers, have been German. This can be said without in any way detracting from the brilliant explorations which from time to time have been carried out, and the important generalisations that have been arrived at by people of every civilised nation. But in geography the aptitude of British workers has been towards the collection, and not the discussion, of facts.

One may search long for notices of theoretical geography in such memoirs as Mr. Clements Markham's "Fifty Years' Work of the Royal Geographical Society," or the "Review of British Geographical Work during the Last Hundred Years (1789-1889)," prepared by him and Mr. Scott Keltie for the Paris Exhibition of 1889; or in Mr. Silva White's "Achievements of Scotsmen during the Nineteenth Century in the Fields of Geographical Exploration and Research," prepared for the same occasion. But these compendia record the accumulation of geographical data from every part of the earth as yet accessible to man, a mass of solid work it does one good to think of. No maps rival those of the Ordnance Survey of the United Kingdom either for accuracy of survey or beauty of execution; no charts show so fully the configuration of the sea-bed round every coast in the world as those of the British Admiralty; the Great Trigonometrical Survey of India is a work of unparalleled grandeur. It would be endless to dwell upon the doings of British travellers in every continent and over every sea which have resulted in thousands of conscientious observations of astronomically fixed positions, and information of every sort which a traveller can possibly accumulate. The frozen seas of the North and the South have been penetrated farther and more frequently by British keels than by those of any other nation. The circumnavigations of Cook and of his followers in British surveying ships, the epoch-making voyage of the *Beagle*, and the culminating glory of the *Challenger* expedition are all just sources of national pride, and each was the occasion of garnering vast harvests of geographical facts. So far as the utilisation and interpretation of these facts are concerned, foreign nations have come before us. We have supplied them with the raw material; they return us the elaborated article stamped with the mark of Continental thought.

The English language is rich in the records of voyages; and the collections of early travels prepared by Hakluyt and Purchas show that bent toward the treatment of geography as exploration which has come to be distinctive of our modern work, contrasting with the typically French conception of geography as history and politics, and the German academic treatment of the theme. In the eighteenth century the Royal Society was frequently concerned with geographical questions, and its great president, Sir Joseph Banks, the companion of Captain James Cook, might, but for the multifarious interests of his active mind, have rivalled Humboldt as an interpreter as well as an investigator of geographical phenomena. His contemporary, Rennell, whom

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[*] See "The Realm of Nature" (London: John Murray); also "The Principles of Geography" in the *Scottish Geographical Magazine* for February, 1892; and "The Geographical Work of the Future" in the same journal for February, 1895.

Mr. Markham hails as the greatest English geographer, did much to bring the methods of scientific criticism to bear on the discussion of the observations of travellers; and from his own early training in the practical work of surveying, his theorising was sobered by a knowledge of the limitations of methods of observation and delineation. Rennell found no successor to continue his masterly handling of the divers strands of geographical science. Men like Rawlinson, Bunbury, Yule, and Freeman followed him in researches into ancient and Oriental geography, piecing together the broken records of past knowledge in the light of geographical principles. Men like Arrowsmith and A. Keith Johnston raised practical cartography to the highest level it ever reached in this country; and the Ordnance Survey of the United Kingdom slowly produced the finest map which has ever been completed.

The Royal Geographical Society and the British Association, originating almost at the same time, have done much to advance and popularise geography in many forms; but even the former, despite great efforts from time to time by the inauguration of valuable lectures on scientific geography by specialists in different departments, has failed to ensure the continuous and systematic pursuit of geographical science. The disquieting feature, from a national point of view, is that our original part of pioneer exploration is almost played out. The Polar areas remain the only unexplored territories. Science must now in large measure take the place of mere pluck; the work of the explorer is giving way to that of the trained investigator, and the popular task of recording explorations must continue to give way to the more exacting labour of discussing investigations. It is in this direction that the great advances of geography in the immediate future will have to be made.

An illustration will give point to this statement, and show how much work lies surprisingly near our hands, yet waiting to be accomplished. If anyone wishes to study the geography of the British Islands he finds no treatise to guide him except some small school books, a few popular and unsystematic compilations of more size than substance, guide books designed for the sightseer, and gazetteers of value only for occasional reference. There is no scientific treatise on the subject, because no one has yet attempted to apply scientific geographical methods to the treatment of the abundant (though by no means complete) raw materials which have been collected, and may be unearthed by the diligent student.

The materials available are:—(1) The Ordnance Survey maps showing the whole surface of the United Kingdom on three scales of ample size; with two different styles of delineations of physical features on the smallest and most convenient scale. (2) The work of the Geological Survey, which has nearly completed a map of the kingdom showing, on the topography of the Ordnance Survey, the nature and structure of the underlying rocks, with evidence of the utmost value as to the distribution of economic minerals. (3) The Hydrographic Surveys of the Admiralty round the coasts, by which the submarine configuration is shown with great exactness, and the shifting features of moving sandbanks traced by periodical re-surveys. (4) The Census, taken decennially, which shows, for every registration district, a mass of statistics as to the number and nature of the population, their occupations, origin, and age. (5) The statistics of births, marriages, deaths, and migration, which serve, though as yet imperfectly, to bridge the long gaps between successive verifications by Census. (6) The Board of Trade returns as to commerce by sea and land, the movements of seaports, and the traffic of railways, showing how the life-blood of the country circulates through its arteries. These Government sources may be supplemented by statistics of climate which have been accumulated partly by the Meteorological Office, more largely by the Royal and the Scottish Meteorological Societies, and by the individual efforts of Mr. Symons for rainfall.

All of these supply data which are essentially distributional, and therefore amenable to the principles of geography for discussion and co-ordination; but they are not officially brought into unison. They remain the separate work of specialists, and one throws the minimum of light upon another. The Ordnance Survey, it is true, provides the topographical outlines on which the geological maps are constructed, and it supplies to the Census Office the outlines of the registration districts which accompany the Census reports. But the Ordnance Survey is itself undescribed. It exists in mere maps, to be turned over carelessly or curiously, and passed by, forgotten and unappreciated. It is only within the last few years that the maps have been completed by the addition of contour-lines of submarine slopes supplied by the Admiralty; although the Admiralty has always been indebted for the coast-lines, and such land features as are shown on the charts, to the Ordnance Survey.

The Admiralty charts are accompanied by official sailing directions which often go beyond the bare facts necessary for purposes of navigation, and give interesting scraps of information as to the bordering land. The Geological Survey also has its memoirs, setting forth for every sheet of the map the details which have been ascertained by the geological surveyors, with theories suggested by the observations, and now and then a good deal of physical geography. In a few instances, such as Topley's "Memoir on the Weald," the work includes a true geographical treatise, tracing the relations of human institutions to the physical character of the ground, and explaining village sites and parish boundaries by reference to the escarpments and dip of the strata. The official Census and Board of Trade reports are extremely elaborate, but their treatment is rather statistical than distributional. All the meteorological data have been treated cartographically and discussed by the societies collecting them.

Only the Ordnance Survey remains without an official description. A memoir to the Survey was commenced for Ireland, but at the commencement it stopped. The data on the various sheets of the map are discussed nowhere, and the scores of interesting features which appear have only received passing notice from chance geologists. I should like to see, and would gladly help to make, a handbook or descriptive pamphlet of every sheet of the one-inch map. This should show the relation of the 216 square miles (432 square miles for the Scottish map) comprised in it, to the great natural features of the country, and then go on to describe the special features of the sheet. It would state the area between the various intervals of altitude, describe the river systems with their associated lakes (if any), and the structure of the valleys, the lines of communication, roads, railways, or canals, with the reasons for them. The sites of towns and villages would be treated so as to throw light on their origin; the distribution of scattered farms, country houses, and cottages would be handled so as to explain the distribution of population. County and parish boundaries would be discussed historically, so far as the vanishing evidence admits, in order to account for the eccentricities of outline and detached areas. The place names would be considered philologically, and grouped so as to throw light on early movements.

No such description could be complete without introducing explanatory facts drawn from the geological, meteorological, and statistical memoirs available; and, in many instances, historical events which are inextricably linked with the locality would be introduced. These would, however, be strictly subordinated in the plan, and nothing should be admitted in the description which did not directly throw light on the structure of the country, or which was not a direct outcome of the action of geographical conditions. Great engineering works which have changed the natural lines of communication of a district would of course be noticed, as well as the economic resources of the country. The whole would conclude with an alphabetical index containing every name on the sheet, with the latitude, longitude, and elevation of all important points.

This would form, if properly carried out, the greatest geographical work of the coming century, and would be completed by a discussion according to natural districts, such as Wales, the Pennine Chain, the Lake District, the Weald, the Fens. Afterwards these could be digested into an authoritative geography of the whole country, written with a perfect unity of plan and aim, and embodying the practical application of the principles of geography.

The preparation of such an ideal work would involve a great amount of geographical research, and would afford an opportunity for founding a school of British geographers, who would study their science practically and at first hand. The conditions of all research are the same. Abstraction on the part of the worker from all but the one aim being pursued is essential, and adequate training in the methods to be employed is necessary before beginning permanent work. These conditions are inconsistent with earning a living by doing work which is demanded by the public. The public does not yet realise either the value or the essential conditions of research. Practically, only a University professorship, in which research is the main object and lecturing is subordinate, would meet the case, unless a man of private means took the matter up, or it were undertaken under Government. Such work, to be efficient, would require to be steady, continuous, and unfettered. The results could not be sensational, and, very probably, would not be popularly appreciated; but participation in such research would be a noble training for students who do not desire to become specialists, for no educative influence is so powerful as personal association with a professor engaged enthusiastically in scientific work involving research in which every student may help.

I have enlarged upon a single instance, not because it is the only one that might be adduced, but because it may serve to suggest to those who have not thought of the matter before what sort of science geography is, what it may become, and how the impress of British thought may yet accompany the record of British work in the scientific literature of all nations.

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THE GREAT RED SPOT ON JUPITER.

By E. WALTER MAUNDER, F.R.A.S.

OF all our planetary neighbours, Jupiter, the easiest to study, offers us the most numerous problems. First of all comes the striking contrast between its enormous mass and low density; next, there is the difficulty of understanding how its atmosphere can have the great depth which it evidently possesses without the lower layers becoming compressed to more than metallic density; thirdly, the great variety in the rotation period of the different markings of the planet; fourthly, the continual changes which the details of the apparent surface present; fifthly, a certain strong persistency about the planet's appearance as a whole; and lastly, summing in itself every variety of enigma, there is the great red spot.

Its history is sufficiently well known. Public attention here in England was first drawn to it by Mr. F. C. Dennett, who stated in the *English Mechanic* of November 22nd, 1878, that he had then had it under observation for fully four months. But other observers had had it in view long before this notice appeared. M. Niesten, at Brussels; Prof. Pritchett, at Glasgow, Missouri, U.S.A; M. Trouvelot, at Cambridge, Mass.; the observers at the Dun Echt Observatory; Herr Tempel, at Arcetri; and others also had been attracted by it during the summer of 1878. The next year it was the subject of general attention amongst astronomers, and not without reason. Its deep colour—a strong brick-red—its great size, its well-marked outline and definite shape, made it a most attractive object. Here there was something relatively stable and permanent; something more substantial than the weird succession of beautiful but evanescent cloud forms which follow each other so swiftly across the Jovian disc. This was just what had been wanting to Jupiter before. The charm of variety had always been his; there had been also a certain stability about the arrangement of his belts; and his detailed markings had been formed after a few distinct types: but there had been nothing of such strongly marked individuality of character and such persistence of life till the red spot appeared.

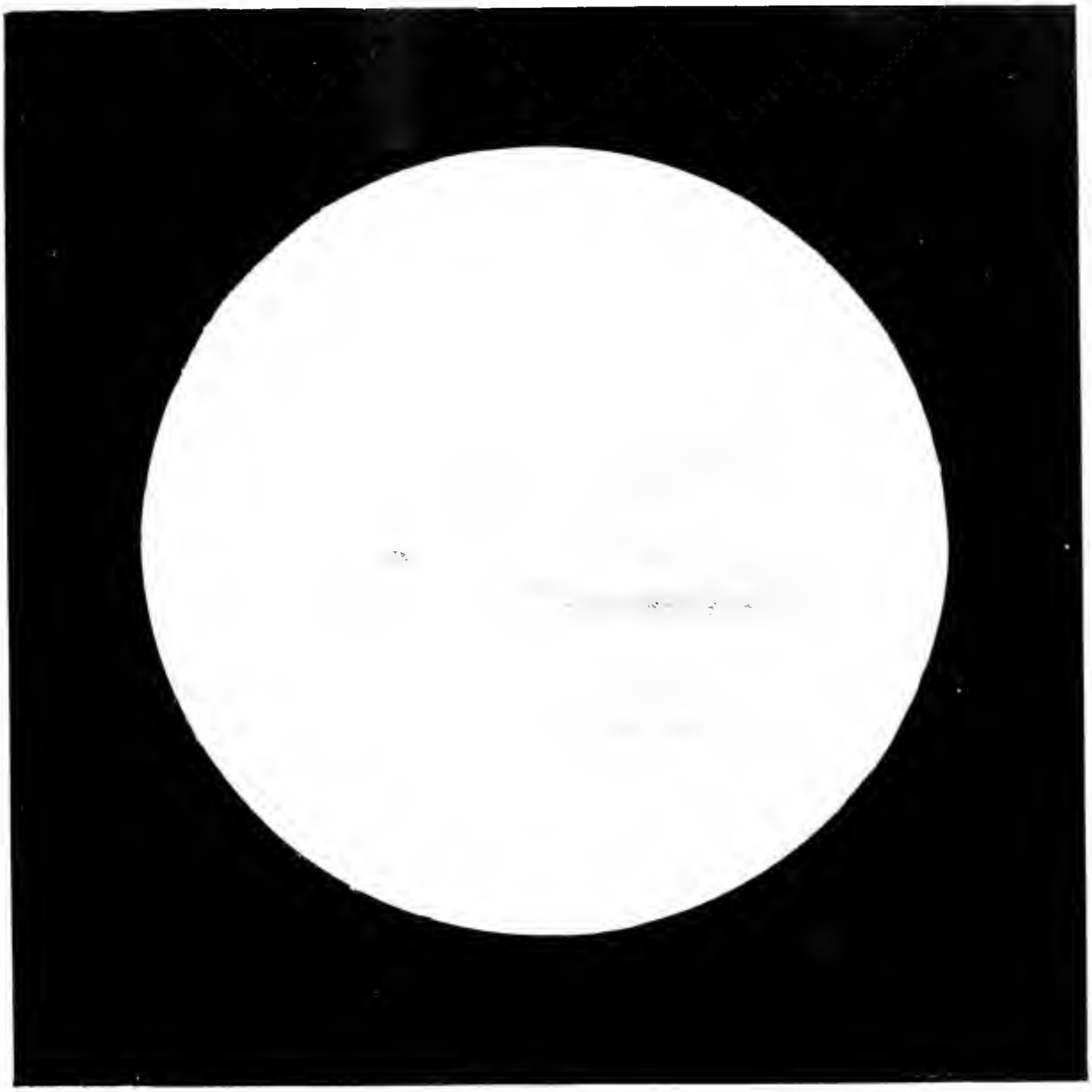
The first question which its discovery aroused was, "Has it been seen before?" Clearly it had not been so conspicuous before, but a fair amount of evidence was forthcoming that, for eight or nine years prior to 1878, the spot had been seen occasionally. Thus, Mr. H. C. Russell, at Sydney, observed what appears to have been the spot in 1876; Mr. Terby and Mr. Corder represented a similarly placed but smaller spot in 1872; and in 1869 and the following year Mr. Gledhill remarked in the same latitude, not, indeed, the red spot as such, but a hollow ellipse, not unlike the aspect it was destined to wear some fifteen years later, during the progress of its fading from its greatest distinctness.

There may have also been earlier records, but from 1878 to the present time it has been under observation at each succeeding opposition; and certainly the impression it then produced upon the most experienced observers of the planet was that it was quite a new order of feature. We may take it, then, as practically a new object in 1878; new, at all events, as to its definiteness.

That definiteness it did not long retain. In the succeeding oppositions it showed itself as continually growing paler and paler. Its outline remained much the same, but the interior of the spot appeared filled with white material, or the white cloud formed above it. By the end of May, 1883, only the faintest, feeblest ghost of the spot remained, and observers feared it was lost to them. It reappeared, however, during the next opposition, though still very faint, and it has undergone some minor fluctuations in brightness since. In 1891, for instance, it presented again the appearance of an elliptical ring, the interior being lighter and whiter than the margin. But it was now quite different from Gledhill's oval of twenty-one years earlier, the dark margin being broad and dense and the white interior small. The following year it was very faint—the preceding end especially so—and the neighbouring belt interfered with its southern border.

We have therefore had the great red spot with us for certainly seventeen and a half years; and it is probable that it existed, but in a less conspicuous form than in 1878, for quite nine years before. During this time its colour and its distinctness have altered much, but its size and shape little.

That a marking of area fully equal to three-fourths that of the surface of the entire earth should continue practically unchanged in size or shape for seventeen years on such a



JUPITER.

From a Coloured Drawing by Mr. N. E. Green, F.R.A.S.

world as Jupiter is a sufficiently striking circumstance, and led at once to the suggestion that here we had a glimpse of the real solid surface of Jupiter. But the observations of three most careful and acute observers—Mr. Denning, Mr. Stanley Williams, and Prof. Hough—combined to prove that the red spot had a most remarkable peculiarity: it changed its rate of rotation.

The following table by Mr. Denning (*Nature*, September 3rd, 1891, vol. xliv., p. 439) speaks for itself:—

ROTATION PERIODS OF THE GREAT RED SPOT.

Limiting Dates.	No. of Rotations.	Rotation Period.
		h. m. s.
1879, July 10th—1880, February 7th ...	512	9 55 34·2
1880, September 27th—1881, March 17th	413	35·6
1881, July 8th—1882, March 30th ...	640	38·2
1882, July 29th—1883, May 4th	674	39·1
1883, August 23rd—1884, June 12th	710	39·1
1884, September 21st—1885, July 8th ...	700	39·2
1885, October 24th—1886, July 24th	659	41·1
1886, November 23rd—1887, August 2nd ...	609	40·5
1888, February 12th—1888, August 22nd	462	40·2
1889, May 28th—1889, November 26th	439	40·0
1890, May 22nd—1890, November 25th ..	451	40·2

The rotation period has remained fairly constant in more recent years.

Briefly stated, it implies that in seven years the rotation period of the spot lengthened by seven seconds, a statement which is equivalent to saying that if the first rotation period given above represents the true rotation period of Jupiter, this vast formation, whatever its real character, had travelled eastwards with a constantly accelerating speed until it was moving at a rate which would bring it back to its starting point in less than six years, and which would suffice to make the tour of the earth's equator in about seven months. If we could imagine Australia to set off on its travels, and to quietly traverse the Southern Ocean towards Africa at a speed of a little over four knots an hour, we should have a very fair representation on the earth of what appears to be taking place on Jupiter, for Australia bears about the same relation as to area and position to this planet as the great red spot to that.

This fact seems to shut us off from adopting the suggestion which the relative persistency of the spot in shape and size so naturally suggests; viz., that we have here a glimpse of the solid surface of the planet, or, perhaps, a partial crusting over a liquid nucleus. The latter idea is not absolutely irreconcilable with these observations of drift, for it is quite conceivable that such a crusting might become gradually dissolved away on the western side—speaking now, as always, as from the point of view of an inhabitant of Jupiter—and be extended at about the same rate on the eastern. A slight variation in latitude which has also been remarked might be explained in the same way; and the greater stability of rotation period at the present time would imply that the crust had now attained a greater consistency, and had ceased to undergo this double process. Its present rotation time would then be the rotation time of the planet itself.

We cannot, however, adopt this suggestion, for if the red spot is a surface marking, then the white region which has surrounded it, and which, as a complete annulus surrounding the spot, has been even more conspicuous on photographs than to the eye, must be due to clouds—must be, in effect, at a higher level. This transfers the marvel of the persistency of the shape and size of the spot from the spot itself to the overlying cloud ring. Of the true shape of the actual spot itself we can know nothing; the shape of that which we see of it is defined wholly and entirely by the gap in the cloud region above.

When the spot was first observed in 1878 and 1879 its similarity in hue to the great ruddy equatorial belt was frequently remarked upon; and, as several observers have remarked—Prof. Keeler in particular (*Publications of the Astronomical Society of the Pacific*, No. 11)—the appearance of the equatorial regions is strikingly like what we should expect if the white cloud-like formations were floating at various heights in a reddish fluid. It is reasonable, therefore, to suppose that were the cloud masses removed we should see the whole of Jupiter as of the same deep hue as the red spot possessed in 1878 and 1879.

This would be in perfect harmony with the opinion at which almost every student of the planet has arrived, and not by one course of reasoning alone, but by many, viz.: that Jupiter still retains a very considerable amount of intrinsic heat, and the red tint might be reasonably ascribed to the glow of heated material far below the apparent surface, or possibly even to the high temperature of the lower strata of the atmosphere itself.

That the problem of the persistency of the outline of the spot is really one of the persistency of the upper cloud masses is, I think, shown by the definiteness of the "shoulder," at one time very clearly an integral part of the complete phenomenon, and its most stable and obvious feature in recent years. Read by the light of some of the photographs taken by the Brothers Henry, the red spot was produced by a disturbance in a bright white belt. The belt at a certain point divided into two arms, which, arching round, the one to the north and the other to the south, reunited again some forty degrees of longitude further on; the enclosed space being the celebrated spot, and the commencement of the arch on the north following side the equally well-known "shoulder."

This transference of the site of the problem does not, however, help us to a solution. We may see in the gradual diminution of the rotation period a subsidence of the cloudy surroundings defining the spot, and in the fact that the spot seems now to have adopted a steady rate, an indication that the vapours have reached a level where they are in more stable equilibrium. But the great mystery how and why, amidst so many changes, the *outline* of the spot has shown so little change remains a mystery still. Perhaps the mode of dissolution of the spot, should it be fated to disappear, may give us a means of fathoming it that at present we lack.

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JUPITER.

THE drawing of Jupiter that accompanies this number of KNOWLEDGE was made on the 17th of April, 1885, at 10 p.m., with an 18-inch reflector and powers of 300 diameters. The opposition of this year was particularly favourable for obtaining views of Jupiter, the writer having made one hundred and fifty-six drawings of the planet. The large red spot, though not so clearly seen as in previous years, was still distinctly visible, although the colour had faded. The general details of the disc were well marked, and with their various colours gave great interest to the study. The large red spot was followed by two similar markings; the first of these was about the length of the spot distant from it, on the same latitude. It was first observed in March of that

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* "The red belts presented on all occasions the appearance of a passive medium, in which the phenomena of the streamers and other forms shown in the drawings were manifest. These phenomena would be exactly reproduced by streamers of cloudy white matter floating in a semi-transparent reddish fluid, sometimes submerged and sometimes rising to the surface, and it is by no means impossible that such is actually their nature."

year as a grey mark, which became red in April, and continued visible till June. The southern edge of the south belt was also very red at times, much more so than the great spot, so that there was a tendency to become red in various portions of the southern hemisphere. The round dark mark near the equator is the shadow of the second satellite.

Nath. E. Green.

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PERIODICAL COMETS DUE IN 1896.

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

Of all the periodical comets whose orbits are known with some accuracy, two only are due to return to perihelion in 1896. One of these has been seen at seven previous returns, all consecutive; the other has hitherto been seen at only one appearance, unless a remarkable theory which was then started should be found on the forthcoming return to have been founded on fact.

The former of these two comets is that known as Faye's, because it was first discovered by the veteran astronomer, M. Faye, at Paris, on the 22nd of November, in the year 1843. Its orbit was calculated to be a short ellipse, with a period of about seven and a half years, and it duly returned to perihelion in 1851, being first seen on that occasion by Prof. Challis, at Cambridge, on the 28th of November, 1850. It has also been observed at every subsequent return, and was last in perihelion on the 20th of August, 1888. Another return to that position will be due on the 19th of March next, but the comet was nearest to the earth in October last, and was seen by M. Javelle at Nice so early as the 26th of September, nearly six months before perihelion passage. This comet is a very faint object, and has never been visible to the naked eye. Its orbit is remarkable for its very small eccentricity, which amounts to only about 0·55. When in perihelion, the comet never approaches the sun so nearly as the greatest distance of Mars; when in aphelion, its distance somewhat exceeds that of Jupiter, and it was probably the attraction of that planet which first brought it into our system.

The other comet to which we referred was discovered by Mr. Brooks, of the Smith Observatory, Geneva, N.Y., on the 6th of July, 1889. Mr. S. C. Chandler, of Boston, U.S., showed that it had made a very near approach to Jupiter three years before, which would have the effect of greatly changing its orbit. Now, a comet discovered by Messier, at Paris, more than one hundred and twenty-five years ago, on the 14th of June, 1770, was calculated by Lexell to be moving in an elliptic orbit, with a period of only five and a half years, but failed to put in an appearance when afterwards due, so that it acquired the name of Lexell's lost comet. This failure, however, was explained as arising from violent perturbations produced by the attraction of Jupiter. The comet had in fact approached that planet in 1767 within a distance of only about one-sixtieth part of the radius of Jupiter's orbit, and this circumstance it was that brought the comet within view from the earth, which it approached in 1770 within a distance of little more than seven times that of the moon. It probably returned to perihelion in 1775 or 1776, but in a position unfavourable for observation; and in 1779, before another return was due, it approached Jupiter even closer than before, coming, indeed, nearer to that planet than the distance of his fourth or most distant satellite, and its orbit thus again undergoing a great alteration. Now, Mr. Chandler thought, from his calculations, that the comet discovered by Mr. Brooks in 1889 might be Lexell's comet, brought once more into visibility from the earth by the attraction of Jupiter in 1886. Dr. C. Lane Poor, however, made a re-investigation of its motions, the result of which was not to confirm this theory. Mr. Brooks's comet was moving when discovered in an orbit with a period of nearly seven years, so that it will probably come into perihelion again in the spring or summer of the present year. It is hoped that it will be possible to obtain observations on that occasion, by which astronomers will be enabled to come to a definite decision with regard to the suggested identity with Lexell's lost comet of 1770. The orbit, as determined from those made in 1889, is even less eccentric than that of Faye's comet, and the perihelion distance from the sun is greater than the mean distances of some of the small planets, being more than twice as great as that of the earth. The eccentricity of the orbit amounts to only 0·48; this is the smallest of any known comet, with the doubtful exception of one denominated Tempel's first periodical comet, which was discovered by the late M. Tempel at Marseilles in 1867 and observed at returns in 1873 and 1879, but not seen subsequently. It should be added that M. Schulhof has recently made some calculations which seem to show that the comet discovered by Prof. Swift in August last year (and not Brooks's of 1889) was identical with Lexell's. The period of Swift's comet is about seven and a-quarter years, but at the next return in 1902 it is likely to be very unfavourably placed for observation, particularly in the northern hemisphere, so that we may have long to wait for the decision of this question.

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WAVES.—I.

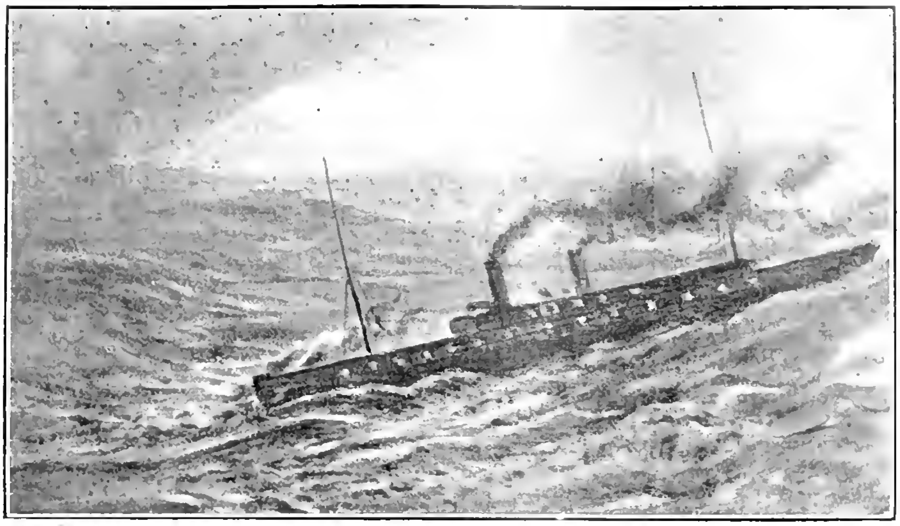
THE WAVES OF THE OCEAN.

By Vaughan Cornish, M.Sc.

When the lightest zephyr passes over a perfectly calm sea the glassy surface remains unruffled. As Byron wrote :—

> "Winds come whispering lightly from the West,
> Kissing, not ruffling, the blue deep's serene."

A breeze which travels at rather more than half a mile an hour just ruffles the water, darkening the surface, which no longer reflects like a mirror; but if the breeze drops the wavelets instantly cease and the water resumes its glassy look. If, on the other hand, the breeze increases until it has a velocity of about two miles an hour, permanent waves begin to rise, which increase in size as the wind continues to blow. The form of the waves in a rising sea is somewhat different from the smoothly sloping curve of a ground swell, for whilst the waves are rising the crests are exposed excessively to the force of the wind, and the troughs are sheltered. The tops of the waves are consequently driven forward, and break at the crest into the "white horses" which chase each other across a rising sea. At first the wind increases the height of the waves over every part of the sea upon which it blows, but after a time the waves near the windward shore attain such dimensions that the power of the wind is only sufficient to maintain, without increasing, them. Further to leeward the waves are still increasing, and still show the "white horses." However long a wind of constant strength may blow, the height to which it can raise the waves in any part of the sea is limited, being greater, however, as the distance from the windward shore increases. This increase in the size of the waves can readily be explained, for at any place the sea is raised not only by the force of the wind there, but also by the energy transmitted from the leeward waves. Off the coasts of Britain the greatest waves—greatest not only in height, but more especially in length from crest to crest—come rolling in from the broad



A Steamer sliding down the Slope of an Atlantic Wave.

Atlantic. The narrow seas of the English Channel give shorter, lower waves: often steep and breaking at the crest, choppy, lumpy, sometimes dangerous and always disagreeable, but lacking the majesty of the great ocean waves. It is with the short, steep waves that most of our marine painters are familiar, and it is rare to find a picture or a photograph which shows the long waves of mid-ocean. Our first illustration is from a water-colour drawing kindly placed at our disposal by the artist, Mr. G. H. Andrews, F.R.G.S. It shows a steamer of about two thousand tons sliding down the long slope of a wave in mid-Atlantic. She was sighted on a moonlight night when passing the ship on which the artist was homeward bound.

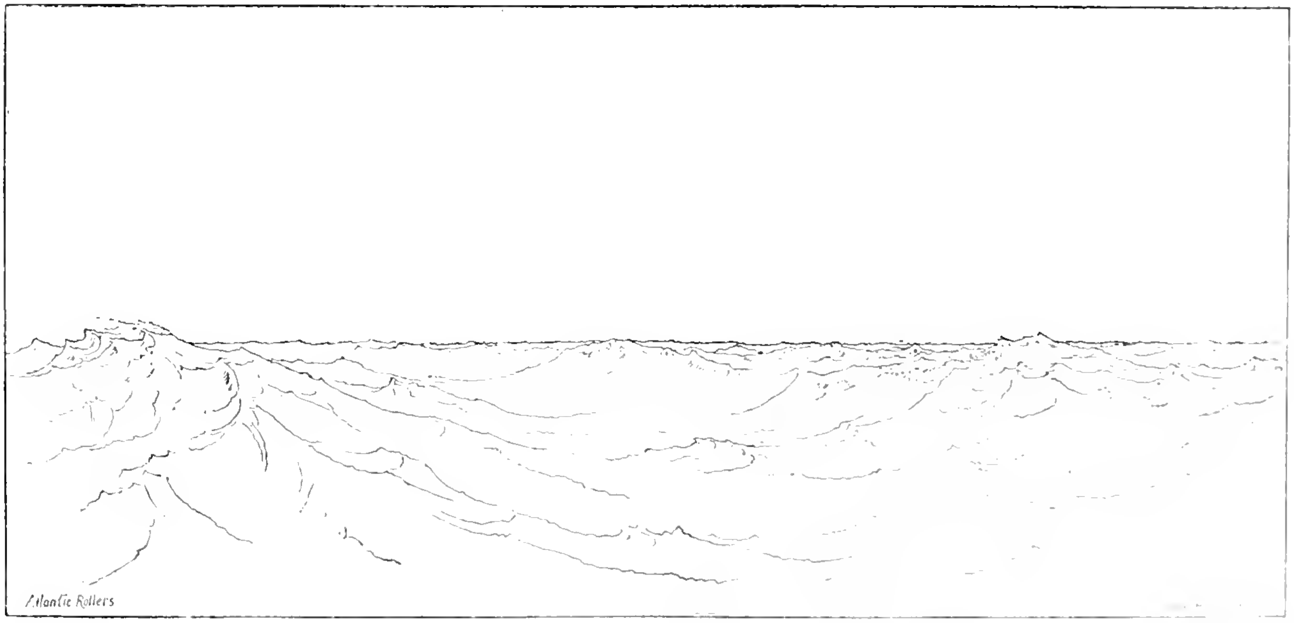


Fig. 2.—Atlantic Rollers. Reduced from an Original Drawing by Henry Holiday.

We have so far dealt with the raising of waves by the wind; let us now examine the course of events when the wind drops after a storm. The storm waves do not die out at once with the falling of the wind, as is the case with the wavelets raised by a passing breeze: on the contrary, the long rollers follow one another in unbroken succession for days after a storm, breaking at regular intervals upon the leeward shore with a solemn booming sound which is the more impressive from the stillness of the air. The smaller and shorter waves, raised latest by the wind upon the flanks and in the troughs of the greater waves, are the first to die out after the wind lulls, and the heaving surface of the sea is no longer chequered with the intricate interlacing undulations of lesser waves, but

> " . . the broad bosom of the ocean
> keeps
> An equal motion, swelling as it sleeps.

These waves, which travel independently of wind, are called *free waves*, in contradistinction to the *forced waves* of a rising sea driven forward by the strength of the wind.

Some of the best observations of ocean waves are those made by Dr. Scoresby during a homeward passage across the Atlantic in 1848. On March 5th the ship *Hibernia* was in lat. 51° N. and long. (at noon) 38° 50′ W., the wind being W.S.W. and the ship's course true N. 52° E. By sunset of the previous day the wind was already blowing a hard gale, which continued with heavy squalls during the night, so that all sail was taken in except a storm-staysail forward. On the afternoon of the same day Dr. Scoresby took up his post of observation on the saloon deck, which gave an elevation of the eye twenty three feet three inches above the water-line. He found, however, that every approaching wave intercepted the horizon, so that from this position he could decide little except that the average height of the waves, reckoned from trough to crest, was more than twenty-four feet. He, therefore, ventured upon the port paddle-box, which was seven feet higher, giving an eye elevation of thirty feet three inches. This level was maintained during the actual moments of observation, for the whole of the ship's length (two hundred and twenty feet) was clear within the trough of the wave when the next following crest was at its greatest apparent height, and the ship at these moments was on an even keel. From this elevated position quite one-half of the waves which overtook and passed the ship were above the level of the observer's eye. Sometimes a crest extending in a ridge one hundred yards long would be from 2° to 3° above the visible horizon, which would give a height from trough to crest of more than forty feet. Sometimes the crossing of two wave-crests would send up a sharp peak of water ten or fifteen feet higher than this, or the crest of a breaking wave would shoot up to similar height. The average height of the waves during the observations of March 5th was thirty feet. On the 6th, at ten a.m., the wind having lulled some hours previously, Dr. Scoresby took up his usual post upon the saloon deck, from which he estimated that the average height of the waves was still as much as twenty-six feet. He then set himself to determine the velocity of the waves, and their length from crest to crest. The ship was travelling at nine knots; the wave-crests overtook the ship at intervals of sixteen and a half seconds, and each wave travelled the distance of two hundred and twenty feet, from stem to stern, in six seconds. The length from stem to stern would appear, therefore, to have been little more than one-third of the distance from crest to crest. This proportion would give a wave-length of six hundred and five feet, but a necessary correction for the effect of the small angle between the direction of the ship's motion and that of the following waves reduces this to five hundred and sixty feet for the true wave-length. It follows, therefore, that five hundred and sixty feet of the wave passed the stern of the vessel in sixteen and a half seconds. But the ship during this time moved two hundred and thirty feet in the direction of the wave's motion. The true distance traversed by the wave in sixteen and a half seconds was therefore seven hundred and ninety feet, which gives a velocity of thirty-two and a half statute miles per hour.

During the height of the gale the forms of the waves were less regular than after the wind had begun to subside; the greater waves were chequered with many minor or secondary waves, and the greater waves did not for the most part range themselves in long parallel series, as do the rollers near shore when retarded by the shallowing water.

Fig. 2 shows an Atlantic wave such as those described by Dr. Scoresby, with a length of about six hundred feet from crest to crest. The wave is travelling from right to left, the right flank of the crest being that which is exposed to the wind. In judging of the relation of height to length it must be remembered that the view is somewhat foreshortened. The figure is from a sketch made at sea by Mr. H. Holiday, who has kindly placed the drawing at our disposal.

In order to understand waves we must study, not only the motion of the wave, *i.e.*, the steady onward rush of the wave-crest, but also the motion of a particle of surface-water situated in the path of the wave. Some information as to the motion of the water-particle may be gained by watching from a pier the movements of a light floating body outside the line of breakers. When a wave-crest approaches, the body moves upwards and forwards; then, at the crest of the wave, it is for a moment moving forwards only; when the crest passes it moves first downwards and forwards, then downwards and backwards, until, in the trough of the wave, the body is again in its first position and is for a moment moving horizontally backwards, *i.e.*, seawards, before rising again as the next wave-crest approaches. More exact observation, agreeing with mathematical calculation, shows that the motion of the particle is, in deep water, almost perfectly circular, the diameter of the circle being in the direction in which the wave is travelling. The particle of water moves with uniform velocity, and the time of one complete swing of the particle round its circle is equal (as follows from what has been already said) to the interval between the passage of succeeding wave-crests. The vertical distance through which the particle moves is equal to the height from trough to crest. Again, from the fact that the motion is circular, it follows that the particle moves through a *horizontal* distance equal to the height of the wave from trough to crest, *not* (be it well understood) equal to the wave-length, or distance from crest to crest.

The velocity of the particle, it must be remembered, is by no means the velocity of the wave. The particle takes the same time to move uniformly round its small circle that a wave-crest takes to pass over a whole wave-length—say ten times the distance, even in a very rough sea.

The more rapidly a wave-crest travels the greater will be the distance which separates it from the next wave-crest. This connection between velocity and wave-length is an important property of water waves, which run by the action of gravity. In sound waves, on the other hand, the velocity is independent of wave-length. In order to explain the connection between the wave-length and the velocity of water waves, we cannot do better than adopt the artifice employed by Newton in the second book of the "Principia." He represents the water as contained in a U-tube (see Fig. 3, taken from an edition of 1729). If the tube be agitated, the level of the water oscillates up and down in the two limbs. The level in one limb being E F, and in the other G H, the *weight* of so much of the left-hand column as is above E A moves the whole of the liquid. This column of liquid is a falling body, but not a body falling freely. Its descent is retarded by the fact that it has to overcome the inertia of the remainder of the liquid. The oscillations of the liquid in a tube of given length are executed in equal times whether they be great or small, just as are the decreasing oscillations of any pendulum. The time of an oscillation depends upon the length of the whole column of water, in the same way that the time of swing of a pendulum depends upon its length. If the length of the pendulum be doubled the time of one oscillation is increased fourfold; if the length be tripled the time of oscillation is increased nine times; and so on, the length of the pendulum being proportional to the *square*

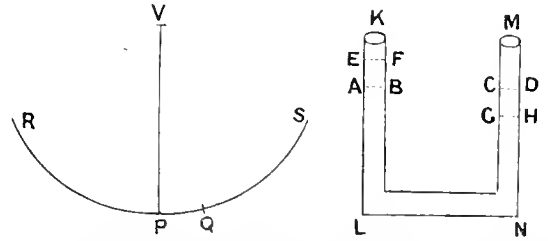


Fig. 3.—"If water ascend and descend alternately in the erected legs KL, MN of a canal or pipe; and a pendulum be constructed, whose length between the point of suspension and the centre of oscillation is equal to half the length of the water in the canal: I say, that the water will ascend and descend in the same times in which the pendulum oscillates."—Newton's "Principia," Book II.

of the time. The relation is due to the fact that the force of gravity is *continually* acting. The relation may be otherwise stated by saying that the time is proportional to the square root of the length. Now, in our U tube the portion E F, at the moment represented, is the crest of a wave, and G H is the succeeding trough. The interval of time which will elapse before G H is the crest is proportional to the square root of the length of the column of water; or, the velocity with which a wave-crest appears to travel over the surface of the water is greater in proportion to the square root of the wave-length. From this we see that, if any cause of disturbance starts a wave of a certain velocity, the distance from crest to crest will depend upon this velocity, and in the precise manner above stated. From the known length of the seconds-pendulum (or, to put it otherwise, from the known value of the acceleration due to gravity) the wave-length proper to any given velocity can be calculated. The following approximate rule will be found useful for numerical calculations relating to water waves, viz., that—five times the wave-length is numerically equal to the square of the velocity, lengths being expressed in feet and time in seconds. This rule gives a velocity of about forty feet per second, or twenty-seven miles per hour, for waves three hundred feet from crest to crest, such as are observed in the Atlantic after a storm.

The depths of the ocean are undisturbed by the waves with which the wind covers the surface, for the excursions of the swinging particles diminish very rapidly as the distance from the surface increases. In an Atlantic storm-wave, with surface particles swinging round a circle of forty-foot diameter, the motion at a depth of three hundred feet is calculated to be not more than half an inch; so that we may say that at a depth greater than the distance from crest to crest the water is undisturbed by winds, and, conversely, where there is such a clear depth of water the formation and the motion of the largest wind-waves is not hindered or modified by the sea bottom. Some seas, however, are really very shallow. The depth of the North Sea is not more than half the distance from crest to crest of a full-grown Atlantic wave; it would be difficult to find a spot in the North Sea where St. Paul's Cathedral would be completely submerged.

When the depth of water is small relatively to the wave-length the motion of the water particles is greatly modified, and we encounter the more varied phenomena of waves in shallowing water, culminating in the waves of the sea-shore and the ever-beautiful breaking wave—of all of which more anon.

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THE BANANA.

By Richard Beynon.

NEVER in the history of the world's trade has there been so marked an example of an edible article of commerce attaining within a comparatively short period the popularity achieved by the banana. It is not long ago that this luscious product of the tropics was only heard of as a vegetable curiosity. Occasional parcels were brought to England by vessels trading from the West Indies or the West African islands; but these reached no farther than the narrow circles of the friends to whom they were sent. The omnivorous British public remained practically ignorant of the rich, wholesome fruit which nature was ready to produce so bountifully. Now, however, no fruiterer's stock is complete without its bunches of richly-tinted bananas; while the enterprise of the "coster" and other itinerant vendors has placed the fruit within the reach of the poorest.

Originally the banana was a native of the eastern tropics, but now it is cultivated in all tropical and sub-tropical countries, whether in the Old or New World.

The plant itself is a peculiar one, the stem, which attains a height of fifteen or twenty feet, being practically formed by the sheathings of the leaves, the blades of which reach the very respectable dimensions of eight or ten feet in length and eighteen inches or two feet across. The fruit clusters, which branch from the stem, have been known to weigh upwards of ninety and even a hundred pounds. A bunch of average bananas contains eight hands of ten bananas, while those of inferior quality will consist of but six or seven hands.

The productiveness of the banana plant is enormous. We are sometimes wont to refer to the productive power of grain or the potato as examples of extraordinary fertility. But, according to Humboldt, the banana is more than a hundred times as productive as wheat and forty-four times as productive as the prolific potato.

As a complete article of food, containing in itself the principal elements necessary to preserve the human machine in health and strength, this fruit is one of the completest with which nature has furnished us. The principal constituent is of course water, which practically forms three-fourths of the weight of the banana. Sugar, pectine, etc., compose about twenty per cent., while nitrogenous matter is, roughly speaking, accountable for the remaining five per cent.

In many tropical areas the banana is the staple food, and from the unripe, sun-dried fruit a most nutritious flour is manufactured. In fact, this fruit is to a great section of the inhabitants of the tropics, and the regions adjoining, what wheat is to the European and rice to the Hindoo.

Twenty-five years ago, some men interested in the New York fruit trade prophesied a big future for this fruit. Thinking that there might be "money in the business," a fruit merchant introduced to the buyers of New York a shipment of four thousand bunches; but this initiatory effort does not seem to have met with much success. Ten years later, another consignment of ten thousand bunches was shipped from Jamaica, and no difficulty was experienced in securing a ready sale. *Now*, the trade in bananas between New York and the West Indies forms a special department of commerce, for which vessels are specially built and equipped.

The quantity of bananas shipped from West Indian and adjacent ports into the United States now amounts to thirteen or fourteen million bunches annually, valued at considerably over four millions sterling. Our own possession of Honduras exported, in 1880, bananas to the value of seven hundred pounds, while at present the annual value of this fruit exported is close upon fifty thousand pounds. From one port alone, on the shores of the Caribbean Sea, two hundred and fifty thousand pounds worth of bananas are exported each year.

The fruit which finds its way to England comes almost entirely from Madeira and the Canary Islands. Before long, however, the West Indian banana will enter the field as a powerful competitor, the arrangements for the safe and speedy sea-carriage of the fruit now rendering such a contingency quite feasible.

The bananas intended for export are cut when green, and consequently unripe, and carefully packed in long and loosely constructed baskets, or wooden crates. The

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* It is to be borne in mind that in the proportions obtaining in actual waves, the vertical limb of the supposed tube is short compared with the length of the horizontal part.

bunches of fruit are encased in cotton wool, and while great care has to be taken to protect them from damp or frost, thorough ventilation must be maintained as well. On arrival at the fruit merchant's warehouse, they are stored in dry, airy rooms, the temperature of which is regulated by the condition of the fruit, and the length of time it is proposed to keep it before placing it upon the market. Thus, fruit which is wanted to ripen slowly may be kept at a steady temperature of 55° to 60° Fahrenheit, while the ripening process may be easily accelerated by increasing the temperature. When properly ripe, the outer skin assumes that delicate canary hue which colour experts maintain has no other exact parallel among the tints with which nature invests her vegetable products.

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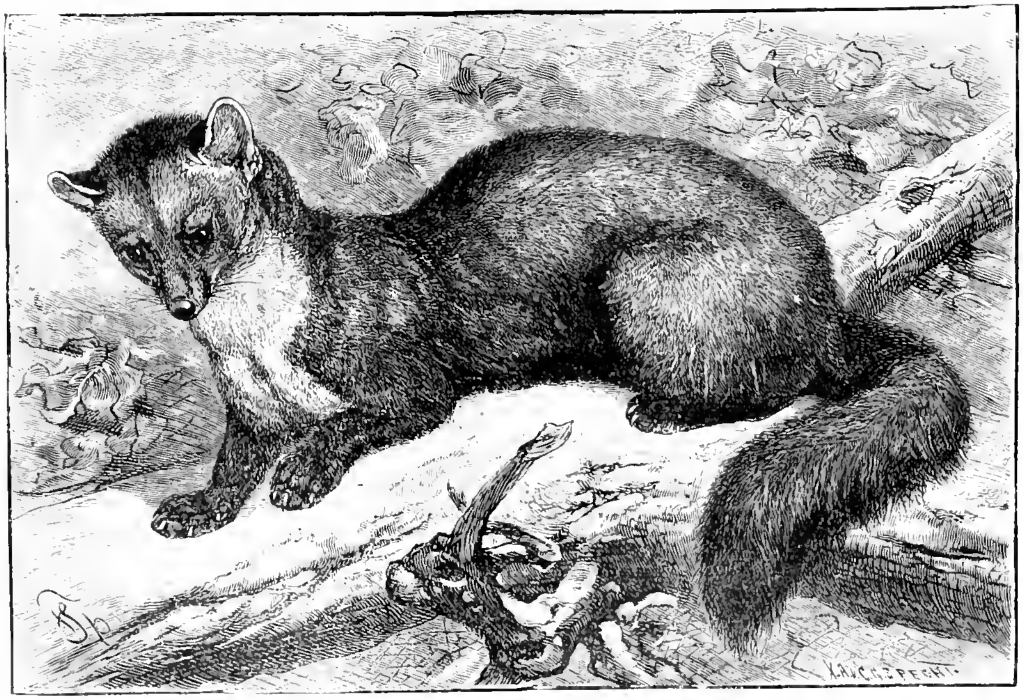
OUR FUR-PRODUCERS.—I.

OTTERS, SKUNKS, BADGERS, AND GLUTTONS.

By R. Lydekker, B.A.Cantab., F.R.S.

THE skins of mammals have always played an important part in human clothing from the very earliest times, when they were dressed with rude scrapers of flint, obsidian, or other kinds of stone. Before the art of weaving became known, they appear to have constituted the entire dress of our savage ancestors. and although in temperate climates they are now to a great extent articles of luxury, in the Polar regions they are absolute necessities. The trade in furs at the present day is enormous, the value of those sold in London alone being estimated a few years ago at little short of a million sterling; and the recent rise in the price of some of the more valuable kinds suggests that this estimate may now be considerably below the mark.

Although the term "fur" is commonly regarded as distinct from wool, yet in nature there is a more or less complete transition from the one to the other, so that in any essay on fur-producing animals, it is difficult to exclude those that yield wool. Nevertheless, whereas wool, as such, is employed in the manufacture of textile fabrics after its removal from the skin, while furs are the whole "pelts" of the animals by which they are yielded, we have an obvious distinction, so far as manufacturing purposes are concerned. Accordingly, in the present series of articles, our attention will be directed to pelts alone. It would, of course, be impossible within the limits of our space to mention even by name all the animals whose pelts are used in commerce; and we must therefore confine ourselves to such as are most commonly employed, and to those which, from their beauty or rarity, command the highest values in the market. It must not, however, be supposed that those which fetch the highest price at one time will do so at another, for fashion in furs, as in everything else, changes; and skins which are in high demand in one season may be a drug in the market in the next. Consequently, fluctuations in value of from forty to sixty per cent. are by no means uncommon; and probably these fluctuations are of some importance in keeping up the supply, for whereas, when its skin is in fashion, a species of mammal will be relentlessly hunted, when the mode changes the creature has a more or less complete respite for a season. Nevertheless, there are certain pelts, such as those of the sea-otter and silver-fox, which always maintain an exceptionally high value.



The Pine-Marten. (One-fourth natural size.)

Fur and wool, both of which are merely varieties of hair, are the products of mammals alone; but whereas the great majority of that class grow hair of some kind or other, it is chiefly among particular groups or families that the most valuable furs are produced. One of the most valuable families of all in this respect is that of the weasel tribe—the *Mustelidæ* of zoologists—which comprises the martens, ermines, otters, and sea-otter; and certainly no other group includes such a large number of valuable fur-bearing species. But the fur-seals (*Otariidæ*), although less numerous in species, likewise occupy a high position, on account of the large size of their pelts and the number of individuals by which they are represented. Among the abundant yielders of less valuable furs may be mentioned the squirrel family and the hares and rabbits.

It is a somewhat curious comment upon the susceptibilities of human nature that, whereas we are continually being reminded of the iniquity of our ladies in adorning their hats and bonnets with the plumage of birds, yet no one has a word to say against the enormous slaughter of mammals that is continually taking place for the sake of their pelts. No one, we believe, has ever thought of establishing a "fur league," and yet it is extremely doubtful whether the cruelty which is certainly exercised in the acquisition of birds' plumes is not equalled, or even exceeded, in procuring the pelts of mammals. Possibly this apathy is largely due to the fact that, whereas mammals, from the nocturnal habits of the majority of the fur-yielding kinds, are but seldom seen, birds are always with us.

Much might be written as to the various modes of dressing and preparing the raw pelts for use, but as this would entail too much space, we proceed at once to notice the chief groups of fur-producing mammals. Here a strict zoological arrangement will not be followed, as it seems preferable to deal first with such groups as either contain the greatest number of fur-bearing species, or comprise forms whose pelts are remarkable for their extreme beauty or high commercial value.

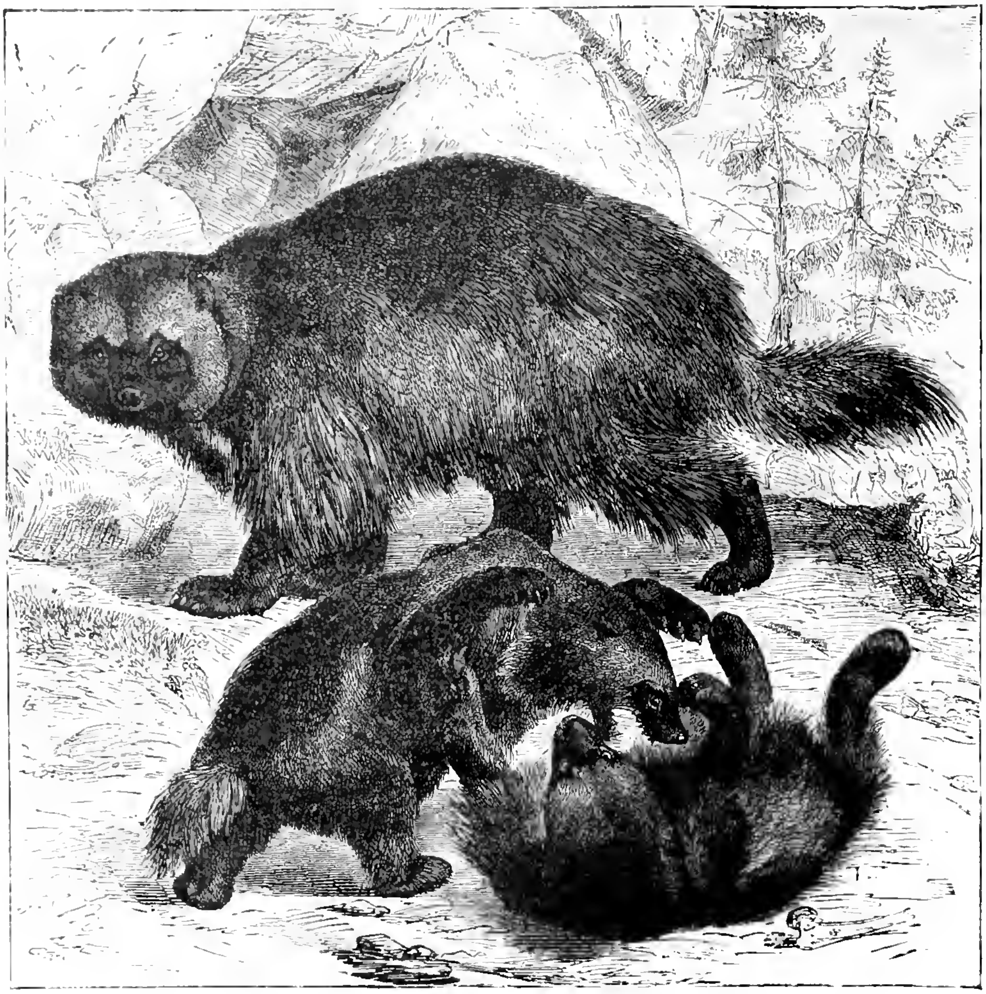
We take then, first, the weasel tribe (*Mustelidæ*), which includes the sea-otter, true otters, badgers, gluttons, ermines, martens, skunks, and others, among which the sea-otter (*Latax lutris*) stands pre-eminent here, having the most valuable pelt of any mammal. It will be unnecessary here to point out the characteristics of the family, but it may be mentioned that all its members agree in having only a single pair of molar teeth in the upper jaw, and never more than two pairs of such teeth in the lower jaw; the upper molars being remarkable in that they are generally wider on the inner than on the outer, whereas in the majority of the Carnivora the reverse is the case. The great majority of the members of this family are inhabitants of the northern hemisphere, where, with the exception of certain otters and skunks, all the species whose pelts are valued in commerce occur. And it may be mentioned that, as a rule, the further north we go the more valuable do the pelts become, while it is only in northern regions that certain species are white for a portion or the whole of the year.

The Cape Polecat. (One-sixth natural size.)

Although presenting many structural features in common with the freshwater otter, the sea-otter stands apart from all in the peculiar structure of its hinder grinding teeth, which, in place of being surmounted by sharp cusps and ridges suited to holding the slippery skins of fishes, have blunted, mammillated crowns, admirably adapted for crushing the shells of the crabs on which this animal feeds. It is also peculiar in having only two pairs of front, or incisor, teeth, in place of the usual three. But its most remarkable feature is to be found in the structure of the hind feet, which form webbed flippers, with the toes much elongated. It has been usually considered that when on land the sea-otter stands with its hind feet bent forward under the body like an ordinary mammal; but according to the observations of Mr. Snow, who has hunted and killed these animals on the shores of the Kurile Islands, this is incorrect, the flippers, both when walking and swimming, being turned backwards, in the same manner as are those of an ordinary seal. In appearance, the sea-otter may be compared to a very large freshwater otter, with a shorter body and legs, a short and blunt face, bearing whiskers somewhat like those of a cat, and a short, flattish, and somewhat bushy tail, ending suddenly in a bluntish point. The fur is generally some shade of dark brown, although occasionally lighter, and among it are a certain number of longer white hairs, which are not removed in dressing, and form its chief beauty. Sea-otters, which are now rare animals, and never appear to have been abundant, are found on both sides of the Pacific, ranging in America as far south as Mexico and California, and on the Asiatic side to Kamschatka and the Kurile Islands; the Aleutian and Kurile Islands being the localities where they are least uncommon. A few years ago, between £80 and £90 was a high price for the pelt of a sea-otter, but by 1892 £100 was no uncommon price, while as much as £200 had been given for an unusually fine example. At a sale in London in the spring of 1895, the hitherto unheard-of price of £225 was paid for one by a Russian nobleman. This splendid specimen had been stripped off the animal entire, glove-fashion, without the usual slit up the lower surface, thus preserving both upper and lower surfaces intact. Such a price has, we believe, never before been given for a single pelt of this or any other animal. Sea-otters are either hunted by men in boats and shot, or caught in nets, when they meet their death by drowning.

True otters (*Lutra*), of which there are a considerable number of species scattered over all parts of the world, except Australasia, Madagascar, and the Polar regions, are too well known to need anything in the way of description:

and their fur, chiefly in the form of trimming, is likewise sufficiently familiar. Although otter-pelts may be classed among the more valuable furs, their price bears no comparison to that of sea-otter fur; and it is noticeable that the pelts of the southern species are of considerably less value than those of the northern kinds or races. For instance, whereas skins of the small Indian otter (*L. cinerea*) sell for only a shilling each, while those of the big Brazilian species (*L. brasiliensis*) fetch only from one to six shillings, the price of a pelt of the common European otter (*L. vulgaris*) ranges from five to thirty shillings. Canadian otters (*L. canadensis*), which are larger and finer, attain still higher values, selling at from thirty to fifty shillings a-piece; while in 1889, fine Labrador skins fetched as much as ninety-five shillings. Some idea of the importance of otter-skins in commerce may be gathered from the fact that, according to Mr. Poland, upwards of ten thousand skins of the European species are sold annually at the pelt fair in Leipsic; while in Prussia alone over four thousand individuals were killed during the winter of 1885-86. As regards the American species, in the year 1891 over eight thousand skins were sold by the Hudson Bay Company, and more than seven thousand by the Alaska Commercial Company. With this incessant persecution, it is a marvel that otters continue to exist at all, especially as they are comparatively slow breeders. Otter-fur is used both in the natural state and when "pulled"—that is to say, when the longer hairs have been removed. When pulled and dyed, it is used largely for glove-tops, and has much resemblance to seal-skin, although it wears much better. In northern countries the darker varieties are largely used for collars and cuffs of coats in the natural undyed condition, but in England lighter-coloured skins are preferred for the same purpose.



The Glutton, or Wolverene. (One-sixth natural size.)

In America, otters are chiefly captured by trapping. "Searching for a 'slide,' or place where the animal habitually crawls from the water up the bank, the hunter," writes Dr. Elliott Coues, "sets the trap on the spot, a few inches under water. No bait is here required, and devices are used in securing the trap by which the animal may be led into deep water when caught, or lifted upward, the design in either case being to prevent its escape by gnawing off the imprisoned limb. The trap may also be placed at the top of the slide, two or three feet back off the slope, in a place hollowed to receive it, and covered with snow. Under such circumstances, care is taken not to handle the trap with the bare hands. It is scented with various animal odours, and, to further ensure success, a 'way' is made to it by means of parallel logs."

The otters constitute by themselves a separate sub-family of the *Mustilidæ*, and next to them comes in the zoological system a second sub-family represented by the skunks, badgers, and ratels. Of these, the most important from our present point of view are the skunks, of which there are several genera, all confined to America, where the range of the various kinds extends from the Hudson Bay territory to Patagonia. The species of most importance, from a commercial point of view, is the common skunk (*Mephitis mephitica*) of North America, which may be compared in size to a small cat, and ranges from Hudson Bay to the Central United States. In common with its kindred, this skunk has a large bushy tail, frequently carried bent over the back in a somewhat squirrel-like fashion, and a beautiful jet-black fur, varied with a larger or smaller amount of white forming a pair of longitudinal stripes on the body and head, and more or less of the tail. In some specimens the white is reduced to a fork on the head and a patch on the tail-tip, and it is not improbable that absolutely black examples may occasionally be met with.

White skunks are rarely found. All skunks enjoy an unenviable notoriety on account of the noisome fluid they have the power of ejecting when irritated; and it is doubtless the consciousness of the safety thus enjoyed that emboldens them to walk about in the open in broad daylight, as they may not unfrequently be seen to do on the Argentine pampas. There are, indeed, few animals that will face a skunk; and although some dogs will "go for" them, they suffer many hours' misery in consequence of their temerity. Indeed, so lasting and disgusting is the odour of the secretion of these animals, that it is by no means an uncommon event for a whole camp to be thrown into disorder at the cry of "Skunk!" It might naturally be supposed that the skin of an animal producing such an ill-favoured odour would scarcely be suited to the purpose of the furrier; but if the creature can be killed without discharging its secretion, or be made to discharge it in such a way that it does not touch the fur, the value of the latter is not impaired. And it appears that the secretion cannot be discharged when the animal is raised from the ground. Consequently, one of the best kind of traps for skunks is the so-called "deadfall," in which one huge log is made to fall suddenly upon an underlying one in such a manner that the unfortunate victim is pinned between the two and instantaneously killed. Even, however, in the manufactured state there is a suspicion of an unpleasant odour about skunk-fur, which detracts considerably from its value. Probably with a view to conceal its real nature, skunk-fur is, or was, termed by the trade "Alaska sable." The trade in these skins has greatly increased in volume during the last few years, over twelve thousand having being sold by the Hudson Bay Company alone in the year 1891. The price of what is called a black pelt varies from seven to ten or even thirteen shillings; while such pelts as have broad white stripes fetch from two to seven shillings, the whiter specimens being of still less value. Black skins are used in their natural colour, whereas all the striped ones are generally dyed black or brown; but it seems a pity that these are not made up as they are, since the contrast of the black and white would present a very striking effect. The smaller skunk (*Spilogale putorius*) of North America, which differs from other members of the group in its arboreal habits, yields skins of no great commercial value, although from six thousand to thirteen thousand are annually imported. These vary in price from sixpence to two-and-threepence each, and are commonly employed as coat-linings. Of still less value are the pelts of the South American skunk (*Conepatus mapurito*), the fur being coarse and harsh. Still, a few thousand skins are annually imported into England, and sell at from a shilling to half-a-crown a-piece.

Of the other members of the sub-family, the common badger (*Meles taxus*) is important in that its hair is largely employed in the manufacture of brushes, although it is too coarse to be much used as fur. It is estimated that about four thousand badger-skins are imported yearly into this country alone; and although we are accustomed to regard the badger as a comparatively rare animal, the fact that over five thousand head were killed in Prussia during the winter of 1885-6 shows that this is by no means the case on the Continent. According to quality and demand, the price of badger-skins fluctuates between one and two shillings each.

The North American badger (*Taxidea americana*), which differs from the true badger in the structure of the skull and teeth, has a finer coat than the latter, and is thus better adapted to the requirements of the furrier. Its general colour is light grizzled yellowish-grey, with longer black hairs, which are white at the tips; while the soft under-fur is light brown, becoming drab near the roots. The pelts are of some value, varying from about six to twenty-two shillings each. In the year 1891, between four and five thousand skins were sold by the Hudson Bay Company, and over five thousand by other traders. Occasionally the fur is dyed dark brown, although more frequently employed in the natural condition. Formerly, the hair was much used for shaving-brushes, but it is generally too soft to make good ones. Like its Old World cousins, the American badger lives in burrows, which in some parts of the country are extremely numerous, and it is endowed with the same fighting powers.

Those near allies of the badgers, the Indian and African ratels (*Mellivora*), have fur of but little commercial value, although a few skins are imported with those of Asiatic badgers. Another member of the same sub-family is the Cape polecat (*Ictonyx zorilla*), whose black-and-white-striped pellage recalls that of the smaller skunks. In spite of the beauty of the fur, but few skins are imported into Europe; the average being only a few hundred yearly, and the price of them varying from fivepence to sevenpence each.

Much more valuable is the pellage of the wolverene, or glutton (*Gulo luscus*), which belongs to the same sub-family as the martens, and is one of the few mammals common to the northern parts of both hemispheres. The wolverene is an animal with somewhat the appearance of a small bear, although furnished with a moderately long and bushy tail. The general colour is dark grizzled brown, but a saddle-shaped area on the back is defined by a ring of lighter-coloured hair, and in some examples the whole pellage is very light-coloured. Although somewhat coarse, the long and rich fur of the wolverene has a considerable commercial value, good skins fetching as much as thirty shillings. In 1868 the Hudson Bay Company disposed of eleven hundred wolverene pelts, and a little over a thousand in 1891. A number of skins sewn together make a very handsome carriage-rug; and by the North American Indians and Eskimo, strips of wolverene-fur are employed to trim their garments. When dyed black, the fur is very handsome.

Science Notes.

A number of the former students of Professor Bonney's geological classes in the University of Cambridge and at University College, London, having felt a desire to recognize the value of his services to geological science, have united in presenting him with his portrait as a mark of their personal esteem and gratitude. The work has been executed by Mr. Trevor Haddon, Slade Scholar and Medallist, and Fellow of the Herkomer School.

The Society for the Protection of Birds has an excellent scheme for imparting a knowledge of birds and their uses to the public. The Society has provided itself with a most beautiful series of lantern slides, which it is ready to lend to any of its members for the purposes of an illustrated lecture on birds and their protection. The slides are accurate and exceedingly good, no expense having been spared to make them so.

The analysis of earths from various places in the Lower Congo district proves that the soils there, sandy as well as calcareous, are provided with reserves of phosphoric acid and potash which insure a high fertility. It is regarded as certain that, in the territories where the disappearance of forests has not modified the rainfall, the cultivation of coffee, cocoa, and other economic plants can be carried on for a long time without the use of manure.

On St. Andrew's Day, Lord Kelvin delivered his retiring address as President of the Royal Society. Referring to the losses of members sustained by the Society during the past year, he mentioned Cayley, one of the makers of mathematics; Franz Neumann, one of the most profound and fertile of all the workers in mathematical physics of the nineteenth century; Huxley, a man who can ill be spared, a resolute and untiring searcher after truth, and an enthusiastically devoted teacher of what he learned from others and what he discovered by his own work in biological science; Louis Pasteur, who, before he entered on his grand biological work, made a discovery of first-rate importance in physics and chemistry—the formation of crystals visibly right-handed and left-handed from one solution—and who, by the line of research to which he devoted most of his life, conferred untold benefits on humanity and the lower animals. Lord Kelvin went on to describe the further work on the nature of argon, and the discovery by means of spectrum analysis of a new element identified with the one called helium, found thirty years before to exist in the sun. After dealing with the awards of the various medals—the Copley medal to Dr. Karl Weierstrass for his investigations in pure mathematics, Royal medals to Dr. John Murray for his editorship of the report of the *Challenger* expedition and to Prof. Ewing for his investigations on magnetic induction in iron and other metals, and the Davey medal to Prof. Ramsay in recognition of his work on argon and helium—Lord Kelvin concluded by referring to the keen regret which he felt that the five years during which he had presided were past, and that he ceased to be the President of the Royal Society.

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Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

VARIABLE STARS.

To the Editors of KNOWLEDGE.

SIRS,—The statements in my note in June (1895) KNOWLEDGE, as to the variations in period and fluctuations in light of Mira and R Leonis at their last appearance, having been fully verified by the observations of Mr. H. M. Parkhurst, of Brooklyn, New York, published in the *Astronomical Journal* of June 2nd and August 5th, and by your own correspondents, Messrs. Corder and Backhouse, to whom my thanks are due, that question may be regarded as settled, and in a way very gratifying to the present writer.

And now, with your permission, I will inquire what has been the experience of observers on your side with R Scutum Sobieski this season. The star has long been observed, and, like those mentioned above, is regarded by the professionals, and those having large telescopes, as a "chestnut," and is neglected. But if there is any relation between variable stars and cometary and other random things, as is supposed, their observation by careful observers with small apparatus may lead to important results.

The magnitude of R Scuti, as given by Webb, vol. ii., is at maximum 4·7 to 5·7, at minimum 6 to 9. The Companion gives the following ephemeris :—Minimum July 6th, maximum August 6th; minimum September 11th, maximum October 16th. The minima, according to Webb, are alternately bright and faint, and Klein says the period is irregular. I took up the star, and estimated its light by comparison to be—July 25th, 5·7 magnitude; August 6th, 5·8; August 21st, 5·7; August 23rd, 5·6; September 5th, 6·2; September 13th, 6·5; September 22nd, 7·00; October 4th, 7·5; October 5th, 8·0; October 8th, 8·0; October 10th, 7·8; October 12th, 7·6; October 14th, 7·5; October 15th, 7·4.

From these observations it appears that the star is behind time in period as well as in light, and that the light fluctuates. Of the four stars, *b*, *c*, *d*, and *e*, east of it, R has been the faintest since October 1st; *d*, by photometric measure, is 7·17 magnitude, falling below over half a magnitude on October 5th.

Memphis, Tenn., U.S.A. DAVID FLANERY.

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SECOND BLOOMING OF THE HOLLY.

To the Editors of KNOWLEDGE.

SIRS,—Among the many second flowerings resulting from the exceptional clemency of the past autumn is one which I have never noticed here before, viz., that of the holly. This district forms part of the high plateau of the Midlands, and our well-known holly woods stand upon so high an elevation as to be exposed to winds from every direction. Nevertheless, a second flowering has occurred this autumn. I found one tree to-day bearing both the red berries from the spring blooming, and a second and plentiful crop of partially opened flower-buds.

ALFRED J. JOHNSON.

Boldmere, Sutton Coldfield,
December 8th, 1895.

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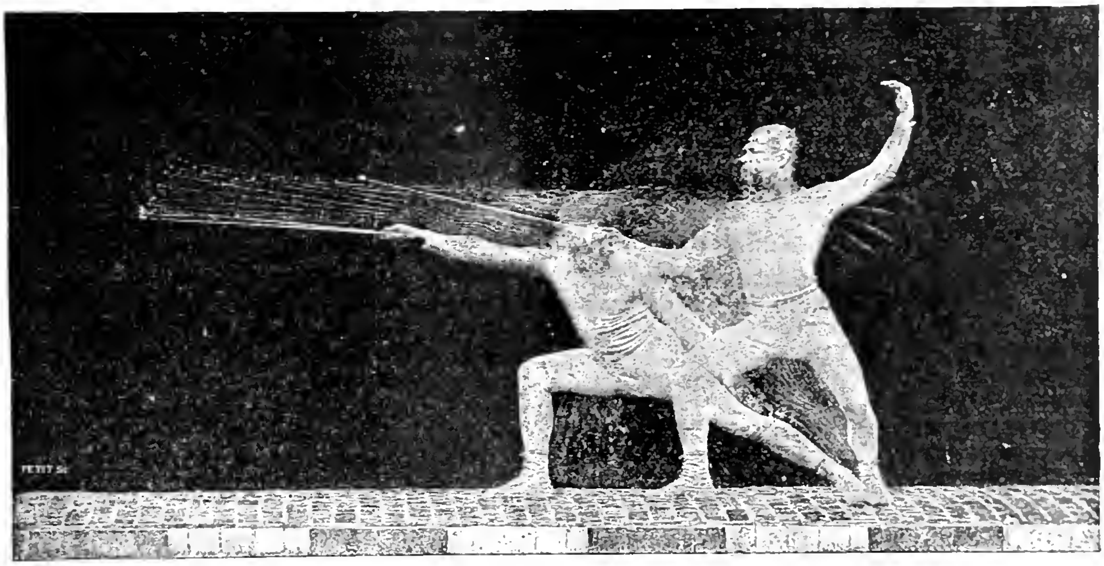
Notices of Books.

Notes on the Nebular Theory. By William Ford Stanley, F.R.A.S., F.G.S., &c. (Kegan Paul.) Illustrated. Although much has been written in support of the nebular theory of Kant and that of Laplace, few original thoughts have been added to it, and quantitative data have been markedly deficient in connection with the subject. There is little doubt that celestial bodies can be arranged in regular order, from nebulæ, "without form and void," through symmetrical nebulæ like Andromeda into stars connected with streams of nebulosity, and then into the finished product; and the form of a nebula in any particular stage of its development is probably the result of the action of gravitation upon it while in the preceding one. But this arrangement is only a scenic one; and though the spectroscope helps very considerably to define the order of celestial evolution, much yet remains to be done in determining the mathematical and physical conditions which lead to the observed differences in structure. Mr. Stanley has treated the subject in a philosophic manner, and his contribution deserves serious attention. It is difficult to trace his arguments in the short space of a review, but we may say at once that they bear the impress of original thought. To begin with, Mr. Stanley points out that the full consideration of the nebular theory requires the existence of a more attenuated form of gaseous matter than the nebulæ. This material he terms the *pneuma*, which he supposes to have pervaded all space, to contain all the chemical elements, and to represent the state of infinite diffusion proposed by Helmholtz. It is suggested that the mode of condensation which renders nebulous matter visible to its extreme outlines is purely chemical, and takes place within the exterior surface of the nebula only. Chemical action is, indeed, believed to cause the degradation of the pneuma to a gas or a nebula. Having traced what he considers to have been the mode of formation of stellar and solar systems from the original pneuma, Mr. Stanley puts forth some ingenious speculations on the formation of orbits, and discusses the conditions upon which our solar-planetary system may have been formed, giving also suggestions for causes of direction of rotation and revolution of the planets and satellites. Finally, several chapters are devoted to the study of the hypothesis of the formation of the earth under purely nebular conditions. We have only been able to give the barest outline of the book, but it will suffice to show the character of the contents. Speculative the book undoubtedly is, but it is suggestive also; and though some of the ideas developed have little or no foundation in fact, they are worth consideration, while, taken altogether, they will help to place the study of the nebular theory upon a broader basis than heretofore.

Heligoland as an Ornithological Observatory. By Heinrich Gätke, C.M.Z.S., &c. Translated by Rudolph Rosenstock, M.A. (David Douglas.) Illustrated. 30s. For the last fifty years, day after day and night after night, as Mr. Harvie-Brown says in his preface to this deeply interesting work, Herr Gätke has studied the migration of birds. As is now generally known, the island of Heligoland is peculiarly suited to be an ornithological observatory. It stands, as it were, as a stepping-stone across the North Sea, both from east to west and from north to south. Very few birds breed on the island, but from January to December, with little cessation, vast multitudes of birds cross and recross it on migration. Each month brings new arrivals with the utmost regularity. Some sweep over without alighting; others stay a few hours, but seldom beyond a day. An uninterrupted spell of east wind combined with frost and snow brings the greatest numbers; then they appear, says the author, in "countless multitudes. . . . Indeed, I have known days on which I have seen, far as the eye could reach, in all quarters of the sky, swarms of these birds crossing each other in all directions. . . . In fact, the whole vault of heaven was literally filled to a height of several thousand feet with these visitors from the far North." Herr Gätke is no romancer—he deals with hard facts, and his observations will be invaluable to the student of migration. He discounts many theories by his facts, and he believes that the phenomenon of the migration of birds will never be fully explained. The direction, altitude, velocity, and order of migration flights are all dealt with by the author in a masterly and graphic manner, and a chapter on "Meteorological Conditions which influence Migration" is deeply interesting. Herr Gätke's remarks on the change of colour in birds without moulting will prove invaluable as an addition to our scanty knowledge of this subject. The larger portion of the book is taken up with excellent descriptions of the three hundred and ninety-eight species of birds which the author has collected on Heligoland; but by far the most fascinating and valuable portion is that dealing with their migrations. We may add that the translator has done his work well in preserving the graphic and logical style of the original.



A Sword Thrust. (From a Chrono-photograph on a fixed plate.) From "Movement."

Movement. By E. J. Marey. Translated by Eric Pritchard, M.A. (Heinemann). Illustrated. 7s. 6d. "Le Movement," the original of this book, which has been very successfully translated by Mr. Pritchard, is one of the most recent and important works of M. Marey, the eminent French physicist. By the aid of chrono-photography in conjunction with many clever devices, the author has been enabled to explain and elucidate in the book before us many of the complicated movements in man, quadrupeds, birds, fishes, creeping things, and even microscopical organisms. M. Marey's experiments have been carried out for the most part at the Parisian Physiological Station, where unique opportunities were granted to him. How well he has used those opportunities may be seen in the study of his book, which will afford interesting and instructive reading to everyone, and a mine of facts for specialists to work upon. The value of the process of chrono-photography in analyzing movement may be gathered from the fact that sixty images of a moving object can be produced per second, and thus every stage of its action can be traced. This book contains many reproductions of such photographs and numerous diagrams, important and useful to all in elucidating the text, besides being of great value to the artist for correctly depicting living creatures in movement.

Nature versus Natural Selection. By Charles Clement Coe. (Swan Sonnenschein.) 10s. 6d. Men of science are almost of one mind as regards the main fact of organic evolution, but they are not in unison as to the process by which the result has been brought about. The great majority of scientific men believe that natural selection is the main agent in the transmutation of species. According to this doctrine, the selecting power is the struggle for existence, which secures the survival of the fittest to live and transmit their species under any given environment. Mr. Coe is among those who doubt that natural selection has been the principal agent of organic evolution. "The object of this work," he says, "is to show that natural selection *thus defined* has no place in the world of nature; that if it did exist, other factors of evolution would anticipate its action in the transmutation of species now going on; and last, but not least, that we have no definite proof of its action in the early stages of organic evolution." We must say that Mr. Coe sums up the case in a remarkably fair manner. He has evidently read practically everything that has been written on the subject, has judiciously weighed the evidence, and has found it wanting in some respects. Whatever the apostles of natural selection may think of his judgment, we are of the opinien that his impartial criticisms deserve the fullest consideration.

Hints on Reflecting and Refracting Telescopes, and their Accessories. By W. Thornthwaite, F.R.A.S. 6th Edition. (London: Horne & Thornthwaite.) 1s. An exceedingly useful little book for anyone possessing a telescope or intending to purchase one. The "hints" supplied are just of the character required, and are brief but clear. That it should have attained a sixth edition shows that it has already been much appreciated; and as it has been carefully revised in the present edition, and a considerable amount of valuable matter added, particularly with regard to the micrometer, the transit instrument, and celestial photography, it should meet with a very cordial reception from all astronomical amateurs.

A Handbook to the Birds of Great Britain. By R. Bowdler Sharpe, LL.D. Vols. I and II. (W. H. Allen.) Illustrated. 6s. each. These volumes from the pen of the editor of Allen's Naturalists' Library will, with two others as yet unpublished, include a description of every bird which has been found in Great Britain. Dr. Sharpe has handled his subject in a masterly style, and the volumes would be of still greater value were there not so many standard works available—some more compact and others more extensive—on the same subject. In the preface to the second volume the author discusses at length the much-vexed question of nomenclature. In this Dr. Sharpe holds his own views, which differ from many other writers'. The sooner the whole question is finally settled by an international conference the better it will be for everyone concerned. A few of the coloured illustrations in these volumes are very good, but most of them are exceedingly poor. When originally issued with the first Naturalists' Library they were, no doubt, the best obtainable; but they will not pass muster when compared with more recent productions.

The Planet Earth. By Richard A. Gregory, F.R.A.S. (Macmillan & Co.) The object of Mr. Gregory's attractive-looking little text-book is to present to students "the facts relating to the earth's movements and place in the universe" in a scientific manner. "Celestial phenomena must be observed before the theories that explain them can be properly understood," and Mr. Gregory hopes that his book may "help to revive the observational astronomy of pre-telescopic times." Such a programme is a most excellent one, and to a certain extent Mr. Gregory has carried it out with considerable success. His style is lucid and pleasing, and the diagrams and illustrations he supplies are clear and good. Yet we fear that he comes short of his ideal. His first words are a reminiscence of the unscientific method he condemns; the statement that "the earth is a speck in the infinite ocean of space" precedes the observations on which this inference is based; indeed, they do not enter into the scope of the book at all. The phases of Venus are instanced as a proof of the Copernican system; they, of course, only demonstrate that Venus is a satellite of the sun, not of the earth—a view held centuries before the telescope was invented. It is not easy for the townsman born and bred to enter into any appreciation of the "observational astronomy of pre-telescopic times," he is too far removed from them, and Mr. Gregory writes like a townsman. As an attempt to put the teaching of elementary astronomy on an observational, or, as Mr. Gregory would call it, a "scientific" basis, or, indeed, as an attempt to improve on the methods adopted in our best known text-books, we fear Mr. Gregory's volume is a failure. As a brightly written little manual on an important portion of the first of sciences it is to be heartily recommended.

A Text Book of the Principles of Physics. By Dr. Alfred Daniell, M.A., &c. 3rd Edition. (Macmillan.) Illustrated. 21s. Here we have a volume for the serious student of physics; not merely a useful compendium of physical facts (like Ganot's "Physics," for instance), but a connected account of the leading principles of modern physical science, containing nothing but what should be known and understood by all who profess and call themselves physicists. To the lay mind the treatment may appear too strict and mathematical at first sight, but a closer inspection of the contents dissipates the apparent difficulty, and shows that an elementary acquaintance with mathematics is quite sufficient to comprehend all the principles described. No preliminary knowledge of these principles is assumed; the descriptions are wonderfully clear, and there is a gradual progression from the simpler to the more complex parts of the subject. We have no hesitation in saying that the author presents the modern aspect of natural philosophy as it ought to be presented—that is, in the light of dynamics and the law of the conservation of energy. For this reason we cordially commend the work to all who are able to assimilate and appreciate the truths of physics.

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SHORT NOTICES.

Photograms of '95, compiled by the editors and staff of the *Photogram*, is a pictorial and literary record of the best photographic work of the year. The volume contains a number of excellent reproductions of very beautiful photographs.

A finely illustrated—both in colour and in pen and ink—edition of Shakespeare's *Merry Wives of Windsor* has just been issued by Messrs. Raphael Tuck & Sons.

The Children's Shakespeare, also well illustrated, and published by the same firm, is a collection of abstracts from Shakespeare re-written in the form of stories for children.

Old Farm Fairies, by H. C. McCook (Hodder & Stoughton), was written, the author tells us, some twenty years ago. Mr. McCook is an authority on American spiders; but in this book he throws science aside, and tells, in a way that will interest every child, of the doings of spiders, under the garb of "pixies." The book is profusely illustrated with quaint pen-and-ink drawings, some of them being the work of children.

A Popular History of Animals, by Henry Scherren (Cassell), written for young people, aims at wakening an interest in the observation of the habits of animals. The book, which is concisely and clearly written, is free from all technicalities, and, considering the great number of subjects treated of, it is remarkably free from error. The coloured plates and a large number of engravings, although not altogether good, admirably serve their purpose.

Physiology, by A. Macalister, LL.D., M.D., F.R.S. (S.P.C.K.), one of the series of Manuals of Elementary Science, presents, in a condensed form, the elementary principles of the physiology of man. It will be found of great value as a first book to the student of physiology, besides being very useful to everyone as a book of reference.

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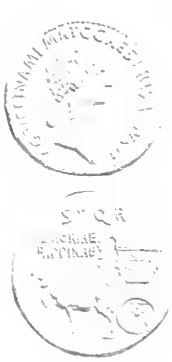

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ITALIAN RENAISSANCE MEDALS.

BOOKS RECEIVED.

Prehistoric Man in Ayrshire. By John Smith. (Elliot Stock.) Illustrated 12s. 6d.

The Wild-Fowl and Sea-Fowl of Great Britain. By A Son of the Marshes. Edited by J. A. Owen. (Chapman & Hall.) Illustrated. 14s.

Birds from Moidart and Elsewhere Drawn from Nature. By Mrs. Hugh Blackburn. (David Douglas.) Illustrated.

Euclid's Elements of Geometry. Edited by H. M. Taylor, M.A. Books 1-6, 8, 11-12. (Cambridge University Press.) 5s.

Molecules and the Molecular Theory of Matter. By A. D. Risteen. (Quin & Co.) Illustrated. 8s. 6d.

The Housing of the Working Classes. By Edward Bowmaker, M.D. (Methuen.) 2s. 6d.

Principles of Metallurgy. By A. H. Hiorns. (Macmillan.) Illustrated. 6s.

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ITALIAN MEDALS.

By G. F. HILL.

IT has long been customary to speak of coins and medals* together as if they were but species of the same artistic genus; and, in so far as method and technique go to constitute a work of art, the connection is to some extent justified. But the objects for which the two things are produced are, it is needless to insist, totally different. It has been usual to speak of certain Syracusan coins as "medallions," but the only excuse for the term is the unusually showy and magnificent character of their design. The beautiful gold piece of Eucratides, King of Bactria, now at Paris, may be meant for a medal; but its weight is equivalent to twenty staters, and it must therefore remain in the doubtful class. Certain "show-coins" struck in Germany at various times cannot be classed with either species exclusively, for they could be accepted as current coin. But if these are medals, they are exceptions to the general rule that the medal is not meant for circulation as a medium of exchange, and should be regarded purely as a piece of metal work. The Roman medallions, which were mentioned in a former paper, are real medals, and were only considered along with Roman coins for the sake of convenience.

In the matter of medals the Italians hold that pre-eminent position which belongs to the Greeks in coins.† Like all the rest of the art of the early Renaissance, the early medallic art of Italy, while stimulated and inspired by the art of Rome, is by no means a mere imitation. It is as distinctively Italian as the sculpture and painting of the nation. Unlike the art of Greek coins, however, the medallic art of Italy sprang into being fully developed, and went through no primitive stages like its sister, sculpture. Sculpture of very considerable merit had existed in Italy since the thirteenth century; but it is not until the middle of the fifteenth century that the medal can be said to be established as a work of art in Italy; for a few exceptional pieces of earlier date need not be considered. In 1380 there was born at Verona, Vittore Pisano, or Pisanello, of whom it may be said that had Italy produced no other medallist she would still have stood at the head of the art. In all essentials Pisano shows more power and more originality than any of his successors. The medal is in the majority of cases, at least in Italy, commemorative of a person; portraiture, therefore, is an essential element, and such portraits as those of Leonello, Marquis of Este (Fig. 3), or the Spaniard, Don Inigo d'Avalos, Marquis of Pescara (Fig. 1), need no praise. These two have been chosen for illustration because they show the same hand working in two utterly different ways. The Italian ruler's bust is in high relief; the features are modelled with extraordinary boldness and even severity. There is nothing redundant, only just sufficient ornament about the bust to prevent the total effect being bare. With such a treatment of the head, Pisano has rightly avoided the bare bust. But contrast with this the soft treatment of the other portrait; the delicate features raised in the shallowest relief from the surface, and shaded by the broad hat, with the drapery sweeping down in bold lines to frame the face. Here nothing could be softer or less severe than the treatment of the flesh, and with it all there is no lack of decision.

Pisano seems to have stood alone among his contemporaries for the beauty of the reverses of his medals no less than for his skill in portraiture. As a specimen we may notice here the reverse of a medal of Alfonso V., King of Aragon and the Two Sicilies (Fig. 2), which represents the king as a boy hunting the boar. Nothing can be finer than the action of the piece. The boar is held by the left ear by a hound: the king has seized it by its other ear and is about to plunge his sword into its flank. Behind is seen the tail of a second dog, and there is a rocky background. Above is the legend VENATOR INTREPIDVS. The slight figure of the boyish king contrasts with the huge mass of the boar, and brings out all the meaning of the epithet. Pisano was famous for his delineation of animals; and the loving care with which he renders details, and the way in which he loses no opportunity of introducing an animal into a scene, remind us of Dürer. Zoologists will perhaps find something to blame in Pisano's, as in Dürer's, animals. But this need not detract from our praise of their picturesqueness and liveliness. The paintings of Pisano are very rare, but the National Gallery possesses two, one of which, "The Crucified Christ appearing to St. Eustace," should certainly be studied in connection with his medals.

Pisano's pre-eminence must justify the space here devoted to him at the expense of his successors. Of these, two must be mentioned here: Matteo Pasti, of Verona, and Sperandio, of Mantua. The former was actually a pupil of Pisano, and it is possible to trace a resemblance in style between the work of master and pupil. The bust of the celebrated condottiere, Sigismondo Pandolfo di Malatesta (Fig. 4), is as fine as anything by Pisano himself. The reverse of Pasti's medal gives a view of Sigismondo's castle at Rimini. The representation of a building is a feat which almost every medallist thinks within his power,

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* The term "medal" was, until the present century, used indifferently for coin (when regarded as a curiosity or preserved in a collection) or medal—more frequently the former. It is now restricted in English to mean the commemorative piece though often used by journalists to translate the French *médaille*, when that word should be rendered "coin."

† See "Coinage of the Greeks," KNOWLEDGE, June, 1895, and "The Coinage of Rome," November, 1895.

* "This man," says Symonds the historian of the "Renaissance in Italy" (Vol. I., p. 157), is "a true type of the princes who united a romantic zeal for culture with the vices of barbarians." The last phrase is hardly strong enough for the villanies which Sigismondo committed, and with which his face, as here depicted, is in thorough keeping. His portrait was also made by Pisano and the medals should be compared with the splendid relief on the base of a column in the cathedral at Rimini.

if we may judge by the number of attempts; but it is hardly too much to say that Pasti has succeeded in adapting the view to the allotted space, and in catching the true perspective of the rugged keep and towers, where ninety-nine out of a hundred would have failed.

Sperandio of Mantua worked in the latter half of the fifteenth century, and stands some way behind the two artists already mentioned, except in the excellence of his portraits. It will be sufficient to notice his bust of Federigo del Montefeltro, Duke of Urbino (Fig. 5). The reverse of the medal, representing the duke on horseback, is vigorous, but the proportions of the figures are not as good as they might be. Before leaving this period we may notice another portrait, that of Giovanni Tornabuoni (Fig. 7). Unlike the men already mentioned, Tornabuoni was a peaceful citizen of Florence, of one of that city's most distinguished families. The modelling of the face, and notably the delineation of the eye, is excellent. The reverse, which is remarkable for its fine simplicity, represents Hope looking up at the symbol of the Trinity.

It has been rightly remarked that there is a distinct line traceable between the work of the fifteenth century and that of the sixteenth. We pass in A.D. 1500 from a series of medals which are, as a rule, large in size, simple in treatment—in fact, so many small pieces of sculpture in relief—to a series which are smaller in size, more elaborate and sometimes even finicking in treatment, and frequently under the influence of painting.[†] There is, in fact, a difference between the medallic work of the fifteenth and sixteenth centuries more or less parallel to that between Greek sculpture of the fifth century and the work of the age succeeding Alexander the Great. Great skill in pure technique goes side by side with, or, rather, is the cause of this change in character. The number of medallists naturally becomes larger: Francesco Francia, the painter; Benvenuto Cellini, the sculptor and chaser; Valerio Belli, Annibale Fontana, Lione Lioni, Pomedello, Pastorino of Siena, Cavino the Paduan, Federigo Bonzagna, are only a few of the more famous names. Some of these artists did work which in style cannot be strictly separated from that of their predecessors of the fifteenth century. A good instance is the portrait by Pomedello of an unknown lady (Fig. 6). On the obverse, the simplicity of treatment, the partition of the relief into masses contrasting sharply with each other and with the background, and not fading into each other, is characteristic of the earlier period. When we analyse the relief we find it to consist of three main parts—face, hair, and bust, the throat being subordinate in effect. Yet, in spite of this clear demarcation of parts, the whole relief is perfectly harmonious, and no part is treated so much in detail as to draw the attention away from the rest. This simplicity, one might almost say *naïveté*, of composition becomes rarer as time goes on. The reverse of this very medal, finely conceived as it is, seems to belong to another period in its elaborate richness of design and crowded field. Pomedello, then, is to be regarded as representing the transition from the fifteenth to the sixteenth century.

A famous medal by Annibale Fontana, who died in 1587, and is also known as a sculptor and gem engraver, takes us further on into the style of the sixteenth century. The portrait is that of another and later d'Avalos, Marquis of Pescara, a well-known general and author. The work errs by over-elaboration, particularly as regards the drapery of the bust, in comparison with which the head is almost insignificant. The reverse (Fig. 8) represents Hercules, with his foot on the dragon, plucking the apples of the Hesperides. An elaborate landscape, with the sun rising over a city, is seen in the background. The detail is admirable, but out of place; the fine proportions of the main figure only lose by being set against such a background. In a painting—and it is a painting which the work suggests—that background could have been made to take its proper place; in a relief, the absence of colouring makes this impossible. The "pictorial" treatment of a subject in a relief may lend it considerable charm; but the artist here has not understood the limits of his art. The unknown maker of the medal of Antonio de Leyva (Fig. 11) has succeeded better. In this piece there is not the same discord between the figure of Fame in the foreground, and the landscape—hardly less elaborate (considering the smaller size of the medal) than that of Fontana—behind it. The portrait of De Leyva, again, is a beautiful example of the pictorial treatment of a bust. Its date is some time between 1533 and 1536.

One of the most prolific of portrait medallists in this age was Pastorino de' Pastorini, a native of Siena. A large number of his medals have no reverse, and the character of the obverses hardly leads us to expect any great originality in design. The portraits are admirably finished, but, as in the work of most artists who devote themselves chiefly to portraiture, they tend to become a little mechanical. One of his most pleasing busts is that of Buonaventura di Gruamonte (Fig. 9), dated 1557. Pastorino died about 1591.

There is one class of Italian medals which has been a source of considerable trouble to collectors of Roman coins; these are the so-called "Paduans." It was at Padua that the earliest known Italian medals were made in 1390, and at this ancient university city lived Petrarca, the first man who is known to have collected Roman coins. In 1390 the lords of Padua had two medals struck bearing their likenesses, but in style resembling Roman bronze coins; but the medals known especially as "Paduans" are the careful imitations made by Giovanni Cavino and Alessandro Bassiano in the sixteenth century. Very often these imitations are so skilful that only an eye long experienced in the Italian style can distinguish them from originals. The difficulty is sufficiently illustrated by the Paduan medal of Agrippina the Elder (Fig. 13), which we give side by side with the Roman coin from which it is copied (Fig. 12). Differences in the lettering, in the metal, in small details of every kind, but, above all, in the general feeling of the composition, have to be considered in order to decide between Paduan and Roman. Broadly speaking, the Paduan is the more elegant, the Roman the stronger piece of work.

The interest of all the medals which we have described so far has been almost purely personal. Only a few Italian medals can be cited which refer to events of a more historical interest. Of these, the best known—at least, in Protestant countries—is, without doubt, the medal struck under Pope Gregory XIII. in 1572 in commemoration of the Massacre of the Huguenots (Fig. 10). The destroying angel is represented advancing with sword and cross against the Huguenots. The medal, which is not otherwise than historically interesting, is by Federigo Bonzagna.

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[*] Federigo is one of the too rare redeeming characters of his age; an enthusiastic patron of the arts and sciences, a general unrivalled in the art of war as it was understood in his day, a plain dealer; in fact, a model prince, and none the less a model husband.

[†] As Keary (*British Museum Guide to the Exhibition of Italian Medals*, p. xi.) remarks: "At the beginning of the fifteenth century the early school of Italian sculpture reached its highest point of beauty in the hands of Ghiberti (1376-1455), and of Donatello (1386-1466). . . . After the time of Donatello the painters deservedly outweighed the sculptors as a body in public estimation."

The changes in style which we have described are, as we have said, accompanied and partly caused by a change in technique, which we may now proceed to consider. The early Paduan medals were struck from dies, like the coins of the period. But from 1390 onwards for nearly a century very few medals were struck. The workmen who cut the coin-dies of the period could only work in low relief, and it was difficult to make dies which would stand the strain of being struck on large masses of metal. The result was that most of the medals of the fifteenth century were cast by the *cire perdue* process. It was thus possible to obtain large pieces in high relief, a relief which it would be difficult to obtain even with the hydraulic press of the modern medallist. The use of the casting process left the artist a free hand in design; he modelled the two sides of the medal in wax, instead of painfully engraving the dies for them on some hard metal. The soft material naturally enabled him to work boldly and in high relief. The wax models were then impressed in some casting material—fine sand or charcoal—and the two sides placed together. The wax having been melted out, the mould was complete. The first proofs were often taken in gold or silver, but extant specimens in these metals are excessively rare; some of those supposed to be originals are apparently later casts. The ordinary medal was cast in bronze or lead. The latter metal was probably used because of the low temperature at which it melts, as well as because of its softness. This was an important quality when the process of casting was employed, because any roughness and inequalities left by the mould had to be removed with the chasing tool. From one of the original medals moulds could be made, and in this way old medals were reproduced down to a late date. These later pieces are somewhat smaller than the older ones, owing to the shrinkage caused by cooling, and, of course, the later the copy the worse the style.[*]

Early in the latter half of the fifteenth century there was born at Venice, Vittore Gambello, better known as Camelius. He was a goldsmith, a sculptor, and an engraver of coin-dies, as well as a medallist. He was popularly supposed to have been the first to strike medals, but, as Friedländer[†] has shown, and as we have seen, medals were struck at a very much earlier period. What he did was to bring the art of striking to a higher degree of perfection, so that deeper relief could be obtained. He is last mentioned in 1523. In the sixteenth century almost all the medals were struck from dies. The influence of the struck medals naturally extended itself to those which were cast. Hence a smaller size, lower relief, minuter detail, and, as a rule, less bold design. The work very often resembles that of the jeweller or gem-engraver, and, as we have seen, the influence of painting was not unfelt. The influence of the change in technique may best be seen in such an artist as Pastorino, of Siena, whose work we have already mentioned as showing great finish. He seems to have devoted himself to obtaining the delicacy and fineness of struck work on a cast medal, and to have done so with success, for it is sometimes hard to believe that his pieces are not struck, so clean and sharp are they in execution.

By the end of the sixteenth century the best traditions of medallic art had become faint in Italy. A large series of medals continued to be issued, especially by the Popes, but the work is decidedly inferior. The best-known medallists are, perhaps, Antonio Moro and Giovanni Mola, who both worked in the seventeenth century. They were followed later by Otto Hamerani (1691-1768), one of the medallists of the Papal Court, who is well known as an engraver of medals for the exiled Stuart family. But long before this time we have to turn to other countries for medals that have either high artistic or high historical interest.

Those who wish to follow up the subject, of which only the barest outline has been given above, will find full information and plentiful illustrations in Friedländer's *Die Italienischen Schaumünzen des 15ten Jahrhunderts*, and Heiss's *Les Médailleurs de la Renaissance*. These are large and costly works; but the *British Museum Guide to the Exhibition of Italian Medals* is within the reach of most purses, and its illustrations are among the best of their kind.

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4. Sigismondo Pandolfo di Malatesta, *Rev.* Castle of Rimini. By Pasti. Bronze. Cast and chased.
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PARASITIC FLOWERING PLANTS.—THE MISTLETOE AND DODDER.

By J. Pentland Smith, M.A., B.Sc.

All plants may be grouped into two classes, according to their possession or non-possession of chlorophyll, and the latter class is sub-divided into two groups, one of which is composed of those organisms that prey upon other living organisms, and the other of those plants which live on the dead bodies of once living beings. The name, parasite, has been reserved for the members of the first group, and the plant or animal attacked is called the host; while the members of the second are characterised as saprophytes.

Fungi (mushrooms, moulds, etc.) compose by far the great majority of parasites and saprophytes, but the flowering plants are by no means unrepresented in either category.

The most familiar example of a parasitic flowering plant is one that flourishes in England, and is much used for decorative purposes at Christmastide. The mistletoe grows abundantly in the South and West of England and on the Continent. Its stem is stout, and much branched in a regular manner. The main branch produces a flower, and further apical growth then ceases. But two lateral branches arise at the same level below the flower. These in turn bud and flower, but, before doing so, they produce two lateral branches like the parent stem. As the flowers die away it appears as if each branch had in turn divided into two branches. The evergreen leaves are lance-shaped, and they and the stems have either a dark or yellowish-green hue. Some plants bear male flowers, others bear female. Both kinds of flower are inconspicuous. The fruit is white, with a very viscid juice. It is almost universally believed that the mistletoe occurs on the oak. This tree is rarely its host: it

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[*] Of the medals represented in the plate, all are of bronze save three (Nos. 8 and 9 of lead, No. 10 of silver). Nos. 1 to 9 and 11 are cast, the rest struck; Nos. 1, 2, 3, 4, 7, and 11 have also been chased.

[†] *Die Italienischen Schaumünzen*, p. 3.

grows chiefly on the apple, pear, service tree, hawthorn, and occasionally on limes, poplars, willows, and firs. The accompanying illustration (Fig. 1) is from a photograph, kindly provided by Mr. Geo. Paxton, of a plant growing on a Siberian crabtree. This mistletoe is a very large one, being five feet three inches in height and fourteen feet six inches in circumference.

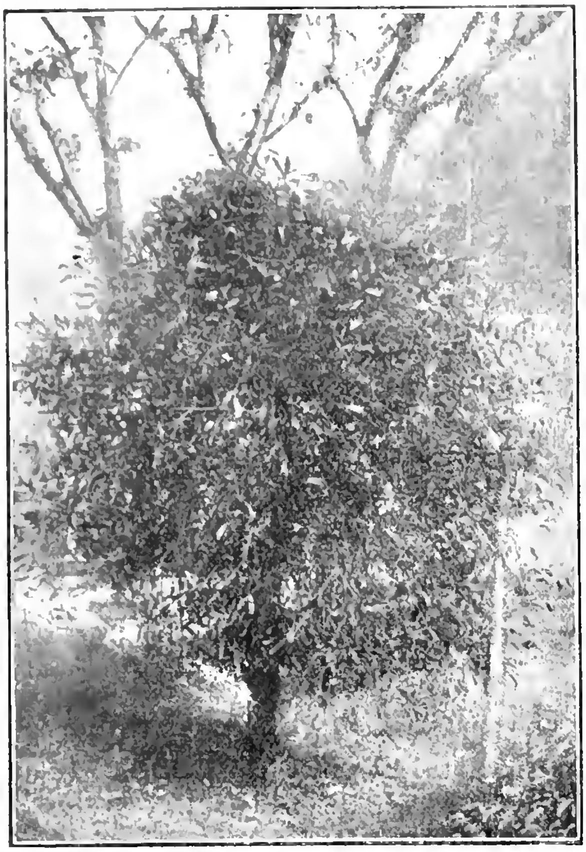

Fig. 1.—Mistletoe growing on a Crabtree.

The young mistletoe, while still enclosed by the seed coat, contains the green colouring matter chlorophyll. This is an unusual circumstance, as chlorophyll is developed, as a rule, only in tissues exposed to sunlight; and equally anomalous is its presence in the cells of the nourishing matter surrounding the embryo. When the seed germinates, the part of it below the cotyledons, the radicle as it is termed, emerges first from the seed coat. It is immediately brought into contact with the bark of its host. "This is the case even when the seed chances to stick with the radicle of the seedling pointing away from the branch; the whole axis of the embryo curving towards the surface of the bark in a very striking manner." The radicle then presses itself against the tree, and at the same time becomes disc-shaped. Then from its centre a growth arises which pierces the stem of the host and penetrates as far as the wood. This portion is called a sinker, borer, or haustorium.

Fig. 2—Transverse section of Thorn Acacia with Mistletoe.

It is shown in longitudinal section in Fig. 2, which is a transverse section stem of the "thorn acacia" on which a mistletoe plant has fastened itself.

Let us now glance briefly at the structure and functions of the component parts of the stem of a green plant that yearly increases in thickness, in order that we may be in a position to appreciate the relations existing between the parasite and its host. We shall examine the transverse section of the stem of the mistletoe itself, an illustration of a portion of which is given in the accompanying sketch (Fig. 3). The central part of the stem is at first occupied by a cylinder of pith (*p*), whose thin-walled cells, as a rule, become obliterated later on. Surrounding it is a zone of wood (*xy*), composed of cells and tracheæ. The cells contain protoplasm, and so are capable of further growth. The tracheæ are devoid of protoplasm. The cells act as storehouses of starch, while the tracheæ are the rapid carriers of "crude" sap from the roots to the leaves. Outside the wood is a layer or layers of cells, to whose activity is due the increase of the stem's girth. It is termed the cambium (*ca*). The cambium is enclosed by the phloëm (*ph*). In the mistletoe it appears in wedge-shaped patches in cross-section. Its constituents are ordinary cells containing protoplasm, and sieve-tubes; the latter are cells whose horizontal, and sometimes also lateral, walls are pierced by holes, giving them the appearance of sieves. The phloëm conducts elaborated food-material from the leaves to wherever growth is going on. Much of this food is of a colloid nature, and so it is necessary to provide apertures to enable it to pass rapidly from one place to another. The xylem, phloëm, and cambium are almost invariably associated the one with the other, and in young annual stems, such as the Common Sunflower, or in the leaf-stalks of the Rhubarb, form the stringy fibres so noticeable when these structures are broken across. These strings are known as the vascular bundles, and as fibrous strengthening material is often associated with them (for purposes of support) they have received the name of fibro-vascular bundles.

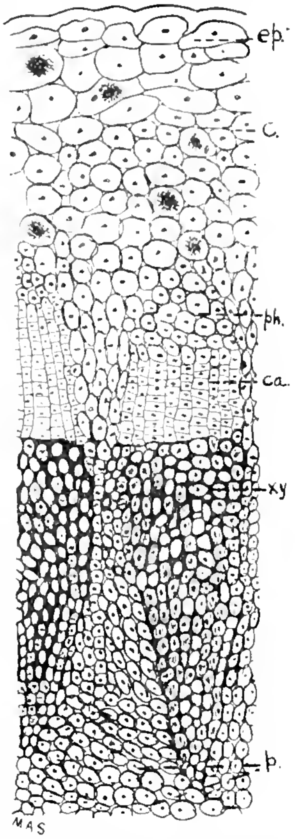

Fig. 3.—Transverse section of Stem of Mistletoe: *ep*, epidermis; *c*, cortex; *ph*, phloëm; *ca*, cambium; *xy*, xylem (wood); *p*, pith.

By the division and sub-division of the cambium cells yearly, zones of wood and phloëm are produced; but the wood increases disproportionately to the phloëm, and ultimately forms the main portion of the stem. To the tissues encircling the vascular bundles the name cortex (*c*) is applied. The outer cortical cells contain chlorophyll, and so are active in carbon assimilation. The epidermis (*ep*) is the layer of cells enclosing the cortex; its outer walls are corky, and so prevent the evaporation of slow currents of water passing from the roots to the leaves. When the epidermis becomes ruptured during the later stages of growth, its place is taken by cork developed by the divisions of one of the outer layers of cortical cells.

Now, all these structures (with the exception of vessels in the wood) can be seen in the stem of the mistletoe. As a rule chlorophyll is present only in the outer cortical layers of a stem and in certain cells of a leaf, but in the mistletoe almost all the cells of the plant, stem, root, and leaves, are filled with the green colouring matter. The ramifications of the parasite in the tissues of the host are thus easily detected.

The haustorium, developed from the inner parts of the radicle, passes through the cortex of the host-plant until it arrives at the wood, which, however, it does not pierce. But next year we find its apex buried in it; the cambium cells of the host have developed new wood, which has surrounded the haustorial tissues. It is clear that the continued production of fresh xylem year by year would result in the destruction of the haustorium; but provision is made to obviate this. The cells situated near the apex of the haustorium of the first year divide up in such a manner as to cause it to increase in length just as much as the wood of the host increases in thickness, and simultaneously an increase in girth occurs, so that in a transverse section of the host (Fig. 2) the sinker appears wedge-shaped. It is thus manifest that year by year the haustorium becomes more deeply embedded in, and thus more intimately fixed with, the wood of the plant on which it is parasitic.

The part of the haustorium in the cortex of the host is composed of a central cylinder of numerous tracheides, surrounded by thin-walled cells densely filled with protoplasms; this is enclosed by a cortex of thin-walled cells becoming thick-walled towards the periphery. The portion of the sinker that has become embedded in the wood possesses a large number of tracheides uniting directly at its sides, but not at its tip, with the wood of the host. Surrounding these are cambium-shaped cells. In a line with the cambium of the host-plant are layers of cambial cells, from which originate lateral branches. The parasite is thus immediately connected, and very intimately, with the wood only of its host.

Now, this is just what might be expected. For the possession of such an abundance of chlorophyll renders it perfectly autonomous in the work of carbon assimilation. It is thus quite independent of its host for the carbon and oxygen necessary for the building up of protoplasm; all it requires from it are water and inorganic salts. These we know, after their absorption from the soil by the root-hairs, are carried up by the wood of the host. The intimate fusion of its wood-elements with those of the mistletoe ensures the passage of those inorganic substances into the body of the parasite.

The mistletoe is thus only a partial parasite. It merely obtains the inorganic portion of its food-supply from its host, and on it it appears to exert no baneful effect. The host, nevertheless, cannot be nourished in turn by the parasite, owing to the absence of sieve-tubes in, and the presence of thick-walled cells at, the periphery of the haustoria, bordered generally by dead phloëm cells of the host.

There are other parasitical flowering plants whose effects upon their hosts are by no means of the harmless nature of those of the mistletoe. The dodders (species of *Cuscuta*) are examples of such. They are found in all parts of the world. One of them (*Cuscuta trifolii*) attacks clover, and its ravages at times are exceedingly destructive. It is said to be a variety of *Cuscuta epithymum* that attacks thyme and allied plants. Two other species are found in the British Isles—*Cuscuta epilinum*, which, as its name implies, is parasitic upon flax (*Linum*), and *Cuscuta Europæa*, a parasite on the nettle, hop, &c. The clover dodder spreads over its host so as to leave a field of bright green clover a mass of yellowish tangled thread-like stems. The seeds of the dodder are doubtless sometimes sown along with the clover seeds. In nature they fall from their seed capsules in autumn, remain on the ground over winter, and germinate the following spring, but a month later than the majority of other plants. By the time the embryo emerges from the seed the seedling clover has attained a fair size, and plants of perennial growth have developed their young shoots. The seed contains a mass of endosperm or nourishing matter, which ministers to the nourishment of the young plant during the early stages of its growth. As in the case of other flowering plants, the root is the first part to emerge from the seed-coat, but, unlike the majority of these, it is unprovided with a root-cap, although it is clothed with numerous short hairs. The root scarcely enters the soil. Owing to its persistent parasitism, its original structure has become much altered. Its central axis no longer possesses vessels, as in other roots, to enable the rapid conduction from the soil of water containing nutritive salts, or sieve-tubes to convey elaborated sap to growing parts; but instead it consists of a cylinder of cells densely filled with protoplasm, whose elongated form gives a hint as to what would occur were the plant to live again an independent existence.

The root enters the soil or creeps along the ground for a short distance. The stem bends slightly above the surface of the soil, and circumnutation then takes place to enable it to come in contact with a support. The moisture absorbed by the root hairs, if the plant grows in a damp atmosphere, is sufficient to convert all the reserve material in the seed into forms available for the nutrition of the seedling, and the stem then grows apace and may attain a length of a few centimetres; but should the surroundings be dry its growth is materially lessened, both in length and thickness. The apex of the stem by-and-bye emerges from the seedling, and it is seen to be devoid of cotyledons or seed leaves. The root soon dies away, and the food-material contained in it is passed on to the growing part of the stem, thus aiding it to further increase in size. The basal portion of the stem also dies away, and the food material there is also conveyed to its apex. Thus, should the stem fail to come into contact with a suitable support before the death of the root, there is additional help given to enable it so to do. The direction taken by the circumnutating stem is from left to right, and the first few spirals formed are very close. This prevents the *Cuscuta* stem being thrust off the host by its own rapid growth.

Fig. 4. Stem with Dodder fastened to it: D, Dodder stem; *f*, its flowers; H, stem of host.

The stem bears scale leaves only, and in their axils arise flowers and branches. No chlorophyll, or, at most, the merest traces are developed in the plant; consequently it must be wholly dependent on green plants for its supply of food. Such is found to be the case, and the mode in which it obtains this we shall now inquire into.

In Fig. 4 is shown a part of the stem of a plant around which a dodder has wound itself; *h* is the stem in question, *d* the stem of the dodder, and *f* its flowers. Fig. 5 is a section of the same stem, and shows the manner in which the dodder has fastened itself to it. It may be noted in passing that when the *Cuscuta* seedling comes in contact with dry, innutritious support, it does not twine itself about it, although, as Von Mohl* notes, the same plant would encircle tightly the stem of a nettle, for instance, in nine hours. There is an obvious advantage in this, as in dry weather the support would absorb water from the slender stem. When the *Cuscuta* has once become attached to a nutritive support, it may afterwards twine round a support from which it can derive no nourishment. At frequent intervals in the close spiral where the stem is brought into intimate contact with the support, small lenticular protuberances make their appearance. The origin of these can be studied by making a number of sections through that part of the stem.

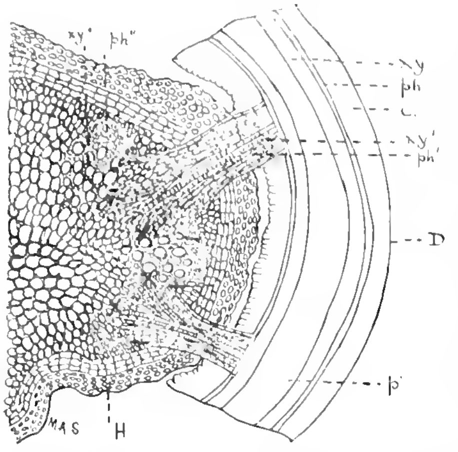

Fig. 5. Transverse section: D, Dodder stem; H, stem of host; *xy*, xylem (wood); *ph*, phloëm; *c*, cortex; *p*, pith; *xy'*, *ph'*, xylem and phloëm of haustorium; *xy''*, *ph''*, the same of host stem.

Through the thin-walled papillate epidermal cells a ferment is excreted, which attacks the epidermal cells of the plant around which the *Cuscuta* is entwined, and ultimately dissolves them. While this is going on the haustorium is increasing in size; it dissolves its way through the overlying cortical parenchyma until it reaches the exterior. Then it passes into the host-plant by the entrance already prepared for it by the epidermal cells, and proceeds towards the centre of the stem. It eats its way through the cortical cells of its host by means of a ferment secreted by its elongated apical cells, the material of the dissolved cells furnishing it with fresh supplies of nutriment. This provides the cells situated behind the apex with energy, that enables them to increase in size and then divide up. In this manner the haustorium increases in length; the dissolution of the host-cells and its own elongation proceeding simultaneously. Should the vascular bundles of the host be far apart the haustorium grows into a medullary ray, and then develops to a greater extent laterally than apically, and so applies itself to one of the bundles. Should the bundles be pretty close to one another it grows equally on both sides, and thus attaches itself to both bundles. This is what has happened in the specimen figured (Fig. 5). The phloëm of the haustorial bundles (*ph'*) has attached itself to the phloëm of the host-bundles (*ph''*) at X, and the xylem of the haustorial bundles (*xy'*) has united with those of the host (*xy''*) at X.

There are many points of interest in connection with the relations existing between the dodder and its host, the recounting of which would take us beyond the limits of this paper.

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* "Annals of Botany," Vol. viii., p. 75.

THE FACE OF THE SKY FOR JANUARY.

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

Sunspots and faculæ are still to be observed in considerable numbers on the solar disc. Conveniently observable minima of Algol occur at 11h. 12m. p.m. on the **14th**, 8h. 1m. p.m. on the **17th**, and 4h. 50m. p.m. on the **20th**.

Mercury is an evening star, but is too near the Sun to be seen during the first portion of the month, and afterwards his great southern declination somewhat interferes with observation. On the **11th** he sets at 5h. 13m. p.m., or about one hour after the Sun, with a southern declination of 21° 7′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{90}{100}$ths of the disc being illuminated. On the **21st** he sets at 6h. 8m. p.m., or one hour and a quarter after the Sun, with a southern declination of 15° 40′, and an apparent diameter of $6\frac{1}{2}''$, $\frac{66}{100}$ths of the disc being illuminated. On the **31st** he sets at 6h. 16m. p.m., or about one hour and a quarter after the Sun, with a southern declination of 11° 2′, and an apparent diameter of $8\frac{1}{2}''$, $\frac{20}{100}$ths of the disc being illuminated. He is at his greatest eastern elongation ($18\frac{1}{2}°$) on the **24th**. While visible he describes a direct path through Capricornus to the confines of Aquarius.

Venus is a morning star, but is rapidly diminishing in brilliancy, and her great and increasing southern declination rather militates against her successful observation. On the **1st** she rises at 4h. 21m. a.m., or about three hours and three-quarters before the Sun, with a southern declination of 17° 3′, and an apparent diameter of 18″, $\frac{65}{100}$ths of the disc being illuminated. On the **11th** she rises at 4h. 45m. a.m., or 3h. 20m. before the Sun, with a southern declination of 19° 44′, and an apparent diameter of $16\frac{3}{4}''$, $\frac{69}{100}$ths of the disc being illuminated. On the **21st** she rises at 5h. 7m. a.m., or 2h. 50m. before the Sun, with a southern declination of 21° 13′, and an apparent diameter of $15\frac{3}{4}''$, $\frac{72}{100}$ths of the disc being illuminated. On the **31st** she rises at 5h. 25m. a.m., with a southern declination of 22° 0′, and an apparent diameter of $14\frac{3}{4}''$, three-quarters of the disc being illuminated. During January she describes a direct path through Scorpio into Ophiuchus.

Mars, Saturn, and Uranus are, for the observer's purposes, invisible.

Jupiter is a resplendent object in the evening sky, being in opposition to the Sun on the **24th**. On the **1st** he rises at 6h. 5m. p.m., with a northern declination of 19° 8′, and an apparent equatorial diameter of $45\frac{3}{4}''$. On the **11th** he rises at 5h. 19m. p.m., with a northern declination of 19° 28′, and an apparent equatorial diameter of $46\frac{1}{3}''$. On the **21st** he rises at 4h. 32m. p.m., with a northern declination of 19° 48′, and an apparent equatorial diameter of $46\frac{1}{2}''$. On the **31st** he rises at 3h. 42m. p.m., with a northern declination of 20° 8′, and an apparent equatorial diameter of $46\frac{1}{2}''$. At the beginning of the month he is about $\frac{1}{2}°$ N. of δ Cancri, and continues a retrograde path through Cancer during the month, passing through the outlines of the scattered cluster Præsepe. The following phenomena of the satellites occur before midnight on the days named, while the planet is more than 3° above and the Sun 8° below the horizon:—On the **1st** an eclipse disappearance of the first satellite at 8h. 6m. 41s. p.m., and its occultation reappearance at 10h. 57m. p.m. On the **2nd** a transit egress of the shadow of the first satellite at 7h. 44m. p.m.; and its transit egress at 8h. 16m. p.m. On the **3rd** a transit ingress of the shadow of the second satellite at 10h. 9m. p.m., and the transit ingress of the satellite itself at 11h. 9m. p.m. On the **4th**, at 7h. 59m. p.m., a transit egress of the third satellite. On the **5th** an occultation disappearance of the second satellite at 9h. 6m. p.m. On the **8th** an eclipse disappearance of the first satellite at 10h. 0m. 27s. p.m. On the **9th** a transit ingress of the shadow of the first satellite at 7h. 19m. p.m., of the satellite itself at 7h. 41m. p.m.; a transit egress of the shadow at 9h. 38m. p.m., and of the satellite itself at 10h. 1m. p.m. On the **10th** an occultation reappearance of the first satellite at 7h. 7m. p.m. On the **11th** a transit ingress of the third satellite at 7h. 36m. p.m.; a transit egress of its shadow at 9h. 57m. p.m., a transit egress of the satellite itself at **11h. 15m.** p.m. On the **12th** a transit ingress of the fourth satellite at 6h. 43m.; an eclipse disappearance of the second satellite at 7h. 53m. 28s. p.m.; a transit egress of the shadow of the fourth satellite at 8h. 36m. p.m.; an occultation reappearance of the second satellite at 11h. 21m. p.m.; a transit egress of the fourth satellite at 11h. 26m. p.m. On the **15th** an eclipse disappearance of the first satellite at 11h. 54m. 23s. p.m. On the **16th** a transit ingress of the shadow of the first satellite at 9h. 12m. p.m., of the satellite itself at 9h. 24m. p.m.; a transit egress of the shadow at 11h. 32m. p.m., and of the satellite at 11h. 45m. p.m. On the **17th** an eclipse disappearance of the first satellite at 6h. 22m. 51s. p.m., and its occultation reappearance at 8h. 51m. p.m. On the **18th** a transit egress of the shadow of the first satellite at 6h. 1m. p.m., of its shadow at 6h. 11m. p.m.; a transit ingress of the shadow of the third satellite at 10h. 19m. p.m., and of the satellite itself at 10h. 51m. p.m. On the **19th** an eclipse of the second satellite at 10h. 29m. 1s. p.m. On the **21st** a transit egress of the shadow of the second satellite at 7h. 30m. p.m., of the satellite itself at 7h. 39m. p.m. On the **23rd** a transit ingress of the shadow of the first satellite at 11h. 7m. p.m., and of the satellite itself at 11h. 8m. p.m. In this case, and on the **25th**, the shadow may be occulted by the satellite. On the **24th** an occultation disappearance of the first satellite at 8h. 14m. p.m., and its reappearance at 10h. 34m. p.m. On the **25th** a transit ingress of the first satellite at 5h. 34m. p.m., of its shadow at 5h. 35m. p.m., ; a transit egress of the satellite at 7h. 54m. p.m., and of its shadow at 7h. 55m. On the **28th** a transit ingress of the second satellite at 6h. 58m. p.m., of its shadow at 7h. 11m. p.m.; a transit egress of the satellite at 9h. 53m. p.m., and of its shadow at 10h. 6m. p.m. On the **29th** an eclipse reappearance of the third at 7h. 43m. 25s. p.m. On the **31st** an occultation disappearance of the first satellite at 9h. 58m. p.m.

Neptune is an evening star, rising on the **1st** at 2h. 11m. p.m., with a northern declination of 21° 15′, and an apparent diameter of 2·7″. On the **31st** he rises shortly after noon, with a northern declination of 21° 12′. During the month he describes a short direct path just to the south-east of ι Tauri. He will be in conjunction with the 6¼ magnitude star B.A.C. 1555 at about 2h. a.m. on the **19th**; 1½ to the north of the star. A map of the stars near his path will be found in the *English Mechanic* for August 16th, 1895.

January is a favourable month for shooting stars, the most noted shower being that of the *Quadrantids*, the radiant point being in R.A. 19h. 12m., and 53° north declination; the greatest display being visible during the morning hours of **January 1st** to **3rd**.

The Moon enters her last quarter at 3h. 25m. p.m. on the **7th**; is new at 10h. 19m. p.m. on the **14th**; enters her first quarter at 2h. 42m. a.m. on the **23rd**; and is full at 8h. 55m. a.m. on the **30th**. She is in perigee at 1h. a.m. on the **4th**, and in apogee at 5h. a.m. on the **20th**.

Chess Column.

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

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

Solutions of December Problems.

No. 1.—(A. C. Challenger.)

Key-move.—1. P to Kt5.

If 1. . . . R × P (Kt4), 2. B × Ktch, &c.
1. . . . R elsewhere, 2. Q × Pch.
1. . . . B × P, 2. Q to B4ch.
1. . . . Kt moves, 2. Kt to K3ch.
1. . . . P × Kt, 2. Q to Q4ch.

Correct Solutions received from G. A. F. (Brentwood), W. Willby, J. T. Blakemore, and A. H. Walker.

No. 2.—(A. G. Fellows.)

Author's Key.—1. Q to Qsq.

This problem, which was received too late for examination, appears to admit of *four* other solutions, viz:—1. R to QBsq, 1. Kt to Q3, 1. Kt to Q7, and 1. Q to Kt4.

Correct Solutions received from J. T. Blakemore (4 Solutions), G. A. F. (Brentwood) (2 Solutions), W. Willby, H. S. Brandreth, Alpha (2 Solutions), J. Lamond, W. W. Strickland, and A. H. Walker.

W. Willby and *G. A. F.*—Quite right as to the dual; but in the presence of the graver defects it may pass unnoticed.

J. W. R. Watson.—If 1. Kt to B7ch, K to B4.

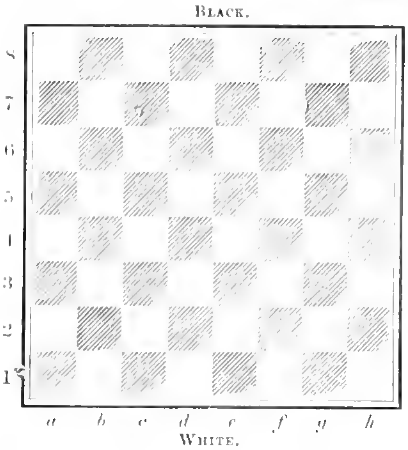
Alpha.—Q to B6ch will not solve the sui-mate. After 1. . . . P × Q, 2. Kt to K3ch, K to Q5ch, the Knight can cover. Your solution could not be acknowledged last month. This page had gone to press some days before it arrived.

A Norseman.—It is too late now to "ignore" your correct solution to November problem (No. 2). At the same time we place on record your protest against the appearance of a problem with a capture for the key-move simultaneously with our remarks on problems of this nature. It should be observed, however, that the Pawn captured was not a movable one.

J. T. Blakemore.—Thanks for the problem. We will examine it, and hope to insert it next month.

THE EIGHT QUEENS PROBLEM.

Probably most Chess-Players are aware that it is possible to place eight Queens on a Chess-Board in such a manner that no Queen can play to a square occupied by any other Queen; but, possibly, some may be surprised to learn that there are ninety-two ways of performing the feat, and may be ignorant of the laws which connect the various methods, and of certain curious coincidences revealed by a study of the positions. At the present season such an examination may prove interesting, if not entirely profitable; and we shall begin by a simple enumeration of the ninety-two possible positions, reserving our remarks on them for a future occasion. We have divided the positions into four classes (A, B, C, D,) according to the position of the Queen on the Queen's Rook's file, and labelled each position with a Greek letter. In many cases the same letter is used. When this occurs it will be found that the positions are rendered identical when the board is turned round. We have used the German form of notation, and give a diagram to explain it. QR3 is a3; KKt5 is g5, and so on.



Here, then, are the positions, which anyone who works methodically can discover for himself in an hour or two.

A.—a1, *b5*, c8, d6, e3, f7, g2, h4. (α)
b6, c8, d3, e7, f4, g2, h5. (β)
b7, c4, d6, e8, f2, g5, h3. (β)
c5, d8, e2, f4, g6, h3. (α)

B.—a2, *b1*, c6, d8, e3, f1, g7, h5. (λ)
b5, c7, d1, e3, f8, g6, h4. (ζ)
d4, e1, f8, g6. h3. (η)
b6, c1, d7, e4, f8, g3, h5. (δ)
c8, d3, e1, f4, g7, h5. (κ)
b7, c3, d6, e8, f5, g1, h4. (γ)
c5, d8, e1, f4, g6, h3. (θ)
b8, c6, d1, e3, f5, g7, h4. (γ)

C.—a3, *b1*, c7, d5, e8, f2, g4, h6. (δ)
b5, c2. d8. e1, f7, g4, h6. (ω_1)

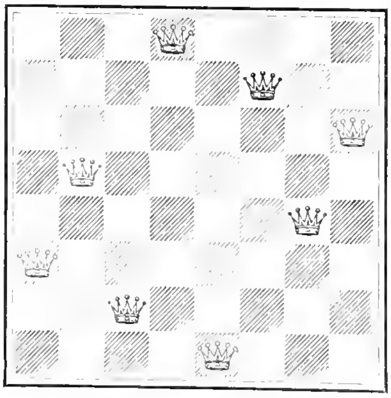
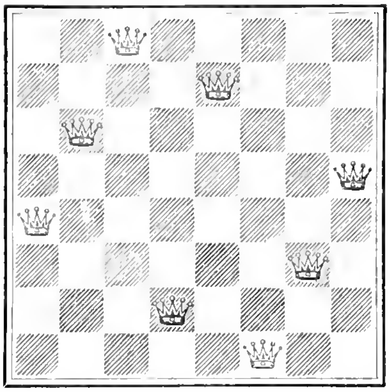


Diagram of the symmetrical position (ω_1).

e6, f4, g7, h1. (β)
c7, d1, e4, f2, g8, h6. (δ)
c8, d4, e1, f7, g2, h6. (ι)
b6, c2, d5, e8, f1, g7, h4. (ε)
d7, e1, f4, g8, h5. (ζ)
e5, f1, g8, h4. (η)
c4, d1, *e8*, *f5*, *g7*, h2. (θ)
d2, *e8*, *f5*, *g7*, h1. (α)
c8, d1, e4, f7, g5, h2. (η)
e5, f7, g2, h4. (ε)
d2, e4, f1, g7, h5. (ι)
b7, c2, d8, e5, f1, g4, h6. (ι)
e6, f4, g1, h5. (κ)
b8, c5, d7, e1, f6, g2, h5. (λ)

D. a4, *b1*, c5, d8, e2, f7, g3, h6. (ζ)
c5, *d8*, *e6*, f3, g7, h2. (γ)
b2, *c5*, *d8*, *e6*, f1, g3, h7. (κ)
c7, d3, e6, f8, *g1*, *h5*. (θ)
g5, *h1*. (α)
d5, e1, f8, g6, h3. (ε)
c8, d5, e7, f1, g3, h6. (ι)
d6, e1, f3, g5, h7. (λ)
b6, c1, d5, e2, f8, g3, h7. (δ)
c8, d2, e7. f1, g3, h5. (ω_2)



[Diagram of the Symmetrical Position (ω_2).]

d3, e1, f7, g5, h2. (ζ)
b7, c1, d8, e5, f2, g6, h3. (ε)
c3, d8, e2, f5, g1, h6. (λ)
c5. d2, e6, f1, g3, h8. (β)
d3, e1, f6, g8, h2. (γ)
b8, c1, d3, e6, f2, g7, h5. (θ)
d5, e7, f2, g6, h3. (η)
c5, d1, e3, f7, g2, h6. (κ)

These are evidently half the possible positions, which must be ninety-two in number. Any position beginning with a5 must be practically the same as one beginning with a4. So a6 is akin to a3, a7 to a2, and a8 to a1.

Contents of No. 122.

NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

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KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: FEBRUARY 1, 1896.

CONTENTS.

SOME CURIOUS FACTS IN PLANT DISTRIBUTION.

By W. Botting Hemsley, F.R.S.

The present distribution of plants, apart from those low in the scale of organisms, exhibits some very curious phenomena. Perhaps those most obvious to the majority of persons are consequent upon the spread of European peoples over other parts of the globe. The domestic weeds of ancient civilization, the road-side weeds and the cornfield weeds, have accompanied man in his most distant wanderings, and in many instances have developed increased vigour and a power of colonization unsurpassed by man himself. In some instances the reproduction and spread of these weeds is so rapid as to become a great scourge to agriculture, overrunning and destroying crops almost as effectually as swarms of locusts; and laws have been framed making it compulsory on farmers to keep their land free of these prolific strangers. Sometimes it is a new weed that makes its appearance and propagates itself in this extraordinary manner, advancing from field to field, farm to farm, county to county, and State to State, at an incredible pace. During the last three or four years the so-called Russian thistle (*Salsola Kali*, var. *Tragus*) has been occupying the serious attention of the farmers and legislators of the Eastern and Central States of North America, and it is already the subject of a considerable literature. Thousands of square miles are infested, and the loss resulting therefrom in 1892 was estimated to exceed two million dollars!

But the object of this article is to direct attention to some of the phenomena of the distribution and existence of plants in nature, uninfluenced and unaffected by man, either directly or indirectly—that is to say, to the latitudinal limits, the altitudinal limits, and other interesting facts of the present distribution of flowering plants.

In the highest latitudes yet reached in the west, in Ellesmere Land and Grinnell Land, between 80° and 83° 6′ north latitude, the ground in localities the most favourable to the development of vegetation is carpeted with plants, many of them having brilliantly coloured flowers, produced in great profusion during the short but continuous summer that there obtains. About seventy species were collected within the latitudes named by the naturalists of the last British Polar Expedition, and they included such familiar showy plants as *Papaver alpinum*, *Silene acaulis*, *Dryas octopetala*, *Saxifraga oppositifolia*, and *Epilobium latifolium*.

The Austrians found a very different condition of things in the same latitudes in Franz Josef Land, eastward of Spitzbergen. Plants were found, and of the same species, but in an extremely stunted state, with scarcely a flower to be seen, and nowhere was there continuous vegetation a few square feet in extent.

In these very high latitudes seed is rarely, if ever, perfected, and plants increase only by vegetative development—suckers, underground stems, and trailing rooting stems. Yet the greatest cold experienced—upwards of one hundred degrees (Fahrenheit) of frost—did not impair the vitality of wheat that had been fully exposed for four winters and four summers. It should be mentioned that none of the plants inhabiting these high latitudes are peculiar to the region; that very few species are confined to the Arctic regions; and that many of them are widely spread in Alpine regions of lower latitudes, some even recurring on the mountains within the tropics, and a few reach the southern limits of vegetation.

In the southern hemisphere there are now no flowering (*phanerogamic*) plants growing within thirty-five degrees of the Pole,[*] and countries in as high a latitude as Scotland are absolutely ice-bound. South Georgia, in the American region, and Macquarie Island, in the New Zealand region, may serve to illustrate the Antarctic flora and the southern limits of flowering plants. They are small islands of comparatively slight elevation, and both situated in 54° south latitude. South Georgia is about a thousand miles east of Cape Horn, and nearly as far from the Falkland Islands, the nearest land, except some very small islands concerning the vegetation of which nothing is known.

Its exceedingly meagre flora has probably been exhaustively investigated, and the result is a list of thirteen species of flowering plants and no ferns. Not one of these species is peculiar to the island, and nine out of the thirteen inhabit both the American and the Australasian or New Zealand regions. When we remember that the Antarctic flora now exists only in such isolated and distant fragments, we are hardly prepared to find almost the same homogeneity as in the north, where there is practically a continuity of land. Yet so it is; and the only satisfactory solution of the problem is a former greater land connection and continuous flora, probably in higher latitudes than the existing fragments. One of the tasks of Antarctic explorers is to search for fossil remains, which might

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[*] Should there be no error in locality, there is a single known exception. In the Kew Herbarium is a specimen of a grass (*Aira antarctica*) labelled "New South Shetland, Dr. Eights."

give a clue to the history of plant life under different conditions.

A noteworthy feature in the small flora of South Georgia is the presence of three northern plants, namely, *Montia fontana*, *Callitriche verna*, and *Phleum alpinum*. Two out of three of these plants are also found in the New Zealand region. As previously mentioned, some northern species extend into the southern hemisphere, but no essentially Antarctic types extend into the northern. The farthest they reach are the Alps of Victoria and the Andes of South America, where a very few outliers occur.

Another peculiarity of the highest Antarctic flora is the almost total absence of colour in the flowers, which are, moreover, exceedingly small. Butterflies and bees are also absent, whereas they abound in the north, where showy flowers are found.

The flora of Macquarie Island, on the opposite side of the world from South Georgia, although very poor, and possessing no endemic element worth mentioning, presents more striking features. For example, there is one very showy plant allied to the Michaelmas daisies, and another, *Stilbocarpa polaris*, belonging to the same family as the ivy, having very large and handsome leaves. Yet, although the climate is much less rigorous than in South Georgia, there is no shrubby plant of larger dimensions than common thyme; and the whole flora consists of less than thirty species. Comparisons with other islands I must leave for a future article.

◆

WAVES.—II.

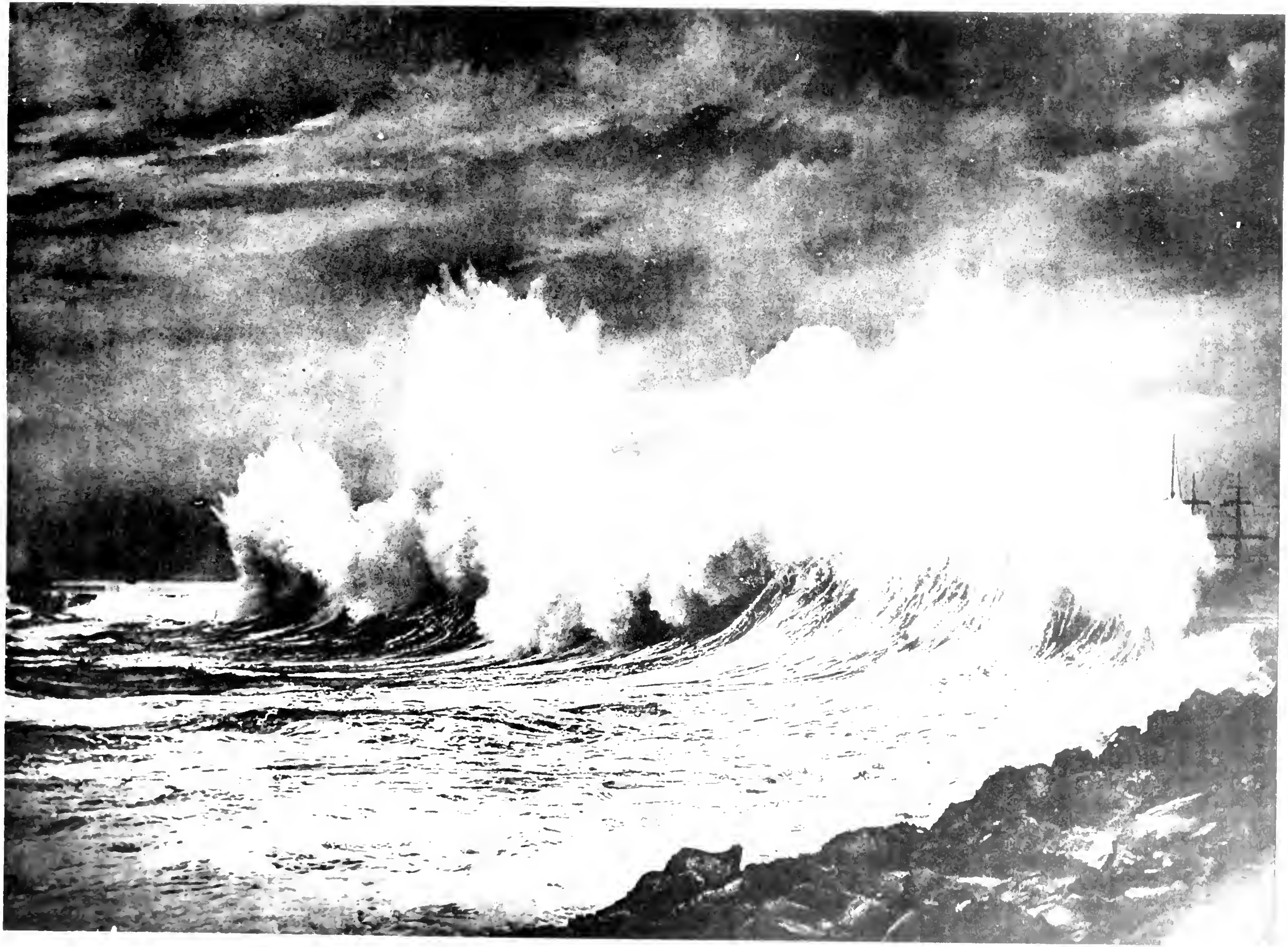
THE WAVES OF THE SEA SHORE.

By Vaughan Cornish, M.Sc.

WHEN the ocean wave reaches the shallowing slopes of the sea shore, the water particles no longer swing freely in the circular orbit which gives rise to the simple form of the deep-sea swell. The circular swing of each particle is exchanged for an elliptical motion, the vertical diameter of the circle being shortened when the depth of the water is no longer great compared with the wave-length, or distance from crest to crest. With the change in the motion of each water particle, which cannot itself be followed by the eye, comes the change in the visible form of the undulating surface of the sea. When the wave is running freely in deep water each crest is preceded and followed by a trough of the same shape and size. Fig. 1 represents the modification of the wave-form in shallowing water. The front of the wave becomes steeper, the back more sloping, until the crest of the wave has the cusped form; when we have reached the breaker, and the crest topples over in a mass of foaming water. This progressive change of form can be better observed from a pier than from the beach, where the troughs and backs of the waves cannot be clearly seen. The cause of these progressive changes in the wave-form is the slower transmission of wave-motion through shallow water. When the distance of the sea-bottom is no longer great compared with the dimensions of the wave, the forward movement of the wave is retarded, and, moreover, the drag on the wave's motion is greater in the trough of the wave than at its crest, where the depth of the water is greater. Hence the crest gets more and more ahead of the following trough, until at last we reach the critical moment when it catches up the preceding trough, overhangs the hollow with a trembling cusp, and then breaks. According to Scott Russell's observations, this occurs when the height of the crest above the general level of the water is equal to the depth of the water at that place.

Fig. 1.—The Forming of the Breaker.

Everyone who has watched the breakers of a stormy sea has noticed the occasional arrival of succeeding breakers of exceptional size, and the occasional occurrence of nearly smooth water. This is due to the coincidence of two or more sets of waves, the result being a complex wave in which the motion of each particle of water at any position is the result of two or more impulses. The amount of the resulting displacement at any point is either the sum or the difference of the several displacements, according as they are at the moment in the same or in opposite directions. The lowest curve in Fig. 2 represents a wave-form in which rough and comparatively smooth water alternate with one another. This curve is drawn by compounding the two upper curves, each of which represents a simple wave. The length from crest to crest is slightly different in the two cases. In sections A and C the simultaneous displacements are in the same direction in the two waves; crest nearly coincides with crest, and we have rough water. In section B the simultaneous displacements are in opposite directions; what would be the crest of the first wave (if the wave were travelling by itself) nearly coincides with the position which in the second wave would be a trough. The resulting disturbance in the actual complex wave is therefore very slight, and there is comparatively smooth water in section B. The wave is supposed to be travelling to the right, so that section C will give large breakers when it reaches the shore, which will be followed by small breakers when section B reaches the shore. It is by availing themselves of the succession of rough water by smooth that skilful boatmen safely beach their small craft in a rough sea. Early training and long practice appear to give them a remarkable power of analysing the components of a complex wave. In rough weather off a shallow shore there are generally several waves breaking at the same instant at different distances from the beach. This would be difficult to understand if the wave-form were a simple one; but with the more usual complex waves, it is easy to see that there may be a smaller wave breaking near the shore and a larger wave breaking simultaneously in deeper water. On a steep shore the wave phenomena terminate with the breaker; on a flat shore it is not so. From each succeeding breaker the



THE BREAKWATER AT COLOMBO DURING THE S.W. MONSOON.

[illegible] from the photograph by Capt. E. [illegible]

water rolls forward on a flat shore in a new form of wave, called the solitary wave, or wave of translation. Fig. 3 illustrates this condition of things. The characters of the solitary wave will be discussed in a later article.

One of the first problems which presents itself to the watcher of waves is the circumstance that, at the opposite shore of a bay, across which we will suppose him to look, the waves travel in exactly the opposite sense (or direction) to those which roll in to the beach on which he stands. To all appearance the waves, when the air is calm, come from some distant source of disturbance—say in the open ocean—and there seems at first no obvious reason why the waves should advance directly upon every part of the shore however much the shore line may twist and turn, so that at every part of the shore the line of breakers, and the crests immediately following the breakers, are parallel to the beach. This is due to the circumstance already mentioned that the progress of a wave becomes slower as the depth of the water becomes less and less. Thus, if a wave crest enter a bay or inlet, the middle part, which is in deep water, will retain its velocity, whilst to right and left the wave is retarded. Where the drag of the sea-bottom is felt the wave hangs back, and the crest swings round each cape or promontory, as a line of soldiers wheels on parade, when the inside man marks time and the outside man marches at the regulation rate. Thus the wave crest wheels and advances towards the beach, its whole length being nearly parallel to the shore at the time the crest begins to break. Those parts of the crest which are a little further from the beach are travelling faster, and quickly come alongside the breaking portion of the crest. At the edge of the shore every circumstance combines to give the impression that the waves for a considerable distance out to sea are advancing directly upon the beach. From the top of a moderate cliff it is, however, easy to see that this is to some extent an illusion. In a side wind, especially, it is only close in shore that the wave crests range themselves in long ridges approximately parallel to the beach.

When the wind sets in at an angle with the shore line, and the waves are no longer free but forced, the windward end of the breaker breaks first, and the curling cusp runs to leeward along the crest as the wave swings round, each portion of the crest successively discharging itself upon the beach when it reaches about the same distance from the shore line as that at which the windward end of the wave first broke. The line to which the surf reaches is consequently very nearly parallel to the shore line. When a light side wind springs up across a sea still agitated from former winds, or from a distant storm, two sets of breakers may sometimes be perceived, the larger rolling in directly upon the shore, and the smaller (small both in height and in length and moving slowly) coming in at an angle, and breaking first at the windward end. More often than not the smaller, slanting wave is caught up and smothered by the larger and quicker waves, so that it is only occasionally, at opportune moments, that the little side waves are able to discharge themselves upon the beach. There is another point to be noticed when a side wind sends smaller undulations athwart the larger waves. These smaller undulations may be observed to indent, or serrate, the crests of the larger waves, carving them into ridge and furrow. If the eye be turned to the roller immediately behind the breaker it will often be noticed that the crest is not a straight line, but has an undulating form. Now let the eye follow this roller as it nears the shore, and becomes in its turn the breaking wave. The crest is higher in some places than in others; the water there is deeper, and these parts of the crest, therefore, move faster than the lower parts. They consequently break first; and by rapidly running the eye along the crest of the breaking wave one may see that there are a number of portions of the wave of about equal length where the crest is breaking, and that these breaking portions are separated by unbroken portions which are the troughs of the sideways undulation.

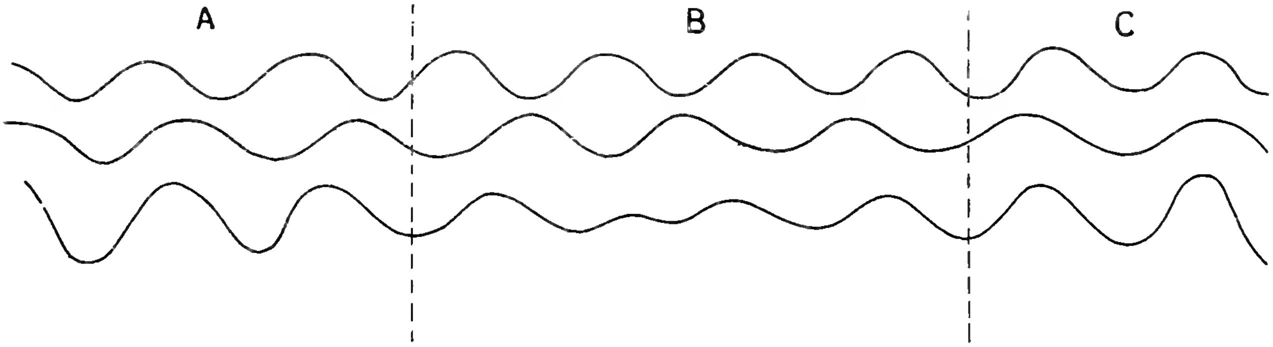


Fig. 2.—The Alternation of Rough and Smooth Water.

When large waves are rolling in to shore on a calm day after a storm, one may sometimes see breakers with straight, unfurrowed crest, which come in direct and discharge themselves simultaneously along their whole length with thundering sound. On a flat shore the finest breakers are these given by the ground swell, especially in a light off-shore wind, when the great wave slides smoothly on to the very margin of the water and discharges itself right upon the beach.

The simple heave of the ground swell is, however, an exceptional condition of the sea. Generally the surface is covered with undulations of various size, moving independently in different directions, which the watcher of waves cannot too early accustom himself to detect. One of the most familiar beauties of the sea, the laughter of the sunlit waves, is due to these complex motions. The dancing, sparkling points of light are one of the great charms of a shore which faces the sun. When the early riser sees the sunlight sparkling on the summer sea, and goes out into the freshness of the new day, he knows, as few others know, the true joy of the morning. When the sun first appears above the sea a narrow lane of ruddy light stretches from the horizon to the shore. As the sun rises higher the band of light broadens out, but ceases to be continuous. As day advances we no longer recognize a band of light, but see the intermittent flashing of the image of the sun from all parts of a broad stretch of sea. Between the observer and the sun the light is caught and reflected, as from a mirror, by the sloping flanks of the waves which are travelling towards him. For a long distance on either hand sideway undulations heave the water to such a slope that the heliographic flash is seen by the same observer. Distance and the quickness of extinction make it difficult to realize that this appearance, so like the quick flashings from the facets of a diamond, is really an image of the sun. Sometimes, however, in slowly heaving water, and when the light is not too strong, the sun's disc may be distinguished in multitudinous repetition. I have noticed this effect very distinctly in the Serpentine when the light of the sun has been suitably reduced by a *soupçon* of London fog. I have also noticed a beautiful effect, somewhat of the same class, on looking down from Beachy Head when a light mist concealed the surface of the sea, which, however, was momentarily revealed by heliographic flashes from the waves.

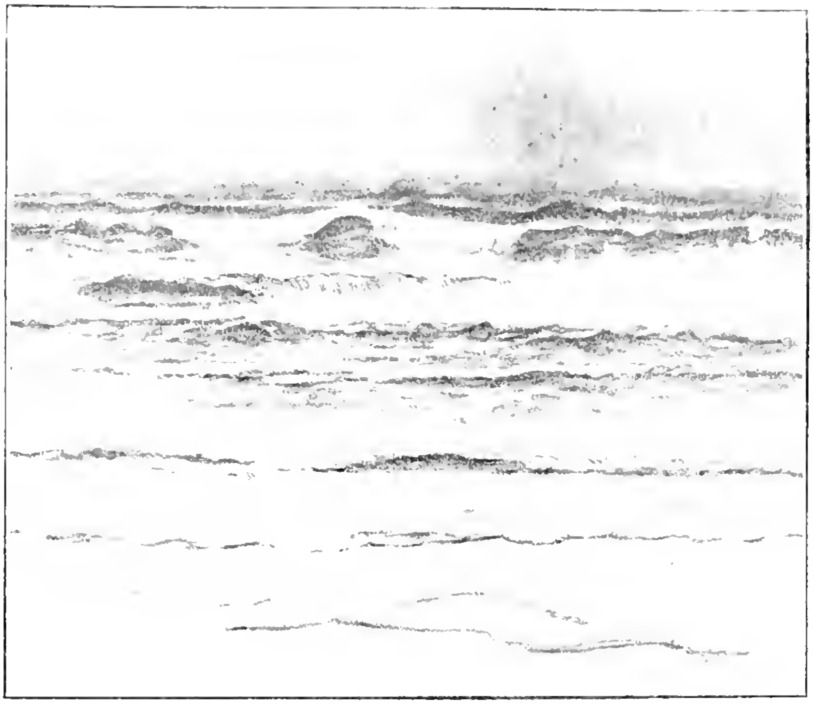


Fig. 3.—Waves breaking on a Flat Shore.

We have explained the deflection of the wave crests which causes the rollers to travel in opposite directions upon opposite shores of a bay. But why does the sea always break upon the coast, even when the wind is dead off shore? One would naturally expect that, if the wind continued to blow off shore for a sufficient time, the waves would run *from* the shore; and in point of fact we know that, if we set out to sea in an off-shore wind, we should find, after going a certain distance, that the waves *are* travelling away from the shore. Again, if we look at a small sheet of water, such as a pond, when agitated by the wind, we observe that there are breakers on the leeward but *not* upon the windward shore. The following may serve as a tentative explanation of the anomaly. The motion of a wave depends upon two things: first, upon the action of the wind upon it; secondly, upon the impulse received from other waves. Quite close to the beach the impulse from other waves cannot act seawards, for the other waves are all upon the seaward side. Again, the power of an off-shore wind to raise the waves at the margin of the sea is no greater than at the edge of a small pond; and we know that the most powerful wind can raise but a very small wave at the windward edge of a pond. If, therefore, there be present any agitation of the sea other than that due to the off-shore wind, there exists no agency close to shore adequate to prevent this agitation from sending in waves and forming a breaker. As a matter of observation the turbulence of the sea is so persistent that agitation from past winds or other causes never seems to be wholly absent. This persistent turbulence of the sea we shall be able to explain to some extent in our next article.

In order to observe the forms and motion of the waves the learner should not seek the tumultuous surgings on a rocky coast, but should rather go in quiet weather to a flat shore, and walk by the furthest edge of the beach at low tide. The most favourable conditions are when the waves break upon a shoal about a gunshot from the shore, and when a ridge or bank of sand or shingle terminates the beach. Then the incoming wave breaks upon the shoal, and the low foaming ridge of the "solitary" wave traverses the strip of shallow water, at the edge of which the foam disappears as the waves once more assume the usual form. A group of these, of shorter length from crest to crest, makes for the shore, where the second (smaller) breaker discharges itself upon the ridge of sand, from which a reflected wave travels back, meeting the next incoming wave, with which it seems to struggle for a moment; then each passes through the other, the one hurrying seawards, the other making its way to shore. These and other intricacies of wave motion may here be seen, best of all when the slanting rays of the setting sun mark front and rear of each smallest wave with a double line of light and shadow.

On the other hand the *force* of waves is most strikingly shown where the sea bursts over rocks or breakwaters, as shown in our full-page illustration. We return to the subject of the "Force of Waves" in our next article.

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ANTARCTIC EXPLORATION.

By William S. Bruce, *late Naturalist to Antarctic Expedition*, 1892-93.

Polar exploration, and more especially South Polar exploration, is the first problem to-day among the geographers of the world. At present there are no less than three North Polar expeditions in the field, Norway, America, and Britain each having a representative in the northern world of ice. It is not our intention, however, at present to deal with these northern expeditions, but, in passing, we must wish them success.

Of the three, perhaps Nansen's and Peary's are of the greatest interest: the one for the boldest, and indeed the most ingenious, dash ever made at the Pole, headed by a man whose Norse blood and sound scientific reasoning gives us the keenest belief that he will accomplish more nearly, if not entirely, the aim of so many of his predecessors; the other because we know that it is headed by a man who has done one of the most solid pieces of Arctic work yet accomplished. We Britons, too—do we not watch with eager interest the work of our countryman Jackson, who will, we feel confident, give us results which not only we, but the whole world, will be proud of? Wellman, too, we trust, will have better fortune next season; and Andrée's unique resolve we hope will be profitable to science.

In looking at the history of Polar exploration, the one thing that strikes us is the immense amount of work done in the north compared with that done in the south: and the reason is not far to seek. The object of early Arctic navigation was not to reach the Pole, but to discover a shorter route to India by the North-East and North-West Passages; then there was the additional interest which Russia and Britain had in delineating the northern coasts of Europe, Asia, and America: and, beyond this, the desire to penetrate the unknown simply for the sake of gaining knowledge of it. "And to what avail?" it is said. To what avail! See the fleets of whalers and sealers leaving Norway and Britain year after year, bringing home the richest cargoes in the world. Behold, also, the wealth of Siberia opened up to the great trading nations of the world. But, more than this, consider the rich treasures that science has gained, and the romance—the heroism—these adventures have called forth.

The history of the North Polar regions fills volumes, but it is easy to give a brief outline of the history of the South Polar regions. To Peru belongs the honour of sending out the first Antarctic expedition, more than three centuries ago. In 1567 the Governor sent out an expedition under the command of his nephew, Alvaro Mendaña, to discover "Terra Australis Incognita;" and a second Peruvian expedition was sent out in 1605, and discovered an island of the New Hebrides group in 1606.

Dirk Gorrits, in the meantime, in 1598, had set sail from Amsterdam accompanied by a small fleet; and, being separated from his companions by heavy weather, near the Straits of Magellan, discovered some high land now known as the South Shetlands. Gorrits and his crew were eventually captured by the Spaniards. France was next in the field, La Roche discovering the island of South Georgia in 1675; and Kerguelen, in 1772, saw what he at first believed to be the Antarctic continent, but returning in the following year he found it to be only a small island. This island now bears his name. Britain, however, was the first nation to do any real work in the Antarctic, and that work is associated with the name of Captain Cook. He was the first to cross the Antarctic Circle in 1773, and, crossing it again in 1774, he attained as high a latitude as 71° 15′ S. In a second voyage he circumnavigated the globe in high southern latitudes, twice crossing the Circle, and was thus the first to confine the southern continent within the Antarctic Circle. Cook described the terrors and inhospitality of these regions, and firmly believed that no higher southern latitude would ever be attained. In 1819, William Smith, of Blyth, re-discovered the South Shetlands, the discovery being confirmed by Bransfield in the following year, who also sighted Bransfield Land. In 1820 the Russian Bellinghausen crossed the Antarctic Circle, and attained the latitude of 70° S. in 1° 30′ W.; he discovered Peter and Alexander Islands, then the most southerly land known. In the following year Powell discovered the South Orkneys. In 1823 our brave and distinguished countryman, Captain James Weddell, exceeded all former records, sailing as far south as 74° 15′ S. in 34° 17′ W. Here, on the 20th of February, he found a sea clear of field-ice, with only three icebergs in view.

John Biscoe, in the service of Messrs. Enderby, was the first to put foot on land within the Antarctic Circle; this was on Adelaide Island in 1831. It was he who discovered the western coast of Graham's Land, the Norwegians and ourselves first seeing the eastern coast in 1893. Several other masters sailing under Messrs. Enderby made discoveries, notably Balleny, who discovered Balleny Islands and Sabrina Land. After these, D'Urville the Frenchman, Wilkes the American, and Ross our own countryman, during the years 1839-43, can alone be classed as Antarctic explorers. The *Challenger* paid a flying visit in 1874, and in 1892-3 Norway and Scotland despatched a whaling fleet to which was attached a scientific staff. And Norway has been again to the fore in the last two seasons, Captain Larsen, of the *Jason*, having added very considerably to our knowledge of the eastern coast of Graham's Land; while Captain Svend Foyn's vessel, the *Antarctic*, has this year reached the latitude of 74° S., the highest attained since the time of Ross. A party from this vessel, led by Mr. Borchgrevink, had the good fortune of being the first to land upon the mainland discovered more than half a century ago by our own countryman, Sir James Ross.

But of all the expeditions to the Antarctic regions that of the *Erebus* and *Terror*, under the command of Sir James Clark Ross, during the years 1839-43, is by far the most important. With the most indomitable courage and perseverance Ross crossed the Antarctic Circle in three successive years. On two of these occasions he attained far higher latitudes than any of his predecessors. He discovered Victoria Land, the vast mountainous tract extending away to 78° S., in the longitude of New Zealand, terminating with Mount Erebus, which, from a height of over twelve thousand feet, lights up the winter darkness of the snowy desert. From this point in about 78° S. he sailed along an icy barrier running eastward for three hundred miles, the termination of the ice-cap of the great Antarctic continent. In 1842-43 he visited the region of Erebus and Terror Gulf, lying to the south of Cape Horn, and became entangled in impenetrable pack; pushing farther eastward, he again crossed the Circle, attaining a latitude of 71° 31′ S., between Bellinghausen and Weddell's tracks. Ross believed he could have landed and travelled over the continent, and had he had steam he would undoubtedly have accomplished what with a sailing vessel was quite impossible.

D'Urville and Wilkes both did good work, and discovered land south of Cape Horn and south of Australia in high southern latitudes.

And now it is suggested that these wintry realms should again be thrown open to scientific investigation, and the cry "*Cui bono?*" has once more to be encountered. But let us frankly confess at the outset that we do not intend to lure on half-hearted supporters with the hope that such an expedition may lead to any monetary gain, although new channels for our commercial energy have been opened up in other parts of the world where, not commerce, but religion, science, and adventure have urged men and women to fathom the unknown. We go forward as eager enquirers, seeking to discover new truths and beauties which nature is ready to reveal to us.

No other part of the world offers a wider field for original research than the South Polar regions, and it is astonishing to one who has had the least practical acquaintance with that part of the globe that more enthusiasm for their exploration has not been shown. Take, for instance, meteorology. The only meteorological records we have of the Antarctic regions are during the three or four summer months; and although we may meet with many charts which picture the meteorological conditions of these regions, yet these, even for the summer, are almost purely theoretical. There are no records of any fixed station south of the latitude of Cape Horn even for the summer months. Our practical knowledge of the terrestrial magnetism of even moderately high southern latitudes is really only gathered from Sir James Ross's investigations, which, excellent as they are, can hardly be said to give us an accurate idea of the present magnetical conditions of these latitudes and the sequence of changes that have taken place during the last half-century. Now, apart from all other investigations, it is of vital importance to us, as the greatest seafaring nation, that our knowledge in these two branches of science should be extended in the south, for without doing so it is impossible to have any complete summary and classification of the laws which govern the meteorology and magnetism of the world. This meteorological and magnetical work can only be done by landing several parties, who shall set up fixed stations for the whole year at different points on the islands and mainland of Antarctica, and who shall thus be able to carry on observations systematically, not only during the summer, but also during the winter months. If possible, these observations should be extended into a second and even a third year, so as to note more completely the regular sequence of events. Besides having these stations, at various other points recording instruments should be set up and the results noted summer after summer. Wintering in the Antarctic has been much dreaded by many, but perhaps the task would not be so trying as in the north, provided, at least, that the wintering stations were not far within the Antarctic continent.

It must be remembered that there is an entirely different distribution of land and water in the south to that which occurs in the north. In the north we have a Polar basin—a Polar sea more or less dotted over with islands—surrounded by the continental ring of Europe, Asia, and America, broken only at two main points by the Greenland Sea and Behring Straits; in the south, probably a Polar continent, surrounded by the great Southern Ocean. In the north, then, we have, even in the highest latitudes, all the ameliorating conditions of a continental summer—bees humming their merry tune and flowers decking green valleys where musk oxen graze; but we have also all the rigours of a continental winter, enabling the Franklin expedition to register as much as ninety degrees of frost, and others even greater degrees of cold. In the South Polar lands (except, perchance, in the heart of the great continent) we have to deal with an oceanic climate, where the variations between winter and summer are very greatly diminished; and although during the summer we may seldom, if ever, have the thermometer rising above the freezing point, yet in the winter the thermometer should not register such extraordinary degrees of cold as in the north. But here, again, our statements are based on theory; the more important, therefore, is it in the near future to make a clear statement of facts from the result of observations.

It is plain that in meteorology and terrestrial magnetism we have two subjects not only of purely scientific interest, but of vast importance for the more accurate navigation and greater safety of our vast fleets throughout the world. There is one other subject which combines scientific and commercial interest, and that is biology. How far is it possible for us to prosecute seal and whale fisheries, and what must be the conditions of administrative protection? The commercial expeditions of the last three years from Norway and Scotland seem rather to indicate that these fisheries cannot be profitably prosecuted, but still we must acknowledge that there has been hardly sufficient investigation to answer this question decisively. The discovery of guano at Cape Adair by Mr. Borchgrevink also opens up a new channel for commercial enterprise. But, apart from the commercial aspect, a very rich biological field lies waiting for us in the Antarctic. Sir James Ross gathered many invertebrate treasures, but these, unfortunately, mostly perished without ever being properly examined. The *Challenger* was more successful, and Dr. Murray has brought to light some very interesting relationships in the similarity of the fauna of the South and the North Polar seas. In order to carry on this interesting and valuable research, it is necessary to equip an expedition which shall dredge, trawl, and tow-net throughout the breadth and depth of the great Southern Ocean. Unfortunately, the *Challenger* was not an ice-protected vessel, and it would have been unwise for her commanders to have carried on further research than they did in such high southern latitudes. Beyond the mammalian and invertebrate fauna, there is also the vast host of birds and fishes to be studied, about which we know next to nothing. Botanically we cannot hope for much, except possibly in marine algæ. It is interesting to note, however, that Mr. Borchgrevink, of the *Antarctic*, found this year on Possession Island a lichen. This is the only recorded land plant found within the Antarctic Circle.

Towards the bathymetrical survey of the Southern Ocean both Ross and the *Challenger* contributed valuable observations, and the *Challenger* observations have been lucidly expounded by Dr. Murray, who has brought to light many very interesting facts regarding the distribution of oceanic deposits. But only the borderland of this new world has been touched, and there still remains a vast field of most interesting and important scientific research. As a result of these investigations Dr. Murray has defined to us what must be more or less the outline of Antarctica, and it is consequently of more interest than ever that a practical survey of this coast-line should be made. There has always been a theory of an Antarctic continent, but Dr. Murray's theory differs from all previous ones, inasmuch as it is founded on fact.

To Captain Larsen, of the *Jason*, who has recently been awarded the Back Grant of the Royal Geographical Society for his valuable Antarctic researches, do we owe the first concrete addition to our knowledge of the geology of the Antarctic. He has landed several times, being the first who ever travelled over the Antarctic ice, and on one or more of his landings secured a most interesting set of fossils. Still, this is only a beginning in the geology and palæontology of the south, and the geologist is enthusiastically eager for further research. Geodetic problems, problems of the Great Ice Age, of oceanic temperature, salinity, and circulation, and other branches of scientific knowledge too numerous to be mentioned here, have to be studied. Such, briefly, is the work of a modern Antarctic expedition.

Since the return in 1893 of the Norwegian and Scottish whalers there has been an endeavour among scientific men and societies to promote a British Antarctic expedition, but more than two years have elapsed and yet no definite plans are on foot. But outside our islands scientists have met with greater success. Dr. Cook leaves New York next year, and possibly two other countries will be despatching Antarctic expeditions. Is the British nation not to be moved? Are we, the maritime power of the world, to stand by and look on while other nations solve the problems of oceans? Much can be done by private enterprise, and such enterprise should be fostered; but if we have our old enthusiasm we can do something more than send out a private expedition from our shores. The scientific world is at present ringing with the praises of the *Challenger* expedition. Do we regret having sent out that expedition? Has it not made Britain a greater maritime nation than she ever was before? Does Cook's work from east to west, from north to south, count for nothing? Do we regret having the names of Weddell, Ross, Franklin, and a hundred others added to our roll of heroes? Let us show that we are still the leading maritime power of the world, and that in peace our victories are even greater and more lasting than in war! Let us unite together again, and add another chapter manifold richer than the chapter of the *Challenger*, since by that expedition we should have learnt how to carry on a similar piece of work to even a more successful conclusion.

We do not in the least advocate that such an expedition should ever attempt to reach the South Pole. A rush to the Pole is not what we desire, but a systematic survey of the whole South Polar regions, and a continuous series of various observations throughout at least two, if not three, years. There is no doubt that such an expedition would furnish inconceivably valuable results, and that a new gem would be added to our nation's records. Even greater would be the glory and the final results if the Antarctic regions were to be explored by the co-operation of the great nations of the world; and it is pleasing to record that the International Geographical Congress has unanimously adopted the following resolution recommended by a most distinguished committee, consisting of Sir Joseph Hooker, Dr. John Murray, Dr. Neumayer, Professor Von den Steinen, and M. Bouquet De la Grise, namely :—

Sir William Herschel. From *The Herschels and Modern Astronomy.*

"The Sixth Geographical Congress, assembled at London, 1895, records its opinion that the exploration of the Antarctic regions is the greatest piece of geographical exploration still to be undertaken; and in view of the addition to knowledge in almost every branch of science which would result from an expedition to the South Polar regions, Congress recommends the several scientific societies throughout the world to urge, in whatever way seems to them most effective, that this work should be undertaken before the close of the century."

Surely the unanimous resolution of so great an assembly will have sufficient weight to move the most retrenching Governments to tread onwards, and

"To grace this latter age with noble deeds."

Note.—The Governments of New South Wales and Tasmania have recently agreed to raise funds for an Antarctic expedition if the other Australian Colonies will also join the project.

Notices of Books.

The Herschels and Modern Astronomy. By Agnes M. Clerke. (Cassell & Co.) 3s. 6d. The subject of Miss Clerke's latest work is not a new one to her, as she had largely treated of the Herschels in her "History of Astronomy in the Nineteenth Century," and had there shown how strongly the subject had excited her interest. With a writer of Miss Clerke's force and charm of expression, and deep and thorough sympathy in her subject, the book before us could not fail to be one to commend itself to every reader to whom astronomy at all appeals, or who can be attracted by the narration of the final success of genius. The author tells us in the preface that the gleanings about William Herschel's scientific works, apart from those taken directly from Caroline's "Journals and Recollections," have had to be sought and studied one by one in the various volumes of the *Philosophical Transactions.* Very naturally the subject divides itself into three parts, which tell in turn of William, Caroline, and John Herschel. The life of William Herschel is still more an account of the birth and first beginning of our present-day observational and physical astronomy. When the elder Herschel tried fitting lenses into pasteboard tubes, in 1772, and obtained but poor results, these sections of the divine science were non-existent; the idea of their possibility, even, had not germinated in men's minds. In sentences that charm the reader by their power and completeness, Miss Clerke narrates how the musician of Bath designed "to carry improvements in telescopes to their full extent" and "leave no spot of the heavens unvisited," and how he trained his senses of sight and touch to render possible the accomplishment of his great design. After *two hundred* failures a tolerable reflecting telescope was produced, about five inches in aperture and of five and a-half feet focal length. The outcome may seem small for so great an expenditure of pains, but those two hundred failures made the octagon chapel organist an expert. But the most interesting chapter is that one which deals with "The Influence of Herschel's Career on Modern Astronomy." Of Sir John Herschel there is a chronological table of successes. "His life was a tissue of felicities. For him there was no weary waiting, no heart-sickening disappointment, no vicissitudes of fortune, no mental or moral tempests." He was a physicist, poet, chemist, mathematician; he was also an astronomer. There is never need to dilate on Sir William Herschel's genius; the fact is self-evident. Miss Clerke insists again and again that Sir John was a great man; that he stood "supremely at the head of the list"; that he was a successful man. The impression remains that it was his very success that was a failure; that if the hill of pre-eminence is smooth, it offers small grip to the foot of the climber. Sir John worshipped many gods: his father, but one.

The Cell: Outlines of General Anatomy and Physiology. By Dr. Oscar Hertwig. Translated by M. Campbell, and edited by Dr. H. J. Campbell. (Swan Sonnenschein.) Illustrated. 12s. "The cell theory," remarks Prof. Hertwig, "is the centre around which the biological research of the present time revolves." The theory that organisms are composed of cells was first suggested by the study of plant-structure, and the term "cell" was applied to the small room-like spaces, provided with firm walls and filled with fluid, to be seen in plants. Both Schleiden and Schwann (1838) believed the cell to be a small vesicle, with a firm membrane enclosing fluid contents; but, later, Max Schultze (1860) defined it as a small mass of protoplasm endowed with the attributes of life. Improved means and methods of observation have shown that this conception must give way to a better, and the definition now held is that the cell is a little mass of protoplasm, which contains in its interior a specially-formed portion, the nucleus. It is around this nucleus that biological investigations are now mostly centred; its nature, functions, changes, and potentialities will form the subject of work and discussion for many years to come. In fact, upon the nucleus is now concentrated the attention that in earlier days was given to the cell. The cell is very uniform in appearance throughout the animal and vegetable kingdom, and contains the key to many problems of life, while its relations to the protoplasm in which it is embedded are of absorbing interest. Prof. Hertwig is recognized as one of the greatest authorities on cell-structure, and this accurate translation of his treatise on the subject will be heartily welcomed by those who do not read German fluently, and yet desire to learn what is known about the "ultimate particles" of life. The historical course of the development of the more important theories relating to the cell is traced, and the knowledge gained by means of microscopical, chemico-physical, and other methods of inquiry is clearly set down. Few works are more valuable to students of histology than this, and in none will a better account be found of the nature and attributes of the cell-organism—that little universe the mysteries of which are slowly being unravelled. Prof. Hertwig is happy in having such an excellent translator and careful editor as those to whom the English version of his work has been entrusted.

British Fungus-Flora. By George Massee. Vol. IV. (George Bell & Sons.) 7s. 6d. This is the fourth volume of a standard text-book of mycology, written by a recognized authority on the subject. In it the species of fungi included in those families of the large natural order of the Ascomycetes are classified and described. Acting on his opinion that "no one can be considered to know a species thoroughly until it has been worked out by himself," Mr. Massee has personally examined type specimens in all cases where they were accessible (his position at Kew giving him exceptional opportunities for doing so), and has thus been able to make his descriptions of the characters of species full and trustworthy.

Simple Methods for Detecting Food Adulteration. By John A. Bower. (London: S.P.C.K.) Mr. John Bower chooses as his text the well-known words of Tyndall: "Apply the principles of science, and make them available to the needs, the comforts, and luxuries of life." This he has very indifferently succeeded in doing in the present volume, which is full of the most glaring errors, and gives such trivial tests for adulteration that those who endeavour to follow them will find that their efforts are thrown away. When we mention that we find such slovenly expressions as "the precipitation of the lime" on boiling hard water, that silver nitrate gives a white precipitate with the "organic impurities" in water, and that a "serviceable filter" can be made out of a flower-pot and some sand and magnetic oxide of iron, our readers will see that this adverse criticism is well deserved.

The Scientific Foundations of Analytical Chemistry. By W. Ostwald. Translated by G. McGowan. (Macmillan.) Prof. Ostwald's work during the last ten years on the borderland of chemistry and physics has naturally led him to look upon routine analytical work in the laboratory as almost devoid of any scientific basis. And in this respect we are fully in agreement with him. In scarcely any of the text-books do we find any mention of theory, and in the majority of examinations the practical work can be passed by a clever student who crams up a set of analytical tables. No student could pass a practical examination by reading Prof. Ostwald's book, but any one who has read it carefully through, and proved the different reactions in the laboratory, would have a real knowledge of practical chemistry. To the older student the work appeals, as it throws new light on many reactions which seem at first sight to be unique and uninfluenced by any general laws. We hope that all teachers will endeavour to frame their instruction on the lines laid down by the author, so that practical chemistry may cease to be simply the art of test tubing.

Text-Book of the Embryology of Invertebrates. By Dr. E. Korschelt and Dr. K. Heider, Translated from the German by Dr. E. L. Mark and Dr. W. Mc M. Woodworth. Part I. (Swan Sonnenschein.) Illustrated. 15s. Students of animal morphology well know the great value of the *Lehrbuch* of which this is a translation. To be able to read the work in English will, however, be a boon to many zoologists who find the perusal of the German text a rather laborious task. And even to those who have no difficulty in reading the original work the translation will be valuable, for numerous additions, recounting the most important results arrived at by embryologists since the date of first publication, have been made by Drs. Korschelt and Heider, and appear for the first time in the present edition. The complete work is published in three parts, and the first of these deals with the Porifera, Cnidaria, Ctenophora, Vermes, Enteropneusta, and Echinodermata. It is the translation of this part that is now before us, and we are glad to notice that translations of Parts II. and III. are in preparation. German men of science have a wonderful faculty for collecting knowledge, and the present volume is a good example of what they can do in that way. Practically all the literature of comparative embryology appears to have been consulted in the preparation of the work, and both students and special investigators will find the volume contains the best modern treatment of their subject.

Handbook of Industrial Organic Chemistry. By Dr. S. P. Sadtler. 2nd Edition. (Lippincott.) The first edition of this handbook was well received in this country, and supplied a gap in the existing literature. During the four years which have elapsed since the first edition was published, England has produced several books dealing with industrial organic chemistry, so that the want is hardly so acutely felt now as formerly. The literature has, however, been more of special character than of the general description covered by Dr. Sadtler's book; and as he has taken considerable pains in incorporating the recent progress made in the several departments, we think that the new edition will be welcome to many chemists. Dr. Sadtler's book is especially valuable for the statistics which it contains of the world's production of raw materials and their finished products; and as he has also completed each section of this work by a bibliography of the special works of reference, the reader has afforded to him information which will enable him to further study any special point. The methods of analysis given by the author are, however, frequently wanting in details. His method of procedure seems to have been to abridge and abstract the information contained in "Allen's Commercial Organic Analysis." The section devoted to vegetable textile fibres is well written, and gives a good *résumé* of the important industries connected therewith; and under "Animal Tissues and their Products" is a good general account of the leather industry and the allied manufactures of glue and gelatine.

Young Grey Lag Geese. From *British Birds' Nests.*

Outlines of Psychology. By Prof. Oswald Külpe. Translated from the German by Prof. E. B. Titchener. (Swan Sonnenschein.) 10s. 6d. The science of psychology can be divided into two main branches: the first is the descriptive and metaphysical branch, which dominated it for ages, while the newer movement is experimental and psycho-physical. Prof. Külpe's work is concerned with investigations in the latter direction. In this country psychology is not given so much attention as in Germany and America, but the number of its students is gradually increasing. Doubtless this translation of a work by one of the foremost investigators of the modern school will give an effective impulse to the study of the science with which it deals. Kant shared with others the view that there could not be an exact science of psychology; but their opinions are refuted by the fact that physiological psychology, or psycho-physics, has established important propositions capable of exact mathematical treatment, whereas Kant argued that mathematics could not be applied to conscious processes. There is certainly an increasing demand for psychological literature at the present time; and though the supply is now kept up mostly by translations from the German, it is to be hoped that the future will see larger contributions from British workers.

A Laboratory Manual of Organic Chemistry. By Dr. Lassar-Cohn. Translated by Dr. A. Smith. (Macmillan.) 8s. 6d. We are very pleased with this guide to practical organic chemistry; it certainly fills a gap in our English chemical literature. Nearly five years have elapsed since the publication of the first German edition, and during that time this most useful work has met with a warm reception among German chemists, and has been introduced as a standard manual into most of the university laboratories and polytechnics in Germany. This success is undoubtedly due to the very systematic method adopted by the author of arranging the several methods of chemical operations into distinct chapters, and giving such practical working details that even the novice need not go far astray when performing a new task. We hope that the book in its English edition will meet with a similar reception both in this country and America, as the translator has performed his duties in an exemplary manner, and has further enhanced the value of the book by his rearrangement of the index.

British Birds' Nests. By R. Kearton. With an Introduction by R. Bowdler Sharpe, LL.D. (Cassell.) Illustrated. 21s.

The originality of the illustrations in this book commends it at once as a work of exceptional interest. The text consists merely of dry but careful descriptions of the nests and eggs of the birds which breed in the British Isles, and where they are to be found. It is true that the author's object is to teach "how, where, and when to find and identify" these nests; but we think that he has made a very great mistake in not recounting more of the many adventures and experiences which his brother and himself must have met with in procuring the many beautiful photographs contained in the volume before us. The advantages of the camera as an aid to the naturalist have never been better illustrated than in Mr. Kearton's book. The nest or eggs of almost every bird that is to be found breeding in the British Isles are here portrayed in their original position, just as they were found amidst their natural surroundings. What could be more useful to the ornithologist, or more interesting to those who never have seen, and perhaps never will see, the actual thing? Beyond this, many of the photographs are beautiful pictures, which will be admired and appreciated by those of artistic tastes. By courtesy of the publishers we are enabled to reproduce one of these illustrations. The photography of birds in their native haunts, their nests and eggs, must always be attended by a great deal of labour, difficulty, disappointment, and even personal danger; and we think that Mr. Kearton and his brother have achieved a great success in obtaining such a splendid collection of photographs.

SHORT NOTICES.

Hidden Beauties of Nature. By Richard Kerr, F.G.S. (R. T. S.) Is a well-illustrated work and forms an excellent introduction to microscopical study. Mr. Kerr unfolds in simple language the marvels and beauties of many forms of life overlooked by most and studied by few. It is hoped that the perusal of this book will induce many to study the microscopical world around us.

Garden Flowers and Plants. By J. Wright, F.R.H.S. (Macmillan.) Illustrated. This little manual will be found of great practical use to amateurs in raising and growing plants and flowers in town, suburb, or country. Each plant is treated separately, and the book is provided with a good index.

Nature's Story. By H. Farquhar, B.D. (Oliphant, Anderson, & Ferrier.) Illustrated. Is written for young people. The author has been very successful in explaining, in a series of brightly written essays, many interesting and instructive scientific facts. The book is eminently fitted for the young, and will bear perusal by many older persons.

Analytical Key to the Natural Orders of Flowering Plants. By Franz Thonner. (Swan Sonnenschein.) To students of exotic floras this little book will prove of great value in extending their knowledge of the subject, and especially in determining the various orders to which the vast number of these plants belong.

An Introduction to the Study of Rocks. (British Museum, Mineral Department.) This useful book gives, from a Museum point of view, a simple sketch of the relationships of rocks, indicating all the more important characters and pointing out their significance.

A Popular Handbook to the Microscope. By Lewis Wright. (R. T. S.) Illustrated. So many books have been written on the microscope, how to work it, and on what is to be seen by its aid, that we need only commend this book to our readers as very reliable and well up to date.

Whittaker's Almanack for 1896 is as complete and full of useful information as possible, and should be possessed by everyone.

Elementary Trigonometry. By Charles Pendlebury, M.A., F.R.A.S. (Bell & Sons.) Will be found of great service to mathematical students, and especially to candidates for military examinations.

An Elementary Text-book of Mechanics. By W. Briggs, M.A., and G. H. Bryan, M.A., F.R.S. (Clive.) Is one of the University Tutorial Series, and affords beginners a thorough grounding in dynamics and statics. Mathematical formulæ have been avoided as far as possible in this book, in order that the fundamental principles of mechanics may be fully grasped.

BOOKS RECEIVED.

British and European Butterflies and Moths. By A. W. Kappel, F.L.S., F.E.S., and W. Egmont Kirby, L.S.A. (Nister.) 25s.

Ethnology. By A. H. Keane, F.R.G.S. (Cambridge University Press.) Illustrated. 10s. 6d.

Leisure Readings. By E. Clodd, A. Wilson, T. Foster, A. C. Ranyard, and R. A. Proctor. New Edition. (Longmans.) Illustrated. 3s. 6d.

Our Household Insects. By E. A. Butler. (Longmans.) Illustrated. 3s. 6d.

Cock Lane and Common Sense. By Andrew Lang. New Edition. (Longmans.) 3s. 6d.

Furs and Fur Garments. By R. Davey. (The Roxburghe Press.) Illustrated.

Minerals: British Guiana and its Resources. By the Author of "Sardinia and its Resources." (Philip & Son.) Cloth, 2s. 6d.; paper, 2s.

Popular Telescopic Astronomy. By A. Fowler, A.R.C.S., F.R.A.S. (Philip & Son.) Illustrated. 2s.

The Story of the Solar System. By G. F. Chambers, F.R.A.S. (Newnes.) Illustrated. 1s.

The Preceptors' Junior French Course. By S. Barlet. (Relfe Bros.) 1s. 6d.

The Koh-i-Nûr Diamond. By E. W. Streeter, F.R.G.S. (Bell & Sons.) Illustrated.

Minerals, and How to Study Them. By E. Salisbury Dana. (New York: Wiley & Sons.) Illustrated.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE CONNECTION OF ASTRONOMY WITH GEOLOGY.

To the Editors of Knowledge.

Sirs,—A journal like Knowledge, which deals with both sciences, affords the best medium for discussing the relations between astronomy and geology. My practical acquaintance with the latter science is very limited, being almost confined to the remarkable cavernous limestone district in the counties of Mayo and Galway, of which but little seems to be generally known. Englishmen know more of Adelsberg than of Aylemore or Cong. But let that pass. My object is to point out that geologists have not sufficiently availed themselves of the results of astronomical research, and perhaps a corresponding remark may apply to astronomers.

One point of connection between the two sciences was brought under the notice of the public by the late Dr. Croll, who inverted the earlier but less known theory of the late Mr. Joseph John Murphy. I am not satisfied that either theory affords an explanation of the Ice Age, but undoubtedly effects must have been produced on the flora and fauna of all extra-tropical regions which the geologists should be able to trace. On the assumption of no permanent ice-cap, a period of maximum eccentricity and winter aphelion must have produced a cold winter and a hot summer, and a continuance of hot summers and cold winters must have modified both animal and vegetable life. The phenomena which depend on mean temperature would be little altered, but those which depend on the extremes of temperature would be extensively changed. There is, I believe, in most animals, and probably plants, a principle of adaptation which would enable them to survive the change. This is the principle which Darwin described as the "survival of the fittest;" but the fact appears to be that even the individual animal can to a large extent adapt itself to the surrounding circumstances, as the winter's cold causes the hair of the horse or cow (that is not housed) to grow long. Of course, it may be said that the most adaptable animal is among the fittest to survive—that on the refrigeration of the climate the animal whose hair became long was as fit as the animal whose hair was long originally. But while I prefer my own term, the point on which I insist is that the changes relied on by Croll must have profoundly altered the climate and left traces on the flora and fauna of the period. A similar remark applies to the case of a maximum eccentricity and a summer aphelion. The mean temperature would be little altered, but the extremes would approach more closely to the mean. Phenomena of this kind could be best investigated a little to the south of the limit of glaciation; and as we know the date of the last period of maximum eccentricity, the identification of its results would be of use to geologists in all problems relating to the age of the earth and its various formations.

Another theory, started by Prof. G. H. Darwin, seems to me of great geological moment; and here, again, if some of the Professor's results are to be regarded as doubtful, it seems certain that the tides must have been slowly diminishing the velocity of the earth's rotation, and that in early geological times the day must have been considerably shorter than at present. The earth was therefore less heated in the day time, and less cooled at night, and the extremes of temperature which now exist must have been considerably modified. As in the former case the mean temperature would probably be unaltered, and the phenomena which depend on it would be the same as at present; but delicate plants which would now be killed by a cold night might have then flourished in this country.

This is not all, however. The equatorial protuberance of the earth is no doubt due to its rotation, and when the rotation was more rapid the protuberance must have been greater. How, then, was this equatorial protuberance lessened? As far as the ocean extends, the answer seems to be clear—by a flow of water from the equatorial towards the polar regions, and a consequent submergence of the land in the temperate zones both north and south of the Equator. The elevated land at the Equator would be slowly washed away by rivers; but if the earth's crust was thin, equilibrium might be more speedily restored by volcanic outbursts beyond the limits of the tropics. Lava might stream out until the land at the Equator was sufficiently lowered and that in the neighbourhood of the outbursts raised by the operation. Such volcanic outbursts might mask the simultaneous rising of the sea-level in the same localities. These polar ocean-currents would, in the northern hemisphere, take a westerly bend for the same reason that the Gulf Stream does so; and in places where there are no great traces of volcanic action we may expect to find evidence of the sea gaining on the land from the south-west, as appears to be the case, for instance, at St. David's. The effects of this reduction of the equatorial protuberance are, at all events, worthy of more attention than they have hitherto received from geologists. The amount of the reduction is, to a large extent, matter of speculation, but the reduction itself seems to be an ascertained fact.

Whether the nebular theory be accepted or otherwise, most persons will concede that the earth was once too highly heated to sustain life. From this fact, and what we know astronomically about its cooling, some inferences follow as to the early history of the earth which have hardly been recognized. Assuming that, whenever the necessary conditions for sustaining life are supplied, life itself will speedily follow, we can in this way trace the history of life on the earth. The Poles must have cooled faster than the Equator, because they received less solar heat. The earth, therefore, became habitable at the Poles when the Equator was still too hot to sustain life. At this early stage of intense heat a great part, if not the whole, of the water on the earth was in the form of vapour. As the cooling proceeded this vapour first formed two polar seas, which gradually extended towards the Equator as the process of condensing the aqueous vapour went on. The first form of terrestrial life was, thus, marine life in the polar seas. This life must have been capable of existing under a great atmospheric pressure, for the quantity of vapour still suspended over the earth must have been enormous. But some forms of marine life are found under great pressure in the deep sea. This great blanket of vapour no doubt moderated the extremes of temperature in summer and winter, and thus assimilated the polar climate pretty closely to that which now prevails in the tropics. Traces of tropical vegetation in the Arctic regions need, therefore, create no surprise. The only cause of surprise is finding them where they were presumably deposited after the earth had cooled down nearly to its present condition. But we have no reason to conclude that the carboniferous period, for instance, at the eightieth degree of north latitude was nearly contemporaneous with the same period at the fiftieth degree. Life had probably already gone through several stages of progress at the Poles when it made its first appearance at the Equator. The condensing of the vapour in the atmosphere, commencing at the Poles, would proceed gradually towards the Equator, thus inducing a flow of water in that direction. This would be entirely opposed to the flow of water caused by the slackening of the earth's rotation, but both would combine to produce a submergence of the land in our latitudes. The effect of slackened rotation probably continued to a later period than that of the condensation of vapour and its precipitation in rain. Rain, again, must, no doubt, have preceded snow, as liquid water preceded ice.

As to the amount of heat received from the stars, there can be no doubt that it has been different at different times, but it may be doubted whether the difference was sufficient to produce a sensible change in the climate of the earth. Nevertheless, this possible explanation of certain terrestrial phenomena should not be wholly overlooked.

One further suggestion I may make. Suppose an equatorial protuberance composed of solid land is formed by the earth's rotation, and that this rotation subsequently diminishes. It then becomes a great mountain chain, no longer in equilibrium, but subject to a double pull to the north and south. Assuming that the earth has a fluid nucleus, might not this pull, assisted by some irregularities in the shape of the range, lead to one half of the range being pulled to the north of the Equator and the other half to the south, the position of both the Poles and the Equator on the earth's crust being thus displaced? The mountain chain would still form a circle round the earth, but would become inclined to the Equator. I merely throw out this hint for the consideration of those better versed in the subject. The great Pamir Steppe is not far from diametrically opposite to the highest part of the Andes or Cordilleras.

W. H. S. Monck.

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GEOGRAPHY AS A SCIENCE IN ENGLAND.

To the Editors of Knowledge.

Sirs,—The programme unfolded by Dr. Mill in his article on "Scientific Geography" in your last issue is brilliant but ambitious. I should like to ask what shape his proposal would take, and whether any work on similar lines has yet been done in Great Britain?

Geographer.

THE PUZZLE OF "26."

Note.—We must express our regret to those correspondents who have sent us further solutions of the ingenious puzzle of "26" that we are unable to insert their communications, in consequence of a request by Messrs. T. Ordish & Co., of 29, Fore Street, London, the publishers of the puzzle, not to disclose any further solutions of it. We have received many solutions, but we do not desire to interfere with the business of Messrs. F. Ordish & Co., even by inadvertence. Eds.

GREEK VASES.—I.

INTRODUCTORY.

By H. B. Walters, M.A., F.S.A.

AMONG the various branches of Greek archæology the study of vase-painting stands out prominently as of far-reaching interest and artistic importance. Until the last twenty years or so, those who devoted themselves to this pursuit were content to confine their attention to such information concerning the mythology or the religious and private life of the Greeks as might be derived from a study of the subjects depicted, without regard to chronological or technical questions. The discoveries of recent years, however, have brought about a demand for a more scientific method, dealing more with questions of chronological arrangement and classification of the various fabrics and technical processes.

It is a common thing to hear these vases spoken of as "Etruscan," although this term, which arose in the last century, when few vases had been found except in the tombs of Etruria, has now been discredited for many years. It still, however, holds sway with all the tenacity of a popular error, and its use cannot be too strongly deprecated, resting as it does on no grounds whatever. A small number of vases were undoubtedly made by Etruscans in imitation of imported Greek fabrics, but all possess unmistakable characteristics which mark them off from the products of Greek artists. The fact that such a large proportion of the Greek vases which are to be seen in European museums were found in Etruria is due to an extensive system of importation from Greece, which went on during the sixth and fifth centuries B.C., the period to which the finest productions of the Greek potter's art belong. These vases seem to have caught the taste of Etruscan noblemen, who employed them to adorn their houses, and more especially for funeral purposes. Of late years, however, excavations on Greek soil have not only enabled a fine collection to be formed in the museum of Athens itself, but have yielded many examples for the European museums in no way inferior to the masterpieces imported into Etruria.

It may be laid down as a general rule that all these vases have been found in tombs, whether in Greece, Italy, or elsewhere. There are, however, a few exceptions, where excavations on the site of an ancient temple have brought to light large quantities of vases or fragments of vases, often with dedicatory inscriptions to some Greek deity. The most notable instance is on the Acropolis at Athens, where excavations have been recently made in the *debris* caused by the sack of the citadel by the Persians in B.C. 480, and a collection of fragments was found, many of unique beauty or delicacy of execution; these had probably been dedicated in the Temple of Athena, and cast aside as worthless when the sack took place. Other instances are at Naucratis, a Greek settlement in the Delta of Egypt, and in the neighbourhood of Corinth (probably from a temple of Poseidon).

The sites on which vases have been found in tombs are very numerous, and cover a large area. In Italy, Etruria and the southern districts (Campania, Lucania, and Apulia) have yielded large quantities, the chief source in Etruria being Vulci, and in the other districts Nola, Capua, Ruvo, and other less-known places. The vases from the latter are mostly the product of local Greek artists in the great colonies of Magna Græcia. Several places in Sicily, such as Gela and Locri, have also been fruitful in Greek vases. In Greece proper Athens and Attica have yielded the largest proportion, especially of the earlier periods; Corinth and Thebes have produced many of local and of Athenian manufacture. Among the islands, Rhodes, Thera, Melos, and Crete have been most productive, especially of vases of the primitive period; but in Rhodes large numbers of all dates have been found. The pottery of Cyprus is mostly local, and under Phœnician influence; other sites which should be mentioned are Kertch in the Crimea, Naucratis in Egypt, and the neighbourhood of Cyrene on the north coast of Africa.

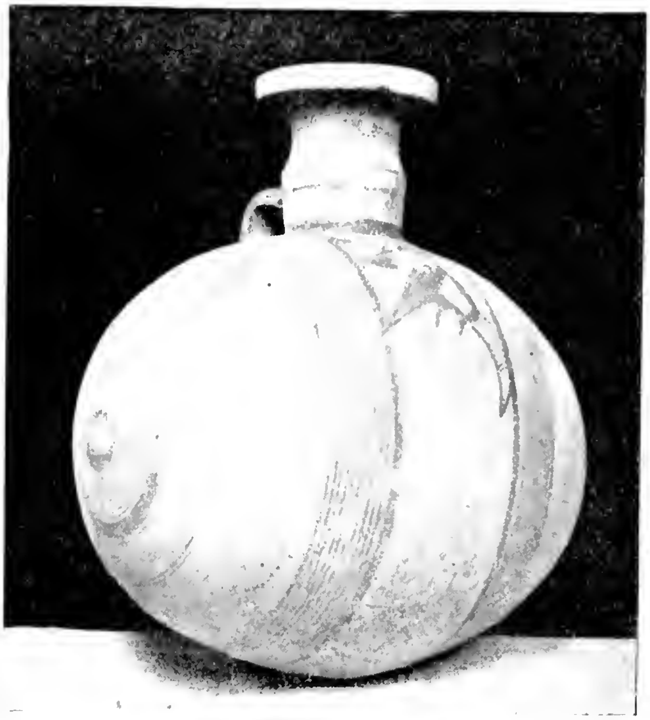
Fig. 1.—Vase from Cyprus.

The purposes for which painted vases were used by the ancients have been somewhat disputed; but the fact of their being found in tombs tends to show that they must have been largely manufactured for this object alone. As will be shown later on, there are two or three classes of vases which, not only from the subjects depicted on them, but from other evidence, can be proved to have been made exclusively for funerals. The vases were placed round the corpse when it was laid out for burial, and were, no doubt, often filled with oil or fragrant perfumes; afterwards they were placed round the body in the tomb, it being the universal belief of the Greeks, as of other nations, that the dead required in a future existence all the objects of which they made use in their daily life. In some cases the vases appear to have been deliberately broken, with the idea that the dead person could only use what was "dead" also.

In daily life it is probable that the use of painted vases was largely analogous to the modern use of china. The ordinary household utensils, such as drinking-cups, wine-jugs, and pitchers for fetching water, would be made of plain unpainted pottery, while the more valuable and elaborate specimens would be applied to the decoration of the house, or only used on special occasions. Some shapes are obviously adapted for hanging up against a wall; while the fact that on many of the later vases the decoration of one side is markedly inferior to that of the other seems to show that they were placed where only one side was meant to be seen. Another use of vases was as prizes in the games held at Athens in honour of Athena; this extremely interesting class will be described more at length later.

It will be necessary to say a few words on the methods of construction and decoration, and the materials used therein.

Of the processes adopted for the preparation of the clay we have little information. It was largely obtained from the neighbourhood of Athens and Corinth, which places may be regarded as the centres of vase-making in Greece proper. At Athens there was a regular potters' quarter, known as the Ceramicus; it adjoined the chief burying-place, and was, therefore, convenient for the manufacture of vases for funeral purposes.

The use of the potter's wheel for modelling the clay was known in Egypt in very remote times, and even in Greece was credited with a legendary origin. There are several references to it in Homer, and the vases which are usually referred to his period are certainly wheel-made. It is, however, possible to point to many specimens, especially those of abnormal size, which must have been hand-made. As to whether the wheel was turned by the hand or the foot there seems to be some little uncertainty, but probably the hand was mostly employed.

When the clay had received the required form the surface was carefully smoothed and the vase placed in the air to dry; the handles, which had been made independently, were now attached. The vase was now ready for the baking, one of the most critical processes in the potter's art, owing to the necessity of adjusting accurately the amount of heat required. Frequent instances have come down to us of discoloured vases, which have been subjected to too much or too little heat. Mishaps during the firing were attributed to the malicious influence of evil spirits, and various methods were resorted to to counteract this influence, as we read in a poem attributed to Homer, where the aid of the goddess Athena is invoked against a long list of evil spirits. The ovens for baking seem to have differed little from those in use at the present day. The remains of several such ovens have been found in Italy, Germany, France, and England.

The vase having passed successfully through the process of baking, the next thing was the decoration. As this varied so much in method and extent at the various periods, it will be impossible to give here a general description of the painting processes, which must be treated of later on under the different headings. In most cases a further firing was necessitated to fix the colours, and, this having been done, the vase was regarded as completed.

The study of Greek vases is of little use until the various shapes and the purposes for which each was employed are mastered. Unfortunately, with the space at our disposal, it is impossible to give a complete list of the forms with the illustration of each which would be necessary: but it is to be hoped that a brief description of a few of the principal ones may be of some assistance.

The purposes for which vases were employed by the Greeks may be roughly divided into—(1) for storing liquids or food; (2) for drawing or pouring out liquids; (3) for drinking-vessels; (4) for the toilet, games, or other occasional uses.

Of those included under (1), the *amphora* is the most important and continuously popular: a large jar with two handles and a rather narrow neck; it was used for storing wine in cellars, and also for funeral purposes. The *stamnos* is another variety, with a very short neck and stout body, used for storing wine or food, such as sweetmeats. The *crater* was a vase more especially in demand at banquets, as it was used for mixing wine and water in large quantities; it is a large bowl with wide neck and two vertical handles. The *lebes* is a large bowl without foot or handles, and was placed on a stand or tripod; metal vases of this shape were specially used for boiling liquids.

(2) The *hydria*, or pitcher, is a vase with three handles, generally of considerable size; its use for fetching water from a well is often depicted on vases. The *oinochoë* is in shape equivalent to the modern beer-jug, and was used for carrying round wine at banquets; it was filled from the crater. It was also used in offering libations to the gods. It has many beautiful varieties of form, each with its separate name.

(3) The favourite drinking-cup among the Greeks was known as the *kylix*—a large shallow bowl on a high stem, with two graceful handles. It is, perhaps, the most beautiful shape of all Greek vases, and all the masterpieces of the greatest vase-painters take this form. Other drinking-cups are the *cotylé*, a deep cup with two flat handles; the *cantharos*, a beautiful form of cup with a high stem and two graceful handles; and the *rhyton*, a drinking-horn, the lower end of which was always moulded into the head of an animal or some other form.

(4) Many vases were used for holding oil, whether for the use of athletes in the games or for general purposes; the chief form is the *lekythos*, a straight, slim vase with a very long narrow neck, the object of which was that the oil might pour out slowly. This shape was especially important for use at funerals. The *alabastron* (so called because originally made of that material) and *aryballos* are varieties of the *lekythos*: the latter was used more especially by athletes. Another very common form is the *askos*, so named as being originally imitated from a wine-skin—a small vase, generally supplied with a spout as well as a mouth. The *pyxis*, or toilet-box, should also be mentioned here: it was generally of cylindrical form with a closely-fitting cover, and contained various objects connected with a lady's toilet.

Fig. 2. Vase from Ialysos.

Thus much having been said by way of introduction to the subject, we will now proceed to treat of it from a historical aspect, taking the various fabrics, as far as possible, in order of date, and pointing out the special characteristics of each. It may, however, be advisable first to say a few words on the chronology of the different periods.

Roughly speaking, we may divide Greek vases into four great classes, as follows:—

A.—*Vases of the Primitive Period*, down to about 600 B.C.; decoration in brown or black on a ground varying from white to pale red, often unglazed; human figures and mythological scenes rare.

B.—*Black-figured Vases*, from 600 to 500 B.C.; figures painted in black, like silhouettes, on glazed ground varying from cream colour to bright orange-red, with background of lustrous black varnish; mostly mythological scenes.

C.—*Red-figured Vases*, from 520 to 350 B.C.; figures outlined on red clay, and background filled in round them with black varnish; inner details painted in afterwards; scenes from daily life or mythological. With these are included vases with figures in polychrome on white ground.

D.—*Vases of the Decadence*, from 350 to 200 B.C.; method of class C, but careless and inferior; scenes sepulchral or fanciful; general striving after effect. With these are included various forms of moulded vases or with decoration in relief.

This classification, though serviceable, is of course far from exhaustive, but will form a convenient division for the four succeeding articles which will be necessary to complete the subject. It must, however, be borne in mind that the transition from one to the other is by no means clearly marked, and any such distinctions as these must perforce be more or less conventional.

(To be continued.)

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WHAT IS A NEBULA?

By E. Walter Maunder, F.R.A.S.

In my previous paper[*] it was my wish to lay stress on the thought that our solar system must not be taken as the type of all systems; that the simplicity of its construction—practically the entire mass of the system being locked up in one central body—must not be supposed to represent, certainly does not represent, the condition of things in other regions of space. To my own mind, indeed, it seems the more probable that such centralized systems are the exception rather than the rule. Possibly the isolation of the solar system has had much to do with this marked autocracy of the sun; if so, we might expect a greater amount of decentralization where two or more systems are in closer neighbourhood to each other.

I wish on the present occasion to suggest that, just as we must not take the mode in which matter is distributed in our system as a type of its distribution in other systems, so neither must we take its distribution in our sun as a type of its distribution in other suns.

In our own sun, as I have before had occasion to point out in Knowledge,[†] by far the greatest portion of the sun's mass lies below the photosphere. From the point of view of mass, the chromosphere prominences and coronæ may be neglected. They are probably less important relatively to the sun than our atmosphere is to the earth.

What is even more germane to our present point, they are practically negligeable as to the amount of light which they emit. In spite of the fact that the corona has been traced to a distance of six solar diameters from the sun, as by Newcomb in 1878, and that prominences of a total elevation of three hundred thousand or four hundred thousand miles have been recorded, it still remains the fact that the corona can only be seen when the sun itself is hidden, and the prominences only by the artifice of the spectroscope. Were the sun removed to stellar distances we should have no hint of their presence.

But though these appendages are not sufficiently important in the case of the sun to reveal themselves from stellar distances, we are not without some direct indications of similar formations in the case of some stars. As to prominences, the continual increase in the number of stars showing not only the lines of hydrogen bright, but the helium lines as well, the recent discovery of a bright C line in some well-known stars, and the confidence with which we look for these lines in the spectrum of any *Nova* which flashes out upon our view, point unmistakably to vastly developed prominences and chromospheres as inseparable appendages of a large proportion of stars; whilst Campbell's remarkable observation of a positive hydrogen disc to the star D M + 30°, No. 3659 (*Astron. and Astroph.*, XII., p. 913), stands out as an example more striking in its character than we could have possibly expected.

The indications of stellar coronæ are much slighter. We could not expect it to be otherwise, since as yet we have secured no clear and indisputable record of the corona of our own sun, except during a total eclipse. And the evidently composite character of the coronal spectrum renders it all but hopeless that the spectroscope should assist us here. In effect, the coronal light is chiefly reflected sunlight and white light from incandescent dust particles. Neither of these sources could give us any sign by which to recognize them in the surroundings of a star.

The only available means of detecting a corona is in its faint bright-line spectrum. This consists mainly of the hydrogen and helium lines, and the so-called "coronal" line—1474 on Kirchhoff's scale. But even here it is a moot point whether we should not rather consider these bright lines as properly belonging to the chromospheric and prominence region than to the corona itself. At best, then, our one chance of any hint of a stellar corona is the occurrence of the bright coronal line—1474 K.

It seems to be sufficient, then—it is the utmost the probabilities of the case would lead us to expect—that on two occasions *Novæ* should have shown the 1474 K. line: Nova Cygni in 1876, as observed by Cornu, Vogel, and Backhouse, and Nova Aurigæ in 1892.

These hints as to the existence of stellar chromospheres and coronæ do more than warrant us in concluding that the stars in general possess a structure which in these features resembles that of the sun. They prove—what, indeed, I claim that we ought on *à priori* grounds to expect—that in some instances the stellar chromospheres and coronæ are of vastly greater relative importance than in the sun. The scheme of the general structure is probably alike in all, whilst the proportion which the different details bear to one another varies indefinitely.

These considerations seem to me to have a distinct bearing on the problem of the gaseous nebulæ. It is hard enough to understand how we can have gaseous masses of such enormous extent. The difficulty is increased when we bear in mind how extreme must be their average tenuity. It will be remembered that Mr. Ranyard showed that in the case of the Orion nebula, evidently one of the densest, there was good cause to think that its mean density could not exceed one ten-thousand-millionth of that of our atmosphere at sea-level. To this we have to add the yet further difficulty that the

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[*] Knowledge for November, 1895.

[†] "The Tenuity of the Sun's Surroundings," March, 1894.

PHOTOGRAPH OF THE NEBULA NEAR 15 MONOCEROTIS.

By ISAAC ROBERTS, D.Sc., F.R.S.

nebula has no slight luminosity, and the extension of its spectrum far into the ultra-violet points to a considerable elevation of temperature. Yet, on the other hand, the presence of the yellow line of helium would indicate that, in those regions which give this line, the gas is at a far higher pressure than that just indicated. Lastly (and perhaps the most difficult feature of all), whilst we should expect a freely expanding gas to diffuse itself equally and indefinitely in all directions, we find nebulæ taking strange and complicate shapes, and showing here and there strongly-marked outlines.

If we think of nebulæ as merely vast extensions of rarefied gas, it is exceedingly difficult to understand this last-named peculiarity. To take the Orion nebula, for example: how can we explain the sharpness which some of its brightest edges show—the Fish's Mouth, the Great Proboscis: how regard its delicate complexity of detail, if we think of it as merely a vast mass of feebly glowing gas? Look for a moment at Dr. Roberts's striking photograph of Messier 78 in the November number of Knowledge. Can it be supposed that this is a purely gaseous object, with so well-defined and yet so irregular a margin as that on the *n.p.* side? Or that the curious conical dark area shown in Dr. Roberts's present plate of the nebula near 15 Monocerotis is formed by the retreat from it, through some unexplained force, of the glowing gases which are in such evidence surrounding it? But if we follow out the idea already suggested, that there are in sidereal space systems wherein the arrangement of matter differs from that in the solar system in two directions—first, instead of being concentrated into one sun it is distributed amongst many; and, next, instead of the chief bulk of each of these suns lying below the photosphere, a disproportionate amount exists in the form of chromosphere and corona—it is easy to see that an appearance might be created not different from that which we recognize in many nebulæ.

The aspect of such a system, as viewed from our standpoint, would vary according to the arrangement of the stars, and the relative importance of the actual stars themselves and of their appendages. The closer the stars were together the greater would be the tendency for the hydrogen and coronal streamers to be drawn out to an enormously exaggerated extent, and these might, in the mass, be more apparent to us than the stars themselves; whilst the character of the spectrum of such a group, whether continuous or gaseous, would depend on the relative brightness and surface of the stellar photospheres and of their prominences. In other words, whether it appeared to us as a star-cluster or a nebula would depend largely upon whether its substance was aggregated into comparatively few bodies or distributed over a vast number of inferior size.

If we imagined such a transformation to take place in our own system, the sun being degraded to the rank of a self-luminous Jupiter and the various planets raised to the rank of miniature suns, all with extended chromospheres and coronæ, and we were to view the whole from a great distance, it would appear to us as a spiral nebula; irregular and broken, it may be, but still approximating to the spiral form.

The example of Saturn's rings, where we have a vast number of small bodies so evenly distributed as to appear like a series of solid concentric rings, and the usual diagrams of the solar system, may suggest that a similar target-like appearance would result. But this would not be the case unless the subdivision were carried to the same extreme extent as in the Saturnian annuli. However complicated the orbits of the various little suns might be, each body would only occupy one part of its orbit at any given time, and there would be no other bodies, except by accident, to mark out the rest of its course. At any given time the distribution of these sunlets would be unsymmetrical; but the general tendency, however irregular and broken their arrangement, would usually be towards the spiral form.

Such an object as the great spiral nebula in Canes Venatici need not, therefore, be looked upon as rotating gases, subject to no control but that of the general mass. It is difficult, indeed, to see how it could be conceived as such. But the gases which make their presence evident in it are probably under the control of a great number of somewhat small suns, which form the bright knots that trace out its remarkable spirals. They form, in effect, the chromospheres of these little orbs.

We are not to suppose that these are true stellar atmospheres. As I pointed out in the case of the sun, the molecules of hydrogen and helium in the prominence region round the sun are probably moving in free paths, and do not build up an atmosphere in which one layer presses on the layer below it. In nebulæ of the kind referred to, but giving a continuous spectrum, we probably have cases where the chromospheric element is less important than the coronal. It is noteworthy—it is a point on which Mr. Ranyard insisted again and again—that the nearest approach to the coronal forms is to be found in the study of nebular structure.

One great objection to the foregoing suggestions lies in the peculiarity of the nebular spectrum. If the sun showed the two lines at wave-lengths 5007 and 4959 the difficulty would be solved. But though the sun fails to give us these two typical lines, yet the balance of evidence appears to show that these are just the lines which *Novæ* give to us in their second or fainter aspect. At their first outburst we get a spectrum which is practically chromospheric: later, when they have faded down, a spectrum which is practically nebular. It may well be that, could we examine the spectrum of the outermost regions of the corona under favourable conditions, we might find these two enigmatical lines; but in the meantime Nova Cygni and Nova Aurigæ are sufficient to form a connecting link between bodies at such opposite ends of the series as our densely concentrated sun and the indefinitely diffused nebulæ.

To sum up, I would wish to urge that our best and safest way to understand the nature of the sidereal structures is to argue from the one system which is sufficiently near us to reveal something of its character—that is to say, our own. But that, whilst we may reasonably take its constitution as a type, just as the structure of one vertebrate may be taken as typical of all, we must be prepared to find the largest differences in the scale upon which other systems are built, and in the proportions which their several parts bear to each other. And a system in which the total mass was distributed amongst very many small members, and in which the chromospheric and coronal element was in large excess of the truly stellar, would undoubtedly appear to us as a nebula. Whether there are nebulæ of an altogether different type is a question beyond my present purpose.

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NEBULA NEAR 15 MONOCEROTIS.

By Isaac Roberts, D.Sc., F.R.S.

R.A. 6h. 35m., Decl. N. 10° 0′.

The photograph covers the region between R.A. 6h. 32m. 56·8s. and R.A. 6h. 37m. 53·8s.; Decl., between 9° 9·6′ and 10° 45·3′ North.

Scale, 1 millimètre to twenty-four seconds of arc.

Co-ordinates of the Fiducial stars marked with dots for the epoch A.D. 1900.

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* Knowledge, March, 1894.

Star (·). D.M. No. 1322. Zone + 9°. R.A., 6h. 33m. 42·0s. Decl., N. 9° 44·5′. Mag., 8·1.

Star (· ·). D.M. No. 1215. Zone + 10°. R.A., 6h. 35m. 3·8s. Decl., N. 10° 28·9′. Mag., 8·8.

Star (·.·). D.M. No. 1344. Zone + 9°. R.A., 6h. 35m. 40·5s. Decl., N. 9° 34·0′. Mag., 8·1.

Star (: :). D.M. No. 1350. Zone + 9°. R.A., 6h. 35m. 57·4s. Decl., N. 9° 56·7′. Mag., 8·3.

The photograph was taken with the 20-inch reflector on February 13th, 1895, between sidereal time 4h. 20m. and 7h. 23m., with an exposure of the plate during three hours.

References.

N. G. C., No. 2264; G. C., No. 1440; h 401; Lord Rosse, *Obs. of Neb. and Cl. of Stars*, p. 53; Prof. Barnard, *Astronomy and Astro-physics*, Vol. XIII., pp. 178, 182.

Sir J. Herschel and Lord Rosse suspected 15 *Monocerotis* to be a nebulous star, or else involved in nebulosity; but they could not detect any nebulosity in the region surrounding the star.

Prof. Barnard took three photographs of the region in January and February, 1894, and upon them found nebulosity covering a diameter of about three degrees: but the photo-instrument which he used had only an aperture of six inches and focal distance of thirty-one inches. The scale of the photographs is, therefore, too small for showing the structural details of the nebulosity, which are partly shown on the print herewith presented, and more clearly visible on the original negative.

The star (15 *Monocerotis*) is involved in the centre of the light-circle at the centre of the print; and the rays of light which are seen in the north, south, east, and west directions, from the star, are not objective, but due to instrumental causes.

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COMETS OF SHORT PERIOD.

By W. E. Plummer, M.A., F.R.A.S., *Director of Bidston Observatory.*

Within the last few years some of the comets of short period have shown a tendency to behave in an irregular and unexpected manner. They no longer present the well-regulated class of objects that they did in, say, the middle of the century, when, less numerous, their return could be counted upon with confidence, and their appearance predicted with an approach to certainty. While some have probably disappeared as distinct comets, fresh discoveries have added others—sometimes, indeed, suggesting reappearances of old friends—till the very nomenclature has become confusing; so that it seems desirable to review the entire history, and endeavour to straighten out some of the difficulties that the addition of fresh members to the solar system has introduced. Evidently and conveniently, the entire family of periodic comets, or rather of those whose aphelia fall near the orbit of Jupiter, can be divided into two classes: those which have been observed at more than one apparition, and those which have only been seen once. The first list can be again subdivided with advantage, since it contains specimens of two very different classes, namely, those which remain with us after one or more revolutions, and those which, after pursuing a regular course, have subsequently been lost. The following table contains those, and those only, whose reappearance can be counted upon with tolerable certainty. The order of arrangement is that of the respective mean distances from the sun.

Ordinary Designation of Comet.	Period in Years.	Date of last Perihelion Passage.	Approximate date of next Return.	Aphelion Distance in terms of Earth's Distance.
Encke ..	3·303	1895, Feb. 4	1898 May 26	4·095
Tempel ...	5·211	1894, April 23	1899, July 10	4·665
Tempel-Swift	5·534	1891, Nov. 14	1897, May 28	5·171
Winnecke	5·818	1892, June 30	1898, April 25	5·583
Finlay ...	6·627	1893, July 12	1900, Feb. 26	6·064
D'Arrest	6·691	1890, Sept. 17	1897, May 27	5·778
Wolf ...	6·821	1891 Sept. 3	1898, June 30	5·601
Faye ..	7·566	1896, Mar. 19	...	5·970

The first fact that strikes one on glancing through the table as a whole, and before entering into any details, is the small number of regularly returning comets that have remained permanent members of our system. The facility with which comets can be lost will be further accentuated when we enter upon the second list, and show the comparatively large number that have been added by recent discoveries and whose return is still doubtful. These recent additions to our catalogues within the last few years seem to suggest that the proportion of elliptical to parabolic comets has greatly increased. This can, in some measure, be attributed, possibly, to the discovery of fainter objects, due to the employment of larger telescopes in "sweeping." Not that this explanation is altogether satisfactory, because it ought to follow that the total number of cometary discoveries of all kinds is strikingly greater than was the case thirty or forty years ago, and this is not borne out by the facts. Another point, not without its interest, is that the increase in the aphelion distance has not kept pace with the increase in the period. From Encke to Faye, this increase in period implies by Kepler's law an increase of the mean distance from 2·218 to 3·854, expressed (here as in all other places where distances have to be mentioned) in terms of the earth's mean distance from the sun. The aphelion distances, however, do not exhibit the same tendency to spread. The controlling influence of Jupiter is here suggested.

It will not be necessary to consider all the comets in the list in detail. For instance, the history of Encke's comet has been many times written, and it is quite unnecessary to refer to the numerous interesting points connected with its motion. It is true that the last chapters, and not the least interesting, in its history have not been given with complete fulness in some recent text-books; and the care that has been bestowed on the difficult problem of separating the effects due to a so-called "resisting medium" from others arising from the use of an erroneous or questionable value of the mass of Mercury, has not yet met with a sufficient notice in popular works.

It is otherwise with the comet described as Tempel—or Tempel 1873—because the comet is very liable to be confounded with another of short period which the same astronomer first saw six years earlier in 1867. The first return of this last-mentioned comet occurred in 1873, and, consequently, in that year *two* periodic comets, both credited to Tempel, were under observation. This comet of 1867 has now probably disappeared, and it will be referred to again under the head of the more doubtful visitants. Number two in our list was seen in 1873 and again in 1878. In 1883, and in 1889, when, according to its period, it must have returned to the sun, the chances favourable for observation were very slight, and it passed through perihelion without being seen. In 1894, however, Mr. Finlay, of the Cape Observatory, was fortunate enough to find it, and so carefully had the calculations been made by M. Schulhof, that, notwithstanding the long interval that had elapsed since 1878, the predicted place was very close to the actual. This happy recovery makes one hesitate before pronouncing a comet lost, and necessitates a close examination of the circumstances under which the return takes place.

The third comet on the list is not likely to cause any confusion, because a second name is attached to that of Tempel, who first found the comet in 1869. This addition of Swift's name marks a particular fact in its history, which serves to identify the comet. No definite orbit was derived from the observations of 1869, although it was known that parabolic elements would not represent the path. Consequently, no indication of its future career was made. The comet made its approach to the sun in 1875 and was not seen, but in 1880 it was independently discovered by Prof. Swift, whose name is therefore linked in the description. One peculiarity in its history arises from the fact that its period is almost exactly five and a half years, so that for a long time the returns will be alternately favourable and unfavourable for observation. In 1886 it passed unnoticed; but in 1891, when its theoretical brilliancy was one hundred times greater, it was well observed, and is apparently as much a permanent member of our system as a comet can be.

Winnecke, D'Arrest, and Faye call for little remark. They have been under regular observation for approximately half a century, and are well under control. Winnecke dates back to 1819 with certainty, and probably to 1766, though it was not till 1858 that its peculiar motion was recognized. D'Arrest was first observed in 1851, and has been repeatedly seen since, though the circumstances of its return are occasionally unfavourable. Faye, a comet which is now under observation in our larger telescopes, has run an uniform course since 1843, and has, thanks to Prof. Axel. Möller's admirable discussion, perhaps proved itself the best timekeeper of the periodic comets.

The two remaining comets, those of Finlay and Wolf, are modern introductions, and are entitled to more consideration on account of the many interesting problems they offer for solution in regard to the capture of comets by Jupiter, or the connection that may exist with older comets since disappeared. In the case of Finlay, the position of the orbit with reference to the ecliptic is very similar to that of the comet 1844 I. (known as De Vico's), a comet which will appear in the second list, for though undoubtedly periodic it has never been seen since that date. The dimensions of the orbit do not accord so well, but the disagreement is not so great but that the plausible hypothesis was raised at the time that the 1844 comet had encountered a small planet and suffered considerable perturbation. But Finlay's comet requires more than a year longer for its revolution about the sun than does De Vico's, a circumstance which evidently tells against the probability of the two objects being identical, since it is difficult to understand how one element of the orbit should be so materially affected and the others remain comparatively undisturbed. If two objects, seen to be moving in similar orbits after a considerable interval, are concluded to be identical because of this similarity, it must be assumed that perturbation in the interval has been slight, and therefore cannot be invoked to explain one point of difference. Another supposition which has been raised is that the comet is a reappearance of that known by the name of Lexell—seen once, and once only, in 1770. This point can be more conveniently considered in treating of the second catalogue, since another comet known as Brooks', 1889 V., also has claims to be considered the lost Lexell. Fortunately, Finlay's comet was seen in 1892 (though somewhat fainter than could have been wished), and its past history can therefore be well determined: but it will remain in our catalogues distinguished by the name of the discoverer. There is another and a much larger question. Is the present condition of cometary astronomy insufficient to decide with certainty the identity of two comets? That is to say, is it possible for astronomers to accumulate observations of the same body and believe them to refer to two distinct objects? That is a question which it is hardly safe to answer categorically, but it is one to which we shall return.

Wolf's comet, the last on the list, has a history as interesting as any. It was first seen in 1884, and the earliest published elements showed similarity with those of a comet discovered by Coggia in 1874, and whose probable period is three hundred years. More trustworthy elliptic elements proved, as Dr. Hind pointed out, that the path of the comet approached very closely to that of Jupiter, and that in May, 1875, the comet was actually so near to that planet as to be brought within its influence. This point has been examined very closely by the lately deceased M. Lehmann Filhés; and he has derived, with very close approximation, not only the elements in which the comet moved when under the influence of Jupiter's attraction, but also the character of the orbit before undergoing that violent alteration. This inquiry explains why the comet had not been previously seen, though it may have regularly revolved about the sun for ages before. The original elements, as we may call them—that is, previous to 1875—possessed a much smaller eccentricity with a longer period. Consequently the perihelion distance had been materially reduced by Jupiter's attraction (as a matter of fact to about one half that which it previously had), and the practical effect for us was to bring the comet within the range of our telescopes. The investigation will probably be made again more rigorously, and with more correct data; but, as it stands, it offers a very satisfactory explanation of the reason why the comet had not been seen earlier, and was seen then. It must have passed us in 1878, but it is known that the position in the sky was then unfavourable.

We have now to consider three comets, all of which there is grave reason to believe have escaped beyond our cognizance, and are no longer to be recognized as comets. They are given in the following table in the order of their period, together with some additional information which may assist us in forming an opinion of their possible recovery:—

Ordinary Designation of Comet.	Period in Years.	Date of last observed Return.	Number of Returns observed.
Brorsen	5·456	1879, March 30th	Five
Tempel ..	6·507	1879, May 6th	Three.
Biela Nucleus I. ...	6·587	1852, Sept. 23rd	Six.
Biela Nucleus II.	6·629		

It is, perhaps, a little premature to consider the first—Brorsen's—hopelessly lost, though the table shows that it has not been seen since 1879, to which must be added the significant fact that though the comet passed through its perihelion this autumn, no serious effort appears to have been made to recover it. In some respects the history of the comet resembles that of Wolf, last mentioned, inasmuch as it was brought within our range by the disturbing action of Jupiter a few years before it was discovered. In 1846, Brorsen first observed it, and in 1842 the comet made a close approach to that planet, with the result that the perihelion distance was much reduced, being brought down from 1·5 to 0·6, an alteration of the same character as was instanced in the case of Wolf, and one which, of course, made the comet brighter, since it brought it closer to us. But there is another point about the orbit of not less interest: the motion is of such a character that every ninety-five years it must come under the influence of Jupiter; but the action of that planet will not always be favourable to its continuance with us, and in 1937, had the comet pursued the even tenour of its way, it might have been deflected into a hyperbolic path. It would have been highly gratifying had the comet remained visible till we could have accounted for its disappearance as satisfactorily as for its introduction. And this may happen yet, for the comet has shown fluctuating values in brilliancy and may recover. If we consider a comet to shine by reflected light it is evident that its brilliancy should vary inversely as the product of the squares of its distance from us and from the sun. On this supposition we can compute its theoretical brilliancy for the first and last time at which it has been seen at each apparition. Of course the quantities are not strictly comparable. Proximity to the sun, or the presence of moonlight, may rob us of the comet where under better conditions it would have been visible in our telescopes. The values of this brilliancy are set out in the following table, and the apparently hopeless expectation of seeing it again is emphasized by the fact that in 1890 the brilliancy exceeded 8·0, and though sought by many experienced observers the comet remained invisible.

Fig. 1.—Spanish Chestnut Tree.

Date.	Brilliancy when first seen.	Brilliancy when last seen.
1846	5·42	0·46
1857	1·67	0·34
1868	1·65	0·16
1873	1·10	1·68
1879	0·12	1·46

In taking into consideration the causes that may prevent the due return of a comet, we must not leave out the chance of a collision with a small planet, when the comet might be scattered, or more probably deflected into a new path and therefore become unrecognizable to us. The chances of such a catastrophe would depend very much upon the angle that the comet's path made with the ecliptic. The smaller this angle, evidently the greater the chance of encountering an asteroid; and usually this angle, known as the inclination of the orbit, is small in the case of the comets we are considering. The inclination of the orbit of Brorsen is, however, very considerable—greater than that of any of the short period comets. Nevertheless, the orbit is so situated that it can approach certainly three of these small objects, namely: Hebe, within 0·073; Hesperia, within 0·013; and Artemis, from which it may be distant one-tenth. Such distances, when turned into miles by multiplying them by the earth's distance from the sun (more than 92,000,000 miles), seem to offer ample space for a comet to pass unmolested; but taking into account the probable large number of small planets yet undiscovered, it is impossible to deny the chances of unexplained perturbation.

The second comet on the list is the one referred to in connection with that of Tempel 1873. This may now be regarded as lost, seeing that it has been unsuccessfully looked for at several returns, and the mean motion must now be very uncertain. Jupiter, whose influence has on several occasions, as we have seen, been exercised to increase the number of our comets, has, in this instance, operated to remove one. Remembering that Jupiter's period is 11·86 years, and that this comet had in 1879 a period of 5·98 years, it is evident that at each alternate revolution the comet and Jupiter must occupy, approximately, the same relative positions. In 1870 the comet was only 0·32 distant from the planet, consequently in 1881 there was another close approach. The perturbations on these two occasions were excessive, and the elements of the orbit of 1885 differ very materially from those in 1867. If we consider only the period, the most important for our purpose, we have—

1869 ...	Period, 5·694 years		Approaches Jupiter within 0·32.
1873 ...	,,	5·964 ,,	No approach.
1879 ...	,,	5·981 ,,	Approaches Jupiter within 0·55.
1885 ...	,,	6·510 ,,	No approach.

This increase in the period, or in the semi-axis major, is accompanied by a corresponding increase in the perihelion distance, so that the comet can never be closer to the sun than twice the earth's mean distance—that is to say, considerably outside the orbit of Mars. Such a removal from the sun has, of course, robbed the comet of much of its brilliancy—never very great; and this, accompanied with the uncertainty in its actual position, explains the reason of its invisibility, and makes us despair of seeing it again.

Concerning Biela, like Encke, it is unnecessary to say anything. It has a history so interesting and special that it is everywhere known. Of its division into two parts, of its subsequent disappearance and re-observation as a shower of meteors, it is unnecessary to speak, as these facts are impressed on the memory of all.

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THE SPANISH CHESTNUT.

By George Panton.

> "Than a tree a grander child earth bears not."

TAKING the word in its widest meaning, what is more useful to man than a tree? or what more ornamental to old mother Earth? A country without trees we cannot imagine to be anything but a desert. Yet our commoner trees are very imperfectly known. A few short papers, treating them in a popular manner, avoiding all botanical names and technical terms whenever possible, will, we think, prove interesting, as well as instructive, to our readers.

If a "tree is known by its fruit," the *chestnut* ought to be one of our best known trees. Few there are unacquainted with the chestnut barrow of the London streets and its hot contents, or who have not burned their fingers roasting chestnuts at the hearth on a cold winter's evening. We purpose, therefore, to confine our remarks in this number to a few facts about the sweet chestnut.

This tree is commonly called the Spanish chestnut, to distinguish it from the horse chestnut; botanists call it *Castanæ vesca*. It is very well known and largely grown in this country, coming next to the oak in point of size and the durability of its timber. Some authors consider it indigenous to Britain, but it appears more probable that, notwithstanding the great age of some of our chestnuts, this is not the case. However, it has a very wide distribution, being found in Europe, Asia, North Africa, North America, and all the sub-tropical islands of the Atlantic.

Fig. 2.—Leaves and Fruit of Spanish Chestnut. (About one-fourth natural size.)

The tree grows to a height of from sixty to one hundred feet, and sometimes attains an immense girth: the leaves are large, oblong, shining, and serrated (Fig. 2), of a beautiful light green colour. Foliation takes place about the middle of May, and the leaves are retained till late in the autumn, sometimes till midwinter. The fruit, unfortunately, does not come to perfection in large quantities in this country, most of the chestnuts we consume being foreign. In France, Spain, and Italy these nuts form an important article of food, where they serve in a great measure as a substitute for bread and potatoes. From these countries we import annually upwards of fifty thousand bushels of chestnuts.

The wood of this tree, when it is cut comparatively young, is excellent for building purposes, and also for furniture, its close grain enabling it to take a good polish. It is also largely used for making wine casks; the wine is said to ferment more slowly in them than in casks made of any other wood.

The most celebrated chestnuts in the world are those growing on the slopes of Mount Etna; the largest, which is said to be over two thousand years old, is called "*Castano di Cento Cavalli*"—the chestnut of a hundred horses. Its girth was over two hundred feet a hundred years ago. The trunk is hollow, and a family reside in it; while a whole flock of sheep is likewise folded in the enclosure! Another tree on the same mountain is seventy feet in girth, and a third sixty-four feet the stems of these trees attain no great height, but branch off near the ground, and their great girths are probably the result of rooting of many of the branches, thus forming immense bushes rather than single trees. The famous Torthworth Court chestnut is the largest tree in England (if still standing), its girth being fifty-two feet. The largest tree in Scotland for many years was the Finhaven chestnut in Forfarshire; its girth was forty-two feet eight-and-a-half inches, but it was cut down about twenty-five years ago.

In the beautiful landscapes of Salvator Rosa this is the favourite tree. In the mountains of Calabria, where Salvator lived, the chestnut flourished; there he studied it in all its forms, breaking and disposing it into beautiful shapes as his composition required.

Virgil mentions the chestnut in his "Eclogues" and in his "Georgics" as a tree. In the first Eclogue he says of its fruit:—

"Ripe apples and soft chestnuts we have there,
And curd abundant to supply our fare."

And in his second Eclogue, as rendered by Dryden, he writes:—

"Myself will search our planted grounds at home
For downy peaches and the glossy plum,
And thrash the chestnuts in the neighbouring grove,
Such as my Amaryllis used to love."

The old English poets frequently allude to the chestnut, and Milton refers to the custom of roasting chestnuts when he says:—

"While hisses on my hearth the pulpy pear,
The black'ning chestnuts start and crackle there."

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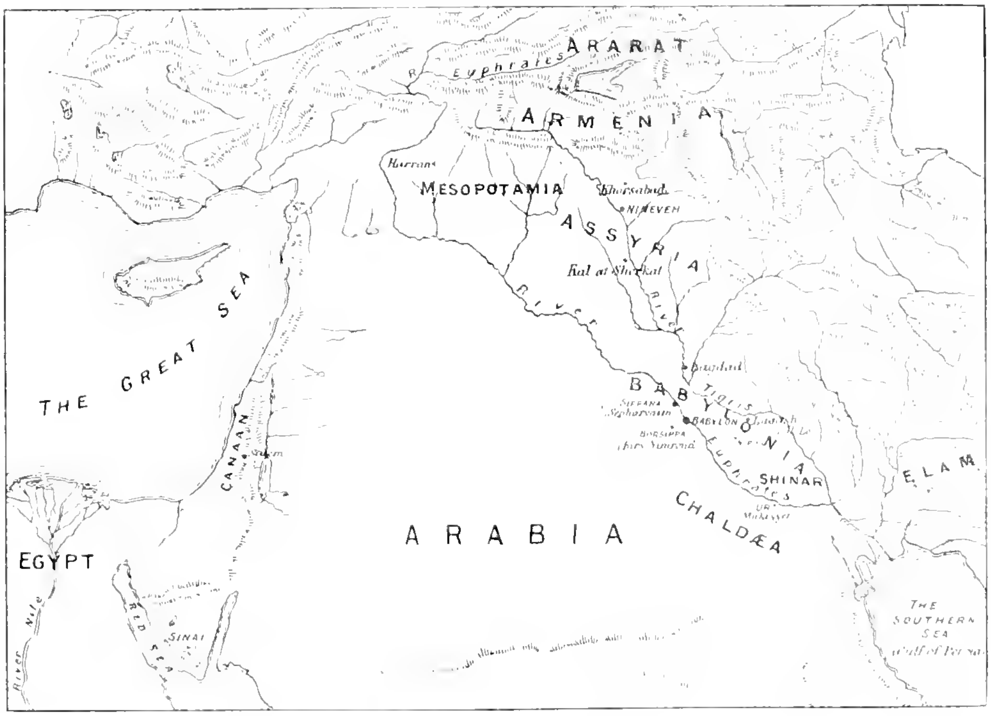
LIFE IN BABYLONIA IN PATRIARCHAL TIMES.

By THEO. G. PINCHES, M.R.A.S.,

Department of Egyptian and Assyrian Antiquities, British Museum.

According to Babylonian chronology, the patriarchal age in Palestine seems to have corresponded with the period immediately following 2200 B.C., the earlier portion probably differing from the received chronology by two or three hundred years. This question of chronology is a difficult one, and, though important, does not really belong to the scope of the present paper. Those who wish to go into the question of dates may consult the works of Sayce, Oppert, Schrader, etc., though, to say the truth, a really satisfactory scheme of chronology must, in the present imperfect state of our knowledge, necessarily be a matter of time. Those who read the present paper to the end, however, will see why the date of 2200 B.C. has been chosen as the earlier limit of the period treated of.



Sketch Map of Western Asia.

The age of the patriarchs in Palestine appears, from the account that has come down to us, to have been one of great simplicity of manners and customs, and of an exceedingly primitive state of civilization. All civilization was then (compared with the present day) exceedingly primitive and simple, but it must not be imagined that the standard of the Hebrew patriarchs is to be that for the civilized world at that age. As early as 3800 B.C. the cuneiform writing in use in Babylonia had not only lost, for the most part, the hieroglyphic form which it originally had, but had also become highly artificial; and certain arts, notably that of engraving on hard stone, had made considerable advances. For sixteen hundred years after that time civilization had been marching with slow and measured pace (for everything goes slowly in the East), struggling in the trammels of superstition, and against the retarding incursions of barbarous hordes—disadvantages with which it had to contend until the world was well within the present enlightened era.

Whether, when Abram, the father of many of the Semitic tribes, was in the district or city known as Ur of the Chaldees, he was living in a town or in the country is uncertain. The general opinion among scholars at present is that Ur is to be identified with the ancient city of Uri or Uriwa, now represented by the mounds known as Mugheir (Mukeyyer), in Southern Babylonia. This may be so; but it seems to be more likely that Ur of the Chaldees (Ur-Kasdim) is simply the Akkadian name of the district (not the city) known as Akkad, which, in the language there spoken, was called Uri. Abram, with his flocks and herds, would probably have preferred to live out in the country, rather than in (or even so near as to be called "in") a city. The cities of Babylonia, however, must have been well known to him during the time that he lived there.

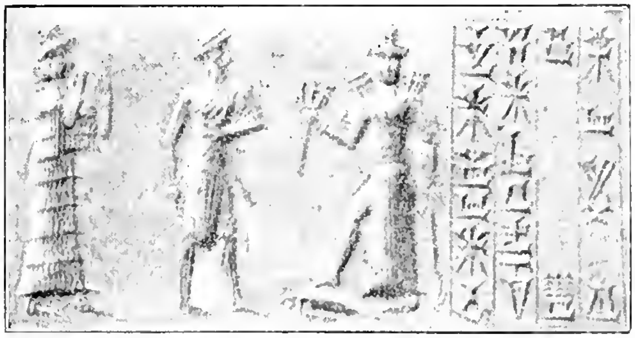
Small reason would an inhabitant of the plains have to love the cities of Babylonia—just as little as he would love the cities of the East to-day. The streets were narrow and the houses small. The walls were mostly of unbaked brick, sometimes plastered over, and the fire-places were primitive in the extreme. The drainage, it is needless to say, was unsanitary. The builders of the houses knew, nevertheless, the importance of keeping the walls free from humidity, for they constructed drains and ventilators in them for that purpose. Life in an old Babylonian town, even with all the comforts of a royal palace of the time, would have fallen far short of what we are accustomed to in most of the houses of Europe to-day. Life outside, in a tent, would certainly have been preferable. To a monotheist, also, the heathen practices of the polytheistic Babylonians must have been far from sympathetic, however much he might have admired their intelligence, their philosophy, their civilization, their love of justice, and their kind-heartedness, which was, to all appearance, often thoroughly disinterested.

In judging the character of the people of that time, with their manners and customs, and their morals, so different from ours, we are bound to take in consideration the influence of their surroundings. For them and their contemporaries there was nothing wrong in polygamy and the possession of concubines, and slaves were chattels to do as one liked with; and it is in consideration of these customs that we must look upon the possession of two wives, as the following, from a tablet in the British Museum, shows:—

Tablet recording the Marriage of Two Sisters to One Husband.

"Arad-Samas, son of Ili-ennam, has taken Iltani, sister of Taram-Sagila, from Samas-tatum, their father, as his wife. Iltani is his consort. He will provide for her, he will care for her, he will carry her seat to the temple of Merodach. The children, as many as have been born, and as they will bear, are their children (*i.e.*, the children of Iltani and her sister). If she (Taram-Sagila) say to Iltani, her sister, 'Thou art not my sister,' then . . . . [†] [if Iltani] say [to Arad-Samas] 'Thou [art not my husband],' then he may set a mark on her and sell her for silver; and if Arad-Samas say to his wife, 'Thou art not my wife,' then he shall pay her one maneh of silver.[‡] And they (two), if they say to Arad-Samas, their husband, 'Thou art not our husband,' then (the people may) strangle (?) them, and throw them into the river."[§]

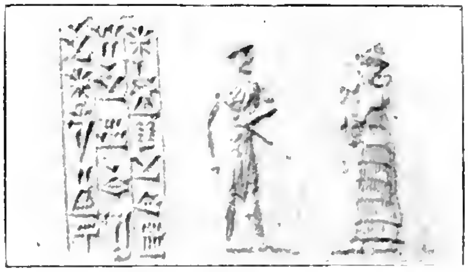
The names of the witnesses close the inscription.



Impression of a Cylinder-Seal such as was used in sealing contracts. Deities and worshipper, with the name of the owner of the seal, his father, and the deity he served. About 2000 B.C.

When two sisters were wedded to the same man each had a tablet very similar in wording to the above, but with the position of their names changed. Such a tablet was, in fact, a woman's marriage certificate, and testified to her respectability. In all probability she had but little chance of re-marriage without it, for the reputation of a woman was a most important thing to her in the ancient East.

It is a noteworthy fact that the ancient Babylonians were at all times great lovers of legal forms, for they invested every transaction of life that could be so treated in the robe of the law. Not only the wedding ceremony, but the hire of a slave, a loan, a gift, an exchange, a sale, were all upon the same footing with partnership and its dissolution, adoption, inheritance, etc. Whenever a difficulty arose (and disputes were not infrequent), a judge was taken to pronounce a decision upon the merits of the case. These legal actions often (perhaps generally) took place in the temple of Samas, the Sun-god, this deity being regarded as the great "decider of decisions" and "the judge of the world," the pronouncements of whose judges he was supposed to direct.



Impression of a Cylinder such as was used in sealing contracts. Deity and worshipper, with the name of the owner of the seal, his father, and the god he served. About 2000 B.C.

The following will give an idea of the circumstance attending a deed of gift:—

"Lamasu, their mother, has given to Sili-Samas one slave (named) Ana-Samas-kalama and 10 shekels of silver; 10 shekels of silver, and 10 shekels of silver (as) the wedding-gift (of the wife that he has taken), to Sin-mubalit, his brother; and 15 shekels of silver to Taribu, his brother. Never shall Sili-Samas, Sin-mubalit, his brother, and Taribu, his brother, have any claim upon what Lamasu, her son Apil-îli, her son Amat-Rammani, and Mâd-Rammani, her daughter, have and will possess. She has written (this) with their consent. At no time shall they make any claim. They have sworn by Sin, Samas, and Khammurabi the King."

The names of several witnesses (whose seals are impressed) follow, after which comes the date:—

"Month Adar, of the year Khammurabi the King renewed for Istar and Nanâa the temple E-tur-kalama."

The sale of a house was couched in similar terms:—

"One *sar* (of land), a house on a platform (?), beside the house of Sili-Nanâa, (and) beside the property of the sons of Ubar-Sin, (one) end the street, and (the other) end the house of Sin-azu. From Minanu son of Migrat-Sin, and Ili-turam his son, Sili-Nanâa son of Ili—), and Apil-ili his brother, have bought it for 3½ shekels of silver, its complete price. At no future time shall they litigate against each other (concerning the house). They have invoked the name of the King."

Here follow the names of nine witnesses.

"His seal and the seals of the witnesses have been impressed. Month Sebat, day 26th, year of Rim-Sin, when the enemy who was wicked (smote (?) the lands)."

That slavery was in full swing may be gathered from the above texts (see the deed of gift), and sales of slaves similar to the following were therefore very common:—

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[*] Or Samassatum.

[†] Apparently one or the other was an adopted daughter of Samas-tatum, as, logically, a real relationship, such as that of sister, cannot be changed by the utterance of *any* formula.

[‡] This was the act of divorce, the penalty for which, in the case of a man, was a money payment only.

[§] See Meissner, "*Beiträge zum alt-babylonischen Privatrecht*," No. 89. He quotes also a tablet (92) in the Berlin Museum which is very remarkable for its form: "Akha-nusa has given Napturum to a husband; no one shall part her asunder. One shekel of silver is her dowry. He who slanders her has committed sin. No one shall part her asunder."

"Two hundred and four and two-thirds *ka* of oil, property of the Sun-god, value one-third of a mana, and two-thirds of a shekel of silver, as price of the fair (-skinned) slaves of the land of Guti, Arad-Marduk son of Ibni-Marduk has received, by the authority of Amel-Mirra son of Ili-usati, from Ubala-abi-ûmê. He will bring the fair (-skinned) slaves of Guti in a month's time. If he do not bring them in a month, then Arad-Mirra shall pay, according to his contract, one-third of a mana and two-thirds of a shekel of silver."*

One might go on, however, indefinitely quoting interesting and important texts referring to this primitive and yet elaborated civilization of those early times. Enough has been given, however, to show what was the nature of the society and the civilization of the time; and it has this great advantage, that it all comes to us at first hand, from the people themselves. The texts are the same now (when they are complete) as on the day when the scribe wrote them, and impressed the cylinder-seals of the witnesses.

There is a noteworthy point in the life of the patriarch Abram that may here be touched upon, and it is a point that must have struck many in former days. Abram, a simple shepherd owning his own flocks, sets out from Ur of the Chaldees, and not only traverses Western Asia, but even visits Egypt; and in all the narrative there is not a word referring to any difficulty that he may have had in making himself understood.†

In Babylonia in ancient times it would seem that many languages or dialects were spoken, and these tongues the tradesman or farmer probably knew from his youth up. One of them, Babylonian (generally called Assyrian), he would speak as his mother-tongue, and of Sumerian and its dialect (Akkadian) he would know at least a smattering. From the Aramaic tribes in the country he would naturally be able to get a knowledge of Aramaic, and from the Amorites who were in Babylonia (there was an Amorite district in or near Sippara, now Abu-habbah, in about 2080 B.C.) he could obtain a knowledge of the language spoken in Southern Palestine and elsewhere—a tongue, in all probability, closely akin to Hebrew. For a journey to Egypt the above would be most likely all that was needed by him to communicate with the natives, for the Egyptian Pharaoh was, it is supposed, of Semitic origin, and he and many of his people must have understood the language of Western Asia. Any further aid that the traveller might require, however, he would find ready to his hand in the language now known as Assyrian (really Babylonian), which, as it was the *lingua franca* of 1500 B.C., must have held the same position in Abram's time; and the traveller could, in all probability, have traversed the whole distance from Babylonia to Egypt (over a thousand miles as the patriarch must have gone), communicating with the inhabitants of the countries he passed through by this means alone. A traveller's linguistic equipment in those days was complete if he possessed some knowledge of Aramaic and Amorite as well.

Recent researches have, indeed, removed not a few hindrances to our perfect knowledge and understanding of the early history of that East which is so full of poetry and romance, and so important for the history of civilization. What may we not find when more of the many buried cities of the East shall have been explored by the excavator? Among the many thousand tablets that still lie buried there, who can say what may not come to light?

Science Notes.

Experiments have been made upon the bending of small bars of ice, supported at the ends in a horizontal position and loaded at the middle; and it is found that if such a bar is so cut that the optical axis is perpendicular to the length the load causes considerable bending, but a rod having the optical axis horizontal shows no appreciable bending under these conditions. This agrees with the supposition that ice crystals consist of thin laminæ, formed of a flexible but almost inextensible substance, the interspaces being filled with a separating medium which is sufficiently viscous to retard the mutual gliding of the plates.

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We learn that both Messrs. Cook & Son and Messrs. Gaze & Sons are making special arrangements to convey astronomers and others to Vadsö, for the purpose of viewing the eclipse of the sun which is to take place on August 9th next.

THE FACE OF THE SKY FOR FEBRUARY.

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

SUNSPOTS and faculæ are evidently decreasing in number. There will be an annular eclipse of the Sun on the **13th**, but it will only be visible in the southern hemisphere. Conveniently observable minima of Algol occur at 9h. 43m. P.M. on the **6th**, at 6h. 32m. P.M. on the **9th**, at 11h. 25m. P.M. on the **26th**, and at 8h. 14m. P.M. on the **29th**.

Mercury is not very favourably situated for observation this month. On the **1st** he sets at 6h. 10m. P.M., or 1h. 24m. after the Sun, with a southern declination of 10° 50′, and an apparent diameter of $8\frac{3}{4}''$, $\frac{2}{10}$ths of the disc being illuminated. He is in inferior conjunction with the Sun on the **8th**. After this he becomes a morning star, but is badly situated for observation owing to his great southern declination. On the **15th** he rises at 6h. 26m. A.M., or 52m. before the Sun, with a southern declination of 14° 13′, and an apparent diameter of 10″, $\frac{12}{100}$ths of the disc being illuminated. On the **20th** he rises at 6h. 7m. A.M., or one hour before the Sun, with a southern declination of 15° 34′, and an apparent diameter of 9″, $\frac{26}{100}$ths of the disc being illuminated. On the **29th** he rises at 5h. 52m. A.M., or one hour before the Sun, with a southern declination of 16° 15′, and an apparent diameter of $7\frac{1}{2}''$, about one half of the disc being illuminated. He is in Capricornus during the month.

Venus is a morning star, but is rapidly fading in brightness, and her southern declination is very great. On the **1st** she rises at 5h. 26m. A.M., or two hours and a quarter before the Sun, with a southern declination of 22° 0′, and an apparent diameter of $14\frac{1}{2}''$, about three-quarters of the disc being illuminated. On the **10th** she rises at 5h. 36m. A.M., or 1h. 50m. before the Sun, with a southern declination of 21° 42′, and an apparent diameter of 14″, $\frac{8}{10}$ths of the disc being illuminated. On the **20th** she rises at 5h. 41m. A.M., or about one and a half hours before the Sun, with a southern declination of 20° 23′, and an apparent diameter of $13\frac{1}{2}''$. On the **27th** she rises at 5h. 38m. A.M., or 1h. 12m. before the Sun, with a southern declination of 18° 21′, and an apparent diameter of 13″, $\frac{83}{100}$ths of the disc being illuminated. During the month she passes from Sagittarius into Capricornus.

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* Meissner, *Beitrage*, No. 4.

† Apparently, also, he was never molested by lawless tribes—a condition of security which could not be claimed for this part of the world now.

Mars, Saturn, and Uranus are, for the observer's purposes, invisible.

Jupiter is a magnificent object in the evening sky, and is admirably placed for observation, being visible all night long. On the **1st** he rises at 3h. 38m. P.M., with a northern declination of 20° 10′, and an apparent equatorial diameter of $46\frac{1}{2}''$. On the **10th** he sets at 6h. 56m. A.M., or half an hour before sunrise, with a northern declination of 20 26′, and an apparent equatorial diameter of 46 . On the **20th** he sets at 6h. 14m. A.M., or 54m. before sunrise, with a northern declination of 20° 41′, and an apparent equatorial diameter of $45\frac{1}{3}''$. On the **29th** he sets at 5h. 36m. A.M., or one hour and a quarter before sunrise, with a northern declination of 20° 5′, and an apparent equatorial diameter of $44\frac{1}{2}''$. He is in Cancer during February. The following phenomena of the satellites occur before midnight on the days named, while the planet is more than 8° above and the Sun 8° below the horizon: On the **1st** a transit ingress of the first satellite at 7h. 17m. P.M., of its shadow at 7h. 30m. P.M.: a transit egress of the satellite at 9h. 38m. P.M., and of its shadow at 9h. 50m. P.M. On the **2nd** an eclipse reappearance of the first satellite at 6h. 55m. 25s. P.M. On the **4th** a transit ingress of the second satellite at 9h. 12m. P.M., and of its shadow at 9h. 47m. P.M. On the **5th** an occultation disappearance of the third satellite at 6h. 53m. P.M., and its eclipse reappearance at 11h. 42m. 31s. P.M. On the **6th** an eclipse disappearance of the second satellite at 7h. 48m. 3s. P.M. On the **7th** an occultation disappearance of the first satellite at 11h. 42m. P.M. On the **8th** a transit ingress of the first satellite at 9h. 1m. P.M., of its shadow at 9h. 24m. P.M.; a transit egress of the satellite at 11h. 21m. P.M., and of its shadow at 11h. 44m., P.M. On the **9th** an occultation disappearance of the first satellite at 6h. 8m. P.M., and its eclipse reappearance at 8h. 49m. 59s. P.M. On the **10th** a transit egress of the shadow of the first satellite at 6h. 13m. P.M. On the **11th** a transit ingress of the second satellite at 11h. 28m. P.M. On the **12th** an occultation disappearance of the third satellite at 10h. 12m. P.M. On the **13th** an occultation disappearance of the second satellite at 6h. 32m. P.M., and its eclipse reappearance at 10h. 23m. 35s. P.M. On the **14th** a transit ingress of the fourth satellite at 11h. 3m. P.M. On the **15th** a transit ingress of the first satellite at 10h. 46m. P.M., and of its shadow at 11h. 19m. P.M. On the **16th** an occultation disappearance of the first satellite at 7h. 53m. P.M., and its eclipse reappearance at 10h. 44m. 42s. P.M. On the **17th** a transit egress of the first satellite at 7h. 32m. P.M., and of its shadow at 8h. 7m. P.M. On the **20th** an occultation disappearance of the second satellite at 8h. 49m. P.M. On the **20th** a transit egress of the shadow of the second satellite at 7h. 12m. P.M. On the **23rd** an eclipse reappearance of the fourth satellite at 6h. 22m. 27s. P.M., a transit egress of the third satellite at 7h. 2m. P.M., an occultation of the first satellite at 9h. 39m. P.M., and a transit egress of the shadow of the third satellite at 9h. 54m. P.M. On the **24th** a transit ingress of the first satellite at 6h. 58m. P.M., of its shadow at 7h. 42m. P.M.; a transit egress of the satellite at 9h. 18m. P.M., and of its shadow at 10h. 2m. P.M. On the **25th** an eclipse reappearance of the first satellite at 7h. 8m. 17s. P.M. On the **27th** an occultation disappearance of the second satellite at 11h. 7m. P.M. On the **29th** a transit ingress of the shadow of the second satellite at 6h. 54m. P.M., a transit egress of the satellite at 8h. 10m. P.M., and of its shadow at 9h. 49m. P.M

Neptune is an evening star, rising about noon on the **1st**, with a northern declination of 21° 12′, and an apparent diameter of 2·6″. On the **29th** he rises at 10h. 14m. A.M., with a northern declination of 21° 13′. He describes a very short retrograde path in Taurus during the month, a little to the south of the $4\frac{3}{4}$ magnitude star ι Tauri. A map of the stars near his path will be found in the *English Mechanic* for August 16th, 1895.

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

The Moon enters her last quarter at 0h. 38m. A.M. on the **6th**; is new at 4h. 13m. P.M. on the **13th**; enters her first quarter at 9h. 14m. P.M. on the **21st**; and is full at 7h. 51m. P.M. on the **28th**. There will be a partial eclipse of the Moon on the evening of the **28th**. The first contact with the penumbra occurs at 5h. 15m. P.M., with the shadow at 6h. 16m. P.M., at 85° from the north point of the Moon's limb towards the east (reckoning for direct image); the middle of the eclipse at 7h. 46m. P.M.; the last contact with the shadow at 9h. 15m. P.M., at 30° from the north point of the Moon's limb towards the west (reckoning for direct image); last contact with the penumbra at 10h. 16m. P.M. Taking the Moon's diameter at 1, the magnitude of the eclipse will be 0·87. The Moon rises at Greenwich at 5h. 27m. P.M.

◆

Chess Column.

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

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

ANSWERS TO CORRESPONDENTS.

A Norseman.—All your postcards were received too late to reply to last month. Please send your address for registration next time you write. Your solutions were correct.

A. G. Fellows.—Many thanks for your letter, explaining that an alteration of your problem at the last moment gave rise to the superfluous solutions. We believe that this is the first unsound problem of yours published in this column.

THE EIGHT QUEENS PROBLEM.

(*Continued.*)

We now proceed to remark on the principal features of the table of possible positions given in the January number:—

1. Evidently the positions of most frequent occurrence are those beginning a3, *b*6, etc. Of course the same would apply to positions beginning a6, *b*3, or ending g3, h6, or g6, h3, for all these are practically the same, the difference being merely one of right or left, backwards or forwards.

2. Each of the positions labelled α, β, etc. . . . . λ occurs *four* times in the table of forty-six positions; it seems, therefore, remarkable that the symmetrical position ω should occur only *twice*. Also that, in both the cases in which it is found, the position is absolutely identical if the board be turned half-way round (*i.e.*, two quarter turns). This may be seen at once by referring to the two diagrams ω and ω_2 in the last number. We believe that the coincidence is confined to these two positions.

3. In three out of the four classes (A, B, C) the squares h7 and h8 are never filled. In other words, a Queen can never be placed on KR7 or KR8 when there is a Queen on QRsq or QR2 or QR3.

4. We now arrive at the interesting question whether

the fundamental positions α, β, γ, etc. . . . λ, and ω are in any way connected—*i.e.*, whether one position can be obtained from another by a uniform shifting of the pieces in some definite direction. To this question we find the remarkable answer that some of the positions are in this way intimately connected with one another, while the remainder seem to be entirely independent. The positions which, for want of a better word, we shall call "transferable" are those labelled α, β, γ, δ, ζ, ι, and λ. The remainder, ε, η, θ, κ, and ω, are not transferable by any process which we can discover. And yet the italicized positions, Nos. 9 and 10 in Class C, and still more Nos. 4 and 5 in Class D, show how nearly the non-transferable θ approaches to the transferable α. In the latter instance the six Queens to the left remain the same; θ being obtained from α simply by shifting the Queens on KKtsq and KR5 to KKt5 and KRsq. In no other case is such a trifling alteration possible, so to speak, at the last moment.

5. The connection between α, β, γ, δ, ζ, ι, and λ is as follows:—To obtain δ from α, move the pieces *forward one square.* (A Queen on c8 must, of course, be shifted to c1.) Now move the position δ forward one square and we obtain ι. Again take α, and move the pieces *one square to the right*; this results in the position γ.

λ is obtained from α by moving the pieces one square *forward diagonally to the right.*

The rule for diagonal shifting is as follows:—A piece shifted to an imaginary square in continuation of a rank or file must be placed at the *other* end of such rank or file, while a piece shifted beyond a *long diagonal* must be placed at the opposite corner of the board. For instance, a piece moved one square forward diagonally to the right from QB8 must be placed on Qsq; if from KR8, it must be placed on QRsq.

To obtain β from α, shift the pieces one square *backwards diagonally to the left*—*i.e.*, precisely in the opposite direction to that used for obtaining λ.

ζ is obtained most easily from δ by moving the pieces one square *backwards diagonally to the right.*

[ω_2 is obtained from ω by a curious method. Move the pieces on files a and b one square *forwards*: files g and h one square *backwards*: the two distant pieces one square to the *left*: and the two nearer pieces one square to the *right.*]

6. We will now endeavour to ascertain why the positions ε, η, θ, κ, and ω are not transferable by any shifting of the pieces in a uniform direction. For this purpose we give a list of these five positions.

	a	b	c	d	e	f	g	h
(ϵ)	3,	6,	2,	5,	8,	1,	7,	4.
(η)	2,	5,	7,	4,	1,	8,	6.	3.
(ϑ)	2,	7,	5,	8,	1,	4,	6,	3.
(κ)	2,	6,	8,	3,	1,	4,	7,	5.
(ω)	3,	5,	2,	8,	1,	7,	4,	6.

[We have placed the names of the files at the head of the columns in order to have the figures themselves close together for comparison.]

Now, examining these figures, we notice—

(i.) That the square e1 occurs in every case except (ϵ).

(ii.) In every case except that of (κ) the figure 8 is next to the figure 1: moreover, this will be found to be the case *whichever way the board is turned.* In the transferable positions the figures 8 and 1 are *never adjacent.*

(iii.) In ε, η, and θ the number of a is within one unit of the number of h. *This is never the case in any of the transferable positions.*

We conclude, therefore, that the conditions which do *not* favour the simple transference of one position to another are:—(i.) The use of e1 (King's square) when a1, a2, a3, or a4 are occupied. (ii.) The use of *opposite* ends of *adjacent* files. (iii.) The use of a number on one Rook's file within a unit of the number used on the other Rook's file.

7. Finally we arrive at the question—why are there ninety-two methods of solving the problem, neither more nor less? Our mathematical abilities proving insufficient for the deductive solution of this question, we tried the device of using smaller chess-boards of 16, 25, 36, and 49 squares respectively, hoping to find some recognizable series of numbers which should determine the law. In this we were disappointed, for whereas the numbers increase generally with the size of the board, there is a remarkable exception in the case of the board of 36 squares. Our results are recorded below:—

Board of						
Board of	16	squares	*Actual methods*	2	*Essential methods*	1
"	25	"	"	10	"	2
"	36	"	"	4	"	1
"	49	"	"	40	"	6
"	64	"	"	92	"	12

In the Six Queens problem on a 36-square board the comparatively small number of solutions seems to be atoned for by their symmetrical beauty. It is remarkable also (1) that the corners are never occupied, and (2) that the *colours* of the squares are never equally divided among the Queens—there are always four Queens on one colour and two on the other. On the full-sized board, four of the Queens must always be on White squares and four on Black.

In conclusion, we must apologize if, in our examination of this (to us) intricate problem, we have anywhere sacrificed intelligibility to condensation. We sincerely hope, also, that any reader who knows or can discover the law which governs the problem will kindly communicate his information.

CONTENTS OF No. 123.

NOTICES.

The numbers of KNOWLEDGE for January and February of 1894 can now be had, price One Shilling each.

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KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: MARCH 2, 1896.

CONTENTS.

THE TRANSVAAL: ITS MINERAL RESOURCES.

By Prof. J. Logan Lobley, F.G.S.

The second half of the nineteenth century has been prolific in remarkable discoveries and developments, but, if for no others, it will always be a memorable epoch from the enormous additions it has given to the world's stock of gold from three continents. Its earliest years witnessed the development of the goldfields of California and Australia, then just discovered, with the sensational finding of large nuggets of gold in surface deposits; and its later years have been marked by the discovery of extraordinary auriferous rocks in South Africa.

A testimony to the African continent having for a long time been productive of gold is afforded by the name "Gold Coast," and many believe that much of King Solomon's golden store was derived from Eastern Africa, while there are undoubted remains of ancient gold workings both north and south of the Equator on the eastern side of the continent. The reputation of Africa as a gold-producing continent will, however, be chiefly based upon the recent discovery of the auriferous rocks of the South African Republic.

This portion of South Africa, commonly called the Transvaal, is an extensive region extending northwards from the Vaal River (by which it is separated from the Orange Free State) to the Limpopo River. Bechuanaland lies on the west, and the Lobombo Mountains and Portuguese possessions separate the Transvaal from the Indian Ocean on the east. Its greatest length is from the south-west to the north-east, and its eastern boundary is within forty miles from the sea at Delagoa Bay. With a very irregular boundary, the Transvaal has an extreme length and breadth of six hundred miles and five hundred miles respectively, and a total area of about one hundred and seventy thousand square miles, all lying between 22° and 29° south latitude and 25° and 33° east longitude.

In this extensive region gold has been found in many places since its discovery by Edward Button in the Klein-letaba in the year 1869. In the northern portion, between Olifant's River and the Limpopo, the widespread Zoutpansberg goldfields have been long worked, and, later, those of Lydenberg and the De Kaap Valley, in the east of the area: while, far to the west, and near the Bechuanaland frontier, there is the less important Malmani goldfield. The southern portion of the Transvaal, however, lying between the Vaal River and Pretoria, has proved by far the richest auriferous region, from the occurrence in it of rocks running east and west along which are several series of parallel outcropping beds, called "reefs," which have been found to be, speaking generally, continuously gold bearing. The elevated district containing these auriferous rocks constitutes the now world-famous Rand, or Witwatersrandt, the gold-yielding character of which was discovered in 1885; and the town of Johannesburg was founded on the Rand, at an elevation of five thousand six hundred feet above sea-level, in the following year. But besides the Witwatersrandt proper there are in this part of the Transvaal, moreover, the goldfields of Klerksdoorp to the west-south-west, Venterskroon to the south-west, near the Vaal River, and the Nigel and Heidelberg gold districts to the south-east of the Rand.

The enormously preponderating importance of the Witwatersrandt district, as well as the relative yield of gold in the other districts, may at once be seen from the following statement from the State Mining Engineer's report on the gold production of the Transvaal for the year 1894:—

Goldfields.	Gold-bearing Rock mined.	Gold.	
		Weight.	Value.
Witwatersrandt ..	3,062,767 tons.	1,948,924 oz.	£6,714,781
Heidelberg ..	25,618 ..	52,685 ..	172,340
Schoonspruit .	182,448 ..	78,358 ..	264,724
Malmani ..	387 ..	494 ..	1,876
De Kaap ..	113,963 ..	87,483 ..	298,598
Zoutpansberg ..	26,613 ,	10,611 ..	38,104
Lydenberg ..	71,568 ..	60,276 ..	173,275
Vryheid	5,500 ..	—	
Carolina	150 ..	13 ..	44
Pretoria ..	—	6	23
Totals ..	3,489,015 tons	2,239,865 oz	£7,667,152

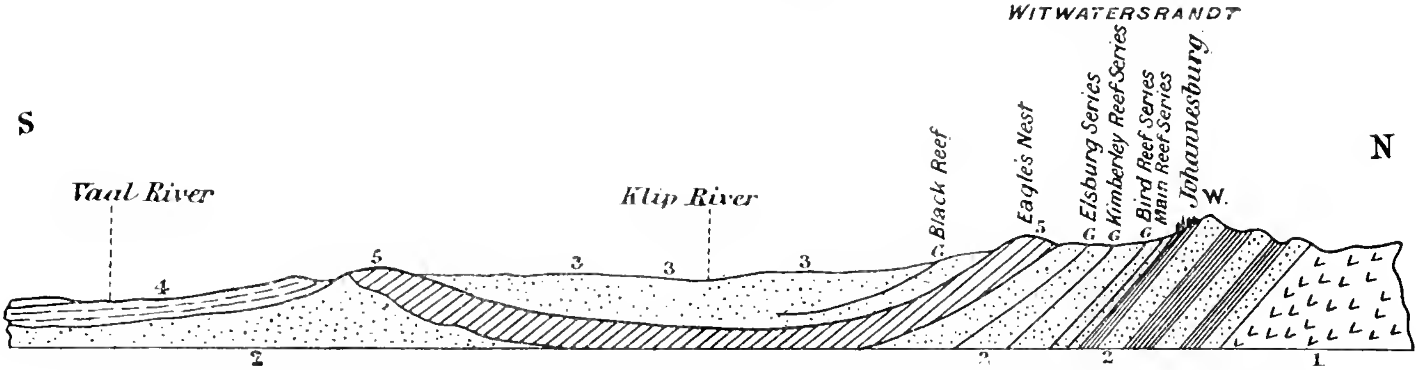
Of this great aggregate production of gold in the Transvaal for one year, only 3666 ounces, of the value of £12,806, was alluvial gold or that obtained from superficial deposits. These auriferous alluvial deposits are at Blauuwbank in the Witwatersrandt, at Barberton and Kaapsche Hoop in the De Kaap gold district, and at places in the Zoutpansberg and Lydenberg goldfields. The number of gold claims registered on the 31st December, 1894, was 3929.

The greater portion of the southern part of the Transvaal is occupied by a plateau of high land called the Hooge Veldt, or High Veldt, which extends generally east and west, but trends towards the south-west; and from these uplands flow the streams that feed the Vaal and Limpopo

Rivers, to the south and north respectively. The Witwatersrandt is, indeed, the water-parting between the two great river-basins, the northern portion of the Transvaal being formed by the slopes, with low hill ranges, from the High Veldt to the Limpopo River.

Eastwards, the High Veldt rises to greater surface altitudes, until it attains the crest of a section of the Drakensberg range of mountains, running north and south, and culminating in the Mauuch Berg, seven thousand one hundred and seventy-seven feet above the level of the sea. This range descends on its eastern side with a steep escarpment—prominent along which is seen the peak of Spitz Kop—to the great De Kaap Valley, about three thousand feet above sea-level, that extends to the Lobombo Mountains, forming the eastern boundary of the State.

Section S. to N. from the Vaal Valley across the Witwatersrandt. Length of Section, 60 miles.



W. Water Parting between the Vaal and Limpopo River Basins. 5. Basalt. 4. High Veldt Beds, Coal-bearing (Karoo Beds). 3. Klip River Series. 2. Quartzite Shale Series, with G, "Banket" (Gold-bearing Conglomerates). 1. Granite.

With the exception of the De Kaap Valley, the Transvaal consists of a portion of the elevated interior land of the continent of Africa that constitutes what is called the Central African Plateau, of which the Witwatersrandt is therefore a part, and the Vaal Valley and the Limpopo northern valley are but depressions in the plateau.

The region generally is occupied by rolling grass-covered uplands, with ridges of bare rocks standing above the general surface—in some districts at frequent intervals. This rocky-surface character is given by a large amount of igneous rock in granitic bosses and dioritic and basaltic masses and dykes, together with the outcrops of the older stratified and metamorphic rocks of the country. Some of the dykes, from their position, have been subjected to less denudation than adjacent masses, and so form in places narrow ridges called "necks," which have sometimes a deep ravine on each side. The whole area is intersected by river valleys formed by the streams (torrents at times) feeding the two bounding rivers, both of which rise in the Transvaal, but flow, however, in opposite directions: the Vaal River running westwards to the great Orange River, which it joins beyond the south-west extremity of the Republic, and the Limpopo flowing eastwards towards the Indian Ocean. An important tributary of the Limpopo, called Olifant's River, traverses the interior of the area, dividing the eastern half very equally into northern and southern portions.

The Transvaal as a whole is formed by Plutonic granites and diorites, volcanic basalts and dolerites, crystalline metamorphic schists and gneisses, with unconformable but undoubtedly Palæozoic stratified rocks; and these are succeeded by a later series of rocks, again unconformable. Over large areas the outcrops of these rocks are concealed by superficial deposits of varying thickness, giving a red soil immediately below the turf. The older stratified rocks have a general southerly dip and east and west strike. The dip is usually at a very high angle, sometimes even nearly ninety degrees, but commonly from forty-five to sixty degrees, though a few miles to the south of Johannesburg and beyond Eagle's Nest the beds are nearly horizontal. It is in these rocks that the auriferous beds of the Witwatersrandt occur. The word "beds" is used here advisedly, for, although the term "reefs" is the name locally and generally given to these rocks, they are unmistakably sedimentary beds, and contemporaneous portions of the geological formation in which they are contained. They are, therefore, of an altogether different character from the well-known auriferous "reefs" of other gold regions, which are quartz veins traversing the massive rocks across their planes of original deposition. The so-called "reefs" of the Rand, on the contrary, are merely certain beds of a quite conformable series of stratified rocks, which consequently have a common dip and strike, and may, therefore, be considered to be one geological formation. It is this fact that gives to the occurrence of gold in the Transvaal an unique character, and renders it, from a geological as well as from an economic point of view, especially interesting.

The massive rocks in which the gold-bearing beds occur—the "country rock"—are for the most part hard quartzites, sandstones, and bluish shales, and the whole formation has been called the "quartzite shale series." It is altogether of enormous thickness, estimated at three miles, or sixteen thousand or seventeen thousand feet. From the absence of fossils—or at least from none having as yet been found—there is great difficulty in assigning to this great series of stratified rocks (which have been correlated with the Table Mountain Sandstone) any other than an approximate geological age; but from its general stratigraphical position with reference to the other South African rocks, and from its unconformability with overlying coal-bearing formations, it is certainly of Palæozoic and most probably of Silurian age. The whole of the rocks of South Africa may be classified as follows in descending order:—

Mesozoic.		16. Superficial deposits.
	Upper Karoo.	15. Volcanic rocks.
		14. Cave sandstone.
		13. Red beds.
		12. Molteno beds.
		11. Karoo beds (Beaufort beds).
	Lower Karoo.	10. Kimberley shales.
		Unconformability.
		9. Ecca beds.
		8 Dwyka conglomerate.
		Unconformability.

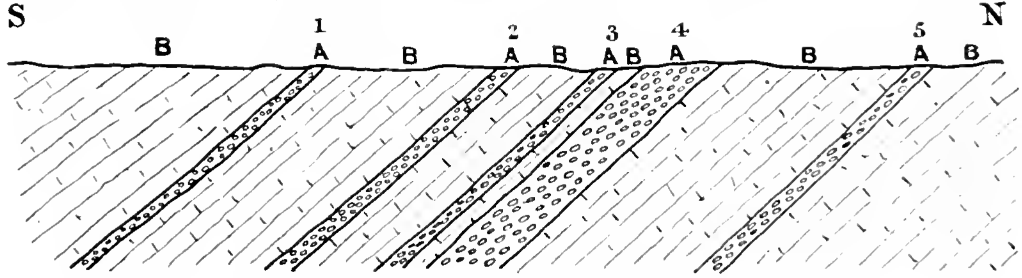
Palæozoic.

7. Quartzites.
6. Malmani limestone.
5. Bokkeveld beds (wanting in the Transvaal).
4. Table Mountain sandstone.*
Unconformability.
3. Malmesbury schists.
2. Gneiss, and
1. Granites.

The auriferous beds or "reefs" are in a succession of series, each series having two, three, or more reefs, separated by the country rock of different thicknesses ranging up to one hundred and fifty feet, while the reefs themselves have thicknesses up to six or seven feet. These reefs consist of conglomerates, in which rounded pebbles of white and tinted quartz are embedded in a quartzose matrix, which, although originally sandy and loose, has been, by the infiltration of silica, rendered a very hard and compact mass. To the conglomerate the name "banket" is given. The quartz pebbles range in size from that of a pea to stones a couple of inches in diameter. It is not, however, in the pebbles that the gold occurs, but in the hardened quartzose matrix, and through this it is disseminated in small particles—so small, indeed, that it is often invisible to the eye; but this is abundantly compensated for by its generally regularly continuous and not intermittent dissemination.

Associated with the gold—which is in a metallic or "native" state, and not as an ore, or chemically combined with some other element—are the following metallic minerals: iron pyrites, with its variety, marcasite, hæmatite, ilmenite, magnetite, copper pyrites, blende, galena, and, more rarely, stibnite or antimonite, cobalt, and nickel. Of all these, iron pyrites is the most abundant. Ratile, zircon, corundum, mica, talc, and chlorite are also met with. Besides "free gold," there are extremely minute particles of gold contained in microscopical interstices of the iron pyrites, and which, accordingly, may escape amalgamation and chlorination, and even the searching cyanide of potassium, and so be lost to the miner. With improved processes and methods the amount of gold thus lost has been greatly reduced, by which much poorer material is being rendered payable than was formerly the case.

Generalised Section showing details of a Witwatersrandt Reef Series. Length of Section, about 100 feet.



A. Banket, beds of Gold-bearing Conglomerate. B. Country Rock, Quartzites and Sandstones. 1. South Reef. 2. Middle Reef 3. Main Reef Leader. 4. Main Reef. 5. North Reef.

Although the gold is not chemically combined with any other element, it is always mechanically intimately associated with other substances, and is therefore never obtained as absolutely pure gold. The proportion of "fine gold," as perfectly pure gold is termed, is here about from eight hundred and twenty to eight hundred and fifty parts per thousand, with from one hundred and twenty to one hundred and forty parts of silver, and from thirty to forty parts of other impurities.

Since the auriferous reefs crop out they can be worked to a certain depth from the surface, or without deep shaftings, and the earlier mines were along these outcrops. It is obvious, however, that if the reefs dip from the surface at an angle of forty-five degrees—the average dip—shafts at some distance from the outcrop in the same direction as the dip, if sufficiently deep, will strike the reef, and thus there are three kinds of levels: upper, middle, and lower; but the lowermost levels as yet are only about one thousand feet deep, whereas workings at five thousand feet depth may possibly be attempted in the future.

In the older goldfields of Lydenberg and the De Kaap Valley the geological conditions are different from those of the Witwatersrandt, for the gold occurs there in thin "leaders," as they are termed, ranging from one-eighth of an inch to eight or nine inches in thickness, which cut through nearly horizontal more or less soft strata of a different geological age from that of the quartzites and conglomerate reefs of the Witwatersrandt. These leaders chiefly consist of siderite or carbonate of iron, and quartz with much oxidized iron pyrites. At Spitz Kop as many as thirty such leaders have been recorded; and sometimes these, when in fine dove-coloured argillaceous shale, become very thin, and then are unusually rich, in some cases being formed of plates of solid gold from one to ten ounces in weight. Here, too, iron pyrites is abundant, sometimes in large crystals and groups of crystals many pounds in weight.

Again, gold is reported as occurring at King's Claim in a soft breccia of sandstone, shales, etc., interpenetrated by decomposed diorite; and in Swaziland, gold associated with native bismuth is found in the heart of quartz. In the Blyde River Valley saccharoidal quartz is in parts richly auriferous, while at Kantoor "flour-gold" is disseminated not only through quartz veins, but also through their enclosing decomposed diorites.

With geological conditions such as those that obtain in the Transvaal it is evident that the total yield of gold will continuously increase with the increase of mining operations both in area and depth, until they are co-extensive with the workable auriferous beds or reefs. Thus, with the establishment of new claims and the working of deeper levels the annual output of the precious metal may be expected to show a yearly increase. What will be the ultimate limit of that increase it is impossible to say; but Mr. Hays Hammond, whose great practical knowledge of the auriferous deposits of the Rand is so well known, says he "would regard as well within the bounds of conservatism the prediction that the annual output before the end of the present century will exceed twenty millions sterling worth of gold."

The metallic riches of the Transvaal are not confined to gold.

Silver in association with copper and lead occurs in granitic rocks in several parts of the country, as near Malmani, Pretoria, Rustenberg, and north of Middleberg.

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* The gold-bearing rocks of the Witwatersrandt are assigned to this formation.

Copper ore occurs at various places near the upper waters of the Limpopo as well as in the north-east of the State, and with galena, sulphide of lead, in veins in granite at the Albert Mine.

Lead ores are mined in the western part of the State in calcareous rocks near the source of the Groot Marico, and at Hamerkop, near Jacobsdal, on the Klein Marico.

Tin ore has been found in alluvial deposits on the Swaziland borders, and there are thin stanniferous veins in the granitic rocks; but it has not yet been discovered in paying quantities.

Zinc blende sometimes occurs associated with galena.

Iron ores, hæmatite, limonite, magnetite, and iron pyrites, are abundantly distributed in small quantities.

Mercury ore, cinnabar, occurs east of Barberton; and cobalt and nickel, as cobalt bloom, smaltine, and nickeline, to the north of Middleberg.

Of non-metallic minerals, diamonds have been obtained just within the Transvaal, near Bloemhof on the Vaal River, and near its confluence with the Makwsi River. Only small stones, however, have been found, ranging from one to five carats.

Salt occurs in beds to the north of Pretoria, and also still further north beyond Olifant's River, in the Zoutpansberg district.

Although true limestones appear to be wanting in the Transvaal, there is a calcareous sandstone that on being burnt or calcined yields lime for economic purposes; and in one locality there are caves with stalactites, resulting from the dissolving out of the calcareous matter from the rocks above.

Coal is a most valuable product of any country, but especially so when motive power for machinery is largely wanted, and there is not a continuously abundant water supply in the rivers available for mills. These are the conditions that give to the coal-bearing rocks of the Transvaal great importance.

The coal-bearing rocks here are in the lower division of the very extensive South African formation called the Karoo formation. To this division the name "Molteno Beds" has been given, but its geological age has not yet been satisfactorily determined, since the formation as a whole, and the coal-bearing rocks, as well as the coal itself, differ considerably from the Carboniferous rocks and the Coal Measures of this and other countries; and the fossils, although similar, are so few and of such a general character that they do not afford a sure ground for correlation. The strata are almost horizontal, and so overlie the older uptilted rocks unconformably—indicating, therefore, a much later age. They form, as a rule, high ground, and constitute an extensive and continuous area of the High Veldt, and also occur as patches sometimes overlying the primative granitic rocks.

The beds of coal are not continuous, as in the British coalfields, but in more or less lenticular masses, usually horizontal, but on slightly different horizons; though there are some seams now known to be continuous for miles. The thickness of the seams varies much, from a few inches upwards; at Belfast there are three beds of a total thickness of thirteen feet. Though the amount of coal in the rocks of the Transvaal is very great, the quality does not appear to be high, some of the samples giving a large percentage of ash: the Belfast coal gave about twenty per cent. of ash, but that of the Douglas Mine only eight per cent. There is also much iron pyrites in the shaly matter in the coal, rendering it a dangerous coal to stack in large quantities. It is generally very inferior to English coal, and unfitted for metallurgical purposes; but nevertheless it is sufficiently good for ordinary furnace coal for steam boilers, and this is the principal requirement of the Transvaal. Near the Vaal River, and near its confluence with the Klip River on the southern boundary, coal is worked, and also at Daggafontein and near the Witwatersrandt at Boksberg, and the Brakpan Colliery, where the output amounts to thirteen thousand tons a month.

With the addition of good building stone, furnished by its sandstones, a vast and varied store of valuable economic minerals available for the use of man is within the bounds of the South African Republic.

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WAVES.—III.

THE FORCE OF SEA WAVES.

By Vaughan Cornish, M.Sc.

When wind blows over the surface of the sea the energy of the lower layers of moving air is employed in raising waves and in giving them a forward motion. The mechanism by which energy is thus imparted from wind to water is not very well understood, for only one aspect of the phenomenon can be observed, namely, the formation of the *water*-waves. Of the air-waves which, it is believed, are generated at the same time we know but little.

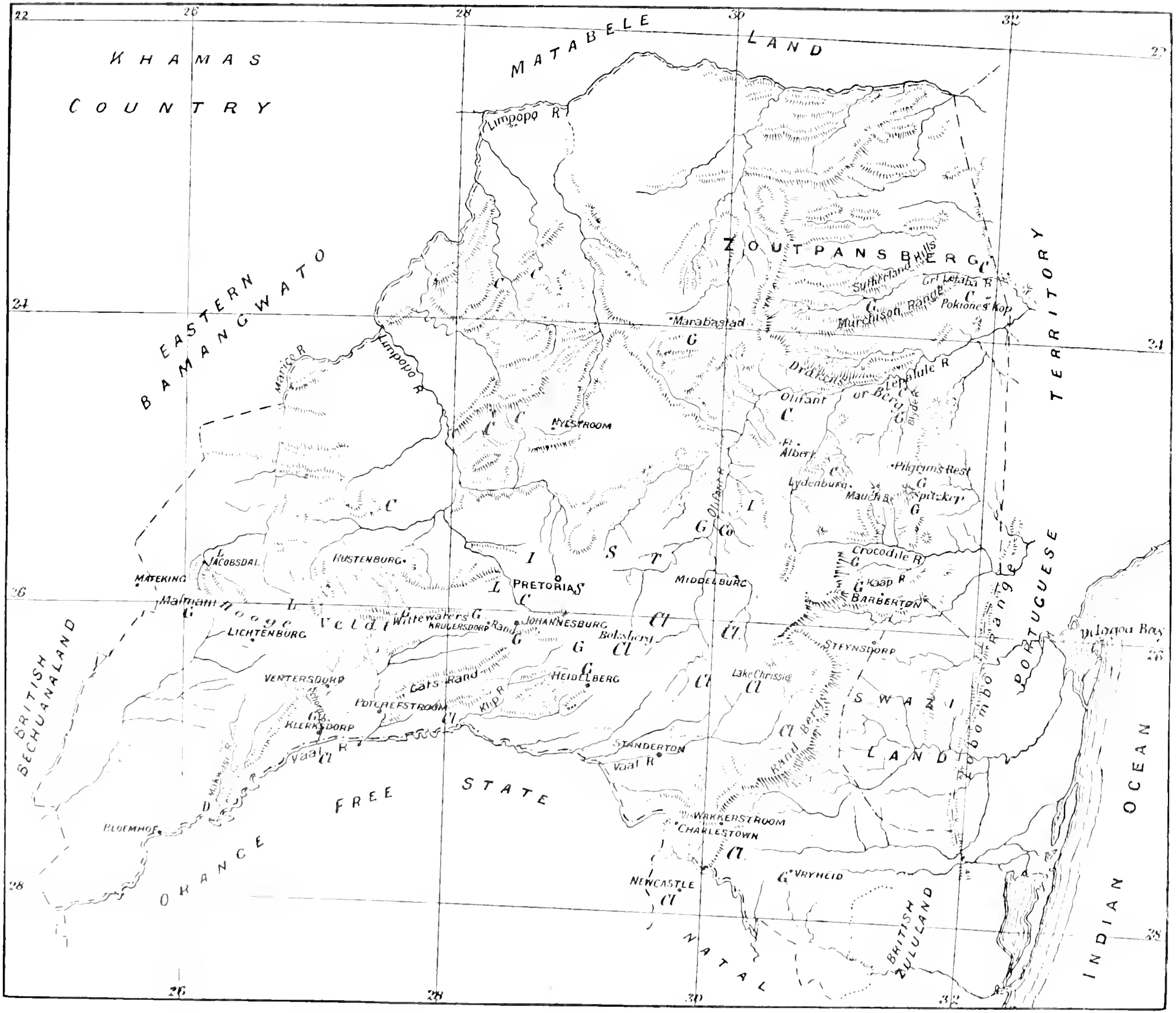
In deep-sea waves which have been raised by the wind, but are no longer subjected to its force, the water particle moves uniformly, under constant pressure, in a circle whose horizontal diameter lies in the direction in which the wave travels. In the upper half of the circle the motion is forwards, whilst the backward swing is on the lower level. Thus at each swing one-half of the energy of motion is transmitted forwards. In virtue of the energy so transmitted the waves continue to travel as free waves when no longer propelled by the wind, and thus spread beyond the tract which has been agitated by the storm.

On the other hand, after each complete swing of the water one-half of the energy of motion is *retained*, so that in the original *locus* of a storm the sea continues to be agitated long after the wind has lulled; whence the persistent turbulence of the sea.

If we fix our attention upon a wave-crest of unusual height (far from the shallows of the shore) and watch the crest as it advances, we shall find that after a time it loses its pre-eminence. At first it seems as if the observer had failed in the attempt to fix his attention upon a particular crest; but repetition of the observation gives the same result. If when the crest has lost its pre-eminence the eye be turned upon the crest which follows next, it will be seen that this in its turn towers above its neighbours. This second large crest will in like manner diminish in size, and will then be followed by a larger crest. Thus the energy of the wave-motion is seen to be transmitted more slowly than the waves themselves advance. As a wave-crest passes over each point in its course it picks up and carries on half the energy of motion at that point, but the other half lags behind. For this reason it is impossible when water has the circular swing for a *solitary wave* to exist; there must always be *a group of waves*.

This may be illustrated by throwing a stone into a pond, a simple experiment from which much may be learnt. The mere displacement of water by a falling stone gives rise to a numerous group of waves, which continue to travel over the surface of the pond long after the water at the original point of disturbance has become quiescent.

On a freely undulating sea the water in its circular swing does not strike a floating body. The great rounded crest of an ocean wave, towering above the ship's bow, looks



MAP OF THE TRANSVAAL SHOWING PHYSICAL FEATURES AND MINERAL RESOURCES.

C. Copper. Cl. Coal. Co. Cobalt. G. Gold.
I. Iron. L. Lead. S. Silver. T. Tin.

as if it were rushing upon the ship and would presently overwhelm her; but the vessel herself is borne aloft upon the crest. On the other hand, when ocean waves are forced by violent wind, so that the tops receive a forward motion beyond that which is shared by the more protected part of the billow, the water may strike a blow upon the vessel. Such is the wave described by Mr. Ruskin, with "overwhelming crest—heavy as iron, fitful as flame, lashing against the sky in long cloven edge—its furrowed flanks, all ghastly clear, deep in transparent death, but all laced across with lurid nets of spume, and tearing open into meshed interstices, their churned veil of silver fury showing still the calm grey abyss below, that has no fury and no voice, but is as a grave always open, which the green sighing mounds do but hide for an instant as they pass." This passage shows a fine discrimination between the fury of the wind-forced crest and the calm of the sheltered trough. Such minute and accurate word-painting, based upon careful observation, is the literary equivalent of a mathematical formula. According to mathematicians, the highest waves driven by the strongest wind lose entirely the rounded crest; the flanks being slightly concave and meeting at a sharply-defined angle of one hundred and twenty degrees. The height of this highest possible wave is very nearly one-seventh of its length, it would travel one-fifth faster than a free wave, and the velocity of a particle when at the summit is equal to the velocity of the wave. Its form is shown in the upper curve of Fig. 1, the lower curve being a free wave, or ground swell, of the same wave-length. It was of the forced waves that Adam Lindsay Gordon wrote—

". . . the stoutest ship were the frailest shallop
In your *hollow backs*."

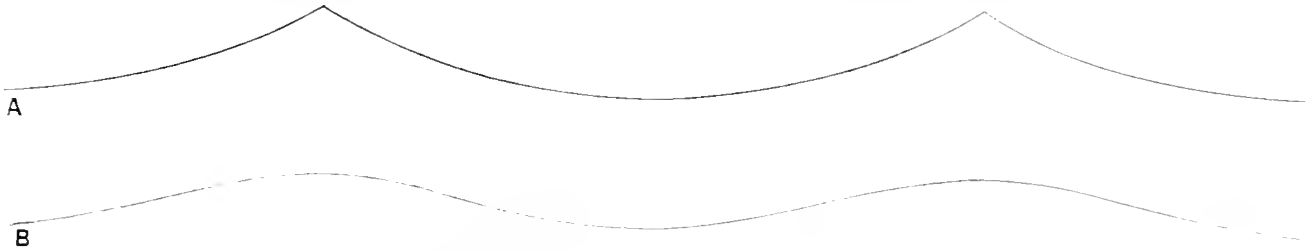


Fig. 1.—Diagrams of, A Forced Waves; B, Free Waves.

The difference of character between the waves in the open ocean and in a closed sea is due to the fact that in the former the transmission of energy from the motion of other waves has greater opportunity to take full effect, whilst the movement of storm waves in a closed sea is more largely dominated by the immediate force of the wind. The difference has been well expressed by Victor Hugo in a comparison of the waves of the Mediterranean with those of the ocean. He writes: "Ce n'étaient pas les lames de l'océan qui vont devant elles et qui se déroulent royalement dans l'immensité: c'étaient des houles courtes, brusques, furieuses. L'océan est à son aise, il tourne autour du monde; la Méditerranée est dans un vase, et le vent la secoue, c'est ce qui lui donne cette vague haletante, brève et trapue. Le flot se ramasse et lutte. Il a l'autant de colere que le flot de l'océan et moins d'espace."

The free wave, as we have said, does not strike upon a ship, but its heave and swing may become a source of danger by causing the ship to roll excessively. The angle through which a ship will roll, so much greater than the angle of pitching, is perhaps one cause of the common over-estimate of the steepness of wave slopes, which in the Atlantic are seldom more than seven degrees to the horizon. The momentary effort of a ship is to place her masts at right angles to the surface of the wave, but owing to inertia the vessel swings beyond this point. If the period of swing of the water harmonizes with the ship's natural period of pendulous oscillation, then at each roll to starboard the ship rolls further to the starboard, and at each roll to larboard she rolls further to the larboard side, the rolling being rapidly and dangerously increased, not by any shock of the waves, but by gravity, which the heaving sea causes to act upon the ship in a succession of well-timed pulls. Fortunately it seldom happens at sea that any considerable number of succeeding waves have the same period, the variety of independent systems of waves being thus a boon to the sailor, for the regularly increasing roll of the ship is generally interrupted before it has grown to a dangerous extent. The natural period of a ship's pendulous swing may be reckoned at about two and a quarter seconds for a vessel of ten-foot beam, and about five and a half seconds for a ship of sixty foot beam. The time of swing of the *Great Eastern* was six seconds. Remembering that the water completes one swing in the same interval of time as that between the passage of successive wave-crests past a stationary observer, and bearing in mind, also, the connection between wave-length and velocity (due to the

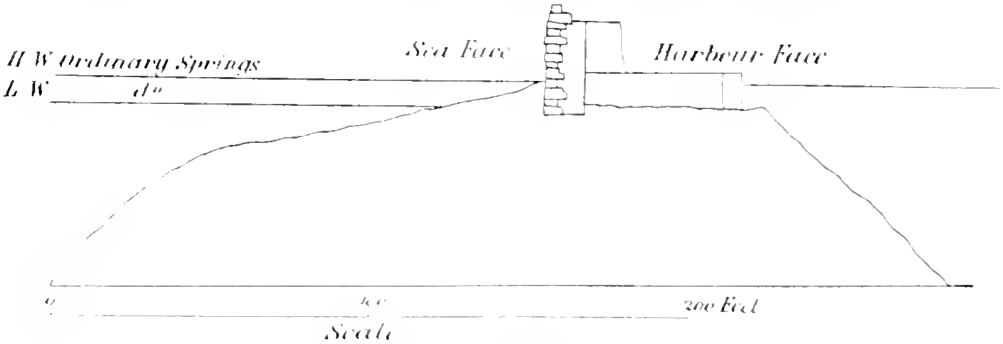
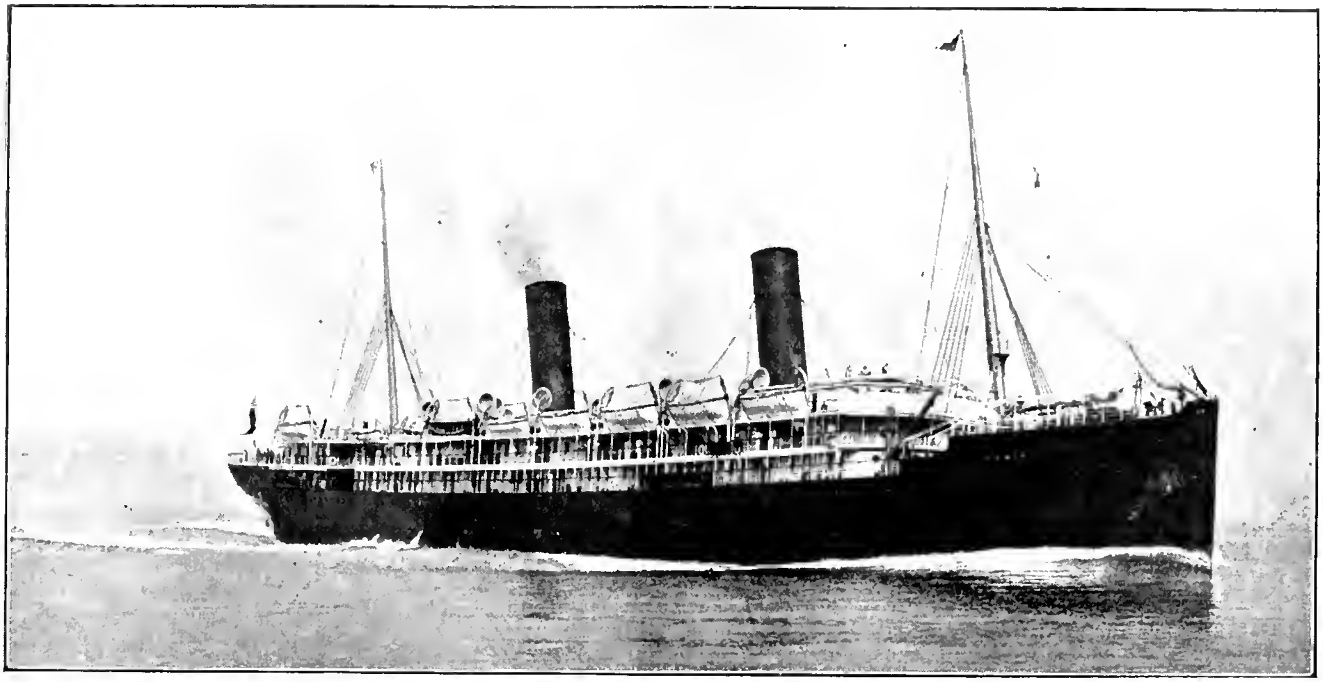


Fig. 2.—Section of Portland Breakwater, from the "Minutes of Proceedings of the Institute of Civil Engineers," Vol. XXII., 1862-3.

pendulous character of the wave), we may calculate the lengths of wave which correspond to the above periods of oscillation. A wave-length of fifty feet corresponds to a period of two and a quarter seconds, and of three hundred and ten feet to five and a half seconds. The greater the natural time of swing of a ship, the less likelihood is there of encountering waves whose period coincides with that of the ship; for it often happens that the longer waves are absent, whereas in a storm the wind is constantly forming new waves which grow in size, so that there are present at the same time waves of all sizes, and, therefore, of all periods up to the largest. A small ship is sure to meet with undulations coinciding with its time of swing, whereas a large ship may often escape.

As the billows travel onwards the energy is passed on from point to point, silently, smoothly, till the leeward shore is reached. Here all is changed. On the one side is the swinging water, ever handing on the energy of its motion. On the other side is the dead resistance of the beach, to which each breaker as it falls yields up its store of energy. There is no finer display of natural forces than the rush of the waves on a rock-bound coast, when each billow as it nears the shore raises a steeper crest, and, dashing down in thunder on the shore, throws upwards and abroad a cloud of glittering spray which falls in salt showers upon the trembling rocks.



Photograph of s.s. "Ophir," illustrating "Ship Waves."

Photograph by Adamson, Rothesay.

Everyone is familiar with the work of the breakers in tearing down cliffs and grinding the fragments into shingle and sand; but it may easily escape notice that the formation of cliffs is also the work of the sea. The space through which the breakers act is chiefly that between high and low water mark, between which a sloping shore is cut away so as to form a nearly flat beach terminated by a cliff. In point of fact the destruction and the formation of cliffs is the same process. Sometimes the waves pile up a bank of sand or shingle which protects the cliff from the direct action of the breakers. The cliff, however, gives way under the actions of wind, rain, and frost; and the material carried down to the base of the cliff by these agencies is removed by the sea, so that the cliff is maintained at an angle steeper than the angle of repose, and is constantly falling. When the jointing planes of a rocky cliff slope downwards from the shore line the waves undermine the cliff, and great masses of superincumbent rock fall by their own weight, as the lumps of coal fall in a mine through the skilful undercutting of the collier.

The work of the waves is assisted not only by the flux and reflux of the tides, but also by the "heave of the sea"; that is to say, the bodily conveyance of water by wind. When wind acts upon the surface of the sea it not only carves the surface into waves, but by the exercise of a powerful tangential force, heaps up the water upon the leeward shore. Something of the kind may be observed in a roadside puddle on a squally day. When a gust of wind has passed the water springs back suddenly to windward. In wind-forced waves the motion is not precisely a completed circle or ellipse. At each swing the water particle is brought slightly further forward than at the end of the previous swing. The result is that a stone on the bottom tends, on the whole, to be pushed towards the shore, and this tendency increases near the line of breakers. On the other hand, the slope of the shore assists the action of the backward swing of the water, so that at a certain depth the two motions balance one another. Outside the position corresponding to this depth a sloping sea-bottom tends to move seawards. Within this line the bottom tends to move shorewards, and to pile itself up into a beach or bar. If the entrance of a harbour be on the landward side of this line the harbour is liable to be silted up, especially in a tideless sea, where there is no scour to remove the heaped-up sand and shingle.

In designing structures to resist the force of the waves the marine engineer has to take account of the length from crest to crest attained by the waves in the locality, for on this depends the depth to which the water is agitated. The time which elapses between the passage of succeeding wave-crests, combined with the height of the waves, enables him to calculate the velocity of the swinging water particles on which depends the force he has to deal with. There has been much discussion as to the proper section which should be given to a breakwater in order that it may best resist the force of the waves. In deep water a vertical wall is presumably the most efficient. A vertical wall changes the running waves in its vicinity into *stationary waves*, in which the water simply oscillates up and down without any forward swing. This results from the reflection of the wave from the wall, the coincidence of a wave travelling towards the wall and a reflected wave travelling seawards giving rise to a wave which does not travel at all, but which retains the vertical motion, so that the position which is at one moment a crest is at the next a trough, and so on. Something of the same kind may be noticed where the sea rises and falls around a sunken rock. The stationary water-waves produced by reflection are very different from the standing waves in shallow running streams, where each crest and each trough maintains an independent fixed position. A vertical breakwater, although it has great advantages, is difficult and costly to construct; and where material is abundant and harbour space not too limited, a common method is to "dump" down a great quantity of rock, leaving the waves to lick the material into shape. This is how the Portland breakwater was made, and Fig. 2 shows the form of section to which it has been brought by the action of the waves. On the seaward side there is first a long, gently sloping beach where the breakers act, and below this is a shorter, steeper slope, where the material lies very nearly at the angle of repose which it would assume under the action of gravity. The form of the breakwater is said to be practically permanent, in spite of the fact that it is constructed of loose materials. It must be borne in mind that the breakwater is not situated like a sea-wall, but is supported by the water on the harbour side.

When waves are raised by wind we are not practically concerned with the expenditure of energy in their formation; but it is otherwise with the waves raised by ships, which retard the progress of the vessel by using up a part of her energy of motion. The resistance which water offers to the progress of a ship is of two kinds: skin resistance and wave-making resistance. As the speed of a ship increases, the wave-making resistance increases much more rapidly than the skin resistance, so that at high speeds the wave-making resistance may become equal to, if it do not exceed, the skin resistance; in other words, at high speeds one half of the resistance to a ship's motion may be due to the work of wave-making. Where, as in the case of torpedo-boats, high speed has to be attained by a vessel of small size, it is especially important that all the circumstances of wave-making should be carefully considered in settling the lines of the vessel.

In our next article we shall describe in detail the beautiful pattern of waves which is formed in the track of a ship.

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OUR FUR PRODUCERS.—II.

SABLE, MINK, ERMINE, AND RACCOONS.

By R. Lydekker, B.A.Cantab., F.R.S.

IN the preceding article of the present series we discussed the more aberrant fur-yielding members of the *Mustelidæ*, and there now remain the typical representatives of that family, or those which may be included in the genus *Mustela*. All these animals, which are severally known as martens, ermines, polecats, and weasels, are characterized by their long bodies and short limbs; and nearly all yield fur of a certain commercial value, while that of some species commands a very high price in the market.

To the larger members of the group, or those characterized by the possession of five pairs of upper and six of lower cheek-teeth, the general name of martens might be applied. Foremost among these, on account of the high value of its fur, stands the sable, or Siberian marten (*M. zibellina*), of Eastern Siberia and Kamschatka, which is a near relative of our own yellow-breasted or pine-marten (*M. martes*). Indeed, there is very considerable doubt whether the sable is entitled to rank as anything more than a local race of the latter species, distinguished by its finer and more abundant fur. In the pine-marten the general colour of the pellage is rich dark brown, but the breast has a light patch of variable size, which is generally some shade of yellow, although its tint may be anything between orange and creamy white; the under-fur being reddish grey with yellow tips. The usual length of the head and body varies from about sixteen to eighteen inches, while the bushy tail measures from nine inches to a foot. In the sable there is less variability of colour, brown and dark brown being the general hue of the fur; but occasionally light brown examples, or specimens with an admixture of silvery hairs, are met with, and in rare instances perfectly white sables are found. Light-coloured varieties appear to be most common in Kamschatka, which yields the largest quantity of sable that comes to market; whereas Siberian skins are generally the darkest, and consequently the most valuable. The highest priced pelts come from the province of Yakutsk: and next to these are those from Okhotsk, although they are of smaller size and less deep colour. The length and quality of the fur varies much with the season, sable killed in summer being of but slight value, and those killed in winter alone commanding a high price. Sable are always skinned entire from the tail forwards, so that the pelt, when removed, forms a bag.

For their size, winter sable-skins command, perhaps, the highest price of any pelts. In Kamschatka, according to Dr. Guillemard, the peasants receive, on an average, about sixteen roubles* per skin; but in St. Petersburg the price of the pelts varies from two pounds to upwards of twenty-five pounds each, and it is stated that as much as thirty-three pounds has been given for unusually fine dark-coloured specimens from Yakutsk. Silvery pelts are those for which there is the greatest demand in Russia, while dark specimens meet with the greatest favour in the markets of London and Paris. From Amurland, where Mr. Poland states from twelve thousand to twenty thousand sables are killed yearly, the greater number of skins are exported to China, where they are used for the robes of the Mandarins. In these the tails are not required, so the latter find their way into the London market, where they sell at from two to six shillings apiece, and are made into boas and trimmings. In Kamschatka about two thousand sables are annually caught; and in 1891 the number of skins sold in London alone exceeded nine thousand.

In Kamschatka, Dr. Guillemard writes that "there are various methods employed in catching sables, but a less number are trapped now than used formerly to be the case. Dogs are almost invariably employed to run them down in the deep snow or to tree them; and they are also smelt out by these trained animals in their holes at the roots of trees. The great object is to tree the sable, if possible.

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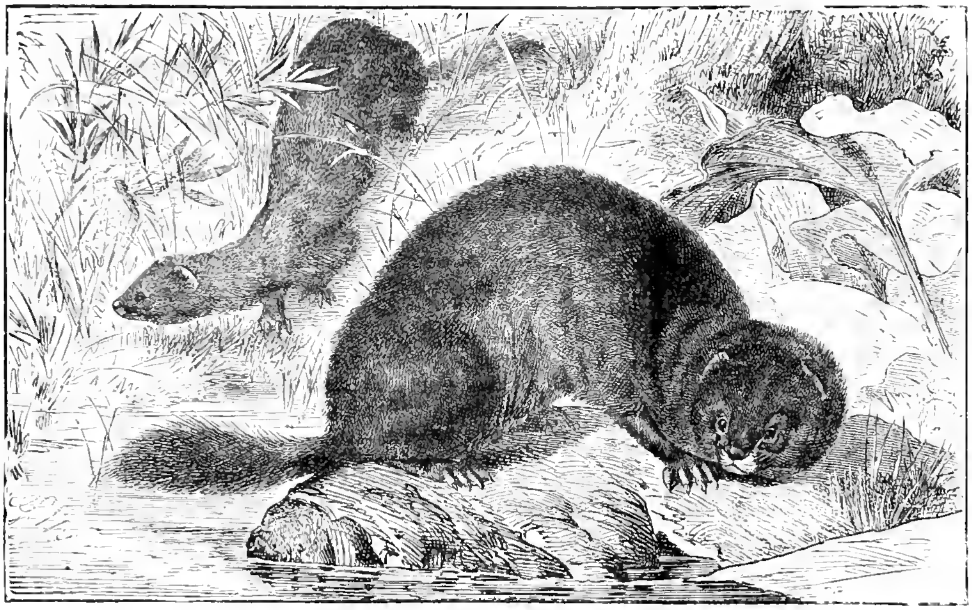
* The value of the paper rouble is about half a crown, and that of the silver rouble three shillings and sixpence.

The hunter then surrounds the base of the tree with nets, and either shakes down his quarry or knocks it off the boughs with sticks. If it does not fall into the net it is run down by the dogs, or again compelled to take refuge in a tree. Should the tree be too high for this method to be successful it is cut down, or the sable is shot; but the hunters generally avoid the use of the gun if possible, as it is apt to spoil the skin."

The pine-marten, which, although now scarce in Britain, is still abundant in many parts of Europe, is much less valuable than the last, skins averaging about half a sovereign apiece. The greater number appear to come from Lithuania and Courland, on the Baltic, whence the annual exportation amounts to about three thousand.

Very closely allied to the two last is the American marten or sable (*M. americana*). It is stated to differ from the pine-marten by certain characters of the teeth, while its fur is generally darker and subject to greater variation in tint. Regarding its relationship to the true sable, Dr. Coues observes that "the animal is, to all external appearance, indistinguishable except in some of those slight points of pellage which, through the whims of fashion, affect its commercial value; but there may be a technical zoological character of importance in the teeth." Probably we shall not be far wrong in regarding the two forms as local varieties of a single widely-spread species, although this is not the view of modern American zoologists. This marten has a wide geographical range in the northern half of the American continent, where it was formerly very abundant, upwards of fifteen thousand skins having been sold by the Hudson Bay Company in the year 1743, while about the same time thirty thousand were imported by the French from Canada. During the present century over one hundred thousand skins have been exported in a single year by the former company; and as late as 1891 they sold over sixty-four thousand, nearly forty thousand being accounted for in the same year by other traders. Great fluctuations occur in the value of these skins, which of late years has tended to depreciate; and in 1892 the range in price, according to quality, fluctuated between half a crown and two guineas each. There appear to have been good and bad "marten years," as is attested by Pennant, who wrote that once in two or three years these animals "come out in great multitudes, as if their retreats were over-stocked; this the hunters look on as a forerunner of great snows and a season favourable to the chase." A later writer, Mr. Ross, adds that the marten "occurs in decades or thereabouts with wonderful regularity, and it is quite unknown what becomes of them. They are not found dead. The failure extends throughout the Hudson Bay territory at the same time. And there is no tract or region to which they can migrate where we have not posts, or into which our hunters have not penetrated. When they are at their lowest ebb in point of numbers they will scarcely bite at all [at the baits of the traps]. Providence appears thus to have implanted some instinct in them by which the total destruction of their race is prevented."



The European Mink (One-third natural size).

In spite of the vast numbers destroyed for the sake of their pelts, these martens appear to hold their own so long as the country is left in its original wildness. Directly, however, civilization makes its presence felt they begin to diminish rapidly, and soon disappear completely; their shy and suspicious nature rendering them incapable of existing in the neighbourhood of human habitations.

Another species of the group, of which but comparatively little is known, is the Japanese marten (*M. melanopus*), its fur being distinguished by its light yellow. Commercially the pelts, of which from two to five thousand are imported annually into London, are of but small value, now averaging only from one to two shillings each.

The beech-marten or stone-marten (*M. foina*), sometimes also known as the white-breasted marten, is widely distributed over Europe and Northern Asia, but is a more southern form than the pine-marten, being unknown in the British Islands and Scandinavia. From the species last mentioned it may be readily distinguished by the dull greyish hue of the fur of the back and the pure white of that of the throat. There are likewise still more decisive differences to be found in the conformation of the skull and teeth, the former being relatively wider than in the pine-marten. The great market for the pelts of this species is Russia, but it is difficult to form any estimate of the number which annually change hands or the price they realize. The finest skins are stated to come from Bosnia.

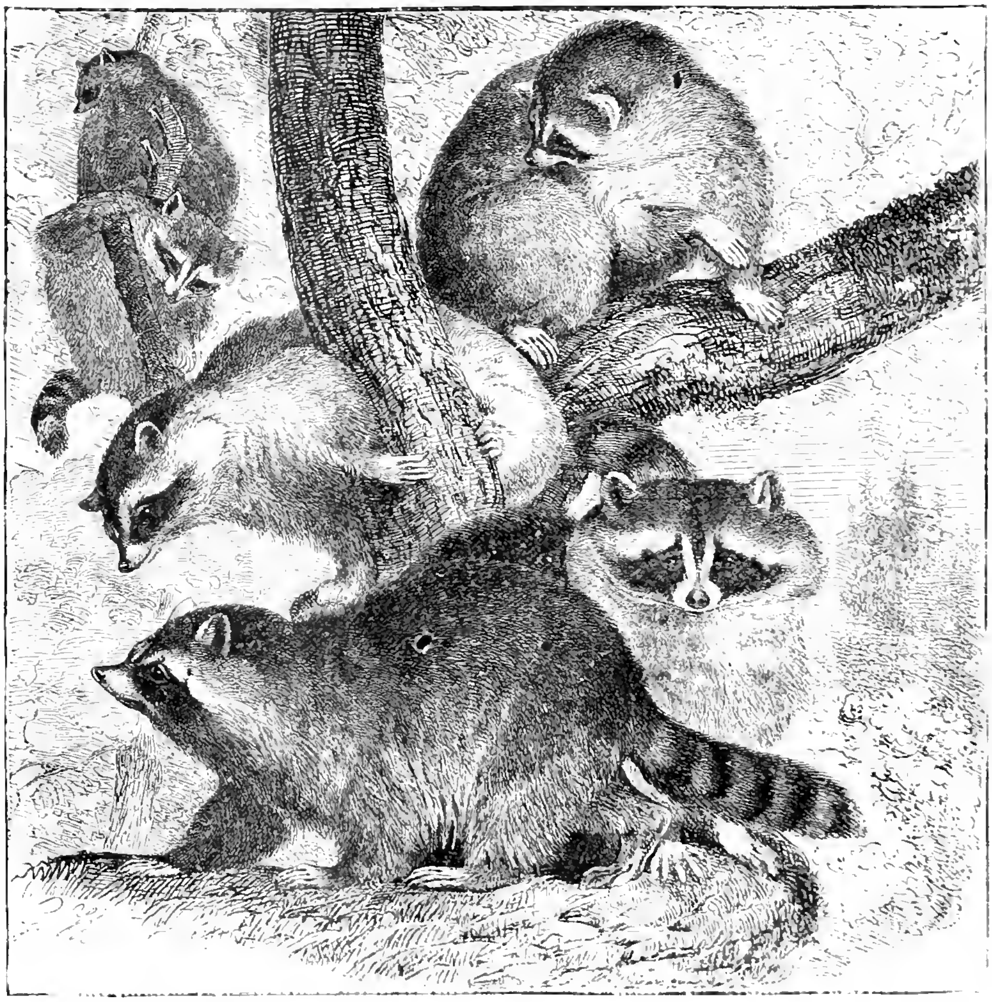
By far the most striking in appearance of the whole group is the Indian marten (*M. flavigula*), which inhabits the hills of India and some of the Malayan countries, and is distinguished by the deep blackish brown colour of the upper-parts and the bright orange or yellow of the chest. Although pelts of this handsome marten sell for about seven shillings apiece, they are so seldom brought into the market that they form no essential element in the fur trade.

Very different from all the foregoing is Pennant's marten (*M. pennanti*), also known as the pekan or fisher-marten, which is a North American species of the size of a fox. As it is likewise more fox-like than other martens, it is commonly termed the "black fox" by the trappers. In general colour it is blackish, darker below than above, and becoming greyish on the fore parts of the body and head. It apparently derives its name of fisher-marten from frequenting moister situations than others of its kind, although there does not seem any evidence that it catches fish. Indeed, its favourite prey is stated to be the Canada porcupine, which it kills by biting on the unprotected lower surface of the body. The finest skins are obtained from northern Canada, and these may fetch nearly four pounds each, although inferior specimens are sold for as little as three and sixpence. In 1891 between eight and nine thousand skins of this species were sold, the great majority by the Hudson Bay Company.

The mink (*M. vison*), which is typically a North American form, although it is represented by a closely allied species (*M. lutreola*) in Eastern Europe, is the first and largest member of the second great group of the genus *Mustela*. From the martens all these animals differ in having only four pairs of upper and five of lower cheek-teeth, as well as by certain structural differences in some of these teeth. On account of these and other points of distinction they are frequently separated as a genus, under the title of *Putorius*. Most of them are much smaller than the martens; but this is scarcely the case with the minks, which measure from fifteen to eighteen inches to the root of the tail. The pellage of these animals is remarkable for its rich silky gloss, the usual colour being a full dark brown, passing into black on the tail; the chest, like that of the pekan, being generally of the same dark tint as the rest of the fur. In habits the minks differ markedly from their allies, being amphibious animals, and subsisting partially upon fish, although they also kill and eat large numbers of the smaller mammals. Like the polecats, minks are decidedly ill-smelling creatures.

Although the fur of the mink is short it is extremely durable, and on this account, as well as from its beautiful gloss, it was at one time held in considerable estimation, and skins have been known to fetch as much as thirty shillings each. Of late years, however, it has declined in favour, and skins of the American species, according to Mr. Poland, now sell at from five pence to a guinea, while those of the Russian kind do not appear to exceed five shillings. Still, in spite of this depreciation in price, mink skins form a very important article of trade, upwards of three hundred and sixty thousand American pelts having been sold in London in 1890, and over two hundred thousand in the following year. Mr. Poland states that mink skins are chiefly used for muffs and coat-linings, while the tails are made into capes. The fur may be used either in its natural condition, or pulled and dyed to imitate sealskin.

The polecats, of which there are several kinds distributed over the northern parts of both the Old and New Worlds, yield a short fur of inferior value, which is known in the trade by the name of "fitch." The European polecat (*M. putorius*), which is too well known to require anything in the way of description, has the fur of the upper-parts dark brown, and that of the lower surface of the body and the tail black. But in the Siberian species (*M. eversmanni*) the back and head are covered with a nearly white fur. Like many other kinds of the commoner furs, fitch is of less value now than formerly; and whereas in the first quarter of the century the price was a little over four shillings per skin, it now varies from three shillings to eighteen pence. Although somewhere about two hundred thousand European pelts are sold annually at the Leipsic fair, but few find their way into the English market; and these, it appears, are chiefly employed for trimming aldermanic robes.



The Raccoon.

Of the smaller species of the genus by far the most valuable commercially is the ermine, or stoat (*M. erminea*), which in the more northern portion of its habitat turns wholly white in winter, with the exception of the black tip of the tail. And it is only these white winter skins that have any commercial value. Like the weasel, which also turns white in winter in the colder part of its habitat—even to the tip of its tail—the ermine is an inhabitant of both the Eastern and Western Hemispheres; and in the former the finest skins are the produce of Siberia. Ermine is chiefly used for the lining of state robes, the black-tipped tails forming an essential part of the fur. "It was once regarded," writes Mr. Poland, "as a princely fur, and only to be devoted to the use of royalty; but it has now become very much neglected, and a few years ago it was practically unsaleable. . . . The skins are very neatly tied up with bass in bundles of ten, twenty, or fifty. They are sold by the timber (forty skins). The present market value is twenty to thirty shillings per timber, and a few years ago it was even less. The highest price recorded for good skins is one hundred and eighty shillings per timber; two hundred and sixty-four thousand, six hundred and six skins were imported into London in 1836." Miniver is the fur of the ermine marked with black spots, instead of having the whole tail affixed. "Greybacks" are skins taken from animals at the time they were commencing to turn white for the winter.

With regard to the change of colour of the ermine at the commencement of winter, it was at one time considered that this was coincident with the autumnal shedding and renewal of the coat; that is to say, that the brown summer dress was shed, and replaced by the white one of winter, without any actual bleaching of the hairs themselves. That this is very generally the case has been conclusively proved by actual experiments. It has, however, also been shown that if an ermine that has assumed its winter dress in a temperate climate—when it will be of the dark summer hue—be subjected to a sudden or gradual lowering of temperature, its brown coat will soon turn pure white, thus showing that the individual hairs are capable of changing their colour.

The ermine closes the list of *Mustelidæ* important as fur producers, and we accordingly pass on to the much smaller group of the raccoons, or *Procyonidæ*. With the exception of a single Himalayan species, representing a genus by itself, the whole of these carnivores are American, the majority inhabiting Central and South America. From the weasel tribe they may be distinguished by possessing two pairs of upper molar teeth; and very generally the tail is marked by alternating dark and light rings, which is never the case in the former group.

The only species of any importance in the fur trade is the common North American raccoon (*Procyon lotor*), which extends over the whole of the United States, ranging towards the north-west into Alaska, and southwards into Central America. The southern examples are larger than the northern race. In size, the raccoon may be compared to an ordinary badger. It is a somewhat clumsily-built animal, with a sharp nose, small ears, plantigrade feet, and a short bushy tail, marked with narrow rings of black and white and generally having the tip black. The fur of the body, which is long, thick, and soft, is of a general greyish brown colour; but fawn-coloured or white examples are occasionally met with. Raccoon fur is an item of considerable importance in the trade; the best pelts coming from Wisconsin and Illinois, those from the southern portions of the animals' range having coarse and short fur. About half a million skins, ranging in price from sixpence to ten shillings, are sold yearly in the London markets; but unusually dark-coloured specimens may fetch as much as thirty shillings. Pale-coloured pelts are generally dyed black or brown, and when "pulled" the fur is often used to imitate beaver. Raccoon-fur is much used for coat-linings, but the better descriptions are employed for trimmings and capes; and, when clipped, it is sometimes manufactured into glove-tops. The prettily marked heads are not uncommonly seen mounted to ornament fur foot-warmers, and the tails are employed in rugs and boas.

Raccoons have less powerful teeth than the majority of the Carnivora, indicating that they are less addicted to a flesh diet; and, as a matter of fact, they are almost omnivorous creatures, feeding on nearly everything eatable that they may come across. They are good climbers, and are most generally found in the neighbourhood of water. Raccoon-hunting is generally undertaken with the aid of dogs; the animal being first treed, and then shot.

Were it not for the scarcity of the animal, the fur of the panda, or Himalayan raccoon (*Ælurus fulgens*), would form an important item in the trade; but since very few pelts come into the market it is necessarily but little used. The fur of the upper-parts is of a beautiful rich reddish brown, but is considerably darker on the lower surface of the body, the long tail being marked with broad reddish rings separated by narrower ones of black. The few skins that come into the market sell at from seven shillings to a guinea each.

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PHOTOGRAPH OF THE "CRAB" NEBULA, MESSIER 1 TAURI.

By Isaac Roberts, D.Sc., F.R.S.

R.A. 5h. 28m., Decl. N. 21° 57′.

The photograph covers a region of the sky equal to nineteen minutes of arc in diameter.

Scale, one millimètre to six seconds of arc.

The photograph was taken with the 20-inch reflector on January 25th, 1895, between sidereal time 4h. 30m. and 5h. 30m., with an exposure of the plate during sixty minutes.

References.

The nebula is N. G. C., No. 1952; G. C., No. 1157; h 357. Rosse, *Observations of Nebulæ and Clusters of Stars*, p. 47. It is figured in the *Phil. Trans. of the Royal Society*, 1833, Pl. XVI., Fig. 81, and in 1844, Pl. XVIII., Fig. 81; and also by Lassell, *Mem. of the Royal Astronomical Society*, Vol. XXIII., Pl. II., Fig. 1.

The drawings and the descriptive matter, referred to above, do not convey to us the same ideas as we gather from the photograph.

The photograph shows the nebula to be elongated in *south following* to *north preceding* directions; irregular in outline, and somewhat resembling an island with deep embayments at intervals round its margin.

More clearly than it is practicable to reproduce in a print, the negative shows mottling and rifts in the nebula. One rift curves round the *north following* margin, another extends across from the *north following* to the *south preceding* side, with a star of about the 14th magnitude at its centre. There are also some star-like condensations involved in the nebulosity.

A photograph of this nebula, taken on the 25th January, 1890, is given in the volume of *Photographs of Stars, Star-Clusters, and Nebulæ*, Pl. XIV., which shows the nebula and the surrounding region of the sky on the scale of one millimètre to twenty-four seconds of arc.

PHOTOGRAPH OF THE "CRAB" NEBULA, MESSIER 1 TAURI

By ISAAC ROBERTS, D.Sc., F.R.S.

[The "Crab" nebula, discovered in 1731 by Bevis (who, after the death of Bliss, the fourth Astronomer Royal, became a competitor for the vacant place), was rediscovered in 1758 by Messier, the "comet-ferret" of Louis XV., and was the occasion of Messier's drawing up his catalogue of nebulæ. This, practically the first catalogue of the kind, was published in 1771, and contained forty-five objects, at the head of which was the nebula with which we are now concerned. His second catalogue, published ten years later, included one hundred and three.

The "Crab" owes its name to the filaments springing from it, as the arms spring from a cuttle-fish, which are represented in the well-known drawing by the elder Lord Rosse. Lassell also represents various projecting appendages, but these do not confirm those recorded by Lord Rosse. There is, however, nothing crab-like in the beautiful photograph of it which Dr. Roberts has produced, nor do the later observations made with Lord Rosse's reflector bear out the earlier descriptions of the claws. The name, therefore, as indicating the shape of the nebula, appears a misnomer. It might, however, be still applicable in the oarsman's sense, for not a few tyros in the art of comet-seeking have been deluded by Messier 1, and have had sorrowfully to confess that they have "caught a crab." Perhaps no object in the heavens has been so often mistaken by beginners for a comet.—E. W. Maunder.]

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ANOTHER DARK 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.*

One hundred and seventeen years ago the star catalogued by Flamsteed as 70 Ophiuchi was discovered by William Herschel to be an easily-divided, unequal pair. Their mutual revolution quickly became apparent, and by 1872 the companion had resumed its original position *precisely* east of its primary. A period of ninety-three years was thus, it might be thought, emphatically asserted; yet the assertion has not been borne out by facts. The star is now certainly known to have been behind time in returning to the starting point. Left to itself, it would have accomplished the circuit in eighty-eight years. But it was not left to itself; and its unmanageability on the supposition of undisturbed elliptic motion is forcibly illustrated by the circumstance that periods ranging from seventy-three to ninety-eight years have been assigned to it by skilled computers, most of them with ample materials at command.

Few double stars have received so much attention as 70 Ophiuchi. It is a beautiful object to view, and a tempting one to measure; hence, all sorts and conditions of star-gazers have tried their hand at it. Much "grey matter," too, has been wasted in efforts to rationalize its movements. Encke exemplified with it, in 1830, his brand-new method for determining stellar orbits; Sir John Herschel followed with a less rigorous, though more satisfactory *modus operandi*: and they have had not a few imitators. The stars, meanwhile, preserved their independence, taking slight heed of the various and sundry orbits assigned to them, from which they diverged unaccountably and at once. Perturbations were tolerably evident; and Captain Jacob, the East India Company's astronomer at Madras from 1848 to 1859, hazarded the conjecture that the visible companion, while circuiting its primary in eighty-seven and a half years, described a secondary ellipse round an invisible or at least undiscerned body once in twenty-six years.[*] Sir John Herschel held a similar opinion, and the persuasion of the star's triplicity was so general that Mr. Burnham thought its telescopic verification worth some pains: but, neither with the Dearborn eighteen-inch, nor with the Lick thirty-six inch, could either of the components be subdivided; each alike was pronounced "round, with all powers."

At last, in 1893, Dr. Schur, of Göttingen, collected all his Teutonic patience for an attack in form upon the star.[†] His work was ably done. If the anomalies which had occasioned so much perplexity could have been got rid of, his skilful manipulation would have accomplished the feat. But his ellipse had not been obtained, so to speak, in the natural course. The observations of distance proving incompatible with the observations of position-angle, he had uncompromisingly rejected the former, and relied exclusively upon the latter; and even these had been subjected to suspicious corrections, implying a consensus of error between various excellent observers, now in one direction, again, after some lapse of time, in the opposite. Moreover, his elements stood very ill the test of prediction.

"While engaged recently," Dr. See writes,[‡] "in the observation of double stars at the Leander McCormick Observatory of the University of Virginia, I took occasion to measure 70 Ophiuchi on three good nights. On comparing the results with Schur's ephemeris, four months later, I noticed with surprise that the observed angle was over four degrees in advance of the theoretical place. As the Virginia measures had been made under favourable conditions and with extreme care, it became evident that the orbit to which Professor Schur had devoted so much attention would need revision."

He accordingly undertook the unruly star, and laid down for it an ellipse differing little from Mr. Burnham's in 1893,[§] or from Mr. Gore's in 1888.[‖] But this did not satisfy him. Comparing one by one the recorded and theoretical places of the revolving object, he detected systematic discrepancies, acceleration repeatedly alternating with retardation. Their genuineness was confirmed by an examination of Dr. Schur's *apparent* orbit—obtained by projection from the elements of his *real* one—showing departures from the observed distances corresponding to the departures from the observed rate of progress by which Dr. See's own calculations were, to a certain extent, vitiated. "We were thus," he remarks, "confronted with a case in which it was apparently impossible to satisfy both angles and distances."

In the accompanying figure, the dotted line represents Schur's ellipse; the smooth line, that constructed to accord with the measures of last year. Both are projections of the actual orbit upon a plane at right angles to the line of sight. So that they profess to portray just the visible facts of revolution, the larger star, as usual, being assumed for convenience to be stationary. The two curves—Dr. Schur's, it will be remembered, based upon angles alone, Dr. See's upon angles and distances alike—differ with curious regularity, one cutting the other at fixed intervals, as it runs in and out. Both are evidently drawn with dexterity and judgment; it would be time thrown away to try and improve upon them; yet neither accommodates itself within plausible limits to the given conditions. The stars were, in point of fact, by turns closer together and farther apart than they ought to have been according to the Göttingen calculations; they

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[*] H. Sadler, *English Mechanic*, Vol. XLI., p. 410.

[†] *Astr. Nach.*, Nos. 3220-1.

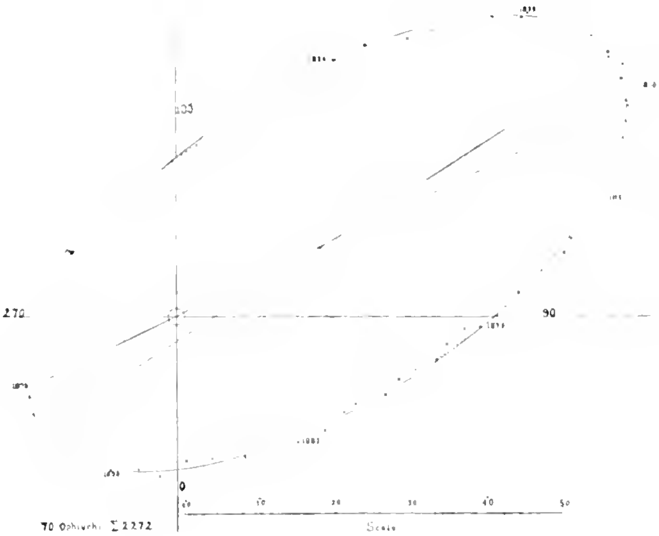
[‡] *Astronomical Journal*, No. 363.

[§] *Astronomy and Astrophysics*, June, 1893.

Monthly Notices, Vol. XLVIII., No. 5.

moved alternately quicker and slower than they were licensed to do at Chicago. And this not fallaciously, through a chance concurrence of deceptive data, but by "a law of order" in a "settled kingdom."

Dr. See tells us what this law is. The difficulties of his predecessors have proved to be his opportunity. They arose from the attempts, necessarily futile, to treat a ternary as a binary star. His discovery—for such it may be termed—of an obscure disturbing body in the system of 70 Ophiuchi exemplifies yet once more the value of "residual phenomena"—of vexatious incongruities undermining accepted arrangements, and bringing in their train, for many a long day, nothing but experimental failure and mental discomfort. Only by the severe treatment prescribed by modern methods can their true meaning be extracted. They have to pass through an ordeal of strict measurement, from which they emerge, if real, definite and unmistakable, while the collapsible sort vanish and are heard of no more. Instances of each kind of result might be cited, but we are here concerned with one that is solid and satisfactory.



There can no longer be any reasonable doubt that 70 Ophiuchi is a triple star, composed of two veritable suns, linked with a body highly influential upon movement, though devoid of appreciable luminous power. Coupled with the shining satellite, it describes round the chief star an orbit of more than planetary eccentricity in a period of eighty-eight years, while revolving in thirty-six round its immediate companion. Now the parallax of this object, reliably determined by Dr. Krüger, at Bonn, in 1858-1862, amounts to about one-sixth of a second of arc, corresponding to a light journey of twenty years.* Hence the mass and dimensions of the system are at once known. Taken together, the three bodies of which it consists possess 2·8 times the gravitative force of the sun; and the mean radius of the path pursued by the subordinate pair is twenty-eight times the distance of the earth from the sun, that of the orbit of Neptune being thirty times the same unit. The stars are, however, at present, separated by only one-third the gap of space which will yawn between them in the year 1910. For they are just now very near—almost at—periastron, and that point of closest approach, transplanted to the solar system, would be situated about midway between the orbits of Saturn and Uranus, while the apastron passage will take place no less than eleven hundred millions of miles beyond the region of Neptune's tardy circulation.

Turning to the secondary system of 70 Ophiuchi, we find the bright component revolving round its centre of gravity at a distance nearly twice that of the earth from the sun, its round of travel being thus considerably wider than the orbit of Mars. The apparent radius of its path is about one-third of a second, and, if the dark body to which it is attached be of equal mass, the interval dividing them is twice as great, so that Dr. See does not despair of its telescopic discovery. For it may not be wholly destitute of stellar lustre; and if clothed with even the imperfect luminosity of the companion of Sirius, it might, although much smaller, and more than twice as remote, be nevertheless detected with the Yerkes refractor. A single measure of its place would suffice to determine its mass, which must otherwise remain unknown.

The distribution of matter in stellar systems is a point of great interest, and of equal difficulty. Relative brightness is no guide to it. Satellite-stars are often attractive out of all proportion to their magnitude. Sirius emits ten thousand times more light than its attendant, yet it is only twice as massive. The stars of α Centauri bear equal sway in the system formed by them, notwithstanding the fivefold superiority in brilliancy of one over the other; and a corresponding disparity seems to exist in the beautiful tinted couple η Cassiopeiæ. Here the yellow primary surpasses its rosy attendant twenty-eight times in light, though no more than three times in mass, according to M. Otto Struve's location of their centre of gravity. Prof. Jacoby, however, proposes to test the accuracy of his result by measurements from the Rutherfurd photographic plates; and intrepid computers will no doubt come forward to execute his plan, which demands the solution of seven hundred and two equations involving sixty-six unknown quantities.

Endless gradations of radiative power seem to be represented in the stellar world; but the discovery of "dark stars," solely through their gravitational effects, must be regarded as a signal triumph of exact astronomy. They are found under varied circumstances. Witness the companion of Procyon, unseen, not assuredly through proximity to that lustrous orb, but through real obscurity; the fourth component of ζ Cancri, and the almost incredibly close satellites of Algol and other eclipse-stars, as well as of δ Cephei, and sundry short-period variables; besides an unknown multitude of undiscoverable orbs, which have ceased or never began to shine, or even of whole systems wrapt in thick darkness.

Dr. See reminds us that, for the carrying out of the geometrical plan of movement in 70 Ophiuchi, it is a matter of indifference whether the obscure component be attached to the larger or to the smaller star. "While we have spoken," he remarks, "of the dark body as attending the companion, it is clear that similar phenomena would result from the action of a body revolving round the central star. In this case, however, the considerable distance which would result from a period of thirty-six years might render the stability of the system somewhat precarious."

Perhaps more than precarious. The alternative arrangement could apparently subsist throughout a single revolution only by a happy chance. For if we ascribe to the central star and its big planet a combined mass twice

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* There seems no good reason for superseding as yet Krüger's parallax of 0″·162. Schur's few recent measures were made under such unfavourable conditions as to deserve, in his own opinion, little confidence.—*Astr. Nach.*, No. 3231.

that of our sun, the mean distance corresponding to a period of thirty-six years would be roughly one thousand three hundred million miles. But, since stellar orbits are mostly very elongated, their separation would, by a safe presumption, greatly transcend and fall short of this measure every eighteen years. Now the visible companion sweeps through periastron at a distance of fourteen hundred million miles: an actual collision, then, with its inconspicuous colleague (using the word in its strict sense) would be no improbable event; and approaches so close as to involve a complete subversion of the system could scarcely be averted. The conclusion is thus fully warranted that in 70 Ophiuchi the companion is the duplex star.

The combined spectrum of the pair was registered by Vogel as of the solar type, for the Arcturian variety of which it is claimed in the Draper Catalogue. Their rays have not yet been separately analyzed; indeed, so delicate an operation is scarcely yet feasible.

The colour of the smaller object of 6·5 magnitude appears subject to change. White, with "an inclination to red," in the elder Herschel's time, it showed to his son and to Sir James South as "livid"; Struve found it purplish; Admiral Smyth, violet; Flammarion, in 1879, termed it rose-coloured; while some intermediate observers recorded it as yellow; and yellow it now indisputably is. There is, in fact, no perceptible difference between its hue and that of its 4·5 magnitude primary. It will be curious to notice whether chromatic divergence sets in as they retire from periastron.

The mechanism of the system must be exceedingly intricate, but can scarcely, for many decades to come, be submitted to detailed investigation. Dr. See barely indicates the arduous nature of the task; we trust that his own powers may one day be employed in grappling with it. By that time, possibly, mathematical resources may have developed to meet the urgency of the demands made upon them by sidereal science. It is certain that the very highest powers of the human mind will be called into play for the solution of the multitudinous problems unfolded by the stars.

[There is just one addition I should like to make to Miss Clerke's graphic and striking account of a fact which must soon bulk largely in astronomical literature. Dr. See has drawn public attention to an interesting feature of the system of 70 Ophiuchi, and he has been the first to actually compute the movements of the companion on the assumption of an unseen third star. But this work can hardly be entitled a "discovery." The presence of the third member has long been postulated amongst those who have devoted themselves to the close study of double-star orbits. Nor does 70 Ophiuchi stand alone in this respect, and herein lies the exceeding importance of the subject. Fully ten per cent. of the best known binary systems show irregularities as truly periodic in character; many of them are even more pronounced and striking. Amongst others I might refer to 36 Andromedæ, ζ Herculis and λ Ophiuchi, and the beautiful pair referred to above by Miss Clerke, η Cassiopeiæ. The "dark companion" is not a rare exception; it has already been recognized in many instances, and future observations will certainly add to the number.

I would also emphasize Miss Clerke's objection to Prof. Schur's method of rejecting the measures of distance in the computation of an orbit. With modern appliances these are at least as trustworthy as the observations of position-angle, and their rejection nowadays can only be condemned as a discarding of important material.—E. Walter Maunder.]

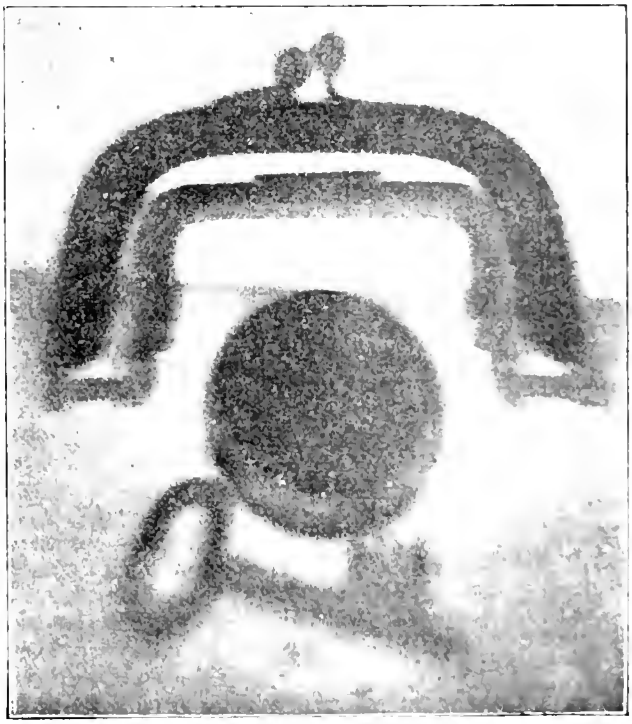
PHOTOGRAPHY OF INVISIBLE OBJECTS.

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

In his presidential address to the Royal Society in the year 1893, Lord Kelvin predicted that future discovery with regard to the relations of the luminiferous ether and ponderable matter would have as its basis knowledge obtained from experiments on the discharge of electricity through highly rarefied gases. What has taken place in the two years which have elapsed since that address was given has abundantly verified the correctness of Lord Kelvin's view as to the line along which future advance in physical science would take place.

The latest discovery in this department of knowledge has been of unusual interest, and has excited widespread attention beyond the limited circle of those more directly occupied with scientific work. Prof. Röntgen, of Vienna, has just published an account of some remarkable experiments he has been carrying out, and the results already attained are in themselves of great importance, whilst the possibilities of future insight into the nature of the ether which they open out cause them to be of intense interest to physicists.

It may be of interest to the readers of Knowledge to have put before them a short statement of the facts discovered and the methods of experimenting employed by Prof. Röntgen. He found that when he caused an electric discharge from an induction coil to pass through a Hiltorf's vacuum tube, or a tube containing a high vacuum like those employed by Crookes and Lenard, he got bright fluorescence produced on a piece of paper covered with platino-cyanide of barium, and this fluorescence was excited even when the tube itself was completely covered over with blackened paper so that nothing within it was visible. Moreover, the fluorescent



Photograph of a Leather Purse, showing metal clasp, coin, and key inside. By Dr. Dawson Turner.

glitter was visible whichever side of the painted paper was next the tube—that with the coating of barium platino-cyanide upon it or the other—and the appearance was produced when the paper was held several feet from the tube. In a similar way fluorescence was caused in many other substances, such as uranium, glass, rock-salt, etc. On interposing a thick book with a thousand pages between the discharge tube and the fluorescent screen, the fluorescence was still generated, the discharge or the effects it gave rise to being evidently able to pierce not only the blackened sheet next the glass, but many folds of paper.

On repeating these and similar experiments, using instead of a fluorescing screen a sensitive photographic film or dry plate, Prof. Röntgen got impressions or shadow pictures formed on the sensitive surface. Thus photographs, if we may call them such, could be taken while the sensitive plate was kept inside a wooden box, and the operations could be performed in daylight, the plate never being exposed to light, but preserved throughout in a wooden or cardboard box. It also became necessary to guard the plate from the effect of the discharge when it was not in use, shutting it up in a box being no protection.

Further researches showed that pine wood was easily penetrable by the rays. They may be called *rays*, for their effects on sensitive films are similar to those of the ultra-violet actinic rays, though whether these effects are due to the direct action of the rays, or to secondary phenomena resulting from the production of fluorescence and chemical change at the plate's surface, is not yet settled. Not only are paper, wood, leather, and suchlike materials transparent to these rays proceeding from a vacuum tube in which a discharge is going on, but metals and almost all substances are so to a certain degree. The amount of obstruction placed in the way of the rays by different sorts of material varies very much. Amongst metals, aluminium is comparatively transparent, while lead is in comparison very opaque. Ebonite and india-rubber allow easy passage to the rays, while some varieties of glass obstruct them much—lead glass especially; though from the fact that the tubes used for the discharge are of glass, it is evident that the rays are by no means cut off by that material.

From the relative opaqueness of lead, gold, and other heavy metals, the investigator was led to compare the obstructive effects of substances as related to their density; and whilst it was found that the density or quantity of matter contained in unit volume played the principal *rôle* in causing stoppage of the rays, the amount of this obstruction or opacity was by no means proportional to the product of thickness and density.

Röntgen next went on to try if these rays were refracted or bent out of their course, as ordinary light rays are, on passing from a rare to a dense medium. The result obtained was striking; no appreciable refraction was obtained when prisms of glass or ebonite were used. When light was passed through the same prism considerable deviation in the beam was obtained, the comparison showing a remarkable difference in behaviour of light rays and the new rays. Similarly the rays cannot be concentrated by means of a lens. Experiments made to test reflection gave not quite decided results. Crosses or stars cut out of metal and placed above a sensitive photographic plate indicated their position by a dark trace or shadow. This apparently pointed to reflection at the surface of the metal, but Prof. Röntgen inclines to the belief that what takes place when the rays pass through a solid or liquid is more like the passage of light through a cloudy medium consisting of discrete particles.

The rays seem to traverse a medium separate from matter and contained between the molecules of all varieties of matter. Substances such as glass when powdered obstruct the passage of light, as is well known, owing to reflection at the manifold surfaces of the particles arranged at all angles. A powdered body placed in the path of Röntgen's rays does not obstruct them more than an ordinary transparent solid. This last experiment seems to indicate the absence of reflection.

What, then, can these rays be which thus behave so differently from light rays? It has been suggested that they are waves of light of very short wave-length far beyond the known ultra-violet rays. If the wave-length is very minute and comparable with the magnitude of a material molecule's diameter, we might expect quite different effects from those of ordinary refraction. The absence of refraction in Röntgen's new rays—the *x* rays as he calls them for shortness—seems to show that the velocity of these rays is the same in all kinds of matter.

Röntgen Ray Shadow-picture of a Living Human Foot. Exposure 8 minutes, through ordinary cardboard.

Experiment clearly shows that the vibrations in the ether to which the phenomena of light are due are transverse to the direction of propagation of the waves.* Now there may also be longitudinal vibrations, and some physicists consider that there must be such. It becomes a most interesting question:—Are these new rays manifestations of the possible longitudinal vibrations in the ether? On the answer which may be given to this question the principal scientific interest in Röntgen's discovery turns. The discoverer himself is inclined to answer the question in the affirmative. Sir G. G. Stokes, our greatest authority on light, considers that it is probable the phenomena may be explained without bringing in longitudinal waves in the ether. In the present open state of the question it is interesting to remember the remarks made by Lord Kelvin in his course of lectures at Baltimore in 1884. He said, referring to longitudinal or condensational waves in the ether: "We ignore this condensational wave in the theory of light. We are sure that its energy is very small in comparison with the energy of the luminiferous vibrations we are dealing with. But to say that it is absolutely null would be an assumption that we have no right to make." Later in the same address he went on to say: "But that there are such waves I believe; and I believe that the velocity of propagation of electrostatic force is the unknown condensational velocity that we are speaking of."

The velocity of propagation of such longitudinal waves is shown by mathematical calculation to be enormously

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* *See* article on "The Luminiferous Ether" in Knowledge, 1894.

greater than that of the transversal vibrations, and may be spoken of as infinitely great. If the existence of such vibrations can be proved, and experimental evidence obtained as to the behaviour and effect of these longitudinal vibrations, a great step forward in our knowledge of the ether may be about to be taken. When it is remembered that the explanation of the cause of gravitation must be in some way bound up with the nature of the ether, it is easy to understand with what keen interest further developments of Professor Röntgen's work are looked forward to by all interested in the progress of science.

Note.—The photograph of a human foot was produced under the direction of J. A. C. Porter, Esq., and is published as a lantern slide by Messrs. Leo Atkinson, of Greenwich, by whom it was kindly lent to us for reproduction.

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In eclipses of the moon the brightness of the surface of the moon within the shadow of the earth depends upon the refraction and absorption of the sun's rays in passing through the earth's atmosphere. I. von Hepperger calculates the refractions and absorptions for various heights above the earth's surface, and from these are deduced the ratios between the eclipsed and ordinary luminosities for the various portions of the shadow. The estimation of the density of the atmosphere at various heights is based upon different theories and the facts as to the incandescence of meteorites. One conclusion reached is that at the beginning and end of totality the element of the moon's disc furthest from the centre of shadow is two or three hundred times as bright as the centre. As to the apparent excess of the size of the umbra beyond the geometrical shadow, this seems to be a physiological effect due to the fact that the eye cannot detect minute differences of brightness below a certain minimum of intensity.

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Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

COMETS.

To the Editors of Knowledge.

Sirs,—Mr. Plummer's interesting article on short period comets, and his mention of Mr. J. R. Hind in connection with them, recalls to my mind an incident in my early astronomical life which may be of interest, considering how recently Mr. Hind has been lost to us. On October 8th, 1858, I had the good fortune to be taken by a mutual friend to Mr. Bishop's observatory in Regent's Park, for the purpose of seeing Doneti's celebrated comet, then just passing its prime. Mr. Hind was of course there, showing the comet to the visitors. In the interval between the turns I got into conversation with the father of Mr. J. R. Hind, who told me that his son had had a taste for astronomy from the time when he was quite a small child, and that he was only twelve when he began regular work as an astronomer with an instrument which he (the father) had presented to his boy. I fear I have forgotten the immediate results of this boyish start, as stated to me, but the ultimate results are known throughout the world; for not only did Mr. Hind possess in a somewhat remarkable degree the gift of explaining in singularly terse and clear English any astronomical matter to which he applied his pen, but his letters to the *Times* through a period of fully forty years on astronomical matters in general and on comets in particular, furnished the general public with astronomical news up to date when writers on our science who appealed to the general press were few in number.

G. F. Chambers, F.R.A.S.

MIRA CETI.

To the Editors of Knowledge.

Sirs,—After reading the discussion on Mira Ceti in your columns, I resolved to watch this star closely during the winter and spring months. Up to the end of 1895 it was invisible to the naked eye, and during the first two weeks of January cloudy weather prevented all observation.

Judge, then, of my astonishment when on the 15th inst. I perceived Mira to be of the 3½ magnitude, quite conspicuous to the naked eye!

On the 19th it had increased to 3rd magnitude, and on the 23rd, with the moon nearly nine days old just above it, was easily visible as 3rd magnitude. On all these occasions Mira appeared, as seen either with glasses or through a telescope, of an orange colour. I should think that this sudden rise of this truly wonderful star is altogether unprecedented.

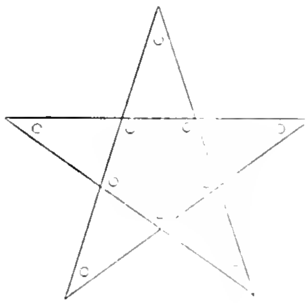
I ought to add that the only observation I know of previous to mine in January was made by Miss E. Brown (see *English Mechanic*, January 10th), who on January 2nd saw Mira as a 6th magnitude star or brighter, and previous to that, on December 15th, as 7th or 7½ magnitude, while Mr. David Flanery (see *English Mechanic*, January 10th) saw it as 7½ magnitude on December 17th. It would be very interesting to hear of any observations between January 2nd and January 15th.

Ivo. F. H. Carr-Gregg.

PENTACLE PUZZLE.

To the Editors of Knowledge.

Sirs,—A short time ago I sent a problem to your readers for solution, and now another equally interesting one has for some time occupied my attention. Perhaps some of your readers would demonstrate how many solutions can be given of it. There seems but one to me, but I cannot help thinking there must be five or more. The problem is to place the numbers 1 to 10 in the angles of a pentacle, as marked in the accompanying figure, so that each of the five sides shall count one and same number, and the five internal angles the same number, and the five external angles double the same number.



I. G. Ouseley.

GEOGRAPHY AS A SCIENCE.

To the Editors of Knowledge.

Sirs,—The views which Dr. Mill has expressed on the nature of geography, in his paper on "Geography as a Science in England," in the January number of Knowledge, are similar to those which I have long held and which I have long known him to hold. But I am much struck by the freshness and vigour with which he has stated them. His practical suggestion of a geographical description to accompany the Ordnance Survey is also well worthy of consideration. The general idea of a careful geographical description of Britain is not new to me, but I frankly confess that I feel much nearer to it now that, in connection with the Ordnance map, it has taken such precise form in Dr. Mill's mind. One point only strikes me as requiring great caution. There is danger lest the band of workers contemplated should approach this task from various standpoints, many of them not geographical. Both English and German experience shows the likelihood that specialists not trained in geography will miss what is geographically important, and will confuse the problems with details of value to geologists, botanists, and historians, rather than to geographers. The results of such a description could not fail to be important, but would be most striking if undertaken by a group of professed geographers whose views were in general accord. A national monument might be raised—a work of art as well as science—in the place of a miscellaneous heap of scientific bricks. Nothing would give me greater satisfaction than to see Dr. Mill carrying out his idea in connection with such a group of helpers. H. J. Mackinder.

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To the Editors of Knowledge.

Sirs,—I cannot, I regret to say, give "Geographer" the name of any work based exactly on the plan proposed in my article in your January number. The idea suggested is, I believe, a novel one, and an opportunity will be afforded at an afternoon meeting of the Royal Geographical Society, on March 6th, to discuss the possibility of carrying it into effect. The suggestion is simply that each sheet of the one-inch Ordnance Survey map should be provided with a concise memoir or handbook giving a complete index of place-names, the calculation of various physical constants, and a discussion of the geography of the district in the light not of the topographical map alone, but of all such supplementary data as are available in the Geological Survey, and the publications of the learned societies which deal in distributions.

There is one work recently published which, on a small scale and in a somewhat different manner, does carry out the geographical description of a part of the United Kingdom in a more complete way than has ever previously been attempted. It is the Royal Scottish Geographical Society's recently published *Atlas of Scotland*, by Mr. J. G. Bartholomew. This epoch-marking work contains a great map of Scotland in forty-five sheets, on the scale of two miles to one inch, showing contour lines of elevation and sea-depth, appropriately coloured so as to give a vivid idea of the vertical relief of the country. But there is in addition a series of small-scale maps showing the general configuration, the river basins, the distribution of vegetation or agriculture, the distribution of population as to density and as to language, the rainfall for each month and the temperature for each month of the year, the geological structure (on a large scale), the distribution of indigenous animals, the limits of deer-forests and fishery districts, and finally the counties. This is a scientific work the value of which to the student of geography it would be difficult to over-estimate. Were it accompanied by descriptive letterpress instead of mere statistics (the introduction, dealing with the physical features of Scotland, by Prof. James Geikie, is an exception), it would be quite such a work as "Geographer" asks for—a unification through geography of all the sciences involving distributions. Hugh Robert Mill.

1, Savile Row, W.
February, 1896.

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Notices of Books.

Justus von Liebig: his Life and Work (1803-1873). By W. A. Shenstone, F.I.C. (The Century Science Series, Cassell & Co.) 3s. 6d. Within a compass of about 200 pages Mr. Shenstone has succeeded in drawing such a vivid picture of Liebig as to enable us to form a clear conception both of the man himself in all his many-sidedness, and of the work in the various fields of pure and applied chemistry to which he devoted himself. Although but twenty-two years have passed since Liebig died, it is to be feared that to the majority of people—at least of the younger generation—he is now little more than a name. And yet he was not merely one of the very greatest chemists that ever lived (and will rank as such for all time), but no other man has ever equalled him either as a teacher of chemistry or in the application of that science to the arts and the various purposes of daily life. After a brief but interesting account of Liebig as a boy and youth, the friendship with his famous collaborator, Wöhler, is well described. This brings us to what we think is the weak point of the memoir, viz., the small space which is allotted to Liebig's discoveries in pure chemistry. The author himself alludes to this in his preface, but at the same time justifies the scale of treatment adopted by saying that "it is right that it should be so, for, vast as were Liebig's services to pure chemistry, they lack in some degree the splendour of his contributions to some other departments of equal intrinsic importance and of far wider general interest." But here we would join issue with him, because not only is much of Liebig's purely chemical work classical, but—what is more—it formed the groundwork to his own investigations in physiological and agricultural chemistry, and also served as a pattern and example to numberless other workers in the science. We trust, therefore, that in the next edition, which will doubtless be called for soon, Mr. Shenstone may see his way to modify his opinion upon this point in some degree, and treat the section in rather more detail. The chapter dealing with Liebig's work in agricultural chemistry is excellent. As a teacher Liebig was unique. Throughout the book, and in the last chapter more especially, justice is done to Liebig's high character and to the great personal influence which he exercised, while we are shown at the same time how intensely human the man was. Space will not admit of our adding anything about the marvellous amount of literary chemical work—scientific and popular—which he also accomplished, or, indeed, of saying more than to advise every student of chemistry, and everyone who is at all interested in the application of chemistry to common life, to read the book.

A Handbook of British Lepidoptera. By Edward Meyrick, B.A., F.Z.S., F.G.S. (Macmillan.) Illustrated. 10s. 6d. This book fills an undoubted want in entomological literature. Several popular books on butterflies and moths have lately been issued, but until now no complete work on British *lepidoptera* has appeared since Stainton's manual, published thirty-six years ago. In an able introduction, Mr. Meyrick explains structural formations, classification, and nomenclature, and thus makes intelligible the descriptions of the insects which follow. From these the collector should be enabled to identify his specimens with accuracy, and also to learn a great deal of their structure, the description of which the author has in every instance drawn up from his own observations. Some entomologists will, no doubt, find fault with Mr. Meyrick's system of classification, but his book will prove invaluable as the outcome of original research.

British and European Butterflies and Moths. By A. W. Kappel, F.L.S., F.E.S., and W. Egmont Kirby, L.S.A. (Nister.) Coloured plates. 25s. This is an excellent popular guide to the *macrolepidoptera* of Europe. Most of the species are included in the volume, and all the British species have English names assigned to them—a feature which has been neglected in many books of recent date. The larva, perfect insect, food plant, time of appearance, and locality of each species is carefully described, while coloured figures are given of a very large number of insects, larvæ and pupæ. These figures are beautifully executed, and with very few exceptions are wonderfully true to nature. With their help a novice could not fail to identify any species which is figured. We would heartily recommend the book to collectors as the most accurately illustrated one on the subject which we have seen.

Elements of Modern Chemistry. By C. Adolphe Wurtz. Translated by Drs. Greene and Keller. Fifth Edition. (Lippincott Co., Philadelphia.) Medium-sized handbooks on general chemistry are multiplying. Many of these new text-books are simply old ones in a new guise. In the majority of these books the theoretical portion of the science is much neglected, so that they become mere summaries of facts and reactions, without making any real progress in their educational value. We are, therefore, better pleased when we find authors content to bring out a new edition of such a standard work as Wurtz's "Elements of Modern Chemistry," which has already done such good service in the past. Its chief aim is to make clear the inner meaning of chemical laws and phenomena, so that one may confidently assert that theory is the strong point in this text-book. Wurtz is by no means an innovator in theoretical chemistry, but he has the very rare gift of expounding his subject in so easy and brilliant a way as to render chemical theories attractive even for those to whom they are still a terror. The present edition has been considerably enlarged by the translators, and we note that argon and helium are already included among the list of known terrestrial elements. The book is especially adapted for the use of medical students, to whom it will give a sound general knowledge of the elements of chemistry, without wearying them with details of secondary importance.

The Wild Fowl and Sea Fowl of Great Britain. By A Son of the Marshes. Edited by J. A. Owen. (Chapman and Hall.) Illustrated. 14s. In this book the author fully bears out his well-known character as a true and observant field naturalist, but, like the decoy man he describes, he is none too free with his information. The book is full of entertaining anecdotes, but we feel sure that it would have been more widely read had the author omitted the minute descriptions (which may be found in any handbook of British birds), and inserted in their stead more of his delightful local touches of man, bird, and beast. As a guide to the wild fowl and sea fowl of Great Britain the book has no particular interest, but as a fascinating book to read it must appeal to everyone, and, above all, to the field naturalist.

Reader's Shakespeare. Vol. I., Historical Plays. David Charles Bell. (Hodder & Stoughton, 1895.) There are, perhaps, few things so neglected by the average Englishman as the art of elocution. This is partly due to the lack of literature on the subject, and Mr. Bell's volume is not altogether an unsuccessful item towards filling up the gap. For although the author scarcely attempts to deal with the "power of speech" in general, the volume before us—the first of a series—may no doubt tend towards the elocutionary study of Shakespeare. And therefore we would recommend its condensed plays and its accentuated lines to the embryo student, or to the man too busy to make his own selections from the great dramatist.

Biological Lectures. (Ginn & Co.) The thirteen lectures contained in this volume were delivered at the Marine Biological Laboratory of Wood's Holl in the summer session of 1894. Nearly every lecture deals with one or other sides of the problem of organic development, and of the value of the whole to all who are concerned with the question of the nature of life there can be but one opinion. A special feature of the meetings at Wood's Holl is that an endeavour is made to bring the thoughts of workers in physical science to bear upon biological matters. Accordingly, we find that the first lecture in the volume deals with life from a physical standpoint, the expositor being Prof. A. E. Dolbear. This lecture alone is sufficient to form the basis of a review; it aims at showing that phenomena which are held to demonstrate the existence of a vital force may also be exhibited by inorganic matter—that, in fact, a definition of life which cannot be applied to the phenomena of non-living things has not yet been obtained. We look at the beautifully symmetrical arrangement of crystals in a snowflake, and ascribe the structure to physical agencies, denying to it the vital force which is assumed to control the movements of an amœba. Even spontaneous movement is not peculiar to living matter, for Quincke and Bütschli have made artificial protoplasm possessing all the characteristics of amœbæ, by means of a mixture of potassium carbonate and olein oil; which facts result in a feeling among biologists that "the phenomena exhibited by a living thing are finally resolvable into physical and chemical processes." We have only referred to one of the many lectures in the volume, but the others are no less interesting. The volume is not written so that he who runs may read its pages: it is for those who are in the current of modern scientific thought, or who wish to know what are the burning questions with biologists of to-day, and to such we heartily commend it.

Molecules and the Molecular Theory of Matter. By A. D. Risteen, S.B. (Ginn & Co.) Illustrated. 8s. 6d. In this volume the elements of the molecular theory of matter as it is held to-day are elucidated. For many years it has been maintained that every substance, however uniform and homogeneous and quiescent it may appear, is composed of separate particles, each of which is in rapid motion. The author brings together the observations of physicists which go to establish this proposition. Beginning with an examination of the kinetic theory of gases, he shows that a large range of phenomena can be referred to it, and then passes to apply the molecular theory to liquids and gases. The methods by which the general order of magnitude of molecules have been determined are afterwards described. In the last section of the book the field of observation is left, and speculations as to the constitution of molecules and the nature of intermolecular forces are dealt with. This brief statement will show the scope of the work, and it only remains for us to say that the treatment is excellent. A knowledge of mathematics is required before a few of the points discussed can be understood; but a large portion of the book can be readily followed and enjoyed by most readers of scientific literature. Every student of physics should add the volume to his library.

Great Astronomers. By Sir Robert S. Ball, D.Sc., F.R.S. (Isbister & Co.) Illustrated. 7s. 6d. No writer or lecturer on astronomy is better able to entertain the public than Sir Robert Ball. His style is attractive, and often ornate, and he does not over-burden his listener or reader with facts. This book is representative of his manner of exegesis; nothing in it is beyond the comprehension of the general reader, but, at the same time, the treatment is too redundant to be admirable. Too many anecdotes are introduced, on account more of their entertaining character than of their suitability: and the only reason one can imagine for the insertion of some of the information in a volume on "Great Astronomers" is that Sir Robert found the material available, and thereupon determined that its goodness should not be wasted. Having said so much—more in sorrow for the author's irrepressible humour and diffusibility than in anger at the inadequate accounts he gives of the work of some of the old astronomers—our depreciation ceases. The book is not for the serious student of astronomical history, but for those who read astronomy *pour passer le temps*. It contains an abundance of chatty information concerning the characters and surroundings of many famous astronomers, those whose lives are sketched being Ptolemy, Copernicus, Tycho Brahe, Galileo, Kepler, Newton, Flamsteed, Halley, Bradley, the two Herschels, Laplace, Brinkley, the Earl of Rosse, Airy, Hamilton, Le Verrier, and Adams. Numerous illustrations of these astronomers and their observatories adorn the pages of the book and add to its interest.

Dynamics. By Prof. P. G. Tait, Sec. R.S.E. (A. & C. Black.) 7s. 6d. It is generally easy to recognize the products of a master-mind, and even if this work had been published without the author's name upon the title-page the originality and force of the contents would at once command attention. Only a worker in the foremost ranks of physicists could expound the science of matter and motion in the manner of this volume. In the main the volume is a reprint of the article, "Mechanics," contributed by Prof. Tait to the "Encyclopædia Britannica;" but parts dealing with attraction, hydrostatics, hydrokinetics, etc., have been added to the original to complete the structure of the work. Those who know Thomson (now Lord Kelvin) and Tait's "Treatise on Natural Philosophy" will have an idea of the character of the present volume. Only students of mathematical mind can fully appreciate the force of the reasoning and the fundamental nature of the problems and theorems considered herein; but they will admire the development of the arguments as much as a poetic naturalist does the opening of a flower. A work by Prof. Tait needs no commendation to such students; all we need say to them is that the author's well-known views concerning the misuse of the word "force" find expression in a few sections.

The Natural History of "Eristalis Tenax," or the Drone-fly. By G. B. Buckton, F.R.S. (Macmillan & Co.) Illustrated. 5s. The author gives a description of the habits and anatomy of the drone-fly which will be serviceable to young entomologists, and may result in increased attention being given to the genus to which it belongs. The essay is almost entirely confined to the natural history of *Eristalis tenax* and *E. arbustorum*—both common in many parts of England. The classification, life-history, morphology, physiology, histology, and development, distribution, and myths connected with *Eristalis* are described in separate sections, and the whole is elucidated by nine plates. Entomologists will be glad to have this handy account of an interesting insect.

Pan-Gnosticism. By Noel Winter. (The Transatlantic Publishing Co.) Upon a train of reasoning which we cannot attempt to analyse, the author establishes the theory that completeness of knowledge is attainable, and he names his doctrine "Pan-Gnosticism." The aims of the book are thus very high, and though to us many portions read like tiresome platitudes, probably there are abstract philosophers who will derive satisfaction from an examination of the propositions advanced.

An Analysis of Astronomical Motion. By H. Pratt, M.D. (G. Norman & Son.) Illustrated. Dr. Pratt's theory, so far as we can understand it, is that the sun we see is in revolution around another sun, which in turn revolves around a third sun, and this travels around a fourth body, designated the central sun. Probably no one but the author believes in this quaternary solar system, and we have no desire to deny him the recreation he finds in exercising his ingenuity upon it. The book may be safely left to run its course. Astronomers have only to glance at a few pages to discover the fallacy of the conclusions drawn, and the unnecessary assumptions made to explain simple celestial motions; while readers who are not familiar with the mechanism of the heavens will find the book quite beyond their comprehension.

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BOOKS RECEIVED.

A Naturalist in Mid-Africa. By G. F. Scott-Elliot, M.A., F.L.S., F.R.G.S. (Innes & Co.) Illustrated. 16s.

Annual Report of the Board of Regents of the Smithsonian Institution. (Washington: Government Printing Office.)

Evolution and Man's Place in Nature. By H. Calderwood, LL.D., F.R.S.E. (Macmillan.) Illustrated. 10s.

Manual of Lithology. By E. H. Williams. (New York: Wiley & Sons.)

Heating and Ventilating Buildings. By R. C. Carpenter, M.S., C.E. Fifth Edition. (New York: Wiley & Sons.) Illustrated.

The Present Evolution of Man. By G. Archdall Reid. (Chapman & Hall.) 7s. 6d.

Applied Magnetism. By J. A. Kingdon, B.A. (H. Alabaster, Gatehouse, & Co.) Illustrated. 7s. 6d.

By Tangled Paths. By H. Mead Briggs. (Warne & Co.) Illustrated. 3s. 6d.

Minerals, and How to Study Them. By E. S. Dana. (New York: Wiley & Sons.) Illustrated.

Insect Life. By F. V. Theobald, M.A., F.E.S. (Methuen.) Illustrated. 2s. 6d.

Roads and Pavements in France. By A. P. Rockwell. (New York: Wiley & Sons.) Illustrated.

The Journal of Malacology. Vol. IV. (Dulau.) Illustrated. Cloth, 5s. 6d.

Remarkable Comets. By W. T. Lynn, B.A., F.R.A.S. Fourth Edition. (Stanford.) 6d.

Matriculation Directory. (University Correspondence College Press.) 1s.

Annuaire pour l'An 1896. (Brussels: Institut Nationale de Géographie.)

The World's Two Metal and Four Other Currency Intermediaries. By J. H. Norman. (Effingham Wilson.)

Submarine Telegraphy. By J. Bell and S. Wilson. (*Electricity.*) 1s. 6d.

The Influence of Literature on Architecture. By A. T. Bolton, Royal Institute of British Architects.

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PROTECTIVE RESEMBLANCE IN BIRDS.

By Harry F. Witherby.

PROTECTIVE resemblance, by whatever form of life it is exemplified, is a well-worn subject; but it is a subject of continual and lasting interest to those who love the beautiful in nature, and it is one of which, if our eyes are opened, we are every day seeing examples.

In the present article it is proposed merely to deal with a few instances of protective resemblance in birds, their nests and eggs, and not to touch on the theories which surround the subject, and which have been so often ably expounded. It is hardly necessary to explain the term "protective resemblance," but to the uninitiated we may say that it is the more or less complete likeness, in colouring or form or both, which a creature or object bears to its surroundings, thus often escaping detection.

In the accompanying full-page plate, which is an enlarged reproduction of a photograph taken by Mr. Geo. Burn Murdoch, of Doune, Perthshire, we have a beautiful example of a living creature so nearly in nature resembling its surroundings that it is difficult even for the practised eye to detect it. In the photograph the outline of the woodcock is, of course, more clearly defined than in nature; but even in the plate it is difficult to distinguish the bird if one stands some distance away. Now this protective colouring is admirably fitted to the needs of the woodcock, both in winter and summer. It is nocturnal in habit, and

WOODCOCK ON ITS NEST AMONGST THE FALLEN LEAVES.

From a Photograph by Mr. George Burn Murdoch

Nest of Little Grebe as left by bird, the eggs covered with weed.

spends the day concealed in woods and copses, often under some thick shrub and always on the ground; and the mottled browns and reds of its plumage so nearly resemble the leaves with which the ground in a wood is always covered, that it is almost impossible to discover the bird even when one is searching for it. Indeed, were it not for its round and lustrous black eye the "cock" would seldom be seen on the ground. In the nesting season its protective colouring is again of the greatest service. The nest is a slight hollow amongst the fallen leaves, often in a sheltered position, as in our illustration, where the bird has ensconsed itself beneath a fallen bough; and here it sits on eggs or young in conscious security, allowing itself to be almost trodden upon before it moves. Few birds are so well protected by their colour as the woodcock, and it is difficult to say why this bird should be so singularly well provided for in this respect; but it may be taken as a general rule that birds (especially the females) which rest or make their nests on the ground are more or less protectively coloured. A striking case of protective resemblance is afforded by the males of many sorts of ducks and geese at certain periods of the year. These birds, as everyone knows, are very gaily attired in comparison to the females, but, strange to say, for several weeks in the summer they lose their brilliantly-coloured plumage and assume the duller garb of the female. On enquiring into the cause of this curious change we find that, contrary to the usual rule, ducks and geese moult all their flight feathers at the same time, and are therefore incapable of flight for a considerable time. When in this helpless state they generally resort to reed beds and such places, and it will be easily seen what an immense advantage the dull and protective plumage is to them at this period.

There are not so many examples of protective resemblance which are easily recognized in birds as in other classes of animal life. The habits of the bird must generally be closely studied in connection with its colouring before it can be ascertained if this colouring is a special protection, and these cases are always of greater interest than those which are more apparent.

Turning from the bird to its nest or eggs, we have abundant examples—especially in those species which build their nests or lay their eggs in positions exposed and easy of access.

What ornithologist has not hunted for hours, and often in vain, for the eggs of some bird such as the ringed plover or tern, which lays its eggs without a nest of any sort amongst the shingle? In fact, the only satisfactory way of finding these eggs is to watch the bird from a distance until it settles on them, and then to walk straight up to the spot. Even then, if the eye is not kept steadily on the mark, one may often walk past or even over the eggs without seeing them, so closely do they resemble the stones amongst which they are laid.

Again, take the familiar examples of the peewit, the goatsucker, and skylark—every countryman must have experienced the difficulty of finding the eggs of these birds. Many birds, too, such as the chaffinch, the long-tailed tit, the wren, and a host of others, make their nests of materials so much akin to those with which they are surrounded that a passing glance would not detect the nest. One is often only conscious of a slight thickening in a bough or of some irregularity of form, until a more careful scrutiny reveals a nest.

Turning now to the two illustrations of the nest of a little grebe or dabchick (also from photographs by Mr. G. Burn Murdoch), we have a curious instance of protective resemblance coupled with a mild deception practised by the owner of the nest. The dabchick lays its eggs on some mass of green floating weed which is so common on streams and ponds. This nest, if we may so call it, is like any other mass of weeds, except, perhaps, that it is a little higher and more compact, but not sufficiently so to enable one to distinguish it. So far, then, the nest is perfectly safe; but when the bird has laid its chalky white eggs it would be instantly detected had not its owner the

Same nest as above, with covering over eggs removed.

means of concealing them. This it effects by covering up the eggs with weed as it leaves them; thus once more transforming the nest into apparently nothing more than a floating mass of weed. In the one photograph we have the nest as it was left by the bird, while in the other the weed covering the eggs has been removed. This covering of wet, dirty weed answers other purposes, for, in a few days' time, the eggs become so covered with dirt that they are exactly the colour of the nest, and thus stand a chance of escaping detection should the bird be forced to leave the nest before it has time to hide its eggs, as sometimes happens. Moreover, the wet weed, by "heating," serves to keep the eggs warm, thus allowing the bird to leave them for a considerable time if necessary.

We have dealt with but a few examples of protective resemblance, but we venture to think that enough has been said to show what variety and interest is attached to the subject.

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THE LIMBS OF TRILOBITES.

By PHILIP LAKE, M.A., F.G.S.

Of all the fossils which are found among the older rocks of the earth's crust, there are none which have attracted more attention than trilobites. Even so long ago as the seventeenth century Lhwyd drew and described certain "figured stones," among which several of these forms may be recognized. The name itself dates from the year 1771, and is derived from the trilobed character of the body.

In spite, however, of the labours of generations of skilled palæontologists, little was known of these animals except the shell or "test" of the back. For it is a remarkable fact that, although trilobites are very common in many localities, yet it is only the back that is seen, and in very few cases indeed has the under-surface of the body been observed, or any trace of limbs. There are several ways of accounting for this. In the first place, the limbs may have been soft and delicate, unfitted for preservation in a fossil condition; and, in the next place, it is pretty certain that trilobites, like most crustaceans, used to cast their shells periodically, and it is probable that many of the specimens we find are simply these discarded coverings.

Within the last few years, however, a great deal of light has been thrown upon the structure of trilobites by the discovery of extraordinarily well preserved specimens near Rome, in the State of New York; and this discovery is so remarkable that it deserves more than a passing notice.

An ordinary trilobite, such as the "Dudley locust" (Fig. 1), so abundant in the limestones near Dudley, is made up of three distinct parts. In front is a semicircular shield-like head, usually bearing a pair of eyes; behind this there are a number of narrow segments articulating with one another, and forming what is called the thorax; and behind the thorax is another broad shield generally spoken of as the tail. We do not know how far the head, thorax, and tail correspond with the similarly named parts of other animals; but the terms will serve if we remember, for example, that the thorax does not exactly represent the thorax of an insect.

Many other crustaceans also possess parts which may be called head, thorax, and tail; but trilobites exhibit several peculiarities which are not met with in other forms. In every trilobite the body is more or less clearly marked out into three divisions by two longitudinal furrows, which run from the head through the thorax into the tail. Between the furrows lies the "axis," which generally forms a prominent ridge extending nearly the whole length of the body; and on each side of the axis are the more flattened "lateral lobes."

The head usually presents another peculiarity which is not found in the adult of any living crustacean. In a form such as *Calymene* it will often happen that even a good specimen does not show the whole of the head, but only the central part. At the same time it will be clear that this is not due to an accidental fracture, for the separation has taken place along a regular symmetrical line; and if we examine a complete specimen we shall find this line distinctly marked. The head, in fact, is jointed, and the line of the joint separates the lateral parts of the head from the central portion. This line is called the "facial suture," and in *Calymene* it runs from the front margin to the hinder corners of the head.

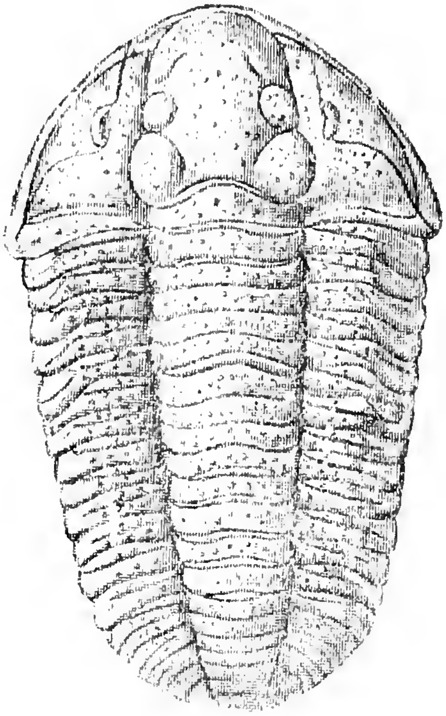

FIG. 1.—*Calymene Blumenbachi* (the "Dudley locust").

The trilobation of the body and the presence of the facial suture are the two most striking peculiarities of the upper surface of trilobites. The king-crab of the present day in its young state is distinctly trilobed, and also shows a facial suture, and hence many writers were led to conclude that it is the nearest living ally of the trilobites. But this idea is probably incorrect.

Of the under-surface of the body, the only part that is commonly met with is the "labrum" or "hypostome" (see Figs. 4 and 5). This is a broad plate attached to the front margin of the head and reaching backwards as far as the mouth.

Nearly half a century ago a Russian geologist named Eichwald found certain jointed cylindrical fossil fragments along with numerous trilobites, and he came to the conclusion that these were the antennæ and limbs. But they were not attached to the bodies, and most palæontologists looked upon them with suspicion.

Other writers found what they supposed to be the points of attachment of limbs; but it was not till 1870 that any specimen was discovered showing the limbs actually attached to the body itself. It was in a specimen of the genus *Asaphus* (Fig. 2), in America, that this fortunate discovery was made; and it showed that each of the eight thoracic segments bore a pair of cylindrical-jointed legs, adapted for walking rather than swimming. About the same time Dr. Woodward discovered a small palp, not unlike the palps of the jaw of an insect, lying close up against the hypostome of another specimen of the same species.

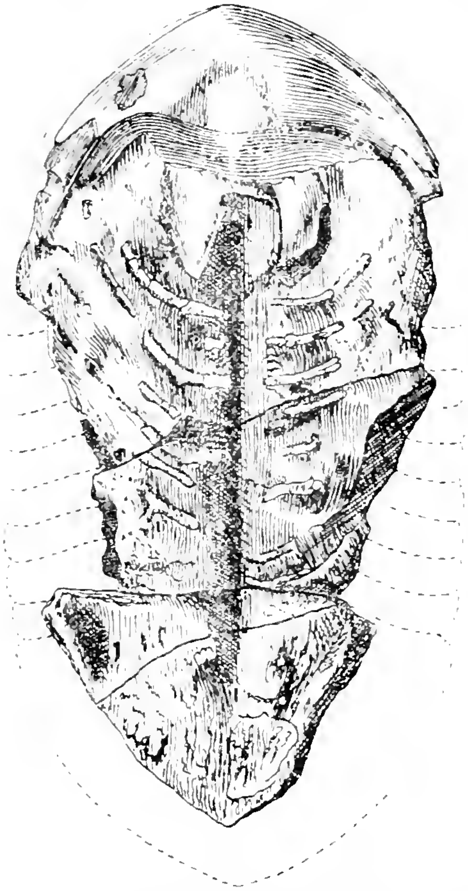

Fig. 2.—Under side of *Asaphus platycephalus*, showing the thoracic legs. (After Billings.)

But in spite of such discoveries there were still sceptics who denied that these were really limbs, and looked upon the "legs" as mere thickenings of the under-surface of the body. In order to set this question at rest an American geologist, Walcott, conceived the idea of cutting across the bodies of well-preserved trilobites and thus exposing the limbs in section, if they should happen to have left any traces of their presence. He made several thousands of sections, but only some two hundred and seventy of them were found to be of any use.

Even with these sections it was no easy task to determine the character of the limbs. A single section could show but little; and it was only by examination of the whole series that Walcott was enabled to form a general idea of the nature of the appendages.

He found no trace of antennæ; but the head bore four pairs of appendages surrounding the mouth (Fig. 3). All were jointed, and the first three were slender, while the fourth was much stronger and broader. Each segment of the thorax and of the tail also possessed its own pair of limbs; and these were all of the same character, but diminished in size towards the tail. Each limb (Fig. 4) consisted of a broad basal joint articulating with the body; and from this joint sprang two branches, both of them slender and made up of several segments. The outer branch was provided with a row of bristles. Such limbs could not have been used for swimming, and the animal must have crawled upon the bottom of the sea.

But this is not all. Many of the legs also bore a delicate doubly-branched filament, which was often coiled into a spiral. These, no doubt, were the gills or breathing organs. Many living crustacea have the gills attached to the limbs, and in the genus called *Cyamus* these gills are spiral.

Walcott's observations thus confirmed the conclusions based on the American specimen of *Asaphus* already noticed, and they were themselves confirmed by the discovery of a second specimen (of a slightly different species) showing the limbs much more perfectly (Fig. 5).

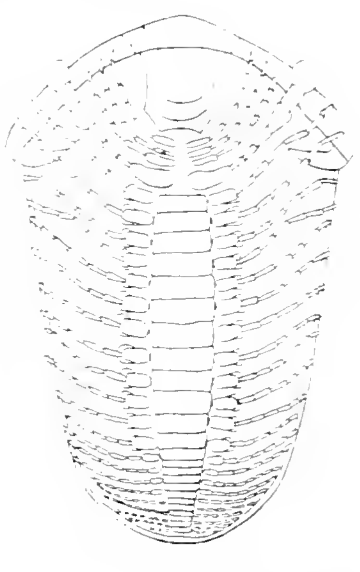

Fig. 3.—Restoration of the under surface of *Calymene*. (After Walcott.)

So matters remained until the last year or two, when a startling discovery was made near Rome, in the State of New York. Trilobites are very abundant in certain slaty beds near that town, and they are more perfectly preserved than any which have hitherto been found elsewhere. Many of the specimens show the limbs, and some of them even possess antennæ, of which no trace had yet been discovered. Most of them belong to the species *Triarthrus becki*, but other forms are not uncommon. The specimens have been partly described by Matthew and Beecher, and the latter is still engaged in studying them.

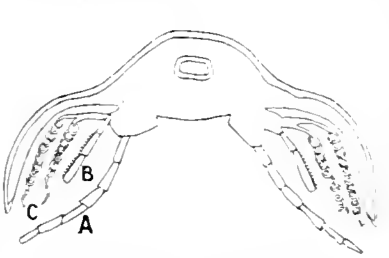

Fig. 4.—Section of *Calymene*. (After Walcott.) A, inner branch of the limb; B, outer branch; C, spiral gills.

The presence of antennæ is, perhaps, the most interesting feature of the discovery (Fig. 6). They are attached to the sides of the hypostome on the under-surface of the head, and extend forwards as slender jointed filaments, not unlike the antennæ of a lobster. Besides these, the head bears four pairs of appendages, as Walcott had concluded. The thorax also and the tail bear limbs, and all of the appendages except the antennæ are built upon the same plan. Each commences with a basal joint articulating with the body of the animal, and from this spring two branches, each of which is made up of a number of joints or segments.

But although the general plan of all the limbs is the same, the details are modified in different parts of the body to suit various purposes. In the head the limbs were required to serve as jaws, while towards the hinder end of the body they were used for swimming. We may look upon the appendages of the second thoracic segment as a kind of middle stage between these extremes. The inner part of the basal joint is here prolonged into a spur projecting towards the middle line of the body; the two branches are long and slender, and the outer one bears a row of bristles.

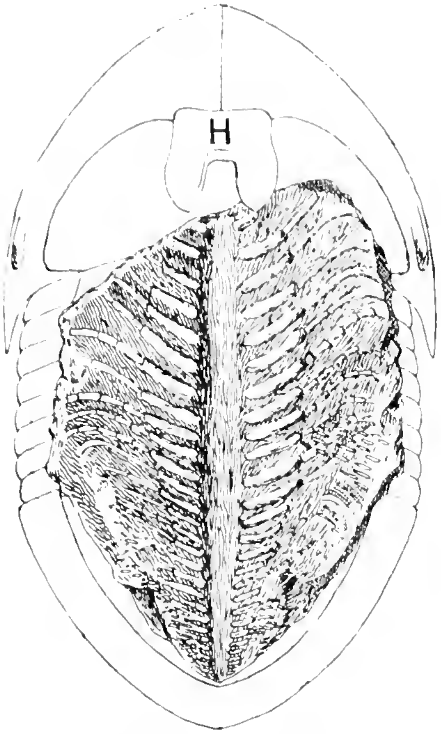

Fig. 5.—Under surface of a specimen of *Asaphus megistos*, showing the limbs. (After Walcott.) H, hypostome.

In the head (Fig. 6) the basal joint is more strongly developed, and the spur is modified to form a jaw working against the corresponding part of the limb on the other side of the body. At the same time the two branches of the limb become smaller and weaker.

As we trace the limbs backwards, on the other hand, we find that the spur of the basal joint becomes shorter; and the segments of the inner branch, instead of remaining cylindrical, become broad and flat. The whole limb, in fact, is adapted for swimming rather than for any other purpose.

Hitherto no trace of the spiral gills described by Walcott has been discovered in these specimens. But it must be remembered that Walcott's sections belonged to quite a different genus of trilobites. Allowing for this and for the great difficulties with which he had to contend, it is gratifying to find that his careful and painstaking researches led him so nearly to the truth. There can be little doubt that the genera examined by him (*Calymene* and *Ceraurus*) bore antennæ, although he did not discover them. Indeed, Walcott himself now believes that he has found a trace of antennæ in some of his sections. It is probable, too, that the appendages of the tail of *Calymene* may have been flattened, but this must remain doubtful for the present.

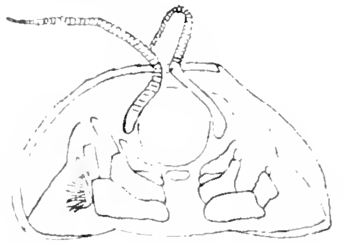

Fig. 6.—Under side of head of *Triarthrus*, showing the antennæ and organs of the mouth. (After Beecher.)

We may heartily congratulate the American palæontologists upon the results of their long-continued labours; but is it too much to hope that Europe may some day join in these researches? Not a single specimen of a trilobite showing appendages has yet been discovered except in America. Surely a diligent search among the least altered of our older rocks might meet with its reward.

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THE FACE OF THE SKY FOR MARCH.

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

Sunspots and faculæ are evidently decreasing in number and size, but should be observed whenever the Sun is visible. Conveniently observable minima of Algol occur at 9h. 56m. p.m. on the **20th** and at 6h. 45m. p.m. on the **23rd**.

Mercury is a morning star, but, in spite of his attaining his greatest western elongation (27¼°) on the **5th**, he rises so soon before the Sun that he is by no means well situated for observation. We give an ephemeris of him for the first third of the month; after that he approaches the Sun too closely to be visible. On the **1st** he rises at 5h. 51m. a.m., or about one hour before the Sun, with a southern declination of 16° 12′, and an apparent diameter of 7½″, just one-half of the disc being illuminated. On the **6th** he rises at 5h. 47m. a.m., or 50m. before the Sun, with a southern declination of 15° 31′, and an apparent diameter of 7″, $\frac{55}{100}$ths of the disc being illuminated. On the **11th** he rises at 5h. 44m. a.m., or 41m. before the Sun, with a southern declination of 14° 14′, and an apparent diameter of 6½″, $\frac{65}{100}$ths of the disc being illuminated. While visible he describes a direct path in Capricornus to the borders of Aquarius.

Venus is a morning star, but is rapidly getting lost in the Sun's rays. In her case, also, we only give an ephemeris for the first third of the month. On the **1st** she rises at 5h. 38m. a.m., or 1h. 10m. before the Sun, with a southern declination of 18° 4′, and an apparent diameter of 12¾″, $\frac{83}{100}$ths of the disc being illuminated. On the **11th** she rises at 5h. 30m. a.m., or 55m. before the Sun, with a southern declination of 14° 51′, and an apparent diameter of 12¼″, $\frac{86}{100}$ths of the disc being illuminated. While visible she describes a direct path in Capricornus, being near θ Capricorni on the **3rd**.

Mars is at present an object of no interest whatever to the amateur, and Uranus rises so late that we defer an ephemeris of him until next month.

Jupiter is still a splendid object, both in the evening and morning sky. On the **1st** he sets at 5h. 32m., or 1h. 16m. before sunrise, with a northern declination of 20° 52′, and an apparent equatorial diameter of 44·4″. On the **11th** he rises at 0h. 47m. p.m., with a northern declination of 21° 0′, and an apparent equatorial diameter of 43¼″. On the **21st** he sets at 4h. 10m. a.m., or 1h. 51m. before sunrise, with a northern declination of 21° 3′, and an apparent equatorial diameter of 42·0″. On the **30th** he rises at 11h. 30m. a.m., and sets at 3h. 31m. a.m. on the **31st**, with a northern declination of 21° 2′, and an apparent equatorial diameter of 40¾″. He describes a short retrograde path in Cancer till the **21st**, when he begins to retrace his steps. The following phenomena of the satellites occur before midnight on the days named, while the planet is more than 8° above and the Sun 8° below the horizon: On the **1st** a transit ingress of the third satellite at 6h. 49m. p.m., of its shadow at 10h. 13m. p.m.; a transit egress of the satellite itself at 10h. 27m. p.m., an occultation disappearance of the first satellite at 11h. 26m. p.m. On the **2nd** a transit egress of the fourth satellite at

6h. 31m. p.m., a transit ingress of the first satellite at 8h. 45m. p.m., of its shadow at 9h. 37m. p.m., a transit ingress of the shadow of the fourth satellite at 10h. 1m. p.m., a transit egress of the satellite at 11h. 5m. p.m., a transit egress of the shadow of the first satellite at 11h. 57m. p.m. On the **3rd** an eclipse reappearance of the first satellite at 9h. 3m. 17s. p.m. On the **7th** a transit ingress of the second satellite at 7h. 38m. p.m., of its shadow at 10h. 32m. p.m., a transit egress of the satellite at 10h. 19m. p.m. On the **9th** an eclipse reappearance of the second satellite at 7h. 27m. 32s. p.m., a transit ingress of the shadow of the first satellite at 10h. 33m. p.m., and of its shadow at 11h. 31m. p.m. On the **10th** an occultation disappearance of the fourth satellite at 10h. 16m. p.m., and an eclipse reappearance of the first satellite at 10h. 58m. 26s. p.m. On the **11th** a transit egress of the first satellite at 7h. 20m. p.m., and of its shadow at 8h. 20m. p.m. On the **12th** an eclipse reappearance of the third satellite at 7h. 41m. 57s. p.m. On the **14th** a transit ingress of the third satellite at 10h. 2m. p.m. On the **16th** an eclipse reappearance of the second satellite at 10h. 2m. 16s. p.m. On the **17th** an occultation disappearance of the first satellite at 9h. 31m. p.m. On the **18th** a transit ingress of the shadow of the first satellite at 7h. 55m. p.m., a transit egress of the satellite at 9h. 9m. p.m., a transit egress of its shadow at 10h. 15m. p.m. On the **19th** an occultation reappearance of the third satellite at 7h. 15m. p.m., an eclipse reappearance of the first satellite at 7h. 22m. 31s. p.m., an eclipse disappearance of the third satellite at 8h. 9m. 38s. p.m., a transit egress of the shadow of the fourth satellite at 8h. 48m. p.m., an eclipse reappearance of the third satellite at 11h. 41m. 42s. p.m. On the **23rd** an occultation disappearance of the second satellite at 7h. 28m. p.m. On the **24th** an occultation disappearance of the first satellite at 11h. 21m. p.m. On the **25th** a transit ingress of the first satellite at 8h. 40m. p.m., of its shadow at 9h. 50m. p.m., a transit egress of the satellite at 11h. 0m. p.m. On the **26th** an occultation disappearance of the third satellite at 7h. 19m. p.m., an eclipse reappearance of the third satellite at 12h. 9m. 8s. p.m. On the **30th** an occultation disappearance of the second satellite at 9h. 57m. p.m.

Saturn is an evening star, rising on the **1st** at 11h. 43m. p.m., with a southern declination of 15° 10′, and an apparent equatorial diameter of 9·1″ (the major axis of the ring system being 42·0″ in diameter, and the minor 15½″). On the **10th** he rises at 11h. 8m. p.m., with a southern declination of 15° 6′, and an apparent equatorial diameter of 9·2″ (the major axis of the ring system being 42½″ in diameter, and the minor 15¾″). On the **20th** he rises at 10h. 26m. p.m., with a southern declination of 14° 59′, and an apparent equatorial diameter of 9·4″ (the major axis of the system being 43″ in diameter, and the minor 16″). On the **31st** he rises at 9h. 41m. p.m., with a southern declination of 14° 50′, and an apparent equatorial diameter of 9½″ (the major axis of the ring system being 43½″ in diameter, and the minor 6¼″). Titan is at his greatest eastern elongation at 2h. a.m. on the **16th**, and Iapetus at superior conjunction at 4h. a.m. on the **7th**. During March Saturn describes a short retrograde path in Libra, without approaching any naked-eye star.

Neptune is an evening star, but should be looked for as soon as possible after sunset. He is in quadrature with the Sun on the **5th**. On the **1st** he rises at 10h. 11m. a.m., with a northern declination of 21° 13′, and an apparent diameter of 2·6″. On the **31st** he sets at 0h. 25m. a.m., with a northern declination of 21° 17′. During March he describes a very short direct path in Taurus, to the south of the 4¾ magnitude star ι Tauri. At 7h. p.m. on the **10th** he is in conjunction with ι Tauri, 13′ to the south, and about 3h. p.m. on the **31st** he is in conjunction with the 6½ magnitude star B.A.C. 1555, 8½′ to the north. A map of the small stars near his path will be found in the *English Mechanic* for August 16th, 1895.

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

The Moon enters her last quarter at 11h. 29m. a.m. on the **6th**; is new at 10h. 48m. a.m. on the **14th**; enters her first quarter at 11h. 57m. a.m. on the **22nd**; and is full at 5h. 21m. a.m. on the **29th**. She is in apogee at 1h. a.m. on the **15th** (distance from the Earth, 252,620 miles), and in perigee at midnight on the **28th** (distance from the Earth, 221,670 miles).

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Chess Column.

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

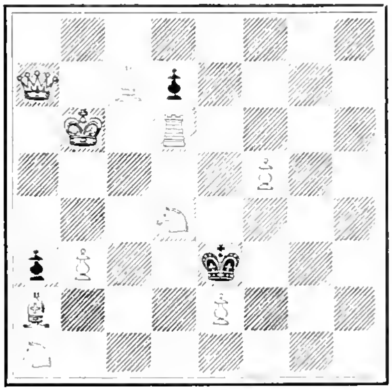
Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

PROBLEMS.

No. 1.

By J. T. Blakemore.

Black (3).



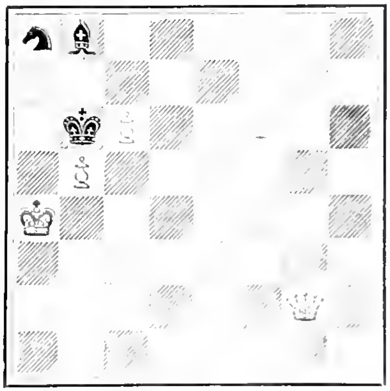
White (10).

White mates in three moves.

No. 2.

By C. D. Locock.

Black (3).



White [illegible].

White mates in two moves.

A. Firth.—Many thanks for the report.

A Norseman.—Thanks for your note and the formula; we have not found time to examine it yet.

The following was, perhaps, the finest game played in the recent tournament at St. Petersburg.

"Queen's Gambit Declined."

White. (H. N. Pillsbury.)	Black. (E. Lasker.)
1. P to Q4	1. P to Q4
2. P to QB4	2. P to K3
3. QKt to B3	3. KKt to B3
4. Kt to B3	4. P to B4
5. B to Kt5	5. P × QP
6. Q × P	6. Kt to B3
7. Q to KR4	7. B to K2
8. Castles	8. Q to R4
9. P to K3	9. B to Q2
10. K to Ktsq	10. P to KR3
11. P × P	11. P × P
12. Kt to Q4	12. Castles
13. B × Kt	13. B × B
14. Q to R5	14. Kt × Kt
15. P × Kt	15. B to K3
16. P to B4	16. QR to Bsq
17. P to B5	17. R × Kt
18. P × B	18. R to QR6
19. P × Pch	19. R × P
20. P × R	20. Q to Kt3ch
21. B to Kt5	21. Q × Bch
22. K to Rsq	22. R to B2
23. R to Q2	23. R to B5
24. KR to Qsq	24. R to B6
25. Q to B5	25. Q to B5
26. K to Kt2	26. R × P
27. Q to K6ch	27. K to R2
28. K × R	28. Q to B6ch
29. K to R4	29. P to Kt4ch
30. K × P	30. Q to B5ch
31. Resigns	

◆

CHESS INTELLIGENCE.

The important quadrangular tournament at St. Petersburg resulted as follows:—

First Prize	E. Lasker	$11\frac{1}{2}$
Second Prize	W. Steinitz	$9\frac{1}{2}$
Third Prize	H. N. Pillsbury	8
Fourth Prize	M. Tchigorin	7

Each player played six games with every other, so that the highest possible score was eighteen. As might have been expected in such a tournament, or, rather, series of matches, none of the competitors approached this ideal score.

The final result is more or less in accordance with established form. Lasker was last year the acknowledged champion of the world, in succession to Steinitz, who had held the post for nearly thirty years. Pillsbury was the new star which had eclipsed all others at Hastings; while Tchigorin, though a very fine player, had never, to our knowledge, won outright any tournament or match of primary importance. In spite of this, all sorts of excuses have been made for his position on the list. One of the four had of necessity to occupy the lowest place. Tchigorin, who had whatever advantage there is in playing in his native land, came out a good fourth, with a by no means discreditable score. It is true that he made more oversights than usual, but Steinitz and Pillsbury were almost equally unfortunate in this respect.

Pillsbury's play is to a certain extent unaccountable. At the conclusion of the first half of the tournament he actually held the lead; in the second half he did not win a single game. This breakdown does seem to require some explanation. Such, however, is not forthcoming, even from the player himself. It is noteworthy, especially, that he did not win a single game from Steinitz.

The last-mentioned player was a little fortunate in this and in some other respects. His position is most creditable, but he owes it entirely to his success against Pillsbury. He won two games from Tchigorin, and one from Lasker.

Lasker, as will be seen from the score, won with comparative ease. No doubt he could, if necessary, have added another half point or so to his score; but with victory certain he may well have been content to draw his last two games without running any risks or incurring any unnecessary fatigue. Certainly he has more than atoned for his comparative failure at Hastings, where, like Tarrasch and Steinitz, he was handicapped by ill-health. Though beaten by Pillsbury in their individual encounters, he would have been equal to him if he had played his first game in anything like his proper form.

The following is an analysis of the score:—

Lasker beat Steinitz ($3\frac{1}{2}$ to $1\frac{1}{2}$) and Tchigorin (5 to 1).
Steinitz beat Pillsbury (5 to 1).
Pillsbury beat Lasker ($3\frac{1}{2}$ to $2\frac{1}{2}$) and Tchigorin ($3\frac{1}{2}$ to $2\frac{1}{2}$).
Tchigorin beat Steinitz ($3\frac{1}{2}$ to $2\frac{1}{2}$).

Matches and rumours of matches have arisen from this great contest. Steinitz will play a match of twelve games with Schiffers at Kharkoff. The latter player should hardly do more than offer a sturdy resistance. The committee of the Hastings Club have offered £150 for a championship match between Lasker and Steinitz, to be played in that town next May, only to find that the Moscow Club had already been in negotiation for a similar contest at the same date, and under conditions more likely, it is said, to be satisfactory to the two parties concerned.

The present score in the Vienna Chess Club Tournament is:—Englisch $7\frac{1}{2}$, Marco $6\frac{1}{2}$, Schlechter 6, Schwarz $5\frac{1}{2}$, Tinkl $5\frac{1}{2}$, Weiss, Albin, Max Judd, and Halprin $4\frac{1}{2}$, Mandelbaum 4.

Contents of No. 124.

NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

Bound volumes of Knowledge, New Series, can be supplied as follows:—Vols. I., II., III., and VIII., 10s. 6d. each; Vols. VI., VII., IX., and X. (1895), 8s. 6d. each.

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Communications for the Editors and Books for Review should be addressed Editors, "Knowledge" Office, 326, High Holborn, London, W.C.

KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: APRIL 1, 1896.

CONTENTS.

ELECTROGRAPHY; OR THE NEW PHOTOGRAPHY.

By J. W. Gifford.

The extreme interest taken by the public in this subject, and the difficulty of obtaining reliable information about it, must be my excuse for venturing to write of what is still so little understood. Most of those engaged in experiment are too busy, and too eager to try for new effects, to care to spend their time in writing. When the news of Prof. Röntgen's wonderful application of this form of electric force first reached this country, it was received with doubt by some and with scorn by others. Now we believe and have seen what would have seemed too absurd for a work of fiction a few years ago. Not only can coins enclosed in a box, or laid under a pie-dish, be electrographed with perfect ease, but bones enclosed in living flesh can be shown with little more difficulty. Any imperfection in the bones, any foreign body in the flesh, is made as clearly visible as though laid bare by the surgeon's knife. Hitherto, this can only be said to have been done to perfection in the case of the hand or foot, but when we remember that the first news of Prof. Röntgen's experiments reached us but a few weeks ago, the only marvel is that so much has already been accomplished.

The earliest experimenters in England who attained satisfactory results by the new influence—call it what you will—were Mr. A. A. Swinton, in London, and myself at Chard.

Shortly before the article appeared in the *Standard* last January announcing Prof. Rontgen's discovery, I had been experimenting with spectrum photography, and for this purpose had bought a hand dynamo and a large spark coil, so as to volatilize the more refractory elements. Some fifteen years ago, when Prof. Crookes' researches on radiant matter were first published, I had bought a set of Crookes tubes, and therefore found myself equipped, by good fortune, with all the necessary material for making the experiments. But so imbued was I with the idea of spectrum analysis and spectrum photography, the study of which had engaged my attention for years, that no explanation of the discovery other than a photographic one occurred to me. I therefore tried a set of experiments—all of which failed—taking as my standpoint the idea that the photographs must be produced by ultra-violet rays. Thinking the thing was a hoax, or at any rate a misconception, and seeing that the experiments in Vienna had, up to that time, failed, I sent a communication to the Royal Photographic Society, detailing my experiments and their failure. This arrived just too late for the meeting on the 14th of January.

After that the papers became more definite, and I tried again, this time abandoning the theory of light for that of electricity; and on Saturday the 18th, to my great delight, I succeeded in electrographing a child's hand through cardboard. This was shown at the Photographic Meeting on the following Tuesday. In this early experiment, and in fact in all the earlier ones, the plate was enclosed in a cardboard box, such as photographic plates are packed in, and the hand laid on the lid of the box about two inches below the glass bulb—for, as far as appearance goes, tube is a misnomer—with the result that a child's hand appeared on the plate after development. In the earlier attempts five minutes' exposure was given, and in the first successful one the nails appeared, but little or no bone. Never since the first experiment have the nails appeared—why is not known. Probably the bones did not appear partly because it was a child's hand and the ossification imperfect, and partly because the exposure was too short for the power used. Later experiments have shown better results, and for the benefit of those who have never seen the apparatus at work I will describe what is used.

First there is a hand dynamo, giving a current of ten volts, fifteen ampères; then a spark or intensity coil, giving a ten-inch spark; and lastly the glass bulb, which is exhausted to about the millionth of an atmosphere. Of course every man has his own fad, but I believe all the most successful experimenters have used apparatus similar to this. The different parts of the apparatus are connected, the circuit closed, and the dynamo revolved. The bulb is filled with a beautiful green light, which looks a very yellowish green by daylight—a colour difficult to describe, but characteristic of this state of exhaustion. Tubes less exhausted show a whitish or violet light, and more exhausted they do not allow the spark to pass freely enough to do the work. The greenish light is, as far as my experience goes, a *sine qua non*. The tube in the later experiments has been placed about eight inches from the object to be photographed, and this, though it lengthens exposure, vastly improves definition.

One must leave off thinking of these pictures as photographs, and think of them and reason about them as shadows. If a match be lighted and the blade of a knife be held up between it and the wall, definition improves and the size of the shadow decreases as the knife is farther from the match and closer to the wall. This simple experiment—which the reader should try—shows why some of the earliest hands appeared so large and had such "woolly" or indistinct outlines.

The subject to be operated on is taken into the dark room. A sheet of celluloid or mica is laid over the film of a sensitive plate; the hand, if that is to be the part electrographed, is laid on the celluloid, and the whole enclosed in a black cloth bag, tied tightly round the wrist, so that no light may get at the plate. The plate may then be taken into broad daylight—not bright sunshine—and laid, with the patient's hand upon it, on a table over which the bulb is hung. I use a small wooden stand, of the size of a whole plate, with a ledge on one side to prevent slipping, attached to one end of which is a glass rod in the form of an inverted L, from the horizontal arm of which the tube hangs. In some experiments no celluloid was used, and in more than one case the warm moisture of the hand partially melted the gelatine. In others a paper bag made of grocer's paper was slipped over the plate to prevent contact. The paper meant is the greased paper used for wrapping up butter, and this is supposed to be quite waterproof; but in some cases the grease melted, and the last state of that plate was worse than the first. With a cool hand paper is better, for it is less slippery; but with a hot one mica or celluloid is best. Both the latter are so transparent to the rays which do the work that a mica disc and a piece of celluloid laid on a plate and electrographed are barely visible in the negative. The exposure varies according to the thickness of bone and tissue to be penetrated, and according to the moisture in the air. No pain is felt beyond a slight cramp, or "pins and needles," owing to the limb being kept in one position so long. After exposure the plate is developed and fixed as in ordinary photography.

Among the subjects hitherto electrographed with my apparatus are, of course, a large number and variety of hands, some well- and some ill-formed. This is the easiest living subject. Several feet have been taken, some elbow joints, a club-foot, living cats' and dogs' paws, a flatfish, a rabbit's shoulder (dead) showing a shot jammed between the small bones, and a boy's forearm with several shot embedded just below the elbow. The accompanying prints of a sparrow (Fig. 1 and Fig. 2) illustrate one of the peculiarities of electrography. The two prints are from the same bird, one photographed in the ordinary way, and one electrographed. The first shows no peculiarity, but the second looks like a half-hatched chick. Although it was known that feathers were transparent to the new rays, the result at first seemed startling. The sparrow, when dead, was laid flat so as to show the ventral aspect. Some confusion of image is caused by the bones of the back appearing through those of the front. The merrythought is plainly visible and the breast-bone. The round black thing is supposed to be the gizzard. This print is important on account of its indications of internal organs, which have, so far as I know, never before (February 29th) been electrographed inside an entire animal. The illustrations of a mouse show internal organs still more clearly. The first one (Fig. 3) is the ventral aspect. It shows the attachment of the hind legs and the vertebræ of the tail especially well. It also seems to show signs of lungs, liver, and kidneys. The second one (Fig. 4), in profile, shows the dental formation of the rodent, and, still more clearly, the internal organs. As the mouse in this case was laid on its side, the legs furthest from the plate are, of course, indistinct. No others of my negatives differentiate so well between the different structures, and, in most of them, only the difference between bone and flesh has been visible.

The child's hand and forearm (Fig. 6) illustrates the incomplete ossification proper to the age. As it was a child of six, it was difficult to keep the hand perfectly still for ten minutes, and the outline is, therefore, somewhat indistinct. The "growing places" between the phalanges of the little finger are well shown. Here the bone is still in a cartilaginous state.

The adder (Fig. 5) was laid on its back and pressed well on to the plate, but being somewhat crushed with packing, and having stiffened after death, it did not touch quite evenly. Hence a little indistinctness here and there. The head is remarkably well defined, every bone being distinct, and the fangs appear clearly.

For a hand from ten to fifteen minutes gives good results, for a foot from thirty to fifty, and for an elbow about the same. The cat objected at the end of four minutes, and the dog at the end of seven. The cat's paw, though a thin negative, was quite clear; but the dog had evidently twitched a little. In these cases the paws were fastened to the plate with two elastic bands, and the paw held well out from the body of the animal. The paw was tightly gripped, and the bag tied round the wrist of the holder above the animal's shoulder, so that both paw and hand were inside the bag. Something of this sort would be necessary in any attempt to electrograph a baby's limb. No fur is shown in any of the negatives. A foot can, of course, be electrographed through a stocking; but the edges of the stocking show, and the definition is slightly impaired. The elbow joint and the club-foot, being thick, did not give good definition, for the further from the plate the more "woolly" the outline. The flatfish was a small dab, and had, unfortunately, been cleaned, so that the viscera are not there; but the bones show through the flesh and skin as clearly as though it was made of glass. In many of the hands and feet the bones show clearly down to the wrist and ankle. In one case, the back of a lady's hand, which had a long exposure, the bones of the wrist look as though they were cut out in stone, they are so distinct; and the ankle bones in one foot are no less clear.

In the case of an invalid it will probably be impossible to get such fine definition, for only one or two of the subjects tried have proved such good sitters as the lady mentioned above. Invalids are usually nervous and inclined to twitch, or they have hot, moist hands or feet, or their malformation renders it difficult, as in the club-foot, to lay the part well on the plate. For taking a foot, a chair placed on a table is used; but for the club-foot, as the side of the foot was to be taken, a table, with a mattress on which the patient lay, was employed, and the leg strapped to the table. The part of the limb electrographed is not the part next to the tube, but that next to the plate. This is obvious if one remembers that it is a shadow. Thus, the hands are all palms and the feet are all soles unless special arrangements are made. The distinction between bone and flesh is very marked, but I have never seen any sign of a nerve or blood-vessel. If these were ever visible, one would have expected to see them in the forearm with the shot, or in one of the elbow joints, which have been taken in various positions, and in which part of the body the vessels must be large enough to show.

As regards the tube, I used at first a Crookes tube, which I had bought more than fourteen years ago. With this I make almost continuous exposures, stopping every five or ten minutes to feel the terminals of my tube, and unless they are hot, which is seldom the case, I go on again at once. My tubes are much larger than those now sold in England. I used only two for all my early experiments. The first one seemed to be deteriorating; it became increasingly difficult to get the spark through, so I tried another. That gave splendid results for about a fortnight, and then began

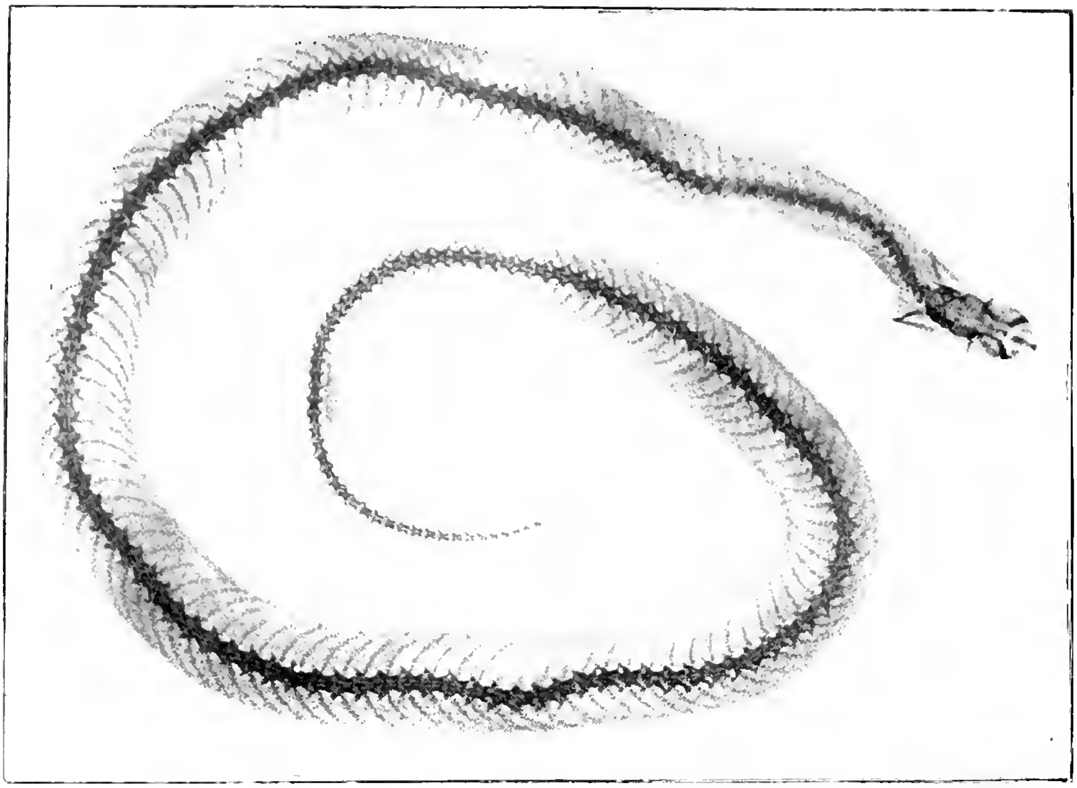

FIG. 5.—Dorsal view of Adder. Electrographed by Mrs. Gifford and Miss Baylis, with a tube by Mr. A. C. Cossor. Exposure, ten minutes. (March 5th, 1896.)

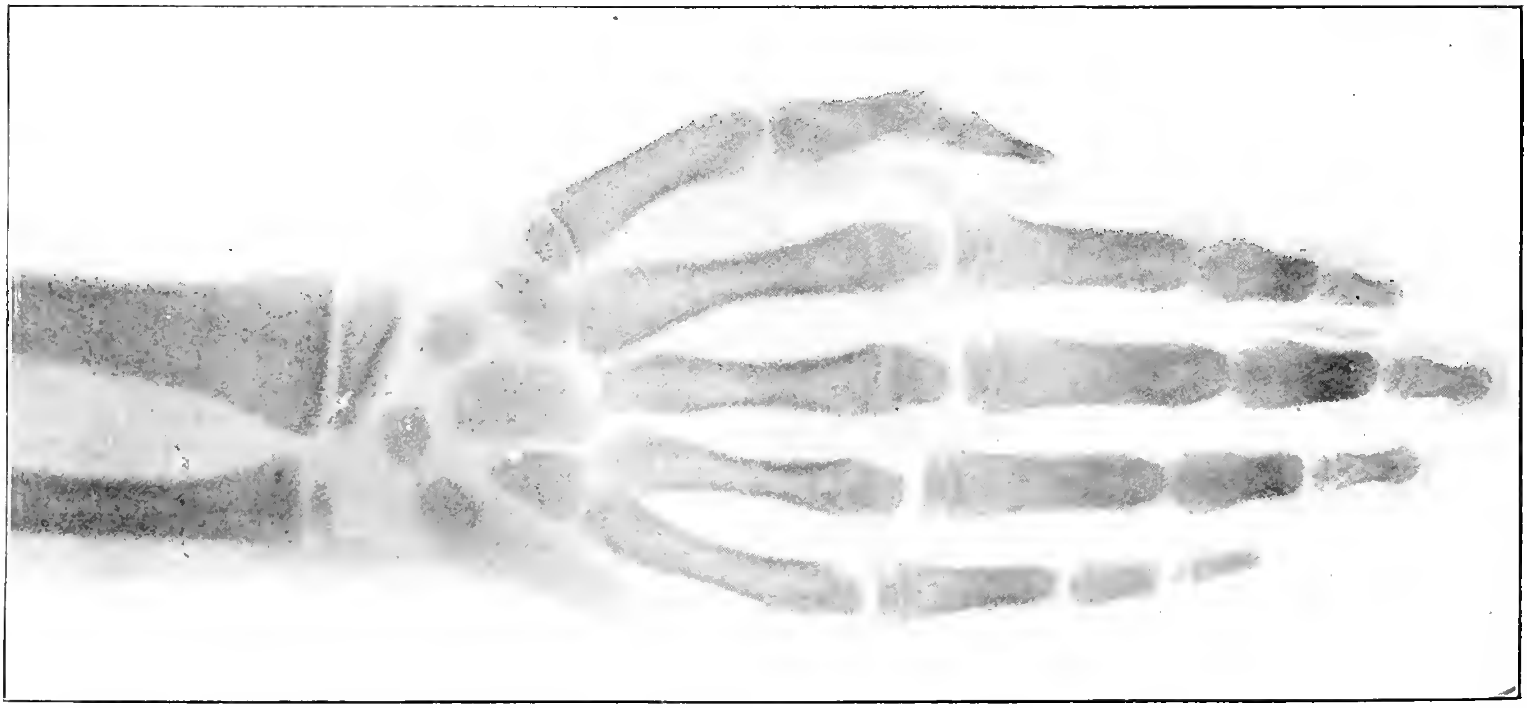

FIG. 6.—Hand and Forearm of Sylvia Gifford, aged 6, showing incomplete ossification. Electrographed by Mr. J. W. Gifford. Tube by Mr. C. Baker. Exposure, one minute. (March 14th, 1896.)

Fig. 1.—Ordinary Photograph of a Sparrow. By Mr. F. Higgins, Photographer, Chard.

Fig. 2.—The same, electrographed by Mr. Gifford and Miss Baylis, showing bones and internal organs, but no feathers. Exposure, three and a half minutes. (February 25th, 1896.)

Fig. 3.—Mouse, ventral aspect. Electrographed by Mrs. Gifford. Exposure, five minutes. (February 28th, 1896.)

Fig. 4.—Mouse in profile. Electrographed by Mrs. Gifford. Exposure, five minutes. (February 28th, 1896.)

to act badly, the spark illuminating the tube fitfully. Then I reinstated the first one, and found it had renewed its youth and worked as well as ever. Of course, until it can be shown that the second improves with rest, one cannot consider the point to be proved: it may be merely that experiment has improved other conditions; but for those who have already spoiled their tubes, even the possibility is cheering.

It is exceedingly difficult to get a tube that will act. Of the first five tubes of English make that I tried, none gave good results. One cracked on being taken out of the box—with no blow, but merely on exposure to the air of the room. Another showed a white and violet light which gave very little effect after very long exposures. A third broke down at the first spark, owing to the air occluded in the terminals being driven into the bulb and spoiling the vacuum. The fourth and fifth are still intact, but appear to require exposures of far greater length than any mentioned above. They are all much smaller than the old Crookes tube, so I tried them with a small coil; but though they looked very pretty, they did little or no work. It has been suggested that an aluminium window let into the side of a tube would shorten exposure; but the difference in tone between a piece of glass and a piece of aluminium electrographed on the same plate, was so trifling as to show that the tube would not be worth the trouble of making. An aluminium tube would be very difficult to insulate. Other English tubes I have tried give good results for a time. The mouse was done with one which gave the proper green light, but which heated so that it had to be worked a quarter of a minute at a time and then have a quarter of a minute's rest, thus doubling the time of the sitting. After three or four exposures it deteriorated, the whitish blue light appearing instead of the green, and a dark fatigue spot showing on the glass in the centre of what had been the brightest ring of the green light. As the tube deteriorated it gave the outline of the object with about the same exposure, but it lost some of its electrographic properties. For instance, the bones of a sparrow hardly showed, while the feathers were indicated, though not so clearly as in ordinary photography. Other tubes gave varying results, but none showed any sign of wearing for more than a few exposures. Of course, if the current is carefully regulated they last longer. The tubes now made are far smaller than my original Crookes tubes, and I cannot help thinking that no great advance will be made in this matter until some maker will give us tubes of from four and a half to six inches diameter, and as carefully finished off as the original ones. Although I should not expect anything from a tube with an aluminium window, a mica one might give very much better results, for mica is far more transparent to the new rays than glass. The focus tube now being talked of seems to me a good idea, but I cannot consider it a novelty, for the tube all my best early results were taken with is one which has a concave cathode focussing on to a piece of platinum in the centre of the tube, and is one of Crookes' original make. To many my exposures will seem inordinately long, but they represent the actual time the sitter or object remained on the table, and take no account of any waiting—treating a pause in the work as exposure, which it practically is in a live subject. I do not wish to boast, but hitherto I have never broken a tube. Atmosphere makes a difference. A tube that had worked very badly in a lecture-room overnight gave excellent results next day in a sitting-room heated by a gas stove, which thoroughly dried the air.

The theory of this subject is at present very hazy. That the phenomena are due to electrical disturbance I have insisted on from the time I made my first successful experiment. They seem to be the product of what is known as the Hertzian ray, so called because it was first investigated by a Swiss electrician, Hertz. A Hungarian professor named Lenard forestalled many of Prof. Röntgen's experiments, as the latter willingly acknowledges; but to Prof. Röntgen belongs the honour of applying the influence to physiology. What its possibilities in that way may be no one can yet foretell.

It seems that the electrical waves are longer than those of light, that they are propagated in straight lines, that they are incapable of refraction, but not, perhaps, of reflection, and are possibly not transverse but longitudinal waves. To this last idea the researches of Lord Kelvin lend colour. If this be so, before we can fully investigate this set of phenomena we shall be in the difficult position of having to divest our minds of all preconceived ideas connected with the laws of light.

Hertz showed that the electrical wave can be propagated by the ether without the intervention of what is generally known as a conductor, much as the sound made by a tuning-fork is given out by a violin string tuned to the same note and placed at some distance off. The tuning-fork gives out a simple fundamental note; the violin string gives out that note too, but, being fastened at both ends, vibrates in nodes besides vibrating as a whole, and gives rise to a host of overtones. For the tuning-fork substitute the Crookes tube, and for the violin string substitute the sensitive plate, and you have a rough and very imperfect, but possibly helpful, analogy. It is not said that this is what does occur, but merely that this helps the mind to imagine what may occur. To carry the analogy further, the electrical fundamental may be able to pass through certain substances which the shorter actinic overtones could not penetrate. When it gets to the photographic plate, it may set up not only the electrical fundamental but the actinic overtones which affect the plate. This is a clumsy attempt to explain what no one as yet understands. In an attempt to electrograph a sparrow under chloroform a piece of cotton wool was placed on the celluloid covering the plate and saturated with chloroform. This came out quite black, whereas dry cotton wool shows no more than feathers. In a further experiment to verify this, some cotton wool saturated with water, some with alcohol, and some with chloroform gave nearly similar results, while a dry piece did not show at all on the negative. This seems an added proof of the electrical nature of the rays. The area of electrical disturbance may easily be demonstrated by holding a small specimen gaseous tube, such as is used in spectroscopy, near the tube, coil, or cables, when it will be seen to glow at a distance of several inches, just as it would if it were connected to a battery. The region where it glows brightest is near the negative pole of the coil.

A paper on this matter would not be complete without some allusion to Prof. Salvioni's experiments in "seeing the invisible." I took a funnel-shaped iron tube. On a piece of black paper (such as is used for wrapping up photographic plates) I gummed an area as large as the large end of the tube. I allowed that to partially dry and dusted it over with barium platino cyanide, using about a drachm. This I attached to the iron tube by means of elastic bands. When held up to daylight or bright gaslight no ray of light appeared, but when held near the bright end of a vacuum tube a glow was seen, and a purse held between the paper and the vacuum tube showed distinctly a coin inside. The bones of the hand show clearly through the flesh, and the lead of a pencil through the wood; but the light seemed to me too dim to be of practical value in surgery. Prof. Salvioni's results are, however, a very striking corollary of Prof. Röntgen's discovery. In repeating Prof. Salvioni's experiments, I first tried his method of saturating blotting paper with a solution of the powder, but I think my plan gives more light. Barium platino cyanide costs, unfortunately, eight shillings a drachm, so the experiment should be cautiously made.

As bearing on the limitations of electrography with regard to surgery, I may mention that an attempt to get at the inside of an incubating egg failed. Only the graining of the shell appeared on the negative, because an egg is completely surrounded with a substance which, like bone, is opaque to the influence. If this be so, what becomes of the marvellous tales about the photographs of the inside of the living skull? If the head be electrographed, what can be obtained but a mass of bone with no definition? For the brain is surrounded by bone, except at the holes for the optic nerve.

As far as electrography has gone, its uses to the surgeon are little or none—at least that seems to be the opinion of the medical men with whom I have talked on the subject; but there is one way in which, even at this early stage, it is of practical use. A girl had a diseased finger-bone on which she did not like an operation to be performed. The electrograph of her hand, though showing little or nothing to the surgeon of which he was not before aware, at once convinced the patient, and the operation will shortly take place. Electrography should also save probing in wounds of the hand or foot, and, probably, at no very distant date, in any part of a limb. I think this is all that can be claimed for it at present, but even that seems a good deal for a few weeks' work.

Many people have curious notions about electrography. A parent wrote to ask if the child's diseased bone could be photographed; there would be no difficulty, as the child was very good and the room to which it was confined had a south aspect. An old lady wished to have her head photographed, for she had lately become deaf—she was not always so—and she thought it would be a good thing to know what caused her deafness; she had tried "other remedies" in vain. A student, hearing me describe my methods, interrupted with "Oh! we know all that; we have done all these experiments here." I asked to see the results. "Well"—in a tone which rebuked the irrelevancy of the question—"there were no results."

The enlargement, due to the distance of the hand from the plate in the earlier experiments, is, I am told by a psychic investigator, caused by the "Odic Nimbus." Call a spade a spade, if you will; but remember that a shadow is an odic nimbus. It is a much nicer name.

In case any reader wishes to repeat these experiments but is deterred by not knowing the cost, I may say that a ten-inch spark coil costs £40, a hand dynamo about £15, and a Crookes tube about 25s. It is not suggested that my apparatus is the best possible, but merely that good results have been obtained by its means. Where there is some means of re-charging them, accumulators are better than a dynamo, because they are less trouble and the current is more even.

Note.—Since writing the above, I have succeeded, with an improved tube, in electrographing my own hand in one minute. The bones show right down to the wrist, and the commencement of the ulna and radius is clearly differentiated. The plate was so much over-exposed that I believe half a minute would be quite enough. No Tesla transformer, nor any other apparatus than that mentioned above, was used.

NOVEL EXPERIENCE WITH RÖNTGEN RAYS.

While carrying out experiments with Röntgen rays we have obtained results which we consider worth further careful investigation.

On exposing a plate contained in an ordinary cardboard plate-box with the object of obtaining a shadowgraph of keys, coins, etc., on the top, we failed to obtain the usual image; on exposing another plate in the same box after a trifling alteration of apparatus, but with an entirely different series of objects, we obtained on development a well-defined image of the objects first exposed. Struck with this phenomenon, we made another exposure in the same box with a plate from a fresh packet, and, on developing, obtained a good image of the objects placed for the *second* exposure. We have repeatedly obtained these remarkable results under the following varied conditions:—

Exposure made and no result; box left for two days; fresh exposure made with entirely different objects, and resulting negative clearly defined objects placed in the box two days before.

Exposure made and box exposed to strong daylight, to ascertain if sunlight would discharge the latent image, but with no effect. After an interval of eight days, box was again subjected to X rays, and a negative obtained of objects exposed eight days previously.

This is at present entirely inexplicable, and as we only seem to get these retained or latent impressions with one box we have not yet subjected the cardboard of which it is composed to more than superficial examination. It is our intention to endeavour to obtain more boxes of this particular batch, and if with these we can confirm our present results, we hope to elaborate a theory which will account for what we can only now term "the storage and transformation of images formed by X rays in certain undetermined varieties of cardboard."

We may add that the apparatus used was a two and a half inch spark coil, operated by a chromic acid battery, using sometimes special Crookes tubes and sometimes a small incandescent lamp with broken filament, for producing the X rays.

Leon J. Atkinson.
Arthur H. Pook.
March 18th, 1896. R. P. Williams.

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ALUMINIUM: ITS HISTORY, MANUFACTURE AND FUTURE.—I.

By Samuel Rideal, D.Sc.Lond., F.I.C.

Very few chemical discoveries of the present century have evoked so much interest as that of the introduction of aluminium. At the Paris Exhibition of 1855 it was exhibited for the first time in public, and was regarded as one of the principal novelties of that year. The new metal was shown as a bar, bearing the very sensational inscription, "Silver from Clay," and was regarded even at that date as the metal of the future, with boundless possibilities of usefulness. The non-scientific press devoted long articles to its description, and pointed out that a metal with apparently all the qualities of the noble metals, and excelling them in having a remarkably low specific gravity and in its general stability, had been produced from one of the most abundant materials on the surface of the earth; and the inventors of the process were hailed as benefactors to humanity and honoured as accomplishing one of the greatest achievements of science. The first burst of enthusiasm was, however, soon abated when the enormous cost of production of the new metal was realized; but it was still confidently expected that, with further work, the price of the element would soon be much reduced, and that from being a laboratory curiosity it would then become one of the principal items of metallurgical industry. Notwithstanding this stimulus to research, and the very considerable attention that was devoted to the elaboration of the processes then proposed for the winning of the metal from clay, progress was by no means rapid. Large sums of money were, however, subsequently expended in the erection of factories in France, England, Germany, and America; and the older processes have gradually been replaced by more modern methods, in which the progress which has been brought about in the perfection of electrical plant, coupled with the utilization of the cheap energy of waterfalls, has been made to contribute to the manufacture of this element, with the result that, whereas in 1856 aluminium was worth £18 per pound, and in 1886 still cost £2 8s., at the present day it can be bought at about eighteen pence per pound. The present low price of aluminium has naturally brought it into the range of metals in general use, and has allowed of its production in large quantities on a metallurgical basis, so that its adoption for the most varied purposes has at last been assured. There can be no doubt that last year's output of the metal will be largely increased in the near future, and that the dreams of the journalists of 1855 will soon be more completely realized. The exceptional position of the metal renders it of interest at the present time to review the history of its progress, as those who are engaged in its development are confident that its use will now rapidly extend in many directions which have hitherto been barred through difficulties attending not only its economical production, but also in the removal of impurities from the metal which affect its durability, and in want of knowledge which prevented the most suitable alloys from being manufactured.

The first attempts at the isolation of this metal from its oxide, alumina, were made by Davy in 1807, and some years later by Berzelius; but both of these distinguished chemists failed to obtain any satisfactory result. In 1824 Oerstedt endeavoured to decompose aluminium chloride by means of potassium amalgam; but although it seems doubtful whether his experiments were successful, he has the merit of having first conceived of the idea that an alkaline metal might be used for the reduction of aluminium compounds. The celebrated chemist Woehler, three years later, succeeded in decomposing anhydrous aluminium chloride by means of metallic potassium, and obtained the metal as a grey amorphous powder. He, however, for some unknown reason, did not continue this research until 1845, when, by passing the vapours of aluminium chloride over heated metallic potassium, he obtained a few grammes of the metal in globules as large as a pin's head, which resembled metallic silver in appearance. Owing to his extraordinary analytical skill, Woehler succeeded in studying very completely the chemical and physical properties of the metal with the small quantity he had at his disposal. It seems strange that this careful and valuable work of Woehler should not have at once rendered its manufacture on a commercial scale possible; but it would seem that the cost of the alkaline metals sodium and potassium at that time was almost prohibitive, even for pure scientific research, and that Woehler, therefore, had to be content with fully establishing the more important characteristics of this remarkable element. It thus came to pass that upwards of nine years elapsed before the commercial importance of Woehler's work was realized. In February, 1854, Henry St. Claire Deville communicated to the French Academy of Science the discovery of a new metal, obtained by decomposing aluminium chloride with potassium, being unaware that Woehler had already practically gone over the whole of this work nine years previously, illustrating how incomplete at that date was the intercommunication of scientific ideas in Europe. The publication of this paper created considerable interest in Paris, and the great importance of the discovery was at once realized. Deville, aided by the support of the Academy and of the Emperor Napoleon, who personally interested himself in the discovery, again set to work; and a few weeks later was able to announce that he had succeeded in isolating aluminium by the electrolysis of the fused chloride, and accompanied the communication with the first piece of aluminium foil which had ever been prepared. Almost simultaneously Bunsen, in Germany, published an independent account of the decomposition of aluminium chloride by means of an electric current. The new metal was thus prepared by two distinct processes: and it is only due to the fact that, as the methods for the production of electrical energy on a large scale at that time were practically unknown, the chemical process for the isolation of aluminium became the only one which was used commercially until the last ten years. Deville himself fully realized that the electrolytic process was destined to be the future commercial one, but found it necessary to devote his attention to cheapening the production of sodium for use in the chemical method of extraction, which, owing to its lower specific gravity, he thought was a more suitable metal to employ than potassium. His improvements in the manufacture of sodium resulted in its price falling from two thousand francs per kilo in 1855 to ten francs per kilo in 1858. At the same time Deville investigated the distribution of the metal in nature, with the view to the production of compounds of aluminium in as pure a state as possible, and thus created the cryolite and beauxite industries. Deville's sodium process was adopted in 1856 by a company which erected works at Amferville, near Rouen, and in 1857 fresh works were completed at Nanterre and Glacière, the former being subsequently transferred to Salindre. The first aluminium works in this country were opened by F. W. Gerhard, in 1859, at Battersea, and in 1860 Messrs. Bell Brothers began the manufacture of aluminium at Newcastle-on-Tyne, which was continued there until 1874.

Although the chemical process for the manufacture of aluminium was thus the only one adopted at this period for its commercial production, the electrolytic method was slowly being elaborated at the hands of Le Chatelier, Moncton, Gaudin, Kagenbusch, Berthaut, and other chemists; and in 1880, when Siemens invented the electric furnace which bears his name, it was soon seen that the alternative process would eventually replace the purely chemical one. The first commercial attempt to produce aluminium by means of electrolysis belongs to Messrs. E. H. and A. H. Cowles, of Ohio, whose process was tried for some years at Milton, in Staffordshire, and these works have quite recently been acquired by the British Aluminium Company. The Cowles process has, however, been overshadowed by the later invention of another American, Ch. H. Hall, whose ideas have been adopted on a most extensive scale by the Pittsburgh Reduction Company, at Niagara. By these last two improvements the manufacture of aluminium attains its mature stage of development.

Before discussing these processes at any length it may be of interest to briefly state some of the chemical and physical properties of this element, and the native materials from which it is produced.

Aluminium is one of the most widely distributed of the chemical elements, but, owing to its strong affinity for oxygen, is never found in the free state, but exists in the form of alumina—its only oxide, Al_2O_3, which, combined with silica and the alkaline oxides in various proportions, forms the chief constituents of most rocks. Beauxite, a hydrated oxide of aluminium, and cryolite, a double fluoride of aluminium and sodium, also exist native in considerable quantities, and being comparatively free from impurities form the more usual source of the metal at the present time. Large deposits of beauxite are found in France—chiefly near the town of Beaux—in Styria, in Wocheim, and in various places in the North of Ireland; and last year a large factory was erected at Larne for the purpose of purifying the beauxite derived from the Antrim mines before shipment to Scotland. Cryolite exists in almost inexhaustible quantities on the west coast of Greenland, and is shipped from there to the principal aluminium producing centres.

Metallic aluminium has a beautiful white silver lustre, which becomes especially apparent when held against a polished silver plate, as the latter is then seen to have a distinct yellow colour. When impure, aluminium has a grey or bluish colour, the latter being caused by the presence of silicon. A dull matt surface can be obtained by washing the metal in a solution of caustic soda, and then, after being washed with cold water, dipping the plate in a bath of nitric acid.

It is ductile, malleable, very sonorous, and a good conductor of heat and electricity. It is as light as glass or porcelain, having a specific gravity of 2·56. It melts at about 700° C., and is not appreciably volatile. The metal is not readily oxidized, and is permanent in air, wet or dry, and, when pure, is not acted upon by water, even at a red heat. Sulphuric and nitric acids in the cold attack it slowly, but hydrochloric acid, especially if warm, dissolves it readily. The purer the metal the less easily is it attacked by acids, but alkalies have a very energetic action on the metal, evolving hydrogen and forming aluminates.

The question as to its behaviour towards organic acids, such as are to be found in wine and beer, has been carefully studied on behalf of the German army; but it would seem that they have no effect upon the metal when it is free from impurities and sodium chloride. It easily alloys with other metals, and many of its alloys are of greater utility than the metal itself. Amongst these alloys must be especially mentioned the aluminium copper alloy (which, under the name of aluminium bronze, has been in use for a great number of years), and the newer alloys, wolfaminium and romanium, which owe their remarkable physical properties to the presence of tungsten. The mechanical properties of aluminium are very remarkable. Its modulus of elasticity is ten thousand; its range of elasticity high, a bar being capable of being stretched one two-hundredths of its length before breaking. Its tensile strength is about twelve tons per square inch, and the tenacity of a wire of 0·145 millimètres section has been found to be about twenty-six pounds. The length of a bar capable of supporting its own weight is 23·040 feet, *i.e.*, equal to that of ordinary steel and more than double that of bronze.

(*To be continued.*)

WAVES.—IV.

SHIP WAVES, AND THE SOLITARY WAVE.

By Vaughan Cornish, M.Sc.

Our knowledge of ship waves and of the solitary wave is largely based upon the researches of William Froude, John Scott Russell, and Lord Kelvin, and their treatment of the subject forms the groundwork of the present article.

When a ship moves through the water, pressure is greatest at bow and stern and least at the sides. The surface of the water accordingly rises at bow and stern and sinks down at the sides, so that the differences of level balance the differences of pressure created by the motion of the ship. Thus a moving ship is accompanied by waves. Three principal factors determine the form and character of these waves, namely: first, the motion of the ship; secondly, the motion of each wave formed by the ship; and, thirdly, the transmission of energy by these waves. As explained in the last article, the energy is transmitted at half the velocity of the wave, consequently a *group* of waves is formed. In the front of the group the waves continually die out as the energy falls behind and forsakes them; and, conversely, in the rear of the group, new waves are formed. Consequently, the rear of the procession of waves falls further and further behind the ship, and, as the ship is constantly adding new waves to the front of the procession, the vessel is accompanied by a lengthening track. As the energy of the wave motion proceeds at only half the pace of the waves (which is also the pace of the ship), the rear of the procession moves at one half the rate of the vessel. We have here two distinct velocities: that of the tail, which is the group velocity, and that of the head, which is the wave velocity. If we could

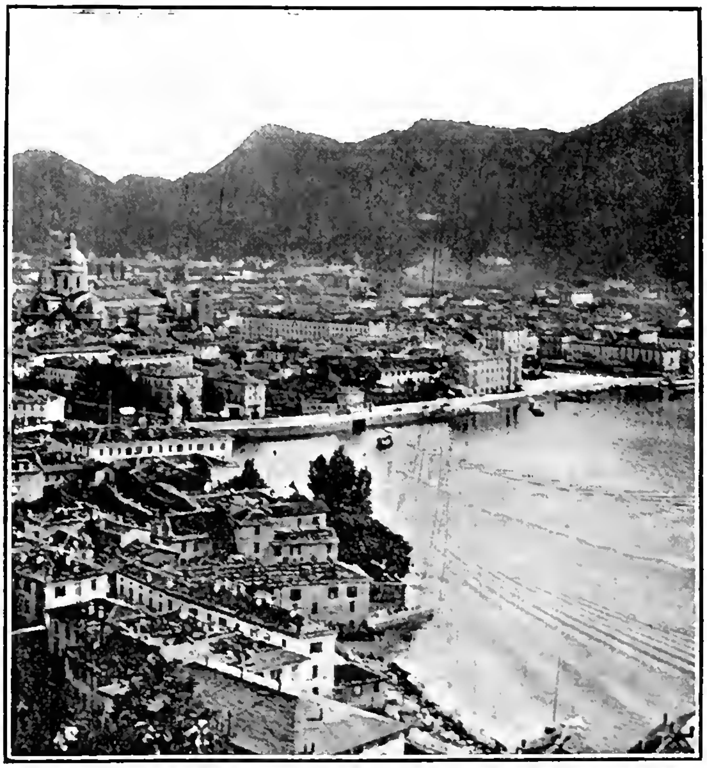

Fig. 1.—Steamer on Lake Como, showing Thwart-ship and Echelon Waves.

observe and follow a particular wave crest in the rear of the procession, we should see it advance *through* the group, and finally die out in front of the group. When a ship, preferably a steamer, moves at a sufficient speed through smooth water, the group of waves is seen to have the form shown in Fig. 1. Allowance must, of course, be made for the fact that the vessel shown in the illustration is moving in a curve. There are two sets of ship waves to be noticed, the thwart-ship waves and the echelon waves. The former are similar in appearance to a ground swell, with gently rounded crest and trough; they follow the ship at her own speed (if that remain constant), and the length from crest to crest is the length proper to a free wave travelling with this velocity. Thus, if the vessel be going at six knots, the wave-length is twenty feet; at ten knots it is fifty-six feet; at twenty knots, two hundred and twenty-three feet; and at thirty knots, five hundred feet: the wave-length being proportional to the square of the velocity. The front of the advancing thwart waves is bent in a curve, of which the radius increases as the waves travel on, the crests flattening out as the curve expands. It will be noticed that there is thus a great similarity between the thwart waves and the waves which spring out from the spot where a stone is thrown into a pond. If the motion of the vessel were suddenly stopped, the thwart waves would, of course, travel on ahead of the ship.

The extremities of the thwart waves seem to rest, as it were, upon the echelon waves. These are very different in character from the thwart waves, being steep and lumpy. They are the waves which form the lateral boundaries of the group, and by which small craft are often swamped. If we observe the echelon waves from their origin at the bow of a vessel, we find that each wave crest has no great extension from end to end, and that they are stepped back one behind the other. Each crest tapers off somewhat from the middle towards the ends, which overlap the next preceding and following crests. Thus the echelon wave pattern does not, as a careless observer might suppose, have a continuous front shaped like a long fish-head. The falling behind of the energy prevents this, the crest continually dying out in front and a new crest forming behind. The distance between the crests of the echelon waves is that proper to so much of the ship's forward motion as is in the direction of advance of the waves. This is a small fraction of her speed; and the wave-length being proportional to the *square* of velocity, we find the crests of the echelon waves from steamers to have generally a length of not more than, say, two feet from crest to crest.

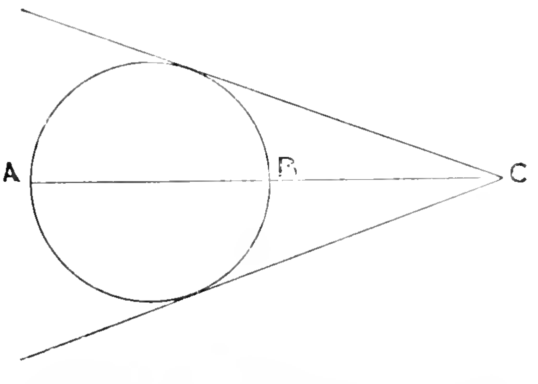

Fig. 2.—Diagram showing the enclosing angle of a Ship's Track.

The outline of the whole wave pattern is the same whatever be the speed of the ship. Thus, let a circle be drawn (Fig. 2), and a diameter A B be produced to a point C, such that the length B C is equal to the diameter A B. From C let tangents be drawn to the circle. Then if C be the bow of the ship, the whole pattern will be included within the tangents drawn from C.

Hitherto we have spoken only of the waves originating from the bow of the ship, but at the stern also the pressure of the water reaches a maximum; there is a hump of water near the stern as well as near the bow, and from the stern there originates a wave pattern similar to that from the bow. The two systems of echelon waves are fairly easy to discriminate, but the two systems of thwart waves are very often undistinguishable from one another. Sometimes, however, if the ship have a long parallel-sided middle body, the thwart waves due to the entrance or bow part have flattened out so much before the run, or stern part, of the ship is reached, that the series of thwart waves due to the stern part can be separately distinguished.

The steam-tugs which ply upon the Thames at London give a fine display of ship waves, especially when going at full speed without any barges in tow. At such times the water rises almost to the level of the deck at bow and stern, while amidships the sides are visible much below the water line. Standing upon one of the bridges one may look down upon the conspicuous echelon waves which form a long track behind the vessels, and which sometimes are of such height and power that they send a surf flying over the landing piers. The thwart waves, with their greater length and gentler slope, are less easy to observe at a distance from the vessel. I have found the steamboat pier near Westminster Bridge a good post for the observation of these waves. After a tug has passed under an arch of the bridge the thwart waves may be seen in profile against the sides of the arch, and their forward motion can still be watched when the vessel has gone nearly a quarter of a mile upon her course. Thwart waves may also be well seen in profile against the side of a long steamer in motion, as is shown in our illustration in the March number of Knowledge (page 54).

If the length of a vessel be known, her speed may be calculated from observation of the length between the crests of the thwart waves as shown by her wave profile. This follows from the connection between wave-length and velocity, the length being proportional to the square of the velocity. If at any particular velocity the wave-length be such that the crest of the wave formed by the entrance of the ship coincides with the crest of the wave formed by the run, or stern part, this velocity is unfavourable to the ship, owing to the great amount of the ship's power which is expended in wave-making. On the other hand, a velocity such that the crest of the wave due to the bow coincides with the trough of a wave due to the stern is a favourable velocity, since the two sets of waves tend to annul each other, the wave-making resistance being thereby diminished. For this reason a curve showing the total resistance experienced by a vessel at different speeds has a series of humps and hollows, depending upon the periodic variation in the wave-making resistance. Again, if a ship be designed for a certain speed, it is advisable that her length should be such that the crests of bow waves and stern waves should not coincide. As far as the skin resistance is concerned it is said to be best for a ship to be all entrance and run, with no parallel-sided middle portion; but the parallel middle body is an advantage where increase of length is required to prevent coalescence of the two wave systems.

Ducks when swimming show the echelon waves beautifully (Fig. 3), and there are no better places to see "duck waves" than the Serpentine and the water in St. James's Park. To get a good general view of the whole track of waves my favourite post of observation is the bridge near the Magazine; whilst for a near view, and to observe the "wave profile" of the duck, I prefer to walk by the edge of the water in St. James's Park, where one is sure to be accompanied at one's own pace by a duck on the look-out for food, the ducks in St. James's Park being both tamer and greedier than those of the Serpentine. The wavelets or ripples which form a fringe in front of the bow wave should be noticed; also the rise of water at chest and tail and its sinking "amidships" when the duck darts forward for a piece of bread. Very pretty also is the interlacing of the wave tracks when a whole fleet of ducks moves off together, especially when the sun is low and the slanting rays give lights and shadows to the waves.

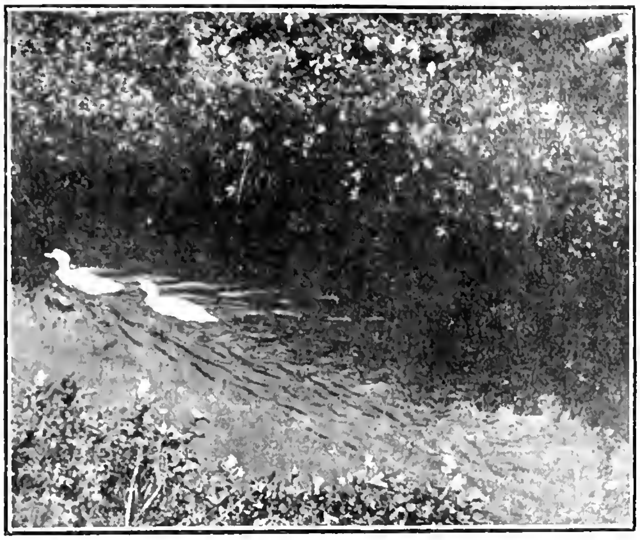

Fig. 3.—Ducks swimming, showing Echelon Waves.

In canals, the heavily-laden barges dragged by horses move too slowly to generate a system of waves; but when there is steam navigation upon a canal, or when lighter boats travel more quickly than the laden barges, a train of waves may be seen to follow the vessel. With higher speeds the wave-length increases, and the disturbance due to an even moderate velocity reaches the bottom of the canal. The surface particles can then no longer swing freely in a circular orbit, for they feel the effect of the bottom, communicated through the water particles which swing in their respective orbits at intermediate depths. As the motion of the swinging particles departs more and more from the original circular, uniform movement, the rear of the procession of waves travels at a rate more nearly equal to that of the boat. This is due to the fact that, as the motion of the swinging particles increases in a horizontal direction relatively to the vertical motion, the proportion of the energy of motion which is handed on at each swing is increased. When the wave-length has increased until the vertical motion of the swinging particles is very small in comparision with the horizontal motion, practically the whole of the energy is transmitted. For a canal of any given depth there is a particular wave velocity corresponding to this condition. If by any means there be instituted a train of waves following one another with this velocity there will be no lengthening out of the train of waves, for the energy does not fall behind the wave, but is transmitted with the velocity of the wave itself. Each wave crest travels on with undiminished height, except for the inevitable loss of energy which takes place through friction. Such a wave is termed a *solitary* wave, because it is capable of existing by itself without giving rise to a group of waves. When the critical velocity has been reached there is no distinction between the group velocity and the wave velocity. Perhaps it would be more correct to say that when the critical velocity is reached there is no such thing as a group of waves, since each single impulse creates only a single wave; and if a number of such waves be created by a succession of impulses each wave remains "solitary," for it neither parts with nor does it receive energy to or from the following or preceding waves.

To return to our canal boat. As the velocity is increased the rear of the group of waves moves more and more nearly at the rate of the boat itself. At a greater velocity the boat is followed by a shorter train of higher waves. At the critical velocity the wave created by the bow of the boat moves along with the boat; the energy of the wave does not fall behind so as to create a train of waves, and if the boat continue to move at the proper speed no new waves are formed. This fact was discovered many years ago, on the Glasgow and Ardrossan Canal, through the accident of a horse taking fright and bolting with a light canal boat in tow. When the horse galloped off with the boat it was observed that the foaming surge which used to devastate the banks had ceased, and that the vessel was carried on through comparatively smooth water *with a greatly diminished resistance.* The value of the discovery was at once perceived, and fly-boats, as they were called, were introduced upon the canal for the rapid conveyance of passengers. The boat, which was drawn by a pair of horses, was started slowly; at a given signal it was by a sudden jerk drawn up onto the top of the bow wave; and the horses were then kept at a trot or gallop, going from seven to nine miles an hour, the boat riding smoothly and easily upon a lump or hillock of water. Wave-making resistance was done away with; the horses had only to overcome skin resistance. After the critical velocity has been attained the only thing like a wave which is to be seen is the solitary hump or hillock of water upon which the boat rides. If the boat be stopped this hillock of water travels on as a free wave. Mr. Scott Russell has described the occurrence as follows:—"When the boat stopped . . . the mass of water . . . accumulated round the prow of the vessel in a state of violent agitation; then suddenly leaving it behind rolled forward with great velocity, assuming the form of a solitary elevation—a rounded, smooth, and well-defined heap of water, which continued its course along the channel apparently without change of form or diminution of speed. I followed it on horseback and overtook it rolling on at a rate of some eight or nine miles an hour, preserving its original figure, some thirty feet long and a foot to a foot and a half in height. Its height gradually diminished, and after a chase of one or two miles I lost it in the windings of the channel."

This is the free solitary wave, which is most generally known in the form of the low, foaming ridge which slides in upon a flat beach after the bursting of a breaker, as shown in our illustration in the February number of Knowledge. Here, by the shore, may be seen the more rapid progress of the solitary wave in deeper water, for the hinder ridges are constantly catching up those in front, which are in shallower water.

It remains to explain why the critical velocity of a canal boat depends upon the depth of the canal, being greater for greater depths. The change from oscillating wave to solitary wave depends upon the change from a circular swing of the water to a backward and forward swing with very little vertical motion. The disturbance of the water in the case of an oscillating wave reaches to a depth of, say, one wave-length. It is true that the surface particles do not descend in their swing to a depth of more than, say, one-tenth of this distance; but each swinging surface particle puts in motion a particle beneath it, so that below any point of the surface there is a vertical column of swinging particles, the amplitude of swing diminishing rapidly with the depth. A certain depth, about equal to the length from crest to crest, is therefore necessary for the free motion of a typical deep-water wave, in which the swing is circular and in which the energy advances at half the velocity of the wave. When the depth of water is much less than the wave-length corresponding to a certain velocity, a boat moving at that velocity will no longer generate a circular swing in the water; the bottom of the canal interferes with the vertical component of the swing, much as a vertical breakwater annuls the horizontal component when it converts a travelling wave into a stationary wave. (See Knowledge for February.) Under these conditions almost the whole of the swing is horizontally backwards and forwards, very little vertical motion remaining. The moving hillock of water, which is the visible thing about the transmission of a solitary wave, travels along the surface of the canal, the actual particles of water in the hillock constantly changing the while, for the march of the hillock is a true wave progression effected by transmission rather than translation. The hillock will have vanished from over section A (Fig. 4), and will surmount the section B, when a quantity of water equal to that contained in the hillock has passed from section A to section B. The rate at which this will be effected depends upon two things—the difference of pressure and the cross section. Now, as the hillock extends across the canal we need not concern ourselves about the width of section, but only about its depth. The given difference of pressure will effect the transference of a given bulk of water across each unit section in each unit of time, and, therefore, as the depth of the section is increased the given bulk of water will be more quickly transferred from section to section. Hence the relation between the depth of the canal and the velocity of the solitary wave. Following this principle, a short mathematical investigation shows that the (horizontal) velocity of a free solitary wave in a canal is equal to the (vertical) velocity which a body would acquire when falling freely in air through a distance equal to half the depth of the canal. Thus, for example, if the depth be eight feet, the velocity of the solitary wave is eleven miles per hour. This is the velocity of free propagation of any *long wave*, such as the tide wave, in which the motion of the water particle is mainly horizontal, and in which the water is equally disturbed throughout its whole depth. To the subject of the Tide Wave we return in our next article.

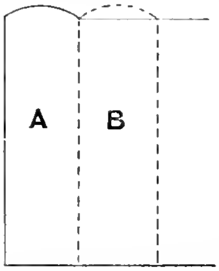

Fig. 4.—The Propagation of the Solitary Wave.

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Notices of Books.

An Exercise Book of Elementary Practical Physics. By R. A. Gregory, F.R.A.S., Oxford University Extension Lecturer. This is quite an elementary book, and must be intended for very small boys. It is, moreover, said to be arranged according to the syllabus of the Headmasters' Association. The plan may appeal to some, but it seems rather suggestive of cramming. Why is it thought necessary to perpetuate the obsolete phraseology of antiquated text-books on mechanics, which treated "power" and "weight" as things of the same character, and confounded "force" and "pressure"?

The Cambridge Natural History. Peripatus, Myriapods, Insects. By A. Sedgwick, M.A., F.R.S.; F. G. Sinclair, M.A.; and Dr. David Sharp, M.A., F.R.S. (Macmillan.) Illustrated. 17s.

Of the five hundred and eighty-four pages in this new volume of the "Cambridge Natural History," only twenty-four are devoted to an account of *Peripatus* by Mr. Sedgwick, and fifty-one to Mr. Sinclair's essay on Myriapods, the remainder being taken up with the first part of an original and strikingly attractive description of insects.

Peripatus is interesting because it is a kind of half-way animal between the *Arthropoda* and *Annelida*, though it really belongs to the former group, and only possesses Annelidan affinities. Mr. Sedgwick is a distinguished authority upon the genus he describes, and his brief essay on the features, habits, anatomy, development, and distribution of it is clear though necessarily special.

Mr. Sinclair's article on the *Myriapoda* is a valuable summary of the natural history of this group. The classification adopted is that of Koch, with two orders added, viz., *Symphyla* and *Pauropoda*. After describing the general characteristics of the whole group the distinctive features of each of the orders are studied, the account concluding with sections on the embryology and palæontology of Myriapods.

Dr. Sharp's work on insects is a masterpiece, as valuable to zoologists as it is to entomologists. The part now given includes the *Aptera*, *Orthoptera*, *Neuroptera*, and a portion of *Hymenoptera*. It is full so far as it goes, trustworthy, interesting, and in every respect satisfactory, and ranks high among the best literature of the subject ever published. Every naturalist, and everyone interested in natural history, should strive to add Dr. Sharp's work to their libraries.

The volume is well printed and excellently illustrated, and is a worthy addition to what will undoubtedly become a standard series.

The Origin of Plant Structures by Self-adaptation to the Environment. By the Rev. George Henslow, M.A., etc. (Kegan Paul.) 5s. This seventy-seventh volume of the "International Scientific Series" carries on the argument set forth by the author in a work published in the same series in 1888. The Darwinian hypothesis assumes (erroneously, according to Prof. Henslow) that plants, when they vary, do so indefinitely in nature, and that the variations which are of service under any particular environment survive and are perpetuated, so that natural selection and heredity may eventually lead to the production of new species. Prof. Henslow denies that natural selection plays any part in the origin of species. He holds that a change of environment induces a plant to form *definite* and not indefinite variations in nature, which are, therefore, always in the direction of adaptation to the surrounding circumstances of life. Environment in its widest sense, and "the responsive power of protoplasm," are thus held to be the causes of adaptive variations in plants, and natural selection is put out of court. In the present volume this view is applied to account for the origin of vegetative structures, as it was used in the former one to that of floral structures. The cases studied by the author to show that definite variations are produced by the responsive action of the protoplasm in various species of plants, called into play by the external forces of the environment, are desert plants, alpine and arctic plants, maritime and saline plants, phanerogamous aquatic plants, subterranean structures, climbing stems, and leaves. A wealth of facts with reference to the structural peculiarities of these plants are described and explained from Prof. Henslow's point of view. The argument is always ingenious and often convincing, and, though we are not inclined to accept it in its entirety, we regard it as affording a strong case against natural selection. But whether Prof. Henslow's views are accepted or not, we cordially commend his book to all who study the biology of plants.

Report of the Total Eclipse of the Sun, observed at Mina Bronces, Chile, on April 16th, 1893. By J. M. Schaeberle (University of California). Illustrated. The excellent results obtained by Prof. Schaeberle during the total solar eclipse of April, 1893, and the fact that a large number of astronomers are making preparations to observe the eclipse which will happen next August, makes this volume a very valuable one, published at an appropriate time. The volume contains a narrative of the expedition, reports of individual observers, several good illustrations of the corona reproduced from photographs, and a discussion of the results by Prof. Schaeberle. It will be remembered that the attention of the expedition was entirely devoted to the corona, so the discussion is practically limited to coronal structure. In a "Mechanical Theory of the Corona," put forward by Prof. Schaeberle in 1890, it was suggested that all the coronal matter was ejected in streams normal to the sun's surface, and that the various appearances presented by the corona during different eclipses were produced by differences in the terrestrial point of view. This theory has, however, been slightly modified in order to accommodate it to the facts revealed by the photographs of 1893, and Prof. Schaeberle now concludes that "all true stream lines can be made to coincide with elliptical arcs having one focus at the sun's centre, the origin of the streams being, in the main, confined to the spot-zone regions." Contrary to the opinion of many solar physicists, he thinks that neither electricity nor magnetism have anything to do with the arrangement of coronal matter in the sun's neighbourhood; indeed, if all the stream-lines have the form which Prof. Schaeberle describes in the foregoing extract, it is unnecessary to introduce electrical and magnetic forces to account for them. How far the views will stand the test of future knowledge is not for us to decide, but at any rate they help to direct attention to the structure of the sun's surroundings, and so assist in the advancement of solar physics.

The Aëronautical Annual. Edited by James Means. (Clark & Co., Washington Street, Boston.) One dollar, post free. The general public, as well as literary men, leader writers, and even some scientific people, entertain very vague and erroneous ideas as to the results likely to arise when man has succeeded in navigating the air. To all such we would strongly recommend a careful perusal of Mr. Means' new annual for 1896. In this volume (the second annual) Mr. Means has most industriously brought into notice the result of a year's work, and has produced a very instructive and readable book. Under twenty-one separate headings, with sixteen well-executed plates (including an excellent likeness of Mr. Octave Chanute) and numerous woodcuts, the subjects are rendered very clear for the reader. M. Lilienthal contributes some novelties in his particular department of flight; Mr. Maxim treats of the allied subjects of natural and artificial flight; Mr. Chanute takes up the subject of sailing flight, Prof. Pickering takes up the subject of bird soaring, Mr. Herring dynamic flight, and Mr. Lawrence Rotch the relation of the wind to aëronautics. Not the least interesting portions of the book are those in which various kinds of kites are well described and illustrated. While the annual proves that real progress is being made, it also shows that very much remains to be accomplished before aërial flight can be rendered practical; and those who look upon it as a mere instrument of war will have to wait a very long time.

SHORT NOTICES.

The History of Babylonia. By the late George Smith. Edited and brought up to date by Rev. A. H. Sayce. (Society for Promoting Christian Knowledge.) 2s. A valuable handbook for students. It possesses a list of Babylonian kings with their approximate dates, and has a useful index.

Frail Children of the Air. By Samuel Hubbard Scudder. (Boston: Houghton, Mifflin, & Co.) Illustrated. $1 50c. In this book a number of interesting facts in relation to butterflies, and especially American species, are discussed and explained. The book is free from technicalities, and will be valued by all amateur entomologists.

Popular Readings in Science. By John Gall, M.A., and David Robertson, M.A. 2nd Edition. (Constable.) 4s. A number of subjects of fundamental importance in science are treated of in a fairly popular way in this volume, and we would recommend it to those who wish to gain a general knowledge of important scientific subjects.

The Climates of the Geological Past, and their relation to the Evolution of the Sun. By Eug. Dubois. (Swan Sonnenschein.) 3s. 6d. This is a translation of a treatise in German and an essay in Dutch, purposing to explain the climatic changes of past ages by changes of the solar heat.

Annuaire Astronomique et Météorologique pour 1896. Par Camille Flammarion. (Paris: Plon, Nourrit.) Illustrated. 1f. 25c. Contains a description of every celestial phenomenon observed during the year 1895.

Mechanics, Hydrostatics. By R. T. Glazebrook, M.A., F.R.S. (Cambridge University Press.) Is an excellent elementary text-book, and will be found of great use for colleges and schools, since it deals both practically and theoretically with the subject.

The Koh-i-Nur Diamond. By Edwin W. Streeter. (Bell & Sons.) Illustrated. Contains an interesting description of this celebrated diamond and its history, and also of the Pitt diamond.

The Story of the Earth in Past Ages. By H. G. Seeley, F.R.S. (Newnes.) Illustrated. 1s. This little book, which is a wonderful production for the price, deals pleasantly and plainly with many facts in connection with the earth in the geological past.

Weather and Disease. By Alex. B. MacDowall, M.A. (Graphotone Co.) Is a very interesting compilation, illustrating by means of curves the history of the variations of weather and disease in recent years. It will furnish useful data for comparison and study to those interested in the subject.

An Introduction to Chemical Crystallography. By Andreas Fock. Translated from the German and edited by W. J. Pope. Is so arranged that the twenty-five brief chapters each elucidate a single idea, and Mr. Pope's excellent translation and revision will bring it within the reach of university and other students.

We have lately received a number of new catalogues, all excellent in their way, from different makers of scientific instruments. The chief features in Messrs. Newton's, Messrs. York & Son's, and Messrs. Wilson's catalogues are their gigantic lists of magic-lantern slides, comprising series of almost every subject of scientific interest. Mr. J. H. Steward has issued a pamphlet entitled "How to Assist the Sight," which admirably explains the uses of spectacles and eyeglasses of every kind. Messrs. Ross & Co. have several novelties in their catalogue, amongst which we might mention their new Eclipse microscope and new Science lantern, the former as an excellent cheap microscope and the latter as a very complete and perfect lantern. Messrs. Horne & Thornthwaite's astronomical instruments range from the plain and inexpensive to the high class and perfect. Messrs. Banks & Co.'s catalogue contains an excellent list of astronomical instruments suitable for amateurs, and that of Messrs. Steinheil Söhne a number of binoculars and telescopes. Messrs. Thornton-Pickard have also sent us a catalogue, the illustrations in which prove the efficiency of their shutters.

BOOKS RECEIVED.

Discoveries and Inventions of the Nineteenth Century. By R. Routledge, B.Sc. 11th Edition. (Routledge.) Illustrated.

Outdoor Life in England. By Major A. T. Fisher. (Bentley.)

British Moths. By J. W. Tutt, F.E.S. (Routledge.) Illustrated. 5s.

Moorland Idyls. By Grant Allen. (Chatto & Windus.) 6s.

On Seedlings. By Sir John Lubbock. International Scientific Series. (Kegan Paul.) Illustrated. 5s.

A Child's History of Scotland. By Mrs. Oliphant. (Fisher Unwin.) 2s. 6d.

Segnius Irritant; or, Eight Primitive Folk-lore Stories. By W. W. Strickland. (Forder.) Illustrated.

The New Photography. By A. B. Chatwood. (Downey.) Illustrated. 1s.

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Science Notes.

At a recent meeting of the Royal Geographical Society, Mr. Clements R. Markham being in the chair, Dr. H. R. Mill read a paper on "A proposed Geographical Description of the British Islands, based on the Ordnance Survey." In the course of an interesting and comprehensive address the lecturer advocated the preparation of a complete geographical description of the British Islands, somewhat upon the lines laid down by him recently in our columns. (Knowledge for January, 1896.) In the discussion which followed, Sir Charles Wilson and Colonel Farquharson both commended the project, while Mr. Clements Markham looked upon the matter as one of the greatest importance, and undertook to recommend to his Council that the work should be carried out under the Society's auspices. We may mention that Dr. Mill has promised to continue the discussion of the project in our columns a little later on.

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At the observatory of the Pic du Midi the zodiacal light is always visible on clear moonless nights, and E. Marchand has, during the last three years, made careful observations upon it. It is not confined to a fusiform region in the neighbourhood of the sun, but continues that region right across the sky as a faintly luminous track, always dimmer than the Milky Way at its dimmest. The cosmic matter surrounding the sun extends far beyond the earth's orbit in a very much flattened ellipsoid, but is especially condensed in the neighbourhood of the sun, and forms there the more brightly luminous fusiform zodiacal light as usually seen in the morning or evening.

The fifth annual report of the Society for the Protection of Birds, which has been sent to us by the hon. secretary, is a very satisfactory one. It shows that the Society is increasing and that it is doing really good work, not only in promoting bird protection, but in spreading a knowledge of bird life by lectures illustrated with lantern slides. By thus interesting and educating the public in birds, the Society will be better able to put an end to the destruction of our feathered friends than by mere legislation.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE RED SPOT ON JUPITER.

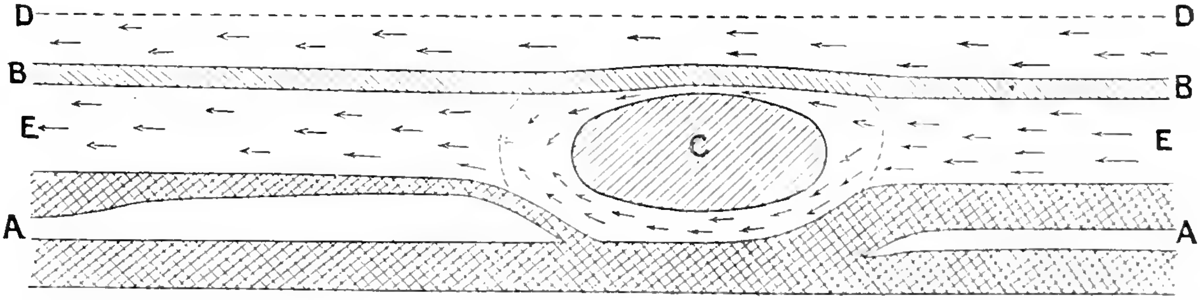
To the Editors of Knowledge.

Sirs,—I have just been reading the interesting article on the "Red Spot on Jupiter," by Mr. Maunder, in the January number of Knowledge. There is necessarily a great deal of mystery as to the nature of the spot; nevertheless I cannot help thinking that it actually acts in the same way as, and has some analogy to, an island in a river. The following rough diagram may make this plainer.

Here A is the S. equatorial belt, the material of the southern portion of which rotates at approximately the same rate as the red spot; B is the S. temperate belt; C is the red spot or island. The whole of the surface material in the zone E, between A and B (and also for some distance south of B), drifts past the red spot in the direction of the arrows with a velocity of sixteen miles per hour. (This is Zone VIII. of my paper on the drift of the surface material of Jupiter in different latitudes, in the January number of the *Monthly Notices*.)

When the white material in the zone E encounters the red spot or island C, it meets with an insurmountable obstacle, and is obliged to force a passage *round* C, which it does chiefly on the north side by forcing the south equatorial belt A northwards. A portion of the white material also usually passes in the narrow channel on the south side of the spot.

The reason why the main channel lies on the north side of the spot would appear to be because the material is in a more plastic state near the equator than it is nearer the poles. (This is also indicated by the well-known fact that the equatorial parts of the planet are the chief seat of disturbance and change, and the region of greatest spottedness.) So that there is less difficulty in forcing A northwards than B southwards.



Here comes an important point. The channels north and south of the red spot are together narrower than the main channel E following the spot. The effect of this to cause the white material to be heaped up in the region *just* following the spot, and also in the channels north and south of the latter; and these regions therefore appear whiter than the average, owing to the greater depth of white material, thus producing the bright annulus encircling the red spot. In the region just preceding the latter, the meeting of the two currents causes eddying and commotion of the white material before it finally flows off along the now broad channel E preceding the spot. The result of this eddying and commotion is to make appear here the bright indefinite patch (part of the annulus) usually visible, even when the rest of the annulus is comparatively inconspicuous.

You will see that this theory seems to account for:—(1) The apparent repulsion of the S. equatorial belt, resulting in the great bay opposite the red spot; (2) the well-known shoulder following the latter; (3) the bright annulus surrounding the red spot; (4) the bright patch (forming part of the annulus) usually visible at the preceding end of the spot; (5) the broad bright channel always seen separating the spot from the S. equatorial belt. And all this in the simplest way possible.

It is true that I cannot imagine what kind of a constitution the red spot can have to act as such a substantial obstacle, and yet to drift about as it has done. Nevertheless it seems to me that the foregoing is worth suggesting as a working hypothesis, especially since there appears to be no theory which is not open to serious objections.

Until lately I was a little doubtful whether the white material in the channel north of the spot does move in accordance with the above hypothesis, but according to a letter just received from Herr Brenner, of the Manora Observatory, there appears to be no doubt of this.

A. Stanley Williams.

MIRA CETI.

To the Editors of Knowledge.

Sirs,—Unfortunately the weather seems to have hindered the observation of this star for a week in the early part of January, and I only know of a few observations of it made afterwards until the middle of that month.

On the 9th I compared the brightness of Mira with that of δ Ceti, and the former appeared to have the benefit in a slight degree. This would make its magnitude not much above the fourth order, at which it was placed by Mr. David Flanery on January 8th.

On January 10th I again observed the star, and placed its magnitude at nearly that of γ Ceti, there appearing to have been a rise of almost half a magnitude in the twenty-four hours.

A few dull evenings then intervened until the 15th, when I could find no appreciable difference between Mira and γ Ceti, although on the 19th the latter seemed to me to be very slightly the brighter.

From that date I have made very few observations of Mira under favourable conditions, but at the end of February no remarkable decrease in its magnitude was noticed.

Exeter. W. E. Besley.

PENTACLE PUZZLE.

To the Editors of Knowledge.

Sirs,—I owe an explanation to the readers of my letter (Knowledge for March, p. 63), which perhaps led some to think I had actually solved the problem myself, whereas it was simply tentative. But I fear the problem is insolvable in its complex statement, and perhaps also in the simple statement touching the summations of the five lines only.

I would suggest that possibly the law may be that such results occur only when the lines of the figure chosen are parallel.

I find further that this problem goes very much on the same lines as the endeavour to find *exact* relations between the radius and the periphery of a circle.

Brighton. I. G. Ouseley.

[Note.—It has been pointed out by several correspondents that the sum of the numbers 1 to 10 being 55, which is indivisible by 3, the sum of any five of the numbers cannot be double or half the sum of the remaining five; and since in the problem the five external numbers are to count double the five internal numbers, the problem is insolvable.—Eds.]

ZODIACAL LIGHT (?).

To the Editors of Knowledge.

Sirs,—I venture to write you respecting an unusual phenomenon witnessed by myself on the outskirts of this town on the evening of March 4th. Happening to look westwards I saw a solitary bright streak of light (in width apparently about 5°) issuing from behind a dark cloud on the W.N.W. horizon, and stretching almost half-way to the zenith.

This was at 8.30, and it remained very bright for three minutes (so bright, in fact, that a light cloud passing over it did not entirely hide it from view), when it gradually faded away to a glimmer, and in ten minutes no trace was to be seen.

Both sides of the streak were well defined, and were parallel to one another throughout the whole length. It attracted the attention of all passers by, who stopped to look at it, and were asking what it could be. Was this the zodiacal light? If so, it was very bright, and was hardly at all inclined to the horizon. It was certainly not caused by any terrestrial agency.

Shrewsbury. W. Lyon Browne, Jun.

"26" PUZZLE.

Note.—We are informed that the publication in our columns of possible solutions of this clever puzzle constitutes an infringement of the copyright; we therefore willingly express our regret to Messrs. T. Ordish and Co., 99, Fore Street, London, E.C. (Publishers), and also to Messrs. Joseph Wood Horsfield & Co., of Dewsbury, the proprietors of the puzzle, for any infringement of their patent or copyright inadvertently committed in the pages of Knowledge.

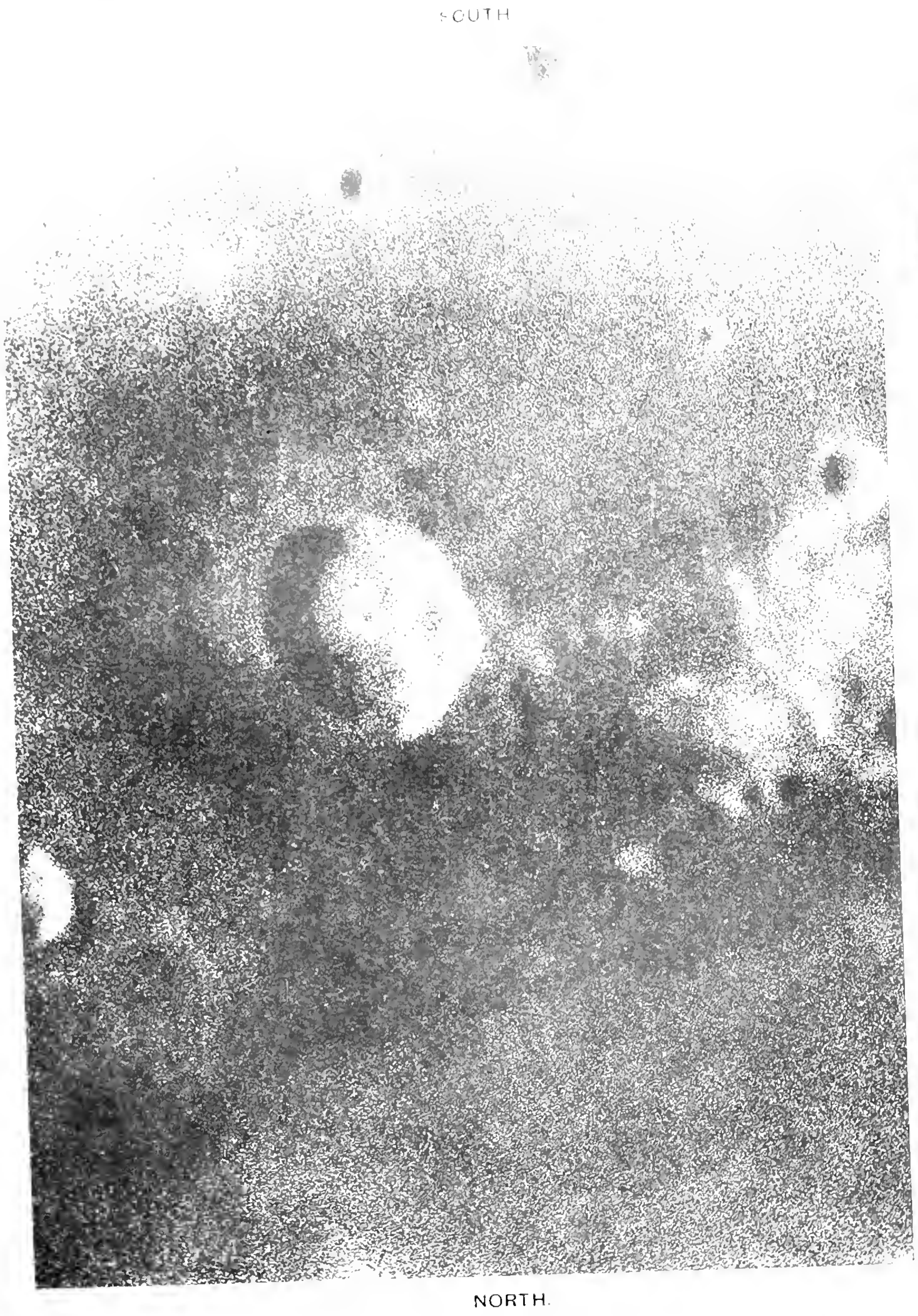
PLINY AND CUVIER.

By E. Walter Maunder, F.R.A.S.

THE two lunar photographs which we reproduce in the present number of Knowledge are, like those which we gave in June, 1895, from enlargements by Dr. Weinek of a photograph taken by MM. Loewy and Puiseux with the large equatorial coudé of the Paris Observatory on March 14th, 1894. Dr. Weinek's photographs were on a scale of four mètres to the lunar diameter, a magnification of 23·36 times linear. The present reproductions are on a scale of 2·9 mètres to the lunar diameter.

The two districts shown are sharply contrasted in character. The left-hand picture shows the borderland between two of the principal *maria* or grey plains—the Mare Tranquillitatis and the Mare Serenitatis—and shows a country mostly open, and but little diversified or broken up. The one on the right hand, on the contrary, is taken from far within the great disturbed region of the Moon which has its centre in Nasireddin, a region strewn with crater-pits and full of overlapping and interlaced formations.

The object occupying the centre of the first picture is

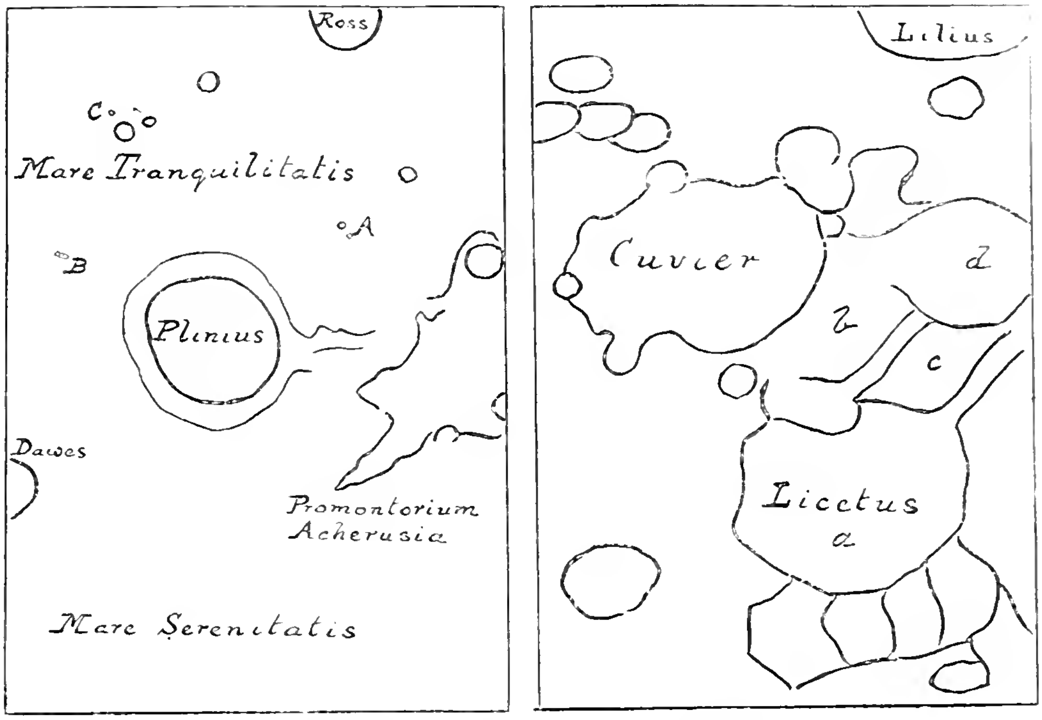


PLINIUS.

CUVIER and LICETUS.

From Enlargements by Dr. L. Weinek of a Photograph of the Moon taken by MM. Loewy & Puiseux with the 60 c.m. Equatorial Coudé of the Paris Observatory, 1894, March 14th, 6h. 33m. 57s. Paris Mean Time.

Plinius, a fine terraced ring-plain some thirty-two miles in diameter, which, on a smaller scale, bears much the same relation to the chief "seas" in the western hemisphere that the superb formation Copernicus does to those in the eastern. Both, completely ramparted rings of especially massive construction, appear to be strategically placed so as to dominate the approach to the neighbouring plains: and Mr. Elger, in his recent and valuable work on the Moon, is led to speak of Pliny as reminding him "of a great fortress or redoubt erected to command the passage between the Mare Tranquilitatis and the Mare Serenitatis." The rampart of Pliny is not, however, raised to any great height above the surrounding country, though its highest point, clearly seen on the photograph on the east wall of the ring, rises some six thousand four hundred feet above the floor of the interior; which is thus considerably depressed below the level of the general surface in the neighbourhood. The floor of the interior is broken up by many hillocks, and two bright hills of very considerable height occupy the centre. They are distinctly shown in the photograph. The southern side of the wall slopes very gradually down to the plain outside, forming an extended glacis some ten or twelve miles broad.



Key Map of Plinius and Cuvier and Licetus.

To the east of Pliny a bright mountainous region is seen—the last ridges of the Hæmus Mountains, one of the four great ranges which shut in the Mare Serenitatis, and render it the most sharply outlined of all the lunar *maria*. These mountains terminate in a great headland nearly five thousand feet high, the Promontorium Acherusia, on the northern slope of which four deep craters are very plainly seen.

North of Plinius a broad "rill" or cleft is seen on the photograph, starting from amongst the Hæmus Mountains, close under the southern slope of the great headland just mentioned, and running right across the photograph to Dawes, a bright ring-plain on the western edge of the photograph. Further north lies a second cleft inclined at a small angle to the first; whilst between the two, but not to be discerned on the photograph, is a third—faint, small, and difficult.

These rills mark the frontier line of the two great *maria*—the more southern one, the "Tranquillity," standing at the higher level of the two, a gentle slope descending from it towards the "Serenity." In the latter, "deep calls to deep," for within a broad grey margin, itself lower than the "Tranquillity," lies an inner "Serenity," deeper still, some eighty thousand square miles in area, which full of a fine, clear, light-green tint"—in Neville's words. The photograph does not, however, reach as far as this innermost region, and the dark grey margin is alone shown.

The only two other prominent features of the photograph are the two smaller ring-plains Ross and Dawes, which, following out the military metaphor, stand as outworks of Plinius to prevent its being outflanked by an invader from the south. Dawes is remarkable for standing on a broad circular platform of brighter material than the surrounding country, a feature well shown in the photograph.

The new objects revealed by the photograph are neither large nor numerous, for this is an attractive region to the selenographer, and it has been well and frequently explored. But Dr. Weinek claims that the following new features are shown:—

(A.) A double craterlet, shown as single and small by Schmidt.
(B.) A set of two, or perhaps three, interlaced craterlets.
(C.) A small doubtful object, *s.* Plinius.

It is difficult, however, to bring out these minute details in a photographic reproduction, which has itself been copied from a copy from an enlargement.

The right-hand photograph, with its mass of detail and intricate structure, is a great contrast to the simplicity of arrangement of the Plinius region. In Licetus we have not one ring-plain, but four, which, by mutual encroachment the one on the other, and the consequent partial destruction of the boundary walls, have been fused into one very irregular walled plain. The principal member of the group is *a*, the one to the north. It is some fifty miles in diameter, and is nearly circular in its real shape (it is, of course, seen somewhat foreshortened). The highest peak of the wall rises nearly thirteen thousand feet above the interior. The other chief object shown in the photograph is Cuvier, a fine walled plain of about the same diameter as Licetus *a*, and walls of about the same elevation. For the minor objects in the field the photograph itself will give more information than much verbal description. Dr. Weinek notes no new objects here.

It may be added that this photograph slightly overlaps, at its lower left-hand corner, that given of the district of Maurolycus in Knowledge for June, 1895.

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THE SPECTRUM OF HELIUM.

By E. Walter Maunder, F.R.A.S.

The first vague glimpse of the spectrum which has won so much attention during the last twelve months would appear to have been caught by Prof. Magrini at Milan, during the total solar eclipse of 1842, July 8th. A momentary glance at the corona through a flint-glass prism showed him three vivid colours, the colours which, following Sir David Brewster's theory, were then considered primary—red, yellow, and blue. No notice seems to have been taken of the observation; the observer himself seems to have laid no stress upon it. Spectrum analysis had not then made sufficient advance for it to be understood; yet it was none the less the first faint forecast of fuller observations to come. It was the evidence, could it have been then interpreted, that the "red flames," so often noticed round the dark moon in a solar eclipse, belonged truly to the sun; that they were gaseous in character; and that amongst the glowing gases which made them up, hydrogen, and a gas at that time stranger to us, were the most abundant.

Twenty-six years after Prof. Magrini's observation, in the celebrated eclipse of 1868, August 18th, the same three colours flashed out their light on the expectant observers who, at Guntoor, Jamkandi, Masulipatam, and Tenasserim, were watching the eclipse, armed not with simple prisms merely, but with complete spectroscopes attached to powerful equatorials. There is no need to quote at length the accounts which have been so often retold. Suffice it—to take one observation amongst many—that Captain Herschel, setting the slit of his spectroscope on a brilliant prominence, needed but to give "a single glance, and the problem was solved. Three vivid lines—red, orange, blue; no others, and no trace of a continuous spectrum." The problem was solved—that is, so far as the question was concerned that the prominences belonged to the sun, and were gaseous in character. The nature of the gas was a different matter, and here the evidence of the eclipse itself was incomplete. M. Janssen was confident that the red and blue lines were the lines of hydrogen; other observers thought it more or less probable; most believed the yellow line to belong to sodium: and so the matter might have rested. But impressed with the extreme vividness of the prominence lines, Janssen resolved to look for them after the eclipse was over, and was delighted to find his anticipation realized, and that they could be seen in full sunshine. Then it was an easy matter to establish decisively the conclusion he had arrived at during the eclipse, that several of the prominence lines were due to hydrogen. But it became equally evident that the bright yellow line was not coincident with either of the two dark D lines due to sodium; it was not, indeed, coincident with *any* dark line in the solar spectrum, and it lay further towards the blue than D_2 by fully twice the distance that separated the latter from its twin brother D_1.

At first the new line, D_3 as it was called, was supposed by many to be a line of hydrogen produced only under conditions which we are not able to reproduce in the laboratory. It was as constant a feature of the chromospheric spectrum as the lines of hydrogen; it rose to the same height from the sun. But more careful scrutiny showed that it did not by all means always respond to the changes and displacements shown by C and F, the undoubted hydrogen lines; and it was not long before it was acknowledged to indicate the presence of a gas unknown to us as yet here, and on Frankland's suggestion the name of "helium" was assigned to it.

Again a little over twenty-six years passed by without our knowledge of "helium" receiving any addition, until Prof. Ramsay's discovery of it, just a year ago, in the gas obtained from the mineral clèveite. The story of that discovery, and of the researches into the properties of the gas which Prof. Ramsay and other physicists lost no time in instituting, has already been well told in the pages of Knowledge by Dr. McGowan (September, 1895). The story of the complete study of its spectrum is of fully equal interest and is of more recent date. The romance of helium is not completed even yet.

It will be remembered that for a short time the identity of the gas obtained from clèveite with true solar helium was called in question. This was owing to the discovery of Profs. Runge and Paschen, of Hanover,* that the bright yellow line from the new gas was not single (as the D_3 line of the solar chromosphere was then supposed to be), but double. Dr. McGowan has already described how the observations of Dr. Huggins and Prof. Hale speedily set the question at rest by showing that the solar D_3 was double likewise, and so completely establishing Prof. Ramsay's claim to have "run helium to earth."

But this discovery of Runge and Paschen was but an incident of the work which they were carrying on with the most powerful of spectroscopic appliances, and with the utmost thoroughness and care. The spectroscope was one of Rowland's concave gratings, with a radius of curvature of over twenty-one feet, a ruled surface of six inches, and ruled with twenty thousand lines to the inch. The photographs taken with this instrument rendered it possible to measure the wave-lengths of the lines in the great majority of cases to the thousandth of a tenth-mètre, the errors of the determinations (due mainly to the unsuitability of some of the reference lines for measurements of such delicacy) lying for the most part in the third decimal place.†

In order to obtain the greatest possible brilliancy of spectrum the vacuum-tube was used "end-on," an arrangement first employed to any great extent in this country by Prof. Piazzi Smyth, then Astronomer Royal for Scotland. By this arrangement, which necessitates a special form of tube, the light from the entire length of the capillary tube is concentrated on the slit instead of that from its breadth only. The electrodes consisted of two cylinders of aluminium foil, one in each of the two wide parts of the tube, and pressing against two platinum wires, thus allowing the capillary to be viewed end-on without interruption. The end of the tube nearest the slit of the spectroscope was closed by a "window"—a flat piece of glass, quartz, or fluor spar, according to the region of the spectrum under study.

A further essential for the work, and one far more difficult to secure, was the purity of the helium gas. The chief impurity was hydrogen gas. The helium was prepared in the same way as it was originally discovered by Prof. Ramsay, *i.e.*, by boiling clèveite with diluted sulphuric acid. This was then mixed with a large quantity of oxygen, and sparked continuously for several days until a whole day's sparking caused no further contraction. The oxygen was next absorbed, and the remaining gas stored in

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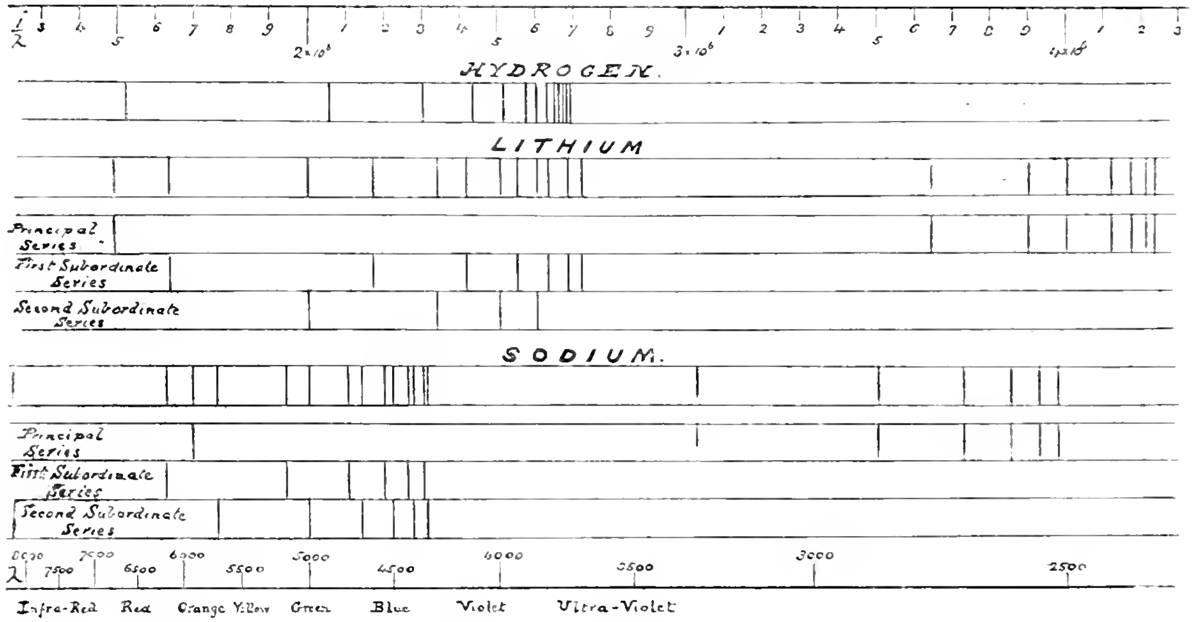
* *Nature* of June 6th, 1895.

† *Astrophysical Journal*, 1896, January.

a vessel provided with stopcocks, so that a small quantity could be drawn off from time to time in order to fill the vacuum tubes. The vacuum tubes were subjected to the strictest discipline before the clèveite gas was admitted to them, being completely exhausted, dried at the air pump, heated as strongly as they would bear, and a strong induction current passed through them; this treatment being repeated until the spectrum of hydrogen was no longer shown, or, if shown, only feebly.

The results obtained were well worth all the trouble and time expended so ungrudgingly on the preparation of the tubes. The wave-lengths of the lines of helium were determined mainly by the measurement of photographs, the lines of sodium which were given by the vacuum tube itself when the glass got sufficiently heated, and those of iron from a pair of electrodes placed close to the slit, being the chief points of reference.

The spectrum of the gas from clèveite, as worked out at fullest detail in this most thorough and painstaking manner, proved at first sight one of great irregularity, and had its discovery fallen some ten or a dozen years earlier, investigators would in all probability have been content to accept it as observed, and to enquire no further.



But we had advanced beyond this stage of spectroscopic work. Even in the infancy of spectrum analysis it was felt that there ought to be some close connection between the undulations indicated by the different lines of a glowing gas; that they must be related to each other by some unfelt rhythm. They seemed like the broken snatches of distant music borne to our ears by fitful gusts of wind; they were parts of a complete harmony to the knowledge of which we had not yet attained, but we were assured that if it could but reach us in its fulness each of these detached and separate vibrations would find its proper place, and show itself as an integral part of a beautiful and perfect whole.

It was with some kindred thought to this that in 1871 Prof. Johnstone Stoney, in a paper communicated to the Royal Irish Academy,[*] suggested that the three lines of hydrogen, now known as $H\alpha$, $H\beta$, and $H\delta$, and which give rise to the three Fraunhofer lines C, F, and *h*, were respectively the twentieth, twenty-seventh, and thirty-second harmonics of a fundamental vibration whose wave-length *in vacuo* was 0·13127714 of a millimètre. But the third line of hydrogen, $H\gamma$,—"near G," or G′, as it is generally called,—had no place in this arrangement, and attempts to fit similar formulæ to other spectra ended only in disappointment.

At that time our knowledge of the hydrogen spectrum—which, as one of the simplest of all spectra, and as given by the lightest of gases, appeared specially marked out for this investigation—did not ascend beyond the violet. The "deep things out of darkness" which the unseen regions of the ultra-violet were to yield were not then disclosed. But when Dr. Huggins' photographs of stellar spectra[*] revealed the long series of lines in the ultra-violet in stars of the first type, it became an almost irresistible inference that these were the completion of the hydrogen spectrum. They made, with the four lines which we knew of old, a series so obviously rhythmical, so obviously one, that the conclusion could hardly be avoided.

A further and an important step forward was due to a study undertaken by Prof. Piazzi Smyth. Prof. Smyth was in the habit of drawing his spectra and expressing the positions of his lines on a scale of "wave-numbers to an inch," instead of, as usual, on a scale of wave-lengths; and in particular had made a fine map of the great green band of the beautiful spectrum of carbonic oxide. This map he submitted to the inspection of Prof. A. S. Herschel in November, 1883, who pointed out that the "wave-numbers" of these lines formed two perfectly similar arithmetical series, so placed with respect to each other that the fifth line of the first series was coincident with the first of the second. Further, the ninth line of the first series showed as a close doublet, and the tenth and following lines as doublets, each slightly wider than the preceding one.[†]

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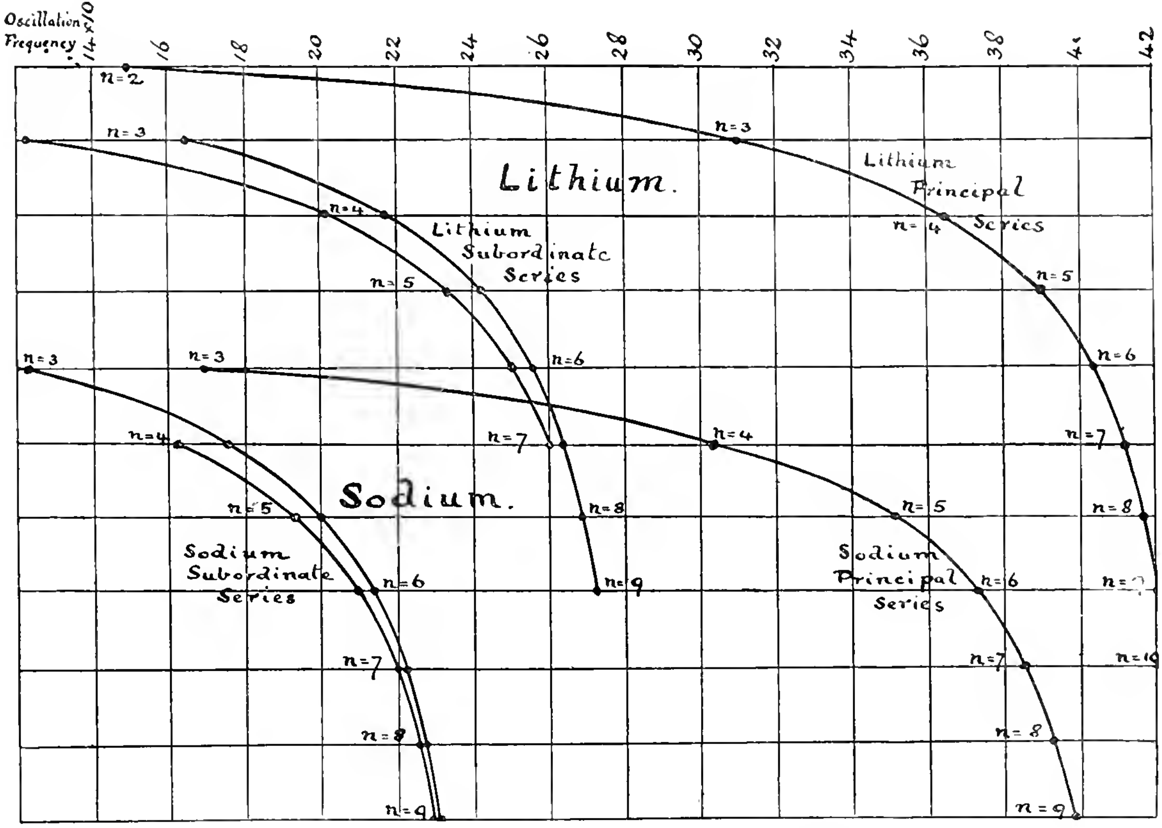
[*] *Proc. Roy. Irish Acad.*, Jan. 9th, 1871.

[*] *Phil. Trans.*, Vol. CLXXI., 1880, p. 669.

[†] *Trans. Roy. Soc. Edin.*, XXXII., 1884.

This discovery was closely followed by several similar ones. M. Cornu, early in 1884,* announced with regard to the three great bands of the solar spectrum, A, B, and D, that the telluric lines of the last named "form two unequal series of double lines, whose channelled appearance immediately recalls that of the telluric groups A and B;" that the three bands may be looked upon as forming three harmonic groups analogous to the triplets of magnesium and zinc; and that the reciprocals of the wave-lengths of the homologous lines of the three groups are very nearly in arithmetical progression. A year or so later Prof. Rowland commenced his study of the same bands, and not only confirmed Cornu's observation of their resemblance, but also found that the lines of each band showed an approximation to the same type of structure which Prof. A. Herschel had remarked in the green carbonic oxide band. But as the lines did not form a series rigidly harmonic within the limits of accuracy of his measurements, he did not publish his results.†



There is no occasion to review all the attempts which have been made to compel various spectra to give up the secret of their structure. The story of the first complete success in this field has already been told in the pages of Knowledge by the late Editor. ("On the Rhymical Group of Hydrogen Lines visible in many Stellar Spectra," by A. C. Ranyard, Knowledge, September, 1891.) Prof. Ames' verification of Balmer's law was followed very quickly by a most important announcement by Profs. H. Kayser and C. Runge with regard to the spectra of the alkalies. These various spectra were all formed, they reported, "in an entirely analogous manner, which is especially manifest if, instead of the wave-lengths, we consider the reciprocals—that is, the number of vibrations. Each spectrum is seen to be made up of several series lines, each of which may be represented with great accuracy by the formula

$$\frac{1}{\lambda} = A - \frac{B}{n^2} - \frac{C}{n^4}$$

where λ is the wave-length; A, B, and C are three constants; and n stands for the series of numbers from $n = 3$ upwards."*

It will at once be seen that Balmer's formula is only a special case of the above in which $C = 0$. And it will also be seen that as n increases, so $\frac{1}{\lambda}$ tends to approach A, which, accordingly, gives the value of the asymptote of the series. The constant B is *nearly* the same for all spectra, whilst the constant C gives the rate of convergence.

The spectra of the alkalies, however, exhibited other and more complicated relations than the spectrum of hydrogen. In each case three distinct series were noted. The principal series—the one giving the strongest lines, and those most easily reversed—is the one of longest stride and greatest extent; and for all the spectra but that of lithium it consists of doublets, the members of which continually approach each other as they approach the red end of the spectrum, the difference of the "wave-number" of the components of any pair being inversely proportional to n.

But besides the principal series of lines each spectrum contains other subordinate series. Lithium contains two. For both these the constant A as well as the constant B are nearly the same; in other words, they both approach

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* *Comptes Rendus*, Vol. XCVIII., No. 4.

† Ames, *Phil. Mag.*, 1890, II., p. 41.

* *Sitz. d. Berliner Akad.*, June 5th, 1890. Profs. Kayser and Runge announced in 1888 that they had discovered the general law of spectra, but do not seem to have published it until 1890.

the same limit. The same is the case with sodium and potassium; but whilst the lines of lithium are single those of sodium and potassium are double, and the successive doublet intervals are always the same. We might therefore express the case a little differently by saying that sodium and potassium each give two pairs of subordinate series, and that the one series of each pair is displaced throughout as compared with its companion series by a constant oscillation-frequency.* And, further, this constant difference is the same as that shown by the two components of the first doublet of the principal series.

The accompanying diagrams will exhibit the character of these relations for the spectra of lithium and sodium better than much verbal explanation. In the first diagram the upper line for lithium and sodium shows the complete spectrum of the element; its analysis into principal and first and second subordinate series is shown below. The second diagram corresponds to that given by Mr. Ranyard for hydrogen in the paper referred to above, and is intended to show the convergence curves of the different series. In each case the scale adopted is one of oscillation-frequencies to the mètre. Doublets are shown throughout as single lines, the scale of the diagrams not permitting them to be shown as distinct pairs.†

Profs. Kayser and Runge have more recently analysed the spectra of a large number of elements after the same manner in which they had treated those of lithium and sodium, but their results for these need not detain us now. But when Runge and Paschen followed up their careful elaboration of the spectrum of the clèveite gas by a similar analysis, a very striking circumstance was revealed. The clèveite lines gave, not one series like hydrogen, nor three like lithium, but six, and of these some were series of single lines, some of doublets.

"We have," the observers report,* "accordingly, here to do with six series, among which it twice happens that two series converge towards the same place. Two of these converging series, namely, those beginning at 7065 and at 5876, consist of double lines with equal differences of oscillation-frequencies. We associate these with the remaining one which has double lines, that which begins at 1·12 μ in the infra-red. Two at all events of the three other series have no double lines; they diverge from the same situation, and we unite them with the remaining series into a second system.

"Both the systems prove to have a similar appearance, and all the lines of the first system are stronger than the corresponding lines of the second system.

"Further, it appears that both these spectra are very similar to the spectra of the alkalies. . . . . We can distinguish in each of them two subordinate series diverging from the same situation, of which the brighter is the more closely spaced. Moreover, each system contains a principal series whose lines are stronger than

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* Prof. Hartley had shown that this relation held good for the triplets of magnesium, cadmium, and zinc as early as 1882 (*Journ. Chemical Society*, 1882 and 1883).

† The constants given for these spectra by Profs. Kayser and Runge are as follows (*Abh. der Kgl. Preuss. Akad. der Wissen., Berlin*, 1890):—

Lithium—

			A	B	C
Principal Series			4·35193 $\times 10^{6}$	1·12186 $\times 10^{7}$	9·069 $\times 10^{5}$
Subordinate	,,	I.	2·858674	1·096255	1·847
,,	,,	II.	2·866669	1·22391	231·700

Sodium—

			A	B	C
Principal Series			4·149634	1·27040	843·841
Subordinate	,,	I. *a.*	2·454912	1·20726	197·891
,,	,,	I. *b.*	2·456583	1·20715	197·935
,,	,,	II. *a.*	2·447534	1·10065	4·148
,,	,,	II. *b.*	2·449484	1·10153	3·487

The lines in the two spectra are as follows:—

Lithium.

Wave-lengths expressed in tenth-mètres.

n	Principal Series.	First Subordinate Series.	Second Subordinate Series.
2	6708·2	....	....
3	3232·77	6103·77	......
4	2741·39	4602·37	4972·11
5	2562·60	4132·44	4273·44
6	2475·13	3915·2	3985·94
7	2425·55	3794·9	3838·3
8	2394·54	3718·9	... ..
9	2373·9	3670·6	... ...
10	2359·4	....	....

Oscillation-frequencies to the mètre.

2	1490713	....	...
3	3093322	1638332	....
4	3647784	2172794	2011219
5	3902287	2419878	2340035
6	4040192	2554148	2508818
7	4122776	2635116	2605320
8	4176167	2688967	... .
9	4212479	2724350	....
10	4238366	....	..

Prof. Snow has observed the line corresponding to $n = 3$ of the second subordinate series.

In the following tables of the sodium lines only the first component of each doublet is given; but the difference between the two components is added, as this will render more clear the distinction between the doublets of the principal and of the subordinate series.

Sodium.

Wave-lengths expressed in tenth-mètres.

n	Principal Series.	First Subordinate Series.	Second Subordinate Series.
3	5896·16 ;—5·97	....	8200·3 ;—12·0
4	3303·07 ;—0·60	6161·15 ;—6·53	5688·26 ;— 5·36
5	2852·91	5153·72 ;—4·53	4983·53 ;— 4·23
6	2680·46	4752·19 ;—3·83	4669·4 ;— 4·2
7	2593·98	4546·03 ;—3·28	4500·0 ;— 5·7
8	2543·85	4423·7 ;—3·5	4393·7 ;— 3·0
9	2512·23	4343·7	4390·7

Oscillation-frequencies to the mètre.

3	1696019 ; + 1719	. ....	1219468 ; + 1787
4	3027487 ; + 550	1623074 ; + 1722	1758007 ; + 1658
5	3505193	1940346 ; + 1707	2006610 ; + 1704
6	3730703	2104293 ; + 1697	2141603 ; + 1928
7	3855080	2199721 ; + 1589	2222222 ; + 2819
8	3931049	2260551 ; + 1790	2275986 ; + 1555
9	3980527	2302185	2311765

M. Becquerel has observed the line corresponding to $n = 3$ of the first subordinate series. A pair of lines, not included in the above table, is also seen at λ = 5675·92 ; 5·52 : oscillation-frequency, 1761829 ; + 1715. Dr. Johnstone Stoney, in an important paper on the "Analysis of the Spectrum of Sodium," read before the Royal Dublin Society, 1891, November 18th, claims this pair as corresponding to a negative value of $\frac{1}{\lambda}$.

* *Proc. Berlin Akad.*, June 20th, 1895. *Phil. Mag.*, Sept., 1895, p. 298.

those of the subordinate series, and which extends to shorter wave-lengths."

Elsewhere they write:*—"There is no instance of an element whose spectrum contains two pairs of series ending at the same place. This suggested to us the idea that the two pairs of series belonged to different elements. . . . . We therefore believe the gas in clèveite to consist of two, and not more than two constituents. We propose to call only one of the constituents helium—the one to which the bright yellow double line" (D_3) "belongs, whose spectrum altogether is the stronger one—while the other constituent ought to receive a new name."

A very suitable name has been accordingly proposed by Dr. Johnstone Stoney, and the second element in clèveite gas is now known as "parhelium." Further evidence that "helium" and "parhelium" are really two distinct elements must form the subject of another paper, in which it will also be possible to glance at their different astronomical relationships.

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THE BIRCH.

By George Paxton.

> "Most beautiful
> Of forest trees, the Lady of the Woods."

WELL does the birch (*Betula alba*) deserve to be called "Queen of the Forest" and "Lady of the Woods." No tree is more generally admired on the ground of its own intrinsic beauty: the favourite of poet, painter, and all lovers of nature. It matters not whether it be seen in a London square, Highland glen, or Lowland pasture; the eye is at once arrested by its light and graceful elegance.

But perhaps all the beauties of a well-grown birch are best brought out when the tree happens to be of the weeping variety, growing beside and overhanging still water. Then note and admire its silvery stem, graceful drooping branches, and light fragrant foliage, perhaps lit up by the rays of the setting sun into festoons of pure gold; the water below reversing and doubling all! Thus seen, on a quiet autumn evening, the birch forms a picture that will linger in the memory—"a thing of beauty and a joy for ever."

With the poet Burns the birch, or birk, as he called it, was chief favourite among trees, being mentioned in his works no less than thirteen times. In the noblest and most pathetic of all his poems, "To Mary in Heaven," the place of last parting is described—

"O'erhung with wild woods thick'ning green;
The fragrant birch, and hawthorn hoar
Twin'd amorous round the raptur'd scene."

Again he goes to meet his "ain kind dearie"—

"Down by the burn, where scented birks
Wi' dew are hanging clear. . . ."

The birch is found in all the colder regions of Europe, Asia, and America. It is common in this country, and a true native of the British Isles. It is very abundant throughout the whole of Russia, and in Greenland it is said to be "the only tree;" but there it is much diminished in size, owing to the coldness of the climate. In Britain it grows to a height of about fifty feet, with a trunk seldom more than ten feet in girth. It is extremely hardy and a rapid grower (especially the weeping variety), but does not live to a very great age. One of the finest birches in Scotland is represented in Fig. 1. It is about seventy feet in height, with a girth of eleven feet four inches, and was planted about seventy years ago on the banks of "bonnie Doon."

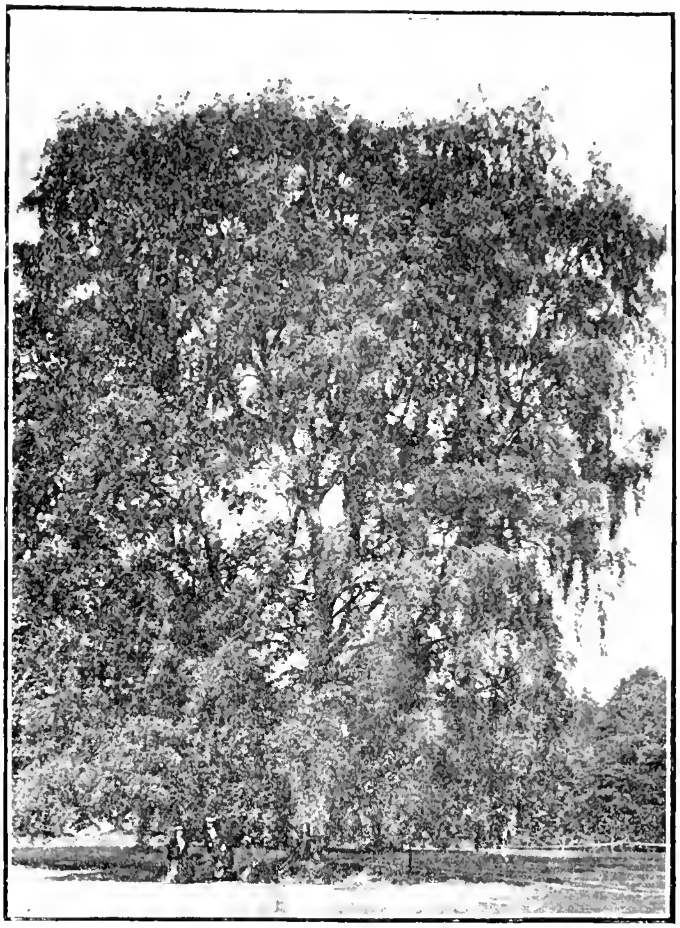

Fig. 1.—The Birch Tree near the "Auld Brig o' Doon."

The tree is known at first sight by its silvery bark, small leaves, and light and graceful form. The leaves are ovate, and unequally serrated. (Fig. 2.) The flowers, in the form of drooping catkins, appear in April and May.

The fragrance to which reference has been made comes from a kind of resin which exudes from the leaves and young twigs, especially after rain or heavy dew. The wood of the birch is tough, but not very durable. It is used for making spoons and shoes chiefly in Russia, and in France and Germany for carriage construction, especially for the felloes of the wheels; but its principal use is for gunpowder charcoal. The bark is remarkable for its durability; it is almost indestructible, and will remain quite fresh long after the wood it has encircled has rotted away. The ancient inhabitants of Britain took advantage of this peculiarity and built their canoes of birch-bark; remains of these canoes have been frequently dug up from the gravel banks of the River Clyde. In Canada, birch-bark canoes are still used; they are made from a species known as the canoe or paper birch. Portions of the smooth bark, ten to twelve feet long, are stripped from the tree, stitched together with fibre, and the seams coated with resin, thus making a very light boat.

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* *Nature*, Sept. 26th, 1895.

It is said one calculated to hold four persons weighs only fifty pounds. An oil distilled from the bark is much used in Russia for tanning the finer kinds of leather; this oil not only preserves the leather and prevents it from getting mouldy, but also imparts that agreeable odour characteristic of Russia leather.

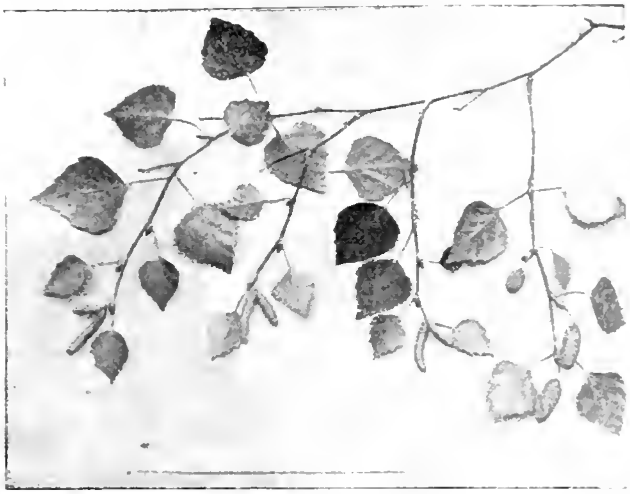

Fig. 2.—Leaves of Birch.

The sweet watery sap with which this tree abounds, and which will flow freely if a notch be made through the bark in spring, was formerly much valued for its supposed medicinal virtues; it was also fermented into a kind of beer or wine, which is still done in some parts of Sweden. The tree not only supplies beer and wine, but also tea, the young eaves being sometimes used in Finland for this purpose.

But the uses to which the birch has been put may be said to be almost too numerous to mention. According to Loudon, the Highlanders made *everything* of it:—"They build their houses, make their beds, chairs, tables, dishes, spoons, construct their mills, make their carts, ploughs, harrows, gates and fences, and even manufacture ropes of it. The branches are employed as fuel in the distillation of whiskey; the spray is used for smoking hams and herrings, for which last purpose it is preferred to every other kind of wood. The bark is used for tanning leather, and sometimes, when dried and twisted into a rope, for candles. The spray is used for thatching houses, and, when dried in summer with the leaves on, makes a good bed where heather is scarce." We suspect the absence of better wood had not a little to do with many of these uses.

The tree is most liable to a disease produced by a very minute gall-mite, which attacks the young buds and causes them to grow into a large mass of twigs like an old rook's nest; these are known as witch-knots or witches' brooms.

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GREEK VASES.—II.*

A.—VASES OF THE PRIMITIVE PERIOD, TO 600 B.C.

By H. B. Walters, M.A., F.S.A.

In this article we shall trace the history of the ceramic art in Greece from its earliest beginnings down to the time when it may be said to have passed out of the primitive period, and to be beginning to take high rank as a decorative art. A rough limit of demarcation between this period and that discussed under the heading B is the introduction of mythological subjects, and, from a technical point of view, the adoption of certain processes for enhancing the effects of an otherwise simple style of decoration. It will be the purpose of this article to show how this development is attained.

The earliest vases that have been discovered on Greek soil are represented by the finds of Dr. Schliemann at Hissarlik, the supposed site of the ancient Troy. These vases are of a very rude type, and must belong to a very primitive civilization. The forms are very varied, but suggest rather experiments on the part of the potter than a fixed number of types, each for a different purpose. We note in the so-called "owl vases," which are roughly manufactured into the form of that bird, a first attempt to establish, in the analogy between a vase and a living thing, a principle of design and decoration (on which principle we speak of the "mouth," "body," "foot," etc., of a vase). The Hissarlik vases are hand-made, and fired to a dull black colour; they are never painted, but patterns are occasionally scratched upon them.

The products of the Island of Santorin (the ancient Thera) and of the neighbouring islands of the Archipelago are of a more developed kind. These vases have been found beneath a stratum of lava, the result of a great volcanic eruption, which, on geological evidence, is supposed to have taken place between 2000 and 1800 B.C.; and there is no doubt they were made from local clay. The most notable feature in this ware is that for the first time we have vases painted with vegetable patterns and figures of animals. This is in itself a very great and remarkable advance. The colours are applied with a brush, and two tones — a yellowish white and a brown — are employed.

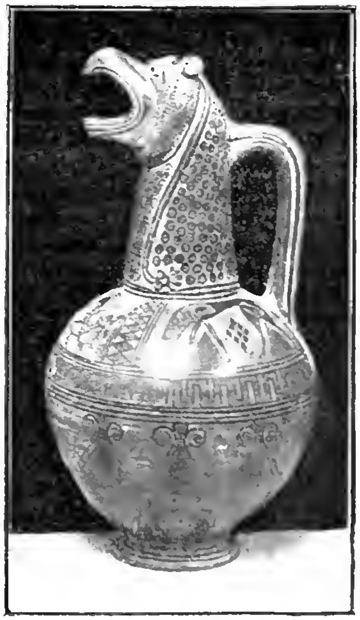

Fig. 3.—Jug of Rhodian Style. From the Island of Thera.

The vases of Thera supply a natural point of transition to the second great stage of early art represented by the Mycenæan ware. Spread over virtually the whole of the ancient classical world there has been found a class of pottery more or less uniform in technique and ornamentation. In the first instance the discovery of vases of this class had been confined to the islands of the Ægean Sea, more especially Rhodes and Crete, and they had attracted comparatively little notice from archæologists. But the excavations of Dr. Schliemann on the Acropolis of Mycenæ from 1876 onwards, together with results obtained near Athens and from other parts of Greece proper, have brought about a great change in this respect. In the tombs of Mycenæ large quantities of vases have been found with the same characteristics as those previously found in the islands. The special interest which they have evoked is due to the fact that they are, with some show of probability,

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* The first article appeared in the February number of Knowledge.

regarded as representing the age of Agamemnon and other legendary Greek heroes, the seat of whose power was at Mycenæ; and if this be so, it would place them in the twelfth and thirteenth centuries B.C.

This Mycenæan ware is probably Greek, but shows traces of Egyptian and Asiatic influence; moreover the subjects of the painted vases are largely drawn from marine objects, a point from which it may be inferred that they are the products of a seafaring people, which would also be implied by the remarkable number of different sites on which they have been found, all on or near the coast of the Mediterranean.

The Mycenæan vases are remarkable for the introduction of lustrous colours, a new factor in vase-painting, and to all intents peculiar to Greek ceramics. Hitherto the colours used were dull and opaque, or what is technically known as *matt:* now the pigments more resemble varnish from their thick and lustrous character. The painting is in all shades of yellow, brown, or black, on a polished warm yellow surface. The shapes are highly characteristic, especially a tall, graceful, two-handled goblet (*see* Fig. 2 in the February article), and a jar with spout and small mouth, over which a bow-shaped handle passes, so as to close it up; this latter form is known as a "false amphora," and it was probably used for oil. A third form is a large capacious owl on a high stem, with two or three side-handles.

On the tall goblets we almost invariably find a cuttle-fish depicted. Seaweed and shellfish are very common, especially on the Rhodian specimens; and the British Museum possesses a unique specimen with a nautilus, found in Egypt. The special feature of these subjects is, however, the extraordinary naturalism which prevails.

On the other hand, with the human figure this is not the case; it is true that such subjects seldom occur on the Mycenæan vases, but when they do it is with all the characteristics of archaic rudeness and simplicity. This is only in accordance with a universal principle in Greek vase-painting, by which the mastery is first obtained over vegetable forms, next in the rendering of the lower animals, and it is not till the perfect development of art that the human figure is represented with absolute accuracy.

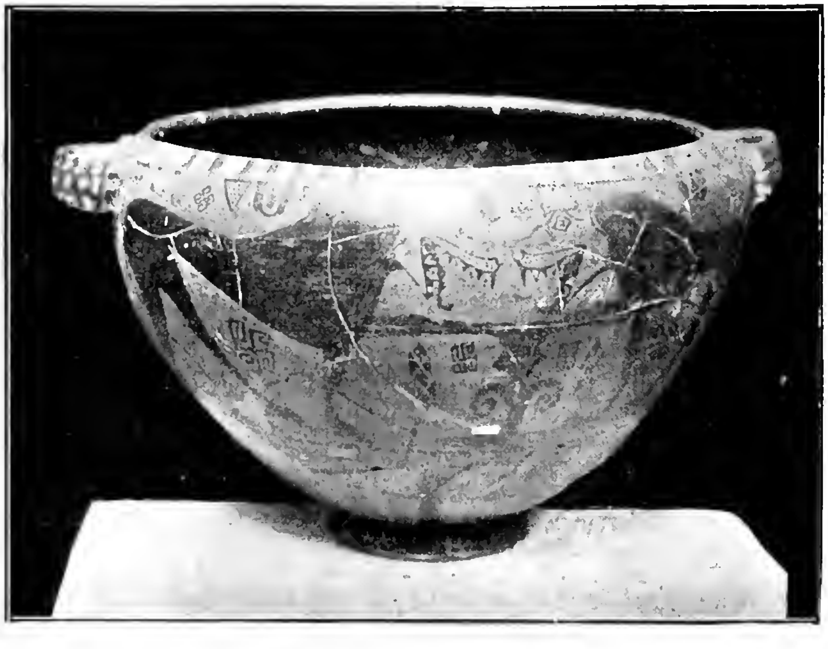

Fig. 2.—Large Vase (*Lebes*) of Phaleron Style. From Athens.

It should be noted that much of the ornamentation of these vases is influenced by the conventional decoration of metal-work; this is especially the case with those found at Mycenæ itself, and it must be remembered that this was an art in which these people pre-eminently excelled; moreover, it is an influence that makes itself felt throughout the whole history of Greek ceramics.

We must now turn aside to consider the products of an island which plays a remarkable part in the history of Greek ceramics, namely, Cyprus. Although the fabrics of this island are to a great extent rather Phœnician than Greek, it is yet impossible to disregard them in the consideration of a history of Greek pottery. The earliest examples of pottery found in the island are the products of the indigenous Greek people before the Phœnicians invaded the island. The vases are covered with a vitreous slip and baked to a lustrous red, and are ornamented with patterns of lines incised with a knife. Other vases are made of fine grey clay, and ornamented with appliqué work, or moulded into all kinds of fancy shapes. No bronze objects have been found with these, but stone spindle-whorls and similar articles. Coming down to a somewhat later period, we have the tombs which belong to the Mycenæan age, and the beginning of the bronze age in Cyprus. The native pottery found in these tombs is often an imitation of the imported Mycenæan fabrics. Many genuine Mycenæan vases have also been found in these tombs, the "false amphora" described above being remarkably common, and a small class of unique interest, of which two examples have lately been excavated for the British Museum; these are large two-handled jars with figures of men and women in chariots, which hitherto have only been found in Cyprus—and, in fact, there are barely half a dozen in existence. The two aforesaid vases were found on the site of the ancient city of Curium, of which we have a record in a passage of the geographer Strabo, that it was founded by the Argives, *i.e.*, the people of Argos in Greece, which at that time was closely connected with the Mycenæan civilization.

The next event of importance in the history of Cyprus was the advent of the Phœnicians, from which time onwards there is a great change in the style of the pottery. The tombs of this period contain many vases with geometrical decoration, corresponding to a development in Greece proper which we shall shortly discuss; and in the subjects we see a very marked Assyrian and Egyptian influence. From the former are derived figures of strange monsters and fantastic deities, while from the latter come such motives as lotos-flowers and aquatic birds. (*See* Fig. 1 in the February article).

Returning now to the mainland of Greece, we find Athens for the first time coming to the front and laying the foundations of the great reputation which, in later times, left her mistress of the field in the production of ceramic masterpieces. The period we have to deal with is that of the Geometric vases (or Dipylon, as they are sometimes called, from the fact that most of them were found near the old Athenian gate of that name). It is, of course, a retrograde step on the Mycenæan fabrics, as may be easily seen by a comparison of the drawing on the examples of each style.

The Geometrical vases fall into three easily-distinguished classes, showing a gradual development in range of subjects. In the first class the decoration is purely geometrical, consisting of such patterns as lozenge and chequer, spirals, the typical Greek mæander and key patterns, and rows of vandykes or wavy lines (Fig. 1). Simple as the scheme of ornamentation is, many of these vases are very effective. In the next stage, panels are introduced containing figures of horses, deer, and swans and other birds. Vases of this class are generally found in Bœotia. In the third class a remarkable advance is made, and scenes from daily life are introduced, such as funeral processions and sea-fights. The human figures are extremely rude and conventional, and the effect is much marred by the prevalent practice of filling up every available space by ornamentation of some kind. Early Greek painters had a strange horror of leaving any part of a vase undecorated. These vases are of great size, and were mostly found in the ancient Athenian burying ground, just outside the Dipylon gate; they had been placed on tombs as memorials. It is possible that these representations of the cult of the dead derived their origin from Egypt, where paintings of this kind were so universal; in any case they imply the possession by the artist of an unexpected power of conception, though the execution falls far short of it. The technique is very similar to that of the Mycenæ ware. The figures are generally painted in lustrous black on a prepared ground, varying from stone colour to deep red. The favourite shape is that of a large jar on a high stem, with two comparatively small side-handles.

The great expansion of Hellenic life in the seventh century B.C., by extended commerce and colonization, placed the Greeks in continuous and intimate relations with all their neighbours. The result of this, as far as vase-painting is concerned, is seen in the new impulse given to the art by Oriental influences. Egypt opened her ports for the first time to foreign ships under the twenty-sixth dynasty (660-530 B.C.), and also stocked her armies with foreign mercenaries; while the same period saw the foundation of Ionian settlements at Naucratis and other places in the Delta. Nor must we forget the various products of Phœnician and Lydian craftsmen with which extended commerce had rendered the Greeks familiar, and we shall see how great an influence the metal-work of the former, and the textile fabrics of the latter, had on the ceramic products of the succeeding period in Greece.

In a small class of vases known as the Phaleron style, because found at Phaleron near Athens, new features are introduced, especially in the employment and treatment of new animal types, based in design and grouping on Oriental models. The only features of the Geometric style retained are small fragments of ornament employed for filling the field of the vase. (Fig. 2.)

Even stronger was the influence at work in the islands of the Ægean Sea, especially in Melos and Rhodes. Although the Melian ware is later in development than the Rhodian, it must be taken first owing to its close connection with the Dipylon style. Only a very few of the Melian vases are in existence, but these are of unique importance. They possess many features hitherto unknown, and show a great advance in drawing and composition. The admixture of Oriental style and design is especially obvious, but the most remarkable advance is shown in the employment of a purple pigment, laid on the black in places in order to enhance the effect. This is the first instance of a technical method which prevails in a varying degree throughout the whole history of vase-painting.

In the Rhodian vases the tide of Orientalism swells into full flood. While, under its influence, the painter evolved an effective and beautiful system of ornamentation, the potter condensed the earlier multiplicity of forms to a few simple and elegant types, of which the most characteristic are the *oinochoë* and the *pinax* or circular plaque. (Figs. 3 and 4.) The influence of metal-work is shown not only in these forms, but also in schemes of decoration.

The influence of Assyrian and Lydian textile fabrics, again, gives the appearance of embroidery to the scheme of design on many vases as seen in the rows of animals placed in bands round the body, while the rosettes which are introduced to fill the field are another result of the same influence.

Fig. 1.—Jug (*Oinochoë*) of Geometric or Dipylon Style. From Athens.

A new and characteristic development introduced by the Rhodian potters is the practice of combining silhouette with outline drawing, leaving parts of the figures in ground-colour with a black contour. Further, the red clay is frequently covered with a cream-white engobe or slip, which was found useful for indicating flesh-colour. The subjects are drawn almost entirely from the animal creation, especially goats and lions; later vases admit human figures and grotesque monsters such as the Sphinx. Among the latter, one vase stands out conspicuous as possessing a subject drawn from Greek legend, of which we give an illustration in Fig. 4. The scene represented is a combat between Menelaos and Hector over the body of Euphorbos, and the figures are identified by the fact that their names are inscribed over them in early Greek letters. By this means we are enabled to give the approximate date of the vase as 600 B.C.; the lettering of the inscription is that of the alphabet in use at Argos at that time, but the style of the vase is undoubtedly Rhodian, and we may suppose that it was painted in Rhodes by an Argive artist. The subject is derived from an epic source, though it is not actually to be found in Homer.

Closely linked in many respects with the vases of Rhodian origin is a very interesting class which was first made known by the labours of the Egypt Exploration Fund at Naucratis, in the Egyptian Delta, in 1883-6. Pottery, mostly fragmentary, was found in layers of different dates, reaching from about 650 or 600 B.C. down to about 400, and including specimens of most classes of Greek vases during those periods. This variety is no doubt due to the cosmopolitan character of a town like Naucratis, where devotees from all parts would make their votive offerings to Apollo or Aphrodite. Most of the fragments that have been found bear dedications, incised after the firing, to either of those deities.

Fig. 4.—Plate (*Pinax*), with contest of Menelaos and Hector over the body of Euphorbos. From Cameiros, Rhodes.

Among all these classes of pottery one is marked off as clearly a local fabric, and apparently dating from the earliest days of the city (650-550 B.C.); it may therefore be appropriately discussed here as belonging to the transition from period A to B. One fragment bears an inscription "to Aphrodite in Naucratis," which was evidently incised on the vase *before*, instead of after, the firing, which is a proof of its manufacture on the spot. The technique of this ware shows a great advance on that of Rhodes; the vases are covered with an opaque white engobe or slip, on which the designs are painted in colours. The same combination of outline and silhouette drawing which has been mentioned in connection with the Rhodian pottery obtains here also. New colours, however, are introduced—no doubt under the influence of the Egyptian wall-paintings, especially a light sienna and an umber red.

It has been advanced by some authorities that the practice of using a white ground for the decoration of vases, in the form of a thick creamy engobe or slip, may be traced to Naucratis for its origin; but seeing how universally this method of decoration has been employed in all fabrics, not only of later date but in those contemporaneous with the Naucratis ware, the question cannot as yet claim to be definitely decided.

In the next article we shall hope to trace the history of vase-painting during the sixth century B.C.

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THE FACE OF THE SKY FOR APRIL.

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

Sunspots and faculæ show a marked decrease in number and size. Conveniently observable minima of Algol occur at 11h. 38m. P.M. on the **9th** and 8h. 28m. P.M. on the **12th**.

Mercury is in superior conjunction with the Sun on the **18th**, and will not be visible till the last week in April. On the **25th** he sets at 8h. 6m. P.M., or 55m. after the Sun, with a northern declination of 16° 48′ and an apparent diameter of 5¼″. On the **30th** he sets at 8h. 47m. after the Sun, with a northern declination of 20° 22′, and an apparent diameter of 5½″. While visible he passes from Aries into Taurus.

Venus is too close to the Sun to be observed, and Mars is, for the purposes of the amateur, invisible.

Jupiter is an evening star, and is still a very fine object. On the **1st** he sets at 3h. 27m. A.M., with a northern declination of 21° 2′, and an apparent equatorial diameter of 40·5″. On the **10th** he sets at 2h. 53m. A.M., with a northern declination of 20° 57′, and an apparent equatorial diameter of 39·5″. On the **20th** he sets at 2h. 16m. A.M., with a northern declination of 20° 48′, and an apparent equatorial diameter of 38·3″. On the **30th** he sets at 1h. 39m. A.M., with a northern declination of 20° 35′, and an apparent equatorial diameter of 37¼″. While visible he describes a short direct path in Cancer. The following phenomena of the satellites occur before midnight on the days named, while the planet 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 9h. 36m. P.M.; a transit ingress of the first satellite at 10h. 31m. P.M., and of its shadow at 11h. 45m. P.M. On the **2nd** an occultation disappearance of the first satellite at 7h. 41m. P.M., an occultation disappearance of the third satellite at 11h. 6m. P.M., an eclipse reappearance of the first satellite at 11h. 13m. 14s. P.M. On the **3rd** a transit egress of the shadow of the first satellite at 8h. 34m. P.M. On the **4th** a transit ingress of the fourth satellite at 10h. 17m. P.M. On the **6th** a transit egress of the shadow of the third satellite at 9h. 52m. P.M. On the **8th** a transit ingress of the shadow of the second satellite at 9h. 17m. P.M., and a transit egress of the satellite itself at 9h. 43m. P.M. On the **9th** an occultation disappearance of the first satellite at 9h. 35m. P.M. On the **10th** a transit ingress of the shadow of the first satellite at 8h. 8m. P.M., a transit egress of the satellite itself at 9h. 12m. P.M., and of its shadow at 10h. 28m. P.M. On the **13th** an eclipse disappearance of the fourth satellite at 7h. 56m. 58s. P.M., a transit egress of the third satellite at 8h. 39m. P.M., a transit ingress of the shadow of the third satellite at 10h. 10m. P.M. On the **15th** a transit ingress of the second satellite at 9h. 23m. P.M., and a transit ingress of its shadow at 11h. 55m. p.m. On the **16th** an occultation disappearance of the first satellite at 11h. 29m. p.m. On the **17th** a transit ingress of the first satellite at 8h. 46m. p.m., an eclipse reappearance of the second satellite at 9h. 40m. 31s. p.m., a transit ingress of the shadow of the first satellite at 10h. 3m. p.m. On the **18th** an eclipse reappearance of the first satellite at 9h. 32m. 56s. p.m. On the **20th** a transit ingress of the third satellite at 8h. 59m. p.m. On the **21st** a transit egress of the fourth satellite at 8h. 35m. p.m. On the **24th** a transit ingress of the first satellite at 10h. 41m. p.m., and of its shadow at 11h. 58m. p.m. On the **25th** an eclipse reappearance of the first satellite at 11h. 28m. 25s. p.m. On the **26th** a transit egress of the shadow of the first satellite at 8h. 47m. p.m.

Saturn is an evening star, rising on the **1st** at 9h. 36m. p.m., or about three hours after sunset, with a southern declination of 14° 50′, and an apparent equatorial diameter of 9·7″ (the major axis of the ring system being 43½″ in diameter, and the minor 10¼″). On the **10th** he rises at 8h. 52m. p.m., with a southern declination of 14° 39′, and an apparent equatorial diameter of 17¼″ (the major axis of the ring system being 43½″ in diameter, and the minor 10½″). On the **20th** he rises at 8h. 15m. p.m., with a southern declination of 14° 27′, and an apparent equatorial diameter of 17½″. On the **30th** he rises at 7h. 31m. p.m., with a southern declination of 14° 14′, and an apparent equatorial diameter of 17¾″. Titan is at its greatest eastern elongation at 1h. a.m. on the **17th**, and Iapetus in inferior conjunction at 4h. a.m. on the **14th**. Saturn describes a short retrograde path through a barren portion of Libra.

Uranus is an evening star, with, unfortunately, great southern declination. On the **1st** he rises at 10h. 23m. p.m., with a southern declination of 18° 30′, and an apparent diameter of 3·8″. On the **30th** he rises at 8h. 18m. p.m., with a southern declination of 18° 15′. He describes a short retrograde path in Libra.

Neptune has practically left us for the season.

Shooting stars are fairly plentiful in April, the best marked shower being that of the Lyrids, with a radiant point in R.A. 18h. + 33°. The radiant point rises on the evenings of the **19th** and **20th**, when the maximum occurs at about 6h. 30m. p.m., and south at 4h. 8m. a.m.

The Moon enters her last quarter at 0h. 24m. a.m. on the **5th**; is new at 4h. 23m. a.m. on the **13th**; enters her first quarter at 10h. 47m. p.m. on the **20th**; and is full at 1h. 47m. p.m. on the **27th**. She is in apogee at 3h. a.m. on the **11th** (distance from the Earth, 252,500 miles), and in perigee at 9h. a.m. on the **26th** (distance from the Earth, 223,320 miles).

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Chess Column.

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

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of March Problems.

No. 1.—(J. T. Blakemore.)

Key-move.—1. Q to R8.

If 1. . . . K to B7, 2. Q to B3ch.
1. . . . K to Q7, 2. Kt to B2disch, etc.
1. . . . K to B5, 2. Q to B3ch, etc.

No. 2.—(C. D. Locock.)

1. P to B7, and mates next move.

Correct Solutions of *both* Problems received from Alpha, J. S. Orr, G. A. F. (Brentwood), Lionel Pfungst, W. Willby, E. W. Brook. Of No. 2 only, from G. G. Beazley, A. E. Whitehouse, W. M. A. E., W. F. H. Worsley-Benison, J. T. Blakemore, W. Willby, E. W. Brook, W. W. Strickland.

H. S. Brandreth.—Q to Q2 will not solve No. 2.

J. T. Blakemore.—Your problem was considered good and difficult, especially in the continuations after the key.

A Norseman.—Thanks; no time to examine this month.

W. W. Strickland.—Many thanks for the book, and your remarks on the Eight Queens Problem. Unfortunately I am unable to find your postcard on the subject. I hope to compare your theory with that of "A Norseman" before next month.

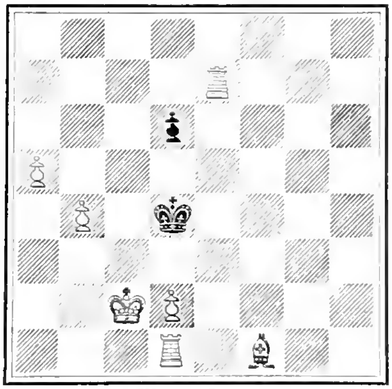
W. Willby.—The problem is a little too elementary considering the amount of force, the King's side pieces not being *necessary* to the problem. Could you not improve it greatly by removing the King's Rook and attendant Pawns, shifting the position towards the centre, and adding, if possible, one or two extra variations natural to the position?

The following curious problem is quoted from the *British Chess Magazine*. The curiosity lies in the fact that the solver who perceives the "idea" correctly will at first be convinced that there is no possible key:—

PROBLEM.

By C. A. Kennard.

Black (2).



White (7).

White mates in three moves.

The following game was the first to be concluded in the Anglo-American Cable Match on March 13th. The notes are quoted from the *Daily News*.

"Giuoco Piano."

White. (E. M. Jackson, London.)	Black. (D. G. Baird, U.S.A.)
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	3. B to B4
4. P to Q3	4. P to Q3
5. P to B3	5. Kt to B3
6. B to K3	6. B to Kt3 (*a*)
7. QKt to Q2	7. Castles
8. Kt to B1	8. P to KR3 (*b*)
9. Q to K2	9. R to K1
10. Castles (*c*)	10. Kt to QR4
11. P to KR3	11. Kt × B

12. P × Kt	12. Q to K2
13. P to KKt4	13. Kt to R2
14. Kt to Kt3	14. B to K3 (*d*)
15. Kt to B5	15. B × Kt
16. KtP × B	16. B × B
17. Q × B	17. P to QKt3 (*e*)
18. QR to Kt1	18. K to R1
19. P to KR4	19. R to KKt1 (*f*)
20. P to R5	20. Q to B1
21. Kt to R4	21. R to Kt1
22. R to Kt6 (*g*)	22. Q to B1 (*h*)
23. R to Kt2	23. Q to Q1
24. Kt to Kt6ch (*i*)	24. P × Kt
25. RP × P	25. Q to K2 (*k*)
26. P × Kt	26. KR to KB1 (*l*)
27. R (R1) to Kt1	27. R toB2 (*m*)
28. R to Kt6	28. QR to KB1 (*n*)
29. Q to Kt3	29. P to QR3 (*o*)
30. P to B6	30. R × P
31. R × KtP	31. R(B1) to B2
32. R to Kt8ch.	32. K × P
33. R to R8ch.	33. Resigns

Notes.

(*a*) B takes B is best.

(*b*) A weakening move. P to Q4 is better.

(*c*) The only way to get any advantage out of the Giuoco Piano is to Castle rapidly on the Queen's side, and follow up with a King's side attack.

(*d*) Further waste of time. Black should have anticipated the King's side attack with such moves as B takes B, followed by Kt to Kt4.

(*e*) Black does not make the best of a bad position. If he wanted a counter-attack he should have played P to QKt4, followed by P to QR3, obtaining open files for his Rooks. The next move is meaningless.

(*f*) R to KKt1 seldom turns out well; it cramps the King too much.

(*g*) White makes the most of his opportunities, and deserves great credit for his spirited play. R to Kt2 would have served here equally well.

(*h*) If Kt to Kt4, P to B6 follows. Q to Q1 was a better move than Q to B1.

(*i*) White obviously had this move in contemplation for some time; it clears the way for the better operation of his Rooks.

(*k*) Obviously if Knight play away, R takes Pch follows.

(*l*) If K takes P, 27. R to Kt6, Q to B1 (as White threatened mate by R takes Pch), 28. P to B6 wins.

(*m*) K takes P was not quite hopeless.

(*n*) K takes P was a better move. For if then 29. R to R1, Q to B1; or if 29. P to B6, R takes P, giving up the Queen for two Rooks.

(*o*) Now he is hopeless and helpless. For if he plays K takes P, P to B6, P takes P, R takes Pch, and mates next move.

NOTICE.

A correspondent residing in London is desirous of playing one or two games by correspondence with a strong player. We shall be happy to forward him the address of any of our readers who may be willing to oppose him.

CHESS INTELLIGENCE.

On March 13th and 14th a match was played by Atlantic cable between selected teams representing the British Isles and the United States respectively. The contest was for a valuable silver trophy presented by Sir G. Newnes, Bart. Considerable care was taken in the selection of the British team, a tournament being held previously in order to decide one or two of the doubtful places. In this tournament Messrs. E. O. Jones and E. M. Jackson came out equal first, and failed to secure any decisive result in playing off the tie.

Mr. Jones was eventually chosen, but owing to ill-health his place was finally filled by Mr. Jackson, who by his brilliant victory quite justified his inclusion.

The British team played at the Cannon Street Hotel, the hours of play being from 3 to 7 and from 8 to 11.30 each day. At the end of the first day's play all the games were adjourned, the positions on the whole being in favour of Great Britain. On the following day the unexpected happened: Mr. Bird overlooked a simple mate in two moves, Mr. Mills unwisely consented to draw a game in which he had winning chances, and Mr. Tinsley was outplayed in an even ending and finally lost. This was the last game to be finished.

The following is the score:—

United States.			British Isles.	
1. H. N. Pillsbury.	0	*v.*	J. H. Blackburne	1
2. J. W. Showalter	1	*v.*	A. Burn . . .	0
3. C. F. Burille .	1	*v.*	H. E. Bird . .	0
4. J. F. Barry . .	1	*v.*	S. Tinsley . .	0
5. E. Hymes . .	½	*v.*	C. D. Locock .	½
6. A. B. Hodges .	½	*v.*	D. Y. Mills . .	½
7. E. Delmar . .	½	*v.*	H. E. Atkins .	½
8. D. G. Baird . .	0	*v.*	E. M. Jackson .	1
	4½			3½

Contents of No. 125.

NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

Bound volumes of Knowledge, New Series, can be supplied as follows:—Vols. I., II., III., and VIII., 10s. 6d. each; Vols. VI., VII., IX., and X. (1895), 8s. 6d. each.

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Communications for the Editors and Books for Review should be addressed Editors, "Knowledge" Office, 326, High Holborn, London, W.C.

KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: MAY 1, 1896.

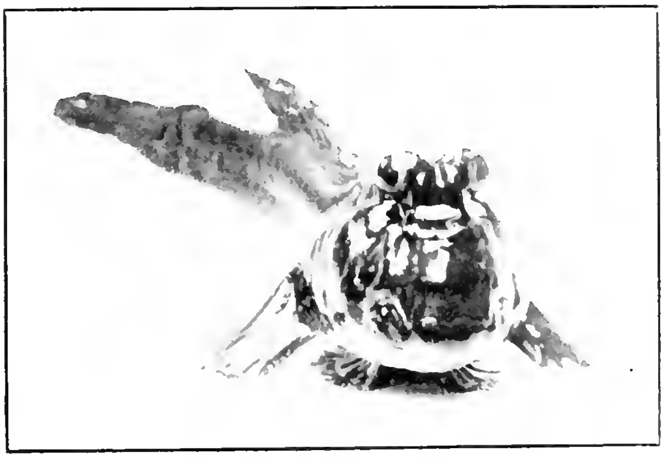
CONTENTS.

THE "WALKING" GOBY.

By HENRY O. FORBES, LL.D.,
Director of Museums to the Corporation of Liverpool.

THE naturalist haunting at ebb tide the sea-shores of the Indian or West African tropics, especially where they are muddy, cannot fail to have his attention arrested by a crowd of curious tadpole-like creatures which stampede before him. He will come upon them congregated together in large numbers, sitting basking in the hot sun a few inches above the water line, either on soft, muddy flats, or in the mangrove swamps, where they seem to delight to sit upon the branching roots of those trees. On his approach, off they will scamper at a headlong pace by frog-like leaps, some into the shallow water, others along the shore into safe hiding. If he proceeds, however, very guardedly, he may advance within a short distance of some of them; he will then perceive that, though enjoying themselves on land, they are true fishes.

The species is *Periophthalmus koelreuteri*, the "hopping fish" of the trader, one of the gobies (*Gobiidæ*). Their tadpole-like look arises from their tapering tail and curiously prominent eyes, which stand up high above the level of the head. It is an elegant little beast, with skin covered with minute scales, and its dorsal fins beautifully spotted with bright blue. If the observer remain quite still, the *Periophthalmus* will sit motionless, staring at him with its great eyes, except that every now and then it will wink apparently, sometimes with one eye and sometimes with both together. What seems to be winking, however, is the inversion of the eye into a depression immediately under it, for the purpose of lubricating the organ when it begins to become dry. The habit that most impresses the naturalist encountering these fishes for the first time is the long period which they can remain out of the water. The writer has timed individuals, both in their native state and in the aquarium, to sit for more than half an hour without a bath. They would then walk slowly into the water, immerse themselves over the head for a second, emerge and remain resting for a short time, with the head and shoulders above and the mouth under the surface, and walk slowly out again on to the margin. This fish rarely, if ever, goes beyond its depth, and only for a few seconds does it at any time completely submerge itself. Their usual habit is to sit propped up on their stiff ventral and strong pectoral fins, with the fore part of the body elevated, and their quick mobile eyes conspicuous and enquiring; either, as already remarked, entirely away from the water, or with only the extremity of the tail dipping in. When out of the water and sitting still the mouth is kept closed, and no motion can be detected in the gills or gill-coverts. Every now and then the eyes are moistened as described above, and the fish flaps its pectoral fins across the gill-coverts and the hind part of the head. When the tide has just receded and the small marine animals are beginning to follow it, they are very busy darting here and there in pursuit, and gobbling them up voraciously. They will even attack and eat smaller members of their own species.

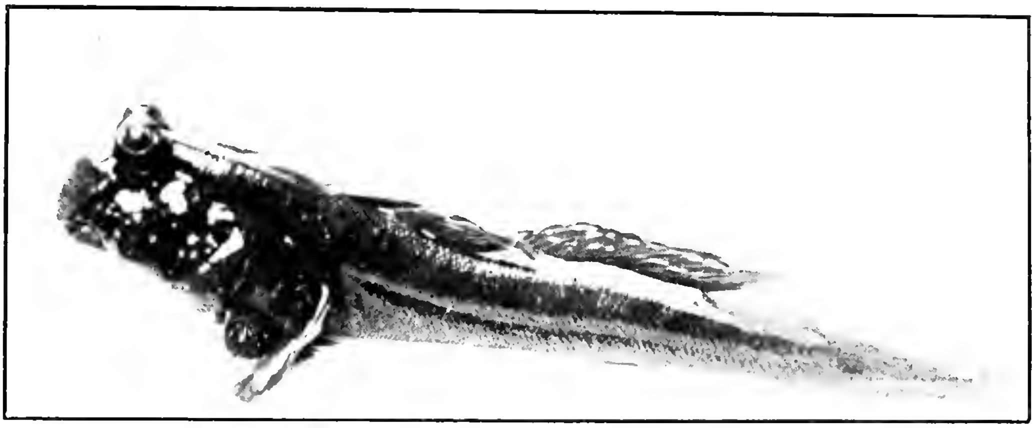


Periophthalmus koelreuteri.—Front view.

When moving forward they oar themselves on their strongly muscular pectorals, which they use simultaneously when hopping or alternately in their more deliberate "walking," which leaves a curious triple track on the soft mud which they have traversed. When in the water the *Periophthalmus* sits on the bottom in the same attitude as on shore, with its upper lip submerged, but with the rest of the head and upper part of the back exposed, the water being driven over its gills very slowly and deliberately as compared with the common trout in an adjoining tank. Its eyes are better adapted for sight out of than under water, and are capable of seeing all round. They are amazingly quick the slightest wriggle of a worm or small crustacean, even at several feet distance directly behind them, will be instantly detected, and the creature at once pounced upon—often by more than one at once, in which case a battle ensues, resulting frequently in each combatant carrying off a share of the prey. The precise structure of the eyes of the "walking" goby is not yet known, though the present writer hopes shortly to be able to give some account of specimens which are now being prepared, and are nearly ready, for histological examination. They seem, however, to differ from the eyes of the Cyprinodont *Anableps*, in which the upper portion is adapted for vision out of water and the lower for vision under water, the fish swimming with the one half above and the other beneath the surface.

The first specimens of *Periophthalmus* which have been imported into Europe were brought from West Africa a few months back for the Liverpool Museum. They have lived remarkably well in a shallow salt-water tank, which has been kept as evenly as possible at a temperature of from seventy-five to eighty degrees Fahrenheit. Though on their arrival they were extremely timid, they became after a short time quite tame, and came to recognize the attendant who fed them, eagerly watching for food on his approach.

Professor Haddon, who studied this species in Australia, being struck with the length of time these fishes could remain out of water, and with the fact that many of them sat by the margin of the sea with extremity of the tail immersed, thought that perhaps this part of its body served as a subsidiary organ of respiration. He accordingly made a series of experiments which he believes tends to prove that the tail does assist in respiration. The manner, however, in which the specimens in the aquarium of the Liverpool Museum have been observed to sit on dry land, under close scrutiny, for lengthy periods, distant from the water, leads the writer to suspect that no aid can be lent to respiration by the immersed portion of the tail. The gill chambers are capacious, and it is probable that a sufficient amount of water can be retained in them to keep up respiration during their absence from the sea.



Periophthalmus koelreuteri.—Side view.

The *Periophthalmus koelreuteri* is widely distributed, being found throughout the Indian and Melanesian seas and on the west coast of Africa. It is absent, however, according to Dr. Gunther, from the Eastern Pacific and from the American side of the Atlantic. It is exceedingly nimble, and can be captured only with the greatest difficulty; and he who would succeed must count on being smeared from his hat to his boots with evil-odoured mud.

The accompanying illustrations are reproduced from photographs of the specimens in the Liverpool Museum, taken directly from life while sitting out of the water. They are, we believe, the only representations of this fish so obtained, the figures in Dr. Gunther's "Study of Fishes," and in Moseley's "Notes of a Naturalist on the *Challenger*," being drawn from spirit-preserved specimens.

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ENGLISH COINS.—I.

By G. F. Hill, M.A.

This paper must begin with an apology for its title. In the first place, it deals briefly with a coinage which existed in our country before the advent of the English race; and, secondly, some notice must be taken of the coinages of Scotland and Ireland. In these, however, there is little to justify a longer title than has been adopted.

The first coinage of Britain must be traced back to a Greek original. In a previous paper[*] we saw that the gold staters of Philip II. attained an extremely wide currency throughout the whole ancient world. It has been proved by the chief authority on the subject, Sir John Evans,[†] that the most important type of the early gold coins of Britain goes back to the stater of Philip. Greek influence probably reached Britain through Gaul, and the barbarous Gaulish imitations of Greek coins were still more barbarously and unintelligently imitated by the Britons. As we might expect, the coinage of Britain seems to have begun in Kent, and spread thence along the southern and eastern coasts, and to a certain extent into the Midlands. If we allow about a century and a half from the time of Philip (who died in 336 B.C.), we may arrive at a probable date for the beginning of coinage in Britain. The plate (Figs. 1 and 2) shows two barbarous Gaulish copies of Philip's coinage, and (Figs. 3 foll.) some specimens of British money. Fig. 3 (from the south-eastern district) is clearly derived from the Greek, but the charioteer has been provided with wings. In barbarous hands the tendency to reduce everything to mere ornament is strong, and in Fig. 4 (from the south coast) the original is hardly to be made out. The opposite tendency to evolve a likeness out of a mere design also, however, exists; and it is not difficult to see how the boar on Fig. 7 has been developed out of the degenerate human face on Fig. 5, through the intermediate stage of Fig. 6.

The coins described above are all of gold or silver, but baser metals were in use. The coins of the Channel Islands are of very base character, copper being the chief constituent, though silver and tin also form a part. The piece here given (Fig. 8) is characteristic in style. These coins probably belong to some time in the first century B.C.

Roman influence began to be felt in the time of Julius

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[*] Knowledge, June 1st, 1895, p. 123.

[†] "Ancient British Coins," pp. 17, ff.

Cæsar, and was soon strongly shown by the coinage. As the coins now begin to bear inscriptions, they supplement to a certain extent the too scanty records of British history. Thus, *e.g.*, we have coins with the names of rulers like Verica, Tasciovanus, Epaticcus, and Cunobelinus, and places like Camulodunum (Colchester) and Verulamium (St. Alban's). Of the four rulers mentioned only the last (Shakspeare's Cymbeline) is known from history; but the coins show that Epaticcus and Cunobelinus were sons of Tasciovanus. The name of Epaticcu(s) appears on the reverse of the gold piece No. 9, and the obverse legend TASCI F (*i.e.*, Tasciovani Filius) gives us his parentage. No. 10, again, gives us the first four letters of Cunobelinus on the reverse, and those of his mint, Camulodunum, on the obverse. Tasciovanus, who ruled over the Catyeuchlani, had Verulamium for his capital; his son Cunobelinus received, perhaps in his father's lifetime, the eastern kingdom of the Trinobantes, with the capital Colchester.

The coins struck by various Roman Emperors (or usurpers) in Britain, of which an instance is given in a previous paper,[*] do not properly come within the scope of this article. We must therefore pass over the period of Roman imperial domination to that which begins with the first advent of the English. An interesting coin (or possibly ornament) illustrates the transition from the one period to the other (No. 11). That it is a copy of a solidus of the Roman Emperor Honorius is clear; but the legend is unintelligible, and the reverse bears an obscure Runic legend. The piece was therefore made by people using Runes (that is, the script developed by the Scandinavian nations out of the Latin alphabet of about the fourth century A.D.); and it is said to have been found in this country. It may be dated approximately 600 A.D.

The series of English coins proper begins in the early years of the seventh century—probably soon after the conversion to Christianity of Æthelberht, King of Kent, in 596 A.D.—with what is known as the sceat[†] series. This is a remarkable series of small coins, the character of which is similar to that of the Merovingian currency of the Franks. While, however, the latter was mainly and primarily a gold coinage, there is only a comparatively small class of English coins in this metal, which was soon replaced by silver. This Merovingian currency, originating in an imitation of Roman money similar to the gold coin with Runic letters which we have already described, soon acquired a distinct character of its own. Both the solidus and its third (*triens* or *tremissis*) were coined by the Merovingians, but the latter eventually became almost the sole denomination—at least in England. The name *tremissis* is the origin of the old English word thrymsa, a money of account, and probably originally the name of the small coins corresponding to the Merovingian tremisses.

Besides the general resemblance there are many other small points which, taken together, prove the connection between the coinages on the two sides of the Channel. One coin in particular bears the name of a Merovingian moneyer (Eusebius) on one side, and on the other the name of Canterbury (DOROVERNIS CIVITAS). There are also coins which appear to be English imitations of Merovingian pieces.

Of the gold coins here illustrated, No. 12 is an imitation of a Roman coin. The legend is unexplained, though apparently not blundered; the reverse is taken from a coin which represented two emperors seated holding the globe of sovereignty, with a figure of Victory behind them. No. 13, on the other hand, is probably imitated from Merovingian money; the legend, which is WVNƎƎTTON, may possibly, as has recently been suggested, be the name of Winchester (Wintonia). These coins have nothing to connect them directly with the English, but another coin of similar fabric in the British Museum with a Runic legend may serve to establish the connection. The silver coins, or sceats proper, have a great variety of types. Three, with reverses evidently derived from the Roman type of the military standard inscribed $\genfrac{}{}{0pt}{}{\text{VOT}}{\text{XX}}$ (*i.e.*, vows made on the Emperor's accepting the empire for twenty years), are illustrated here (Nos. 14-16). The first has on its obverse a degraded bust, with a Runic legend equivalent to EPA in front of it. The second shows on its obverse a pattern which can actually be traced back to a human head looking to the right. The third shows the same type in an altered form, where the "artist" has evolved a strange bird out of the degraded form of head. It would be easy to multiply the fantastic types; but we must be content to notice one or two sceats for which some historical connection can be established. The first of these belongs to a series which bears in a more or less blundered form the name of London (No. 17). The second (No. 19) bears the name (in Runic letters) of Pada, and is naturally to be connected with Peada, King of Mercia (A.D. 655-656 or 657). The type of the reverse is the degraded standard type which we have already noticed. Another (No. 18) similarly gives us the name of Æthelred of Mercia (675-704).

Before leaving this early period we must mention the early coinage of a district of England which we have up till now left out of account: the district north of the Humber. The earliest known coins of this district belong to the last third of the seventh century, and are therefore later than the earlier sceats. They are all, however, marked with the name of the king who issued them, in Anglo-Saxon letters (thus we have the name of Ecgfridh,[*] who reigned from 670-685, on No. 20, a copper coin). About the end of the eighth century the variety in design disappears, and practically all the coins are struck in copper. These copper pieces are known as stycas (the same word as the German Stück). The use of copper in the place of silver north of the Humber has been explained by the existence of vast quantities of Roman copper coins in this district. Another remarkable change is the introduction of moneyers' names, which now regularly appear on the coins. Thus the coin of Eanred here illustrated (No. 21) has on its reverse the name of PINTRED (*i.e.* Wintred) the moneyer. This modification is due to the influence of the more advanced coinage south of the Humber. But the full effect of the southern coinage was not felt until the time of the Danish kings of Northumbria.

The coinage of Northumbria during this period comprises not only a regal series, but an interesting series struck by the Archbishops of York, and corresponding in significance to the coins of the Archbishops of Canterbury with which we shall deal in a later passage. These coins (which begin about the same time as the regal series) are nearly all copper stycas. The piece given here (No. 22) was struck under Eanbald II. (Archbishop A.D. 796-808?) and reads on the obverse EANBALD AREP. The second word is an abbreviation of Ar(chi)ep(iscopus). On the reverse is the moneyer's name EADVVLF (for

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[*] KNOWLEDGE, November 1st, 1895, No. 23.

[†] Sceat treasure.

[*] For purposes of convenience, I represent the three Runic letters which survived into English by w (for the wen), th (for the thorn), and dh (for the corresponding soft sound).

Eardwulf). The legend on each side is preceded by a cross, and this is a very usual practice on all coins of the middle ages. The most interesting piece in this archiepiscopal series is, however, the gold solidus (No. 23) struck by Wigmund (A.D. 837-854 ?). It reads on the obverse VIGMVNDAREP, and presents a (conventional) portrait of the archbishop, with tonsured crown. The reverse reads MVNVS DIVINVM ("An offering to God"?). The occurrence at such a date of a full-faced bust on coins struck north of the Alps, or of a bust of any kind in Northumbria, is exceedingly rare.

Keary* bridges the gap between the series which we have described and the penny coinage which succeeds them by means of a transition piece (No. 24), which he ascribes to Beonna, perhaps an East Anglian king. In fabric and weight this coin stands nearer to the sceat series, but in design and style of inscription it must be ranked with the pennies. The inscription on the obverse is partly in Runic letters, and equivalent to BEONNA REX; the name of the moneyer is EFE.

The introduction of the silver penny was one of the most far-reaching changes in the history of English coinage; and this change was due to a similar change in the coinage on the other side of the Channel. The denier was introduced in France by Pepin the Short about 755. The transition piece described above is dated by Keary about 760.† The earliest pennies certainly attributable to any king are those of Offa, King of Mercia (757-796). Some time after 760, therefore, it is probable that this great innovation was made. The penny coinage was, however, not adopted in Northumbria until a century later. For nearly five centuries henceforth there was no real change in the English coinage, the silver penny being the only currency.‡

The weight of the denier when first introduced was about 19 grains troy, but in twenty years it had risen to 23·6 grains. The English pennies began lower, and rose in time to about the same average weight, though they are occasionally in excess of the weight of 24 grains which, from its connection with the silver penny, came to be known as the "pennyweight."

Offa's coinage presents a remarkable variety of types. The commonest are the conventional bust of the king, and a cross in some form or other. The name of the moneyer on the first piece given here (No. 25) is meant for Eadhun or Eadmund. The second piece (No. 26, reading OFFA REX and BAHHARD, *i.e.*, Bannard) is one of the many pieces from which the king's bust is absent.

The coins of Offa are artistically quite the best produced in England during all the period which we have to consider in this article. The money of his successors does not show the same variety of types and skill in workmanship.§ As to the origin of these types, some of them are doubtless due to native ingenuity; others are copied from the deniers of France, others from sceats, and others again from Roman coins (for at this time Roman gold coins were still in wide circulation).

It will be most convenient to divide the history of the coinage, from the introduction of the penny up to the point at which the present article is to stop, into two main periods: (1) the history of the various kingdoms up to the unification of England; (2) thence to the Norman Conquest.

The first period is one of considerable political confusion, but the state of the country had not so disastrous an effect on the coinage as it had, for instance, in later times under Stephen. The coins are fairly legible and neat. We may divide them into two series: a regal and an ecclesiastical or semi-ecclesiastical. The regal series naturally divides itself into the coinages of the various kingdoms: Kent, East Anglia, Northumbria, Mercia, and Wessex. Of these the first had ceased to be important while the anonymous sceats were still the only coinage.

The last King of Kent, Baldred, was deposed by Ecgbeorht of Wessex in 825. The coin given here (No. 27) reads BELDRED REX CAN (*i.e.*, Baldred, King of Kent) on the obverse, and OBA (*i.e.*, the moneyer's name) on the reverse.

The coinage of East Anglia may be illustrated (in addition to the piece of Beonna described above) by a coin of Æthelberht (No. 28), who was killed in 794. The name of the king is partly in Runic letters; the reverse bears the title REX and a type copied from the wolf and twins so common on the Roman coinage. This penny is, however, quite exceptional; the later pieces belong to the usual kind.

Of the Northumbrian penny series, which begins with the invasion of the "great army" in 866, we may describe a halfpenny struck by Siefred (894 to about 898) at York. (No. 29; obverse RSIEVERT; reverse EBIAICECIVI. The spelling EBRAICE CIVI(tas) corresponds to the form EBORACVM by which the Romans represented the British name which, through the form Eoferwic, has come down to us as York.) The halfpenny and farthing were also sometimes produced (less frequently at this time than later) by simply cutting the coin into halves and quarters, a process to which their thinness and frequently their cruciform types specially adapted them. We have already described some specimens of the earliest Mercian pennies, and we may therefore pass to the kingdom of Wessex. The greatness of this kingdom began with the battle of Ellandune, in 825, in which Ecgbeorht defeated Beornwulf, King of Mercia. On this soon followed the acknowledgment, more or less formal, of Ecgbeorht's supremacy on the part of East Anglia and even Northumbria. Kent was entirely absorbed in Wessex, with curious results as regards the coinage of the latter kingdom; for it appears that the coinage of Ecgbeorht is really a Kentish coinage, issued very largely either in Kent itself or by Kentish moneyers. A series of coins of Ecgbeorht exists with a monogram generally explained as that of the Latin name of Canterbury (*Dorobernia*). There are, however, coins with the legend SAX or SAXONIORVM, which most probably are of pure West Saxon origin; and the coinage of Mercia had also considerable influence on that of its conqueror. In this connection two most important coins, discovered within the last few years, must be mentioned. The first (No. 30) has the obverse legend ECGBERHT REX M, *i.e.*, King of the Mercians; and on the reverse LVNDONIA CIVIT. This is the first instance of the appearance of London as a mint on English pennies. On the second, which gives the king the same title, we have the name of the moneyer Redmund, who is otherwise associated with Wiglaf, the Mercian king deposed by Ecgbeorht some time after the battle of Ellandune. These two coins are therefore interesting illustrations of the beginning of the rise of Wessex.

After the establishment of the West Saxon supremacy, the chief element in English history is supplied by the great invasions from across the North Sea. Into the

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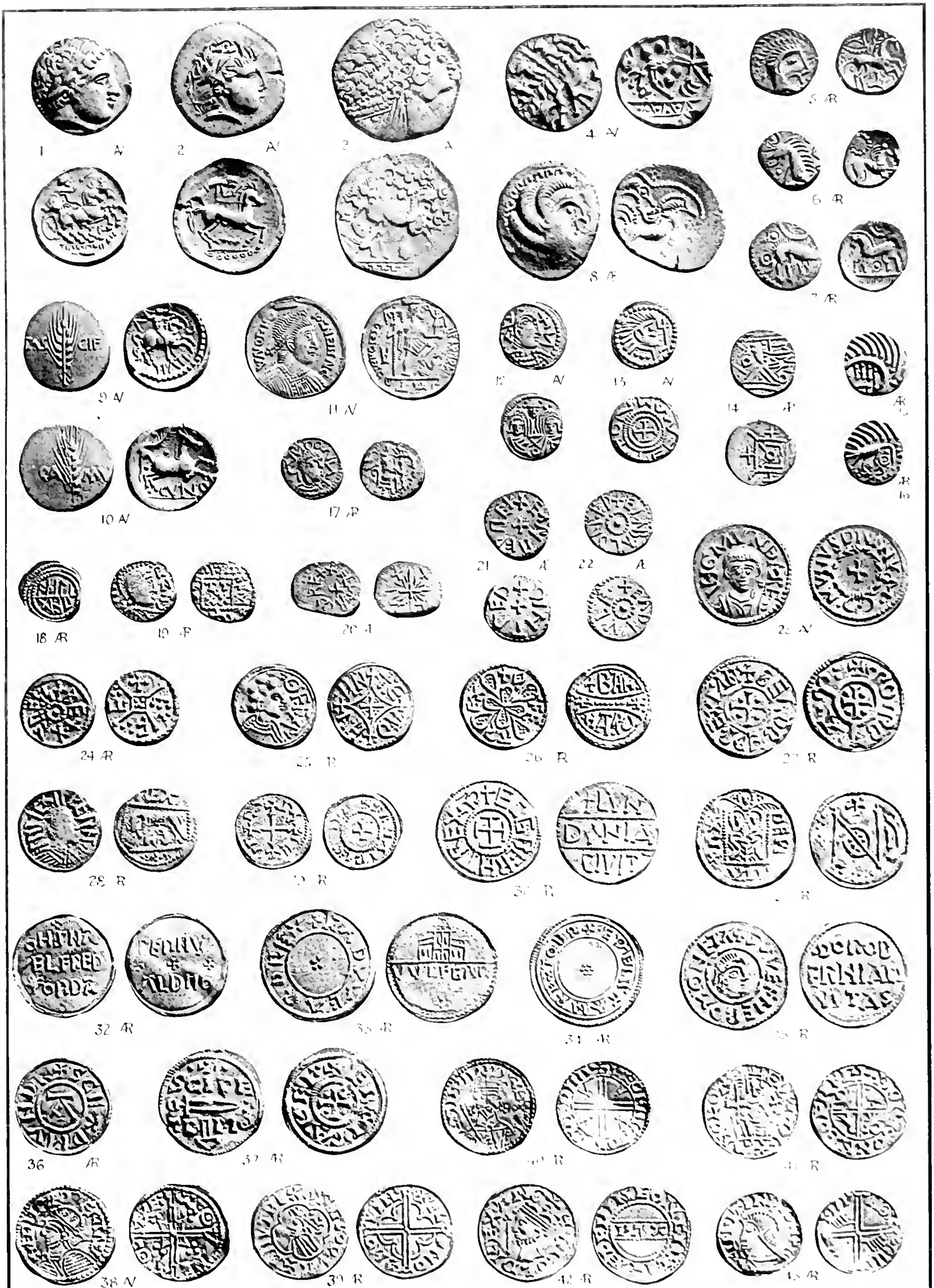
* Introduction to Vol. I of the "Catalogue of English Coins in the British Museum," p. xxiii. I must here acknowledge my constant indebtedness to the introductions to Vols. I and II. of the English Catalogue.

† A Beorna is mentioned by Florence of Worcester in 758

‡ Apparent exceptions will be dealt with as they occur

§ The heads on some of the coins of Offa are so good that one is almost justified in calling them portraits



BRITISH AND ENGLISH COINS

history of this period it is impossible to go in detail here, and we can only briefly instance coins of a few of the better known rulers of the time.

In 874 the Viking army under Halfdan deposed Burgred, King of Mercia, and England was now practically divided between Wessex and the Danish power. One of the most remarkable coins issued by the invaders is the penny of Halfdan, when he was in London after the deposition of Burgred. The obverse type (No. 31) is similar to that of the reverse of the gold sceat described above (No. 12), while the reverse bears the monogram of London.

Ælfred the Great succeeded to the throne of Wessex in 871, and reigned till 901. By 878 (when he won the victory of Æthandune) he had succeeded in getting rid of the Danes from England west of Watling Street and the Lea, and consolidating his kingdom; his coins probably date from after this year.

The following penny (No. 32) was struck at Oxford: obverse, ÆLFRED OHSNAFORDA (for ORSNAFORDA); reverse, BERNVALD MO (for MONETARIVS, moneyer). Under Eadweard the Elder, who succeeded Ælfred, we find a great variety of types, including one which may be meant for Canterbury Cathedral (No. 33). The workmanship of the coins of this king is neater than any since the time of Offa, and there seems to have been some attempt at portraiture. Eadweard's successor, Æthelstan, also struck a fine series of coins, but of less varied types. The number of mints (the names of which it had become not unusual to place on the coins in the time of Ælfred) begins to increase in this reign, and the new places from which coins were issued are evidence of the steps by which England was gradually recovered from the Danes. Æthelstan sometimes calls himself King of all Britain (REX TO BR on No. 34). From this time to the reign of Eadgar (959-975) there is no important change in the coinage to be chronicled.

We may now, before passing to the coinage of unified England, look briefly at some of the exceptional issues of the period just described. Beginning with the archiepiscopal coinage, we illustrate (No. 35) a coin struck at Canterbury in 832-833 during the interval between the death of Wulfred and the appointment of Ceolnodh. On the obverse is a head to the right and the name of the MONETArius SVVEFNERD; on the reverse DOROBERNIA CIVITAS. The coins struck by the archbishops themselves are not of any unusual interest; but there are at least two remarkable series of quasi-ecclesiastical coins which must be mentioned here. These are the memorial pennies of St. Eadmund, struck in East Anglia chiefly during the end of the ninth century, and a somewhat similar series with the name of St. Peter, struck probably about the middle of the tenth century. The former series is represented here (No. 36) by a coin which reads SC (*i.e.*, Sanctus) EADMVND R on both sides, but the reverses are more commonly occupied by moneyers' names, sometimes of a very strange character. Most of them appear to be Frankish, and the coins may have been issued by Frankish traders settled in the district. The St. Peter coins were struck at York during the Danish occupation, and probably under the direction of the archbishops. The type of the obverse of the coin figured (No. 37) is a sword, the legend SCI PETR MO, *i.e.*, Money of St. Peter. These coins have of course no connection with the Peter's Pence, which were a tribute paid into the Papal Treasury on St. Peter Mass. The other subsidiary coinages of this period we must pass over unnoticed.

Under Eadgar, the first King of all England, there is a great increase in the number of mints, but otherwise nothing remarkable to chronicle. Æthelred II., the Unready (*i.e.*, devoid of counsel), issued a very large number of coins, in spite of the distressful state of his kingdom. He is occasionally represented wearing a helmet (sometimes combined with a crown). The combination is seen on the gold piece here illustrated (No. 38), which was made at Lewes (LÆPE) by the moneyer Leofwine (LEOFPINE). This piece is usually regarded as a proof or pattern; but it may equally well have been struck as an offering penny or presentation piece. A similar gold piece of Edward the Confessor exists. This coin also gives us an instance of the double cross, which now becomes common, owing probably to its convenience with a view to cutting the penny into halfpennies or farthings.

During the reign of Æthelred II. the English coinage had an enormous circulation all over the Scandinavian world, and the later coinage of these parts was modelled on the English money. The English coinage presumably travelled abroad as ransom or plunder, though, did we not know the facts, we should naturally conclude from the numismatic evidence that Æthelred's reign was one of great prosperity.

The remaining rulers of England previous to the Norman Conquest must be briefly dismissed. Under Cnut we notice the occurrence of the crowned bust (No. 39, reading CNVT REX ANGLORVM and ÆLFNOD MO LINC, a Lincoln penny, therefore), which Cnut adopted from the German emperors. The legend PACX (common enough on later coins) now first occurs on some of Cnut's coins, having reference probably to the peaceful settlement of English affairs in 1017-18. Cnut also sometimes wears a pointed helmet, like that found on the Bayeux tapestry.

Passing over Harold I. and Harthacnut we come to Edward the Confessor. In this reign two interesting types are introduced. The king is sometimes represented seated, holding sceptre and orb surmounted by cross—the symbols of sovereignty. (No. 41, EDPAD RX ANGLOR and DORR ONN EOFRPC, *i.e.*, Dhorr at York. On the reverse are four martlets in the angles of the cross, generally supposed to be the heraldic device of the king, though there is doubt as to their true character.) Another new type, so far as the regal series is concerned, is the facing bust, which occurs, *e.g.*, on the coin struck at Cricklade (No. 40, LEOFRED ON CRECLA).

We close the English series with a coin of Harold II., who seems to have adopted only one type. The coin we give (No. 42) was struck at Chichester, and reads HAROLD REX ANG and ÆLFPINE ON CICEI, with the legend PAX in the centre of the reverse.

The Scottish coinage does not commence till the reign of David I. (1124), nor the Irish until the period of the second Scandinavian invasion of England, at the end of the tenth century. At that time we find a number of coins bearing the names of Æthelred II. and Cnut. These were only imitative coins, and do not imply that these kings ruled in Ireland. They preceded the coinage of the Norseman Sihtric, who reigned in Ireland, dying in 1042. His silver pennies (No. 43) are copied from those of Æthelred II.; the objects in the two angles of the cross are probably meant for hands. The name of Sihtric is generally more or less blundered. From this period till the time of the English conquest, under Henry II., there is no Irish coinage.

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[*] It also occurs on coins of Ceolwulf II. of Mercia (who was set up by the Danes in 874) and of Ælfred the Great.

[*] ON or ONN has been explained as a corruption of MON, but this is improbable.

SOME CURIOUS FACTS IN PLANT DISTRIBUTION.—II.

By W. Botting Hemsley, F.R.S.

Some particulars have already been given of the composition of the vegetation of several of the remote islands in the highest southern insular limits of flowering plants, especially in relation to its general poverty, the absence of shrubby plants, and the extreme rarity of conspicuous and brightly-coloured flowers. Proceeding northward from Macquarie Island, in the New Zealand region, the climatic conditions are rapidly less rigorous; a few degrees of latitude bringing considerable change, and a corresponding increase in the variety and character of the plants constituting the vegetation. This is exemplified in Campbell Island, in about 52° 30′ latitude, and still more in the Auckland group, two degrees further north. On the windward side of these islands the vegetation is poor and stunted; but on the leeward side, and in the sheltered valleys, there is a comparatively rich and varied flora. There are no very large trees, it is true, but small trees and shrubs abound. The commonest, largest, and most conspicuous tree is *Metrosideros lucida* (myrtaceæ), which attains a height of twenty to forty feet, with a trunk occasionally as much as three feet in diameter. It bears showy crimson flowers, and is a very striking object in the landscape. *Dracophyllum*, a genus of the heath family, having leaves much like those of a *Dracæna* or a small screw-pine, is represented by two arboreous species, totally unlike anything in north temperate regions, and no less striking than the myrtle just mentioned. *Veronica elliptica* is another small tree inhabiting these islands. Most of our northern species of *Veronica* are herbs or quite low shrubs; whereas in the New Zealand region, where the species are much more numerous and varied than in any other part of the world, they are nearly all shrubby. *V. elliptica* is the only really arboreous species, sometimes growing as much as thirty feet high, and when covered with its bright blue flowers it is a beautiful sight. It is also still more remarkable that this tree is found in the South American region, growing as far south as Hermite Island (lat. 55° 52′), Fuegia, within three latitudinal minutes of Cape Horn. This, I should explain, is a somewhat higher latitude than the remote islands whose vegetation I have described as the highest southern latitudes where flowering plants exist at the present time. I should have added, in remote islands. Among the shrubs of the Auckland Islands flora are many bearing showy berries; and the herbaceous element includes handsome plants of the aster, orchid, lily, and other families. There are also some very robust and ornamental pink-flowered umbelliferæ, allied to our *Angelica*. Ferns abound, too; but the characteristic beech-trees and conifers of the New Zealand mainland are wholly wanting.

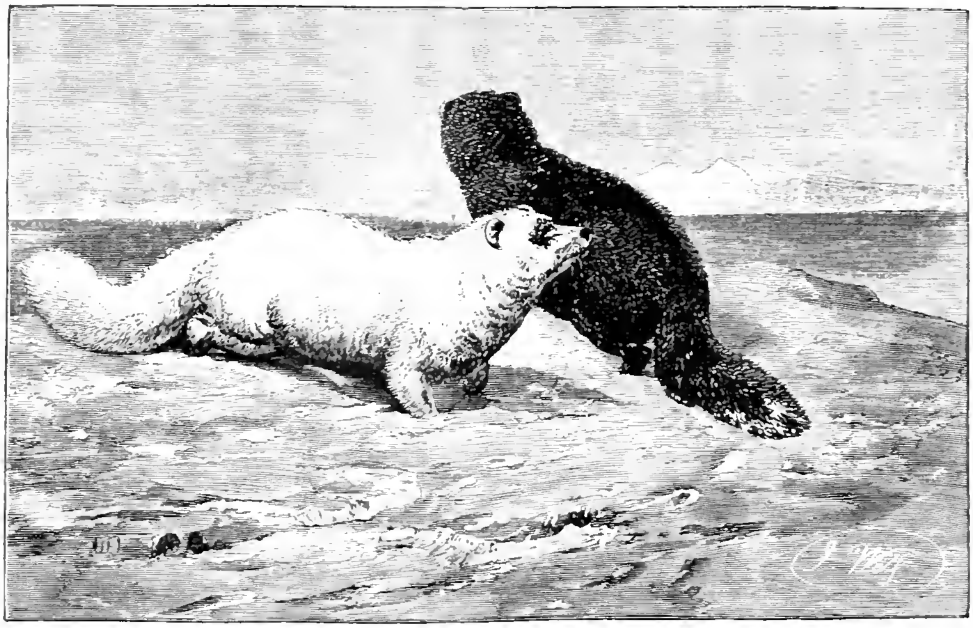
Proceeding no farther northward than Stewart Island (47° lat.), in the extreme south of New Zealand proper, we encounter a subtropical vegetation, in which tree ferns and trees having brilliantly coloured flowers are conspicuous features. This island, having an area of only six hundred and forty square miles, and altitudes up to three thousand feet, is still imperfectly explored; yet no fewer than three hundred and eighty species of flowering plants and seventy species of ferns have been discovered within its narrow limits. I must not dwell on the attractions of this rich southern flora, which owes its wealth to a combination of local conditions. Taken as a whole, however, the flora of New Zealand is poor in generic forms; such familiar and wide-spread genera as *Ranunculus*, *Epilobium*, *Senecio Veronica*, and *Carex* contributing very largely to the total number of species, nearly all of which are endemic or restricted to the islands. The relatively numerous endemic genera are mostly represented by one or few species, and present many interesting phenomena in plant distribution which I cannot attempt to discuss or explain here. I may add that, with the exception of Stewart Island, all the small islands referred to are uninhabited.

I will now invite the reader to accompany me, in imagination, to some groups of uninhabited islands in the southern part of the Indian Ocean, midway between Macquarie Island to the east and South Georgia to the west, but in somewhat lower latitudes, ranging from about forty-seven degrees to fifty-three degrees south. These are the Prince Edward group and Crozets, corresponding in southern latitude to the centre of France in the north; and Kerguelen and the Macdonald group, corresponding to Cornwall and Nottingham respectively. A glance at the map will teach more than many words the distances these groups of small islands are from each other and from the nearest continents. With the exception of Kerguelen, which has an estimated area of a little more than two thousand square miles, these volcanic islands are all of small extent. Their vegetation is of the scantiest, and its composition is nearly the same throughout, except that Kerguelen has twice as many species as any of the other islands or groups of islands.

The climate is not very severe and the range of temperature is not great; yet the nature of the climate is unfavourable to vegetation. In Kerguelen, for example, the thermometer rarely rises to 70° Fahrenheit, and rarely falls more than a few degrees below the freezing point; but it is almost continuously cold, bleak, and stormy, due to these islands being in the track of the Antarctic currents. Heard Island, in the Macdonald group, is still in a glacial period, with glaciers almost down to high-water mark. This island is about twenty-five miles in length by six in its greatest breadth, with mountains rising to a height of seven thousand feet. Only five species of flowering plants have been collected there, and the same number in the Crozets, with two ferns added; fourteen of flowering plants and ferns combined in Marion Island, Prince Edward group; and twenty-seven in Kerguelen. Not one is of a woody nature, but fossil wood discovered in Kerguelen affords evidence of the existence of forests at some probably very remote period. Six species out of an aggregate of thirty have not been found elsewhere. One of these, the Kerguelen "cabbage" (*Pringlea antiscorbutica*), is specially deserving of notice, both on account of its history and its value as a pot-herb or salad. Captain Cook, although not the discoverer of the island, was the co-discoverer of the cabbage, and took great interest in it in connection with its antiscorbutic properties. Cook was keenly alive to the ravages of scurvy among seamen, especially those engaged on long voyages, away from civilized countries; and, through the precautions he took, he was very successful in combatting this dreadful disease.

But in the narrative of the voyage it is William Anderson, surgeon and naturalist to the expedition, who is quoted on the vegetation of Kerguelen, and he says: "Perhaps no place hitherto discovered in either hemisphere on the same parallel of latitude affords so scanty a field for the naturalist as this barren spot." He then goes on to describe, in a general way, the principal plants, including the cabbage, and places the total number of species at about eighteen. He also mentions that they ate the cabbage both raw and cooked. This was in 1776, and it was left to the now veteran Sir Joseph Hooker, who accompanied Sir James Ross on his memorable Antarctic expedition, 1839 to 1843, to publish a full and illustrated account of this remarkable plant, partly from his own experience and observations and partly from Anderson's manuscript in the British Museum. The name *Pringlea* he adopted from Anderson, who proposed it to commemorate the name of Sir John Pringle, who wrote a treatise on scurvy, which is appended to the account of Cook's first voyage.

This plant is the largest and the most abundant in Kerguelen, growing most luxuriantly, however, on the sea-shore, where it is the first to greet the grateful mariner. It belongs to the cruciferæ, the family to which belong our cabbages, cauliflowers, radishes, turnips, cress, and other valuable esculents; and it is one of the most distinct of its family, not being very closely related to any existing member. In addition to being abundant in Kerguelen, it also occurs plentifully in the Prince Edward, Crozet, and Macdonald groups, which, although uninhabited, are the resort of whalers, to whom it is a great boon and luxury. Sir Joseph Hooker states that during the three months' stay of the *Erebus* and *Terror* at Kerguelen in 1840, the native cabbage was cooked daily for the use of the officers and crew. I have written somewhat fully on this plant because of its immense utility to man in a region where there is so little vegetation, and where in the islands of the Indian Ocean in question it is the only member of the natural order which, in corresponding northern latitudes, is so numerously represented and produces such a variety of esculent vegetables.



Arctic Foxes.

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OUR FUR PRODUCERS.—III.

FOXES, WOLVES, AND BEARS.

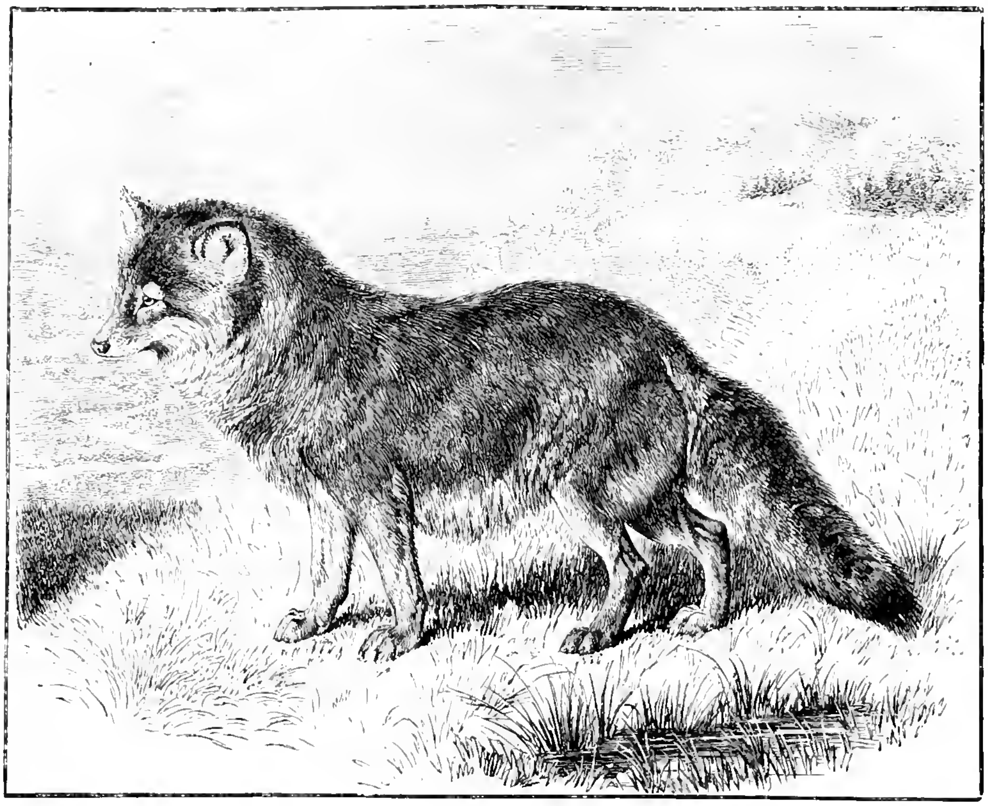
By R. Lydekker, B.A.Cantab., F.R.S.

Next in importance to those of the weasel tribe, among the land carnivora, are the furs of the various species of wolves and foxes, the pelt of the renowned silver fox of North America realizing prices second only to those paid for skins of the sea-otter. Both foxes and wolves belong to the great dog family (*Canidæ*), and as the general appearance of all these animals is sufficiently well known to our readers there is no necessity for giving any description.

Few mammals are subject to greater variation in colouration than the ordinary fox (*Canis vulpes*); and hence it happens that whereas this animal is really a very widely spread one, with numerous local varieties, it has been split up into a host of nominal species, such as the cross fox, silver fox, Himalayan fox, and Nile fox. Wiser counsels fortunately, however, now obtain, and (among European naturalists at any rate) these and other varieties are reckoned merely as peculiarly coloured races of the common fox. Even in England there is a certain amount of variability in this widely-spread species, examples being sometimes killed in which the characteristic white tip to the "brush" is wanting; while one has been caught with the under parts as dark as in the Italian race. In the latter instance it is, however, of course possible that the animal may have been a foreign "bagman" imported into this country.

The descriptions of all the colour variations to which the fox is subject are far too long to be even referred to here, and belong more properly to a work on natural history; and we shall consequently confine our notice, in the main, to the prices and numbers of the different varieties of pelts that come into the market. As the most expensive and most beautiful of all, the North American silver fox claims our first attention. With the exception of the tail-tip, this variety is almost entirely black, the hair on the hinder part of the back, outsides of the thighs, and head being ringed with grey; but some examples are wholly black and others wholly grey. It is now a comparatively scarce animal; but about five-and-forty years since it was sometimes seen in the mountains of Pennsylvania and the wilder districts of New York State. The American Fur Company obtained most of its skins from the Upper Mississippi and the districts to the north-west of the Missouri River. From about one thousand five hundred to two thousand skins are annually sold in London. Of these, the pale-coloured varieties realize only from some five to eight pounds apiece; but even in 1890 fine black skins sold at from fifty pounds to seventy-two pounds. In 1894 the price went up to an extraordinary degree, and many skins were sold at more than one hundred pounds. The highest price was, however, realized at a sale in London in the spring of 1895, when an unusually fine skin sold at no less a figure than one hundred and seventy-five pounds. The pelts, which are usually made up into muffs and trimmings, are chiefly bought by the French and Russians; the most costly of all furs finding their way to Russia.

Next in scarcity of the American varieties is the so-called cross fox, taking its name from the transverse band of darker hair across the shoulders; the under surface of the body and legs being black. Ordinary skins of this variety sell at from one pound to two pounds ten shillings; but unusually dark-coloured specimens vary in price from five pounds to seven pounds each. According to Mr. Poland, the number of pelts that come annually into the London market oscillates between five and seven thousand. The commonest of all in America is the red fox, in which the general colour is reddish yellow, becoming grizzled on the hinder part of the back. Probably the Kamschatkan fox is identical with this variety.



The Coyote.

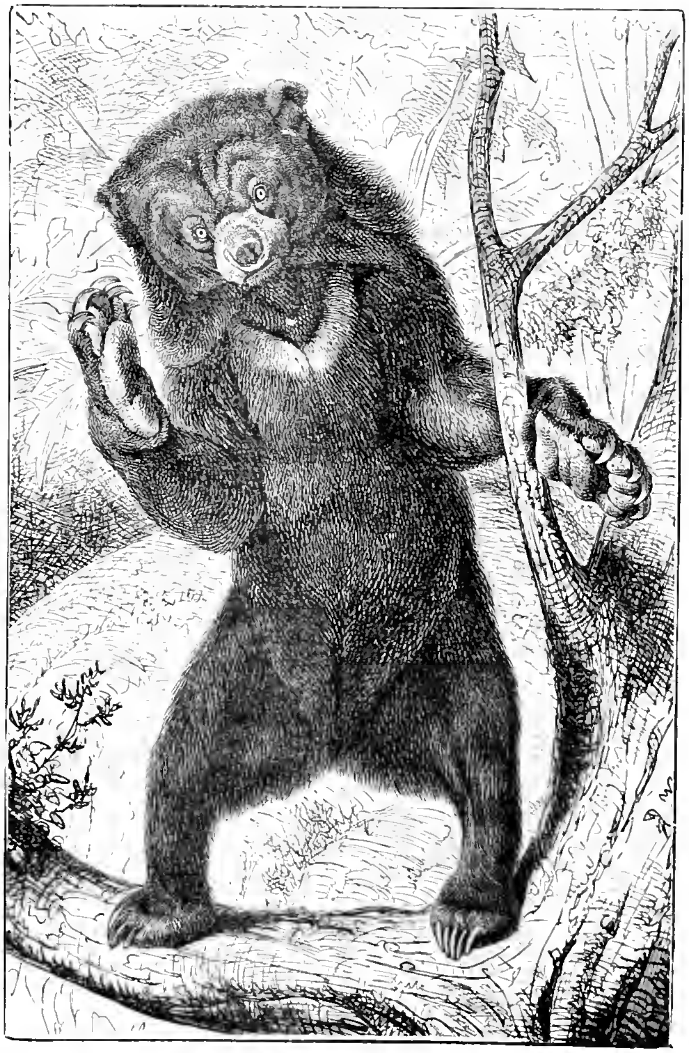
The trade in American red fox skins is enormous, from seventy to ninety thousand being yearly sold in London, at prices varying from two to sixteen shillings each. In the earlier part of the century the value was, however, considerably greater. Mr. Poland states that "red fox skins are mostly purchased for export to Russia, Turkey, Greece, Servia, Bulgaria, and other Eastern countries, where they are used for trimmings, coats, etc."

Although in Britain but few pelts of the European fox are saved, on the Continent there is a very large trade in them, about one hundred and thirty thousand being sold annually at Leipsic, and some two hundred thousand at the Irbit Fair in Siberia; while the number collected yearly in Germany is stated to reach about half a million. Average specimens sell at about two shillings.

There is a considerable trade in the skins of the Oriental foxes, although it is far from easy to determine which species yields the maximum supply. Probably, however, the greater number are the product of the Himalayan fox, the so-called *Canis montanus*, which is, however, only another variety of the common species. This form has black under-parts, and not unfrequently a dark cross mark on the shoulders. It is found from Afghanistan throughout the Himalaya. Skins vary in value from eighteen pence to three shillings each; and it is stated that several thousands are imported to Leipsic by way of Arabia, in addition to about a hundred thousand through Nishin. In Kashmir and Cabul these skins sell at about nine annas each; and when a number are sewn together they form a very warm and handsome carriage rug. Although the fur of the small Indian desert fox (*C. leucopus*)—with which the Persian *C. persicus* is probably identical—is short and of but little value, a small number of skins are exported every year from Karachi.

Very distinct from all the other members of the group is the Arctic fox (*C. lagopus*); also known either as the blue or the white fox, according as to whether it is in the summer or the winter coat. From other foxes this species differs by having the soles of the feet thickly clothed with hair, while it is further characterized by the bushiness of the tail. Some writers appear to be in doubt whether a blue fox turns white in winter, but that this is the case is certain. In the summer the general hue of the fur is bluish, or occasionally brownish grey. Dr. Mivart writes that the change from grey to white "does not, by any means, invariably take place, even in this species. Individuals seem often to be met with in their native haunts with their summer dress in winter, while others remain entirely white the whole year round." Although inhabiting all lands within the Arctic Circle, this fox extends a considerable distance south of the latter in both hemispheres, but more so in the Eastern than in the Western. The white winter skins vary considerably in quality, those from Alaska and Siberia being coarse-haired, whereas Greenland and Labrador samples are finer. From Siberia it is stated that between twenty and sixty thousand skins are imported into Europe, most of them being sold at the fairs of Irbit and Leipsic; while about nine thousand came to hand in 1891 through the Hudson Bay and Alaska Fur Companies, and nearly a thousand were obtained from Greenland by a Danish company. The price per skin varies from half a crown to about sixteen shillings and sixpence. Blue fox is much more valuable, the prices varying from about a pound to as much as fourteen or even fifteen pounds per skin. A certain number of pelts are obtained from Iceland, where the species retains its "blue" tint throughout the year; but the entire out-turn is comparatively small, the number exported by the American companies in 1891 being a little over three thousand, while in the same year the Danish company accounted for about one thousand four hundred. In the Pribylov Islands the Arctic fox subsists chiefly upon young seals and sea-birds and their eggs. The white skins are largely employed in the natural condition for wrappers and rugs; and when dyed black or brown are manufactured into muffs or used for trimmings, in imitation of silver fox. The tails are also made up into boas.

Of the other foxes the one of most commercial importance is the Virginian, or grey fox, of North America (*C. virginianus*), taking its name from the general dark grey hue of the fur. Mr. Poland states that in 1891 over twenty-five thousand grey fox skins came into the London market, which realized from sixpence to four and sixpence each. This, however, is one of the furs that of late years has gone out of fashion, since considerably higher prices were formerly paid. In habits the grey fox differs considerably from the common species, as when hunted it always runs in a circle, instead of in a straight line, and when hard pressed will not unfrequently seek refuge by running up the stem of some sloping tree. In spite of its soft and thick fur, the smaller American kit fox (*C. velox*), characterized by the light grey colour of the back, the yellowish flanks, and the white under-parts, is of still less importance from a commercial point. But few skins now come into the market, and these realize only from eightpence to a little over two shillings each. Although sometimes dyed black they are chiefly employed, for the cheaper kinds of fur wraps.



Malayan Bear.

Of the South African forms, the only one of which skins come into the market appears to be the asse fox (*C. chama*), which is a somewhat long-eared species, intermediate in character between the typical foxes and those small very long-eared forms known as "fennecs." Even of this species only a few skins are imported into Europe, and there appears to be no regular price quoted. In parts of South Africa its skins are used by the natives for making their cloaks or karosses.

South America is the home of several small species of the genus *Canis* commonly spoken of by the English settlers in that country as foxes. They differ, however, from the true foxes in several characters of the skull, and belong to a different group of the genus. Although they have in general good fur, but very few skins find their way into Europe, and such as do so sell at between one and two shillings each. Probably the majority belong to Azara's fox (*C. azaræ*), which is one of the commonest of the Argentine species.

A very remarkable member of the canine family is the so-called raccoon-dog (*C. procyonides*), from Japan and other parts of North-Eastern Asia, which derives its name from its curious superficial resemblance to a raccoon. It has long loose fur, of a general dark brownish grey colour, small ears, and a short bushy tail; the under-fur being short and very close. Although by naturalists this animal is frequently regarded as somewhat rare, the number of its skins imported for commercial purposes indicate that it must really be extremely common. According to Mr. Poland, upwards of thirteen thousand pelts were imported in 1884, and about seventy thousand in 1891; the majority of these coming from Japan. It is sold under the names of either Japanese fox, jackal, or badger; and some of the skins are received in England with the long hairs removed and only the short under-fur remaining. From fourpence to seven shillings and sixpence each appears to be the range in the value of the pelts of this species, the price fluctuating both with the quality of the skins and the demand for them. This fur, which is used both dyed and of the natural colour, is made up into trimmings or capes.

The jackals, which are intermediate in point of size, and in some respects also in external character, between the true foxes and the wolves (although differing from the former and resembling the latter in the structure of their skulls), are of little or no commercial importance. This is not to be wondered at in the case of the common jackal (*C. aureus*) of South-Eastern Europe, Western Asia, and Northern Africa, seeing that its fur is harsh and little suited to the purposes of the furrier. Consequently the pelts of thousands of these animals annually destroyed in Algeria are wasted. It seems, however, a pity that the fur of the handsome black-backed jackal (*C. mesomelas*) of Central and South Africa is not made more use of, seeing that the difference in colour between the black of the back and tail, flecked with silvery grey, and the bright tawny of the flanks, head, and limbs, forms a striking and pleasing contrast. Only a few skins appear to be imported, which average about three shillings in price, and are chiefly employed for fur wraps. We cannot find that the pelt of the side-streaked jackal (*C. adustus*), which is likewise an African species, is ever used at all.

Of more importance are the wolves, of which some of the skins are very handsome, and command a considerable price in the fur market. As in the case of the common fox, we here again once more meet with the difficulty of deciding what degree of difference constitutes a species, and what ought to be reckoned as a mere variety. It is, however, now generally conceded that the North American wolf is not specifically distinct from its European and Asiatic cousin (*Canis lupus*), and that the dark-coloured woolly wolf (*C. laniger*) of the highlands of Tibet is likewise only a local race of the same. Probably also the so-called blue wolf (*C. hodophylax*) of Japan comes under the same category; but there is some difference of opinion with regard to the Indian wolf (*C. pallipes*). Including all these, save the last, under the head of the common species, we may have grey, brown, black, white, yellow, and "blue" wolves; long-haired and short-haired wolves; and wolves with a thick woolly under-fur, as well as others in which there is scarcely any under-fur at all. The greater portion of the European supply of wolf pelts comes from Siberia, whence several thousand annually find their way to the markets of the South; a few hundred also coming from China. From America less than a thousand skins come yearly to England; the grey samples, according to Mr. Poland, selling at from four to twenty-four shillings, the white at from seven and sixpence to four pounds ten shillings, and the blue at from two pounds ten shillings to six pounds each. There appear to be no quotations for black Tibetan wolf skins—doubtless on account of their rarity—but Chinese pelts average about sixteen shillings. Wolf skins are especially used for wrappers and carriage and sleigh rugs; while, when dyed black or brown, they are made up into boas, for which purpose they are specially suited on account of the unusual lightness of the skin. The skin of the Indian wolf would probably be valueless, on account of the absence of under-fur.

Whatever question there may be as to the right of the latter to specific separation from the ordinary wolf, there can be none with regard to the so-called prairie wolf or coyote (*Canis latrans*) of the United States and Canada. It is a considerably smaller animal, with the fur generally grey or grizzled, and the tail-tip usually black. Although the long and thick fur is somewhat harsh, skins of the coyote form an article of some importance in the trade, but we have been unable to ascertain their price. Probably from four thousand to six thousand pelts come annually into the market, which are used both for rugs and boas, in the latter case being generally dyed black or brown. From its extreme wariness the coyote is one of the most difficult of North American fur-bearing animals to trap. Of the small Falkland Island wolf (*C. antarcticus*)—the sole South American representative of the wolves—it is stated that from fifty to a hundred skins are imported annually into this country. The fur is dark brindled, and is said to be sometimes used to imitate that of the grey fox.

Before leaving the *Canidæ* mention must be made of certain large Chinese and Siberian dogs, of which the skins appear to form a very important item in the fur trade. The Chinese dog is described as being about the size of a retriever, with a long but not bushy tail; while the Siberian dog is larger, and its black coat of a still finer texture. Of the Chinese dog, Mr. Poland states that from fifty thousand to one hundred thousand skins yearly reach the London market; but in addition to this the value of the yearly collection in Manchuria amounts to between £40,000 and £60,000 in value. Of those exported from China the bulk are made into robes of eight skins (sometimes four), and sent from Shanghai to London and New York. They vary in colour; black, white, and fawn being the predominant tints, while a few are brindled.

The amount of space taken up by the foregoing account of the foxes and wolves leaves but little room for the bears. Among these latter by far the most valuable pelts are those of the white Polar bear (*Ursus maritimus*), of which from thirty to a hundred are annually imported from Greenland to Copenhagen by a Danish company. The best of these realize from ten pounds to thirty pounds apiece; but of those imported by the Hudson Bay Company the price is much lower, owing to their bad condition. Less than a hundred is the usual annual import. The fur, which is occasionally dyed black, is made up into rugs and wraps. Naturalists are now pretty well agreed that the grizzly and black bears of North America, as well as the Isabelline bear of the Himalaya, are nothing more than local races of the European brown bear (*Ursus arctus*). Including such varieties, bear skins range in colour from pale cinnamon to black. We have been unable to come across any account of the annual number or value of European skins, but of grizzly pelts about three thousand five hundred were sold in 1891 at prices ranging to as much as seven pounds ten shillings for fine specimens. Many bears are also killed in Kamschatka, some of their skins being of enormous dimensions, as also are those obtained from Alaska. More valuable is the American black bear, of which fine skins realize as much as twelve pounds; upwards of seventeen thousand being sold in 1891. Still more precious are the pelts of the cinnamon bear of the same country, which now fetch about thirteen pounds, although they formerly sold for as much as thirty pounds. About three thousand skins came into the market in 1891. Bear skin is used for trimmings, wrappers, rugs, and boas; that of the black bear (dyed) being employed for the headpieces of the Foot Guards. The fur of the cubs of the same variety is valued for coat-collars. The Himalayan black bear (*U. torquatus*) and the Indian sloth bear (*Melursus ursinus*) have such short or coarse hair that their pelts are practically valueless.

Science Notes.

Remarkable results have been obtained in France by M. le Bon, who has been continuing his researches for some years. He finds that the light of an ordinary petroleum lamp will print a photographic positive on a dry plate through a sheet of iron, especially if the dry plate be arranged with a sheet of lead behind it, the lead being folded over round the edges of the iron. Other metals, and also cardboard, act in the same way, and it seems only to be a question of time. The name of *dark* or *invisible light* has been given to the agent concerned in these phenomena. It does not pass through black paper, and differs in this respect from the X rays of Röntgen.

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In a further description of his work, Le Bon mentions experiments in which photographic effects were obtained from ordinary sources of light, the plate being screened by optically opaque bodies. It is suggested that "dark light" is a form of energy intermediate between light and electricity. It is possible that it does not act directly, but by means of phosphorescence.

In the application of the Röntgen rays to surgery in France, the shadow photography has indicated that in a case of bone disease the centre of the bone was affected, and not the periosteum. The limits of tubercular affection of bones of the hand have been ascertained, and an internal ulceration of bone, lying beneath an ulceration of the skin, has been discovered. In our own country Dr. John Macintyre, of Glasgow, has got remarkable shadow pictures of the spinal column and ribs of a man. He finds that the head is easily penetrated, and expects great things from the application of Röntgen rays to surgery when a more powerful source of these rays has been obtained.

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Experiments have been made by A. M. Bleile upon dogs in order to determine the cause of death in electric shock. The conclusion reached is that for a given animal in normal condition as to health a definite amount of electrical *energy* will produce fatal results. It is thought that the action of the electrical discharge is to contract the arteries and increase the pressure of the blood, and that death is due to inability on the part of the heart to sustain the increased pressure of the blood so produced. Post-mortem examinations seem to show that the passage of the current does not cause any anatomical disintegration.

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The results of the use of antitoxic serum in the treatment of diphtheria are clearly indicated by the report recently issued as to the cases in the hospitals of the Metropolitan Asylums Board. In 1894 there were 3042 cases and 902 deaths, the mortality per cent. being 29·6; in 1895 the number of cases was 3529 and the number of deaths 796, the percentage of fatal cases being 22·5. The reduction in mortality of 7·1 per cent., occurring in the second year referred to, must be attributed to antitoxin.

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Observations taken during the second half of the year 1895 by Tacchini, at the observatory of the Roman College, show that during this period sunspots have continued to decrease, with a secondary minimum in November, when spotless days were observed. The protuberances have shown very little change during 1895.

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Moissan in France has analysed specimens of opium as used by the Chinese, and finds that the smoke is formed of volatile perfumes and a small quantity of morphine. It is the latter which produces the phenomena sought by opium smokers, and it is said that they do not appear to find more ill effects from the practice than most tobacco-smokers, provided that they use the preparation known as *chandu* of the best quality. The commercial quality of opium is, however, very different, and the inferior sorts when decomposed by heat produce various poisonous compounds.

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Some observations of the surface of the planet Mars recently made by Prof. Barnard with the Lick telescope suggest that a possible change may take place in present ideas as to what represents land and water on Mars. The so-called "seas" did not appear to consist of seas and oceans, but seemed to be exactly the reverse. They were rich in markings which are compared to the aspect of a mountainous country as seen from a great elevation. On the "continental" regions irregular features represented by delicate differences of shade were noticed, but no straight sharp lines were seen on these surfaces.

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A plea for the increased use of imagination in science was put forward by Prof. R. Meldola in a presidential address recently delivered to the Entomological Society of London. That prince among experimental philosophers, Michael Faraday, used to say, "Let us encourage ourselves by a little more imagination prior to experiment"; and there is a tendency among men of science to-day to act upon his advice. Science is organized knowledge, and no mere collection of facts can constitute it. Observation and experiment are primarily essential; but we only become scientific when we compare the facts accumulated, and use the imagination to generalize them and to guess at the principles which they teach. The hypotheses thus arrived at may be, and often are, wrong; nevertheless, real progress only begins when facts are sought in relation to at least the suggestion of a principle.

Mark how extremely fruitful has been the late Mr. H. W. Bates' explanation of the phenomena of mimicry and protective resemblance among butterflies and moths. While pondering over the meaning of the remarkable superficial resemblances among the butterflies of different groups which he had collected in the Amazon Valley, it occurred to him that the resemblance might be a real advantage in some cases. There is, for instance, a beautiful group of butterflies (the Heliconii) in the South American forests, which, though they possess conspicuous colouration and fly slowly and weakly, are not eaten by birds, and are therefore very abundant. The reason they enjoy immunity from birds appears to be that they possess a strong and offensive odour, which is probably combined with a nauseous flavour. But the curious thing is that certain butterflies of groups which are not characterized by these disagreeable attributes, are coloured in much the same way as their less edible companions, so as to be commonly mistaken for them.

Mr. Bates pointed out the protection from foes afforded by such resemblances as these, and speculated on the importance of adaptive colouration in the preservation of species. The explanation which he suggested as the cause of the phenomena gave vitality to what would otherwise have been a disconnected and meaningless set of facts; it prompted further observation and experiment, and has resulted in the accumulation of many new instances of the same principle. The history of science furnishes numerous similar cases where the use of the imagination has stimulated enquiry and made for scientific progress, though few investigators recognize them. The growth of a broader feeling has, however, lately shown itself; to which statement Prof. Meldola's remark, that "the philosophic faculty is quite as powerful an agent in the advancement of science as the gift of acquiring new knowledge by observation and experiment," will bear witness.

VARIABLE STARS.

By Dr. A. Brester Jz.

Since writing my article on red variables and Novæ, two remarkable investigations have been published which are of the greatest importance for the development of my theory, and especially in the case of variable stars.

I have first to mention Mr. Alex. W. Roberts' study of "close binary systems" in the November Number of the

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* *See* Knowledge, December, 1895. The results of Messrs. Jewell, Humphreys, and Mohler's investigations as to the effect of pressure on the displacements of spectral lines give a new support to my theory that the compound spectrum of a Nova does not prove that it is caused by two oppositely moving bodies. Such a spectrum is much more easily explained, I think, by the great differences in depths and corresponding pressures at which the bright and dark lines originate. (*Astrophysical Journal*, February, 1896.)

Astrophysical Journal. Mr. Roberts has chiefly investigated δ Cephei as a good example of a short-period variable of constant variation.

Now we know, since M. Belopolsky's researches, that in the case of δ Cephei its variation is intimately connected with a revolution in a very elliptical orbit. But as all trustworthy observers of this star bear testimony of the continuous waxing or waning of its light, every eclipse theory of variation must be rejected. This theory would also be inconsistent, as Mr. Roberts shows, with the position of the maximum and minimum phases. Apart from eclipses, there must be, therefore, another phenomenon able to cause variability in close binary systems.

That phenomenon, according to Mr. Roberts, is the increase of heat at periastron, the heat falling upon the companion being then in the orbit of δ Cephei nine times greater than at apastron. Mr. Roberts supposes that this greater heat near periastron causes the two stars to be brightened up by an increase of temperature, the subsequent cooling near apastron being the cause of the minimum. But that explanation cannot be granted if the two stars have some analogy with our sun. A sun cannot rise or fall one or two magnitudes by changes of temperature in the space of three days.

But the brightening by periastric heat and darkening by apastric cooling can be easily understood if we assume that one of the two stars is a red star with an obscuring cloudy atmospheric veil, alternately dissipated by the greater heat near periastron and slowly recondensed again by the subsequent cooling near apastron. Thus, near periastron both stars would be visible, and near apastron (at least clearly) only one. There, as well as in other red variables, the change of brightness would be caused precisely as the darkening of our sun is caused by even the smallest clouds in our sky. If the hypothesis of Mr. Roberts is thus amended it fits admirably well in my theory, as will be seen in the following

CLASSIFICATION OF VARIABLES.

Cl. A.—*More or less irregular Red Variables and Novæ.*—Single stars internally always red, but covered by cloudy atmospheric veils, alternately growing thicker by cooling and then again dissipating by heat, which, due to the intermittent formation of chemical compounds, is also produced by cooling. Besides the somewhat capricious changes of brightness thus caused (always attended with a bright luminescence of the condensing atmosphere), symptoms of a more regular periodicity can be expected if phenomena analogous to those in the Classes B and C are also working here.

Cl. B.—*Regular Variables with continuous variation.*—Close binaries with very eccentric orbits. One of the stars is a red star with a cloudy atmospheric veil (as in Cl. A). This veil is dissipated by the greater heat when the stars are closest, and re-condenses by the subsequent cooling near apastron.

a. The plane of the orbit does not pass through the earth (δ Cephei, X Sagittarii, T Vulpeculæ, etc., etc.).

b. The plane of the orbit passes through the earth. Apart from the periastric and apastric maxima and minima, secondary minima are produced by eclipses (η Aquilæ, R Sagittæ, β Lyræ).

Cl. C.—*Regular Variables remaining invariably bright for most of the time, with minima of short duration.*—Close binaries revolving fast in orbits whose planes pass through the earth, and where eclipses of short duration are the only cause of the variation.

a. The binary consist of a bright and a dark star (Algol).

b. The binary consist of two equally bright stars (Y Cygni).

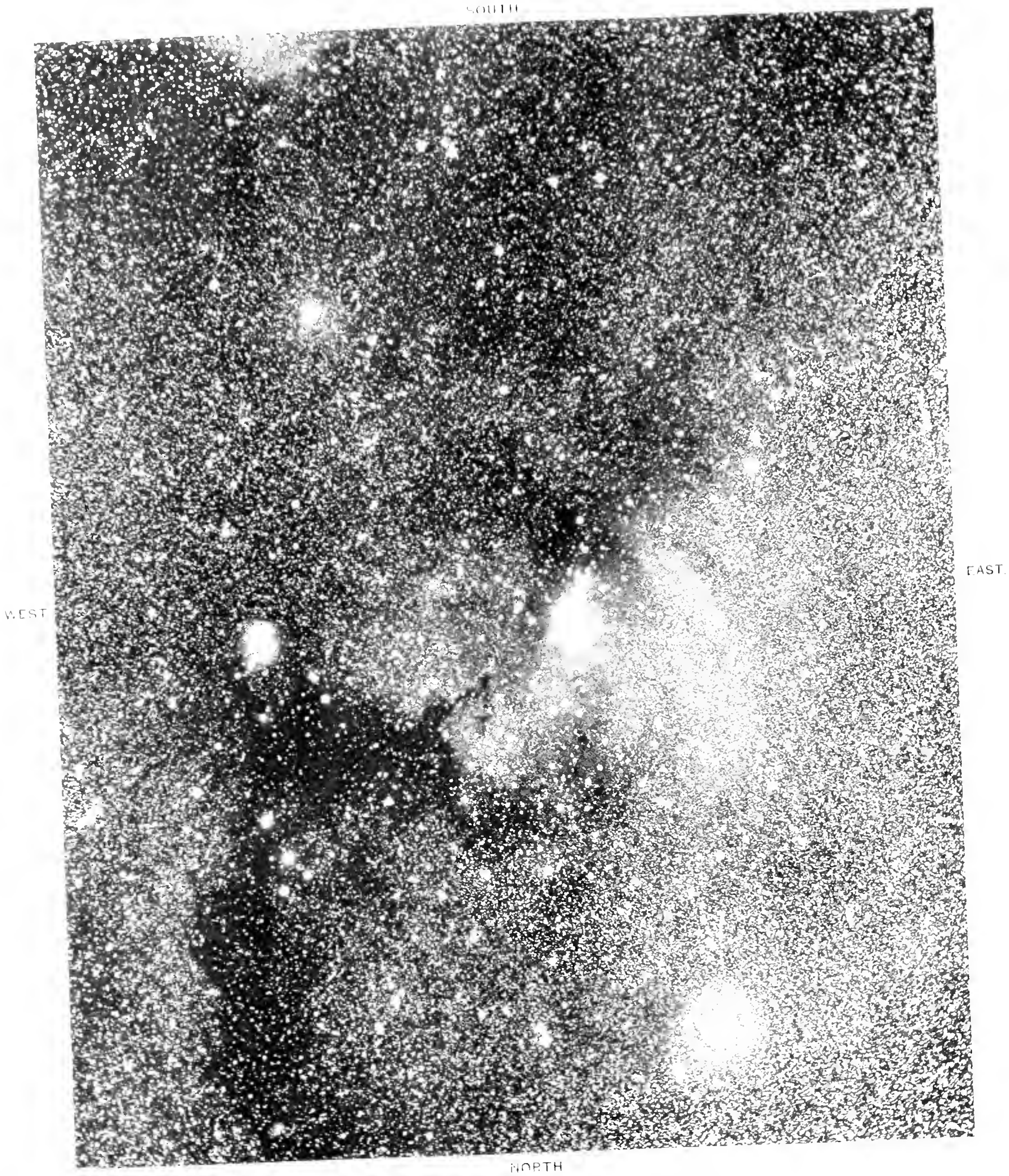
c. The binary consist of two differently bright stars (Z Herculis).

Variables with long periods of invariable brightness and darkness (as are not uncommon in double stars), though belonging, in a measure, on account of the cause of their variability, to Cl. C., will be better classed in a separate Cl. D.; this class becoming thus finally intimately connected with still another Cl. E., containing the stars which, as so many components in double stars, are varying in colour. The description of the further particulars of these Classes D and E may be postponed to a later occasion.

The case of η Aquilæ and R Sagittæ has been studied by Mr. Roberts (*loc. cit.*, p. 289). In the case of β Lyræ (if my explanation is right) the secondary eclipse minimum must occur in the midst of the periastric maximum. The cooler variable bright-line companion is then between us and its primary. So we comprehend why (the major axis of the orbit being nearly in our line of sight) the bright lines of the companion and the corresponding dark lines of the primary have always been observed as exactly coincident during the secondary minimum, and why, before and after that secondary minimum, these bright lines have been seen displaced respectively to the red and blue sides of their dark representatives. During the principal minimum near apastron no eclipse minimum occurs, because the eclipsed variable, then being in its darkest state, has as little effect upon the brightness of the whole system as the dark companion in the case of Algol. If, however, this eclipse should be total, the bright lines of the companion, which are never wholly extinguished, should temporarily disappear, which phenomenon has been observed indeed by Father Sidgreaves a few hours before the principal minimum (*Monthly Not.* 54, 2, p. 95).

The red companion being relatively small, and completing, moreover, by its red, yellow, and green light, the excess of blue and violet in its primary of Cl. I*a*, the white colour of β Lyræ seems thus to be explicable. The absorption-lines of the companion, though necessarily hard to see on the relatively very bright and more continuous spectrum of the primary, may possibly be detected afterwards. For, according to Prof. Vogel, "especially good photographs have led to the supposition that with sufficient dispersion the spectrum of β Lyræ would be found very rich in lines" (*Astr. and Astrophys.*, 1894, p. 362).

The second investigation, about which I should like to say a few words, is especially important in connection with my idea suggested in KNOWLEDGE, December, 1895, that all gaseous nebular spectra may be due to clusters wherein the great majority of stars are Novæ. That hypothesis demands the existence of clusters wherein numerous stars should be mutually equal, and very different from those which are clustered in our neighbourhood. Though this demand seemed to be in a measure supported by the fact that stars of the same description show often a distinctly gregarious tendency, and by Dunlop's and Sir J. Herschel's discoveries of clusters wherein all stars are respectively blue or differently coloured, "like a superb piece of fancy jewellery" (*Obs. at the Cape*, p. 17, a. 102), it has been quite recently much more strikingly verified by Prof. Bailey's discovery, at Arequipa, of certain globular clusters containing an extraordinary number of variable stars (*Astrophys. Journ.*, November). In the cluster N. G. C. 5272 no fewer than eighty-seven stars have been proved to be variable; in the cluster 5904, at least forty-six. On the other hand a similar examination of each of the clusters 6218, 6397, 6626, 6705, and 6752 failed to detect



PHOTOGRAPH OF THE NEBULOUS REGION ABOUT 15 MONOCEROTIS.

Taken by Mr. E. E. BARNARD, at the Lick Observatory, Mount Hamilton, California, on February 1st, 1894, with the Willard lens of 6 inches aperture and 31 inches focal length. Exposure, 3 hours. Scale, 1 mm. 2′ 21″ of arc.

among several hundreds of stars in each cluster one single variable.

Prof. Bailey's discovery, which has been independently confirmed by Mrs. Fleming, Prof. Pickering, and Prof. Hale, gives most valuable support to my idea; and that support is the more valuable because the phenomena of variability, when caused (as is mostly the case) by cooling, have much resemblance to the phenomena of Novæ. What we want now is the spectrum of such a cluster rich in variables. Possibly it will show us the gaseous lines of its numerous dark stars.

THE NEBULOSITY ROUND 15 MONOCEROTIS.

By E. Walter Maunder, F.R.A.S.

The original of the accompanying photograph was taken by Mr. E. E. Barnard in the course of a photographic study of certain regions of the Milky Way undertaken by him, at the Lick Observatory, with the Willard lens of 6-inch diameter and 31 inches focus. He found the region lying north and east of Orion to be singularly rich in large diffused nebulosities, of which one connected with 15 Monocerotis was most especially noteworthy. Commenting on a plate exposed on January 24th, 1894, for 2h. 30m., on the field of which ξ Geminorum is the centre, he points out that "this group of bright stars is mixed up with a knotted and wispy nebulosity, extending faintly and irregularly north and westerly to an extent of nearly two degrees. The nebula is irregular in outline, but quite well defined, with numerous black gaps running into it, and in general conforming with the peculiarities of the Milky Way in that region," showing it to be actually mixed up with the Galactic stars, and resembling in this respect a large nebula which Mr. Barnard has photographed in Cepheus. He draws attention to a sinuous vacant strip in this region of the Milky Way running from 15 Monocerotis, at first to the west for some three degrees, and then northerly nearly to γ Geminorum.

The photograph of which Mr. Barnard has kindly sent a copy for reproduction in the pages of Knowledge, was taken on February 1st, 1894, with three hours' exposure. The diameter of the great nebula is roughly three degrees. Mr. Barnard describes its character as follows: "It clusters densely about the groups of stars, and then spreads out in a weak, diffuse light, with rifts in it, and irregularly terminated along the edges of a vast vacancy in the Milky Way. The condensation, which is very strong, is not at 15 Monocerotis, but twelve minutes south, preceding that star, where it becomes a compact mass, with numerous wisps and holes in it. The whole group of three or four bright stars are involved in this denser wispy light, but 15 Monocerotis itself does not seem to be particularly connected with the nebulosity further than to be apparently in it; that is, there are no indications of condensation about this the brightest star of the group. This remarkable nebula—the denser part of it—is worthy of study with a more powerful photographic telescope."

It will be noted that Mr. Barnard drew special attention to the suitability of the brighter portions of this remarkable object for the more detailed study which might be effected by a more powerful instrument, and the readers of Knowledge have been put in a position to make such a fuller examination by the courtesy of Dr. Roberts, who supplied the reproduction of his fine photograph taken on February 13th, 1895, which appeared in the February Number of the current volume. The scale of Dr. Roberts' photograph, taken with the 20-inch reflector, is almost exactly six times that of Mr. Barnard's. A rectangle eighty-five millimètres in height, by eight-one in breadth, with its lower edge thirty-two millimètres from the lower edge of the accompanying photograph, and its west side forty-one millimètres from the corresponding side of the photograph, would inclose precisely the same portion of the sky as is shown on Dr. Roberts' plate.

The two photographs are not, however, for comparison, in the ordinary sense of the word. They were taken with widely different instruments, for widely different purposes; and each is, in its own special line, of the highest beauty and value. The Willard lens brings up the faint widely-diffused nebulosity which is so striking a feature of the region, and gives what one may call a bird's-eye view of the general stellar distribution; whilst in the delicacy and fineness of the details of the nebula which it reveals, in the number of stars shown, and in the neatness and precision of their images, the photograph with the reflector is unapproachable. The two photographs are, therefore, in no sense antagonistic; rather, they are the necessary complements the one of the other.

Beside the great nebulosity around 15 Monocerotis, the photograph shows another of considerable extent discovered by Mr. Barnard whilst sweeping over this region soon after the opening of the Lick Observatory in 1888. It is shown very markedly on the plate as an irregular elliptical mass about thirty-six minutes in diameter. The position of the nebula is given by Mr. Barnard as

$$\alpha = 6\text{h. } 23\text{m. } 27\text{s.} \qquad \delta = +10° \ 7' \text{ for } 1860.$$

The entire photograph covers the region between R.A. 6h. 17m., and R.A. 6h. 45m.; declination between 5° 21′ and 13° 57′ north.

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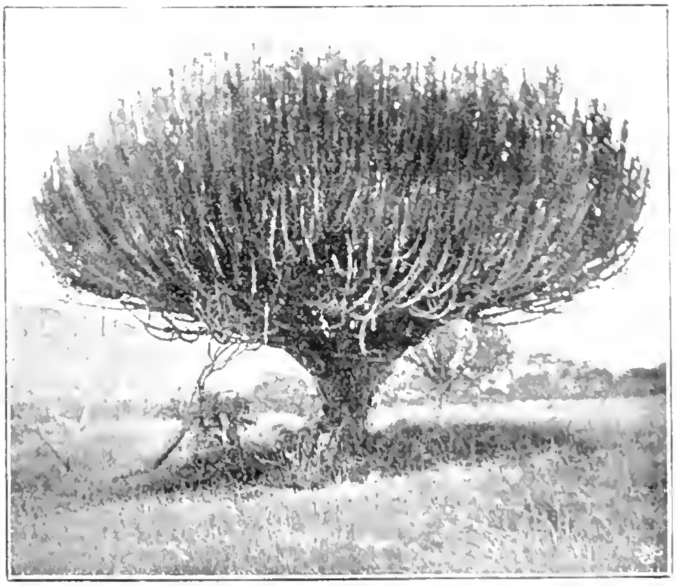
Notices of Books.

A Naturalist in Mid-Africa, being an Account of a Journey to the Mountains of the Moon and Tanganyika. By G. F. Scott Elliot, M.A., F.L.S., F.R.G.S. (Innes.) Illustrated. 16s. Mr. Scott Elliot's object in undertaking the expedition of which this book is a description was entirely a botanical one. Unlike most books of travel,



Euphorbias of the Albert Edward Plains. From "A Naturalist in Mid-Africa."

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[*] *Astronomy and Astrophysics*, March, 1894, p. 178.

we are not wearied in the one before us with minute descriptions of each day's march, and the book will prove interesting reading to everyone. Beyond this it is full of valuable information and shrewd conclusions bearing on the natives, natural history, and general aspect of the region traversed. The author seems to have been greatly hampered by fever and other ills, and although the results of the expedition are not startling, a considerable amount of useful work has been done. The book is provided with two maps—one, showing coffee zones and areas fit for colonization, being particularly instructive. Although the illustrations, which are taken from the author's photographs, are not very successful as pictures, they are very useful in showing the characteristics of the country. Altogether the book is a valuable one, and especially so to naturalists and those (and who is not ?) interested in Africa.

Birds from Moidart and Elsewhere. By Mrs. Hugh Blackburn. (Edinburgh : David Douglas.) Illustrated. The illustrations occupy the bulk of this volume. They have been exceedingly well reproduced from drawings by the author, mostly from life. Some of the drawings are excellent—perfectly natural and accurate—notably those of the tawny owl on page 28, and the guillemot on page 162. A good many of the drawings, however, are stiff and unnatural. Although limited, the text has considerable value, as Mrs. Blackburn has written solely from personal observation. Moreover, she has had many opportunities for observing rare birds. These observations have been faithfully recorded, and on this account the book will prove of undoubted interest.

The Structure and Development of the Mosses and Ferns. By Prof. D. H. Campbell, Ph.D. (Macmillan.) Illustrated. 14s. Within the past ten years a large number of investigations have been made upon the structure and development of the numerous plants included under the name Archegoniatæ. "The present work was undertaken," says Prof. Campbell, "mainly for the purpose of presenting in somewhat detailed form a *résumé* of the substance of the great mass of literature upon the subject which has accumulated, and much of which is necessarily out of reach of the many botanical workers who have not access to the great libraries." The author himself has greatly assisted in extending and improving the knowledge of the Archegoniates, and some of his papers form the basis of this book, while the results of researches upon representatives of most of the groups discussed are now published for the first time. The book thus possesses the sterling ring which results from personal observation, and is thereby distinguished from mere compilations. Botanists should be grateful for this solid and comprehensive contribution to the literature of the Archegoniate series—the best that has appeared for some years. Prof. Campbell's work will be long recognized as a standard one for students of the structure, development, and inter-relationships of the lowly but important families of plants described in it.

Our Household Insects. By Edward A. Butler, B.A., B.Sc. (Longmans.) Illustrated. Mr. Butler's writing is too well known to readers of Knowledge to need any eulogium on our part. The book before us is an interesting series of articles, which originally appeared in Knowledge, on the insect pests found in dwelling-houses. Although the book is intended primarily for the novice, it will, no doubt, be of considerable service to more advanced students of entomology, because it brings together information which has hitherto only existed in a scattered form. The illustrations, which have been prepared from microscopical slides, are excellent, and the book deserves every commendation.

By Tangled Paths: Stray Leaves from Nature's Byeways. By H. Mead Briggs. (Warne.) Illustrated. Rather a mixed collection of short essays is brought together in this book. The author's style is quaint, and is rather suggestive of "padding." But it is pleasing in parts, and although the book will not bear close reading it makes a delightful volume to skim through. Birds form the chief subject, but the author makes frequent digressions and often strays from "nature's byeways."

The Story of the Solar System. By George F. Chambers, F.R.A.S. (George Newnes, Ltd.) Illustrated. 1s. This little book provides accurate and interesting reading on planetary astronomy at a price within the reach of everyone, and we trust that the publisher's enterprise and the author's work will be rewarded by a large sale. "Astronomy, like charity," someone has said, "should begin at home"; and the remark has much to commend it. Therefore we say to those persons who wish to commence the study of astronomy, Procure this descriptive and practical account of the astronomical home-circle, and you will derive from its perusal a sound foundation upon which to erect future knowledge. We are glad to be able to state that the illustrations in the present book are far better than those of the companion volume, in which the "Story of the Stars" is told.

A Laboratory Course in Experimental Physics. By W. J. Loudon, B.A., and J. C. McLennan, B.A. (Macmillan.) Illustrated. 8s. 6d. It may be possible to write a perfect book on experimental physics, but it has not as yet been accomplished. It is, therefore, not invidious to say that in this volume, which in many respects is well presented, there exist blemishes which could have been avoided. The book is divided into two courses, of which the former deals with instruments for measuring lines, hydrostatics, optics, and heat in a very elementary way. The latter treats of sound, of heat more fully, and of magnetism and electricity. At the end there are short additions on gravity determination and on the Torsion Pendulum ; and, of course, there are some tables borrowed in the usual way, and not always transcribed with perfect accuracy. The chief fault in the book is that, in spite of its title, it is written too much from the theoretical standpoint. In the hydrostatic methods of determining specific gravities no instruction is conveyed on the important correction rendered necessary by the buoyancy of the air, neither is anything said about volume determinations by the hydrostatic balance. But probably the optical portion of the book is the least satisfactory. The use of the collimator in goniometrical work seems to be quite misapprehended. The instructions imply (and a figure actually supports this view) that only a narrow beam of light issues from the lens, as from a slit, for the student is told to carefully place the edge of the prism accurately at the centre of the instrument. The optics are, in fact, far from practical. But acoustics and heat are handled more completely. The many practical points which have actually to be attended to are either not noticed at all or only in a very incomplete way. The authors, however, make an observation in describing the determination of magnetic inclination from which the Kew Committee of the Royal Society may derive illumination, viz. : that if the instrument is turned through two right angles to eliminate certain errors for which that operation is necessary, then other errors, for the correction of which directions are given in the Kew system to reverse the needle on its agate bearings, also disappear, so that this latter operation really is waste of time.

Consider the Heavens: a Popular Introduction to Astronomy. By Mrs. W. S. Aldis. (The Religious Tract Society.) Illustrated. 2s. 6d. "The heavens declare the glory of

God, and the firmament sheweth His handiwork." This appears to have been the text which Mrs. Aldis had in mind when preparing the book before us. Taken altogether the Biblical quotations aptly illustrate the points in connection with which they are employed, and the book loses nothing by their use. We have carefully gone through the text, and have come to the conclusion that it is admirably and accurately composed. The chief criticism we have to offer applies not only to this book but to others of a similar kind; it relates to the practice of using without acknowledgment the ideas of other authors. Anyone familiar with astronomical literature will have no difficulty in naming the sources from which Mrs. Aldis has drawn much of her information. For instance, an impressive word-picture drawn by Young to convey an idea of the intensity of solar radiation is used on page 50 without a line of credit to the originator; and there are many similar cases. We think that the authoress should have given references to the works of a modern philosopher like Young, just as much as she does to those of the prophets of old. A half-dozen or so excellent illustrations brighten the pages of the book, but the remainder of the twenty-nine are either old friends or line diagrams, and are not worthy of the text. Taken as a whole, the book is a remarkably clear and easy guide to astronomy, and one for which we anticipate a successful career.

Evolution, and Man's Place in Nature. By Prof. Henry Calderwood, LL.D., F.R.S.E. 2nd Edition. (Macmillan.) Illustrated. 10s. *The Present Evolution of Man.* By G. Archdall Reid. (Chapman and Hall.) 7s. 6d. The first edition of Prof. Calderwood's book appeared in 1893, and though it received some adverse criticisms from materialistic reviewers, it secured the approval of many readers and thinkers interested in the philosophical aspects of evolution. The present edition is practically a new work, for, in order to meet the demand for a detailed statement of the evidence upon which his conclusions are based, Prof. Calderwood has rewritten almost the whole of the matter, and has added nine new chapters. The purpose of the volume is to show that the history of mind is distinct from the history of organism. We cannot do better than give the author's own words to define his position :—

> "The evolution of brain," he says (p. 293), "as represented in the successive stages of the monkey, the ape, and man, has proceeded in accordance with the history of evolution in the lower order of vertebrates. These three higher stages, in so far as they illustrate continuity of organic life, are accounted for by the cosmic process which has had constant application to animate life. The marked superiority of the human brain arises in part from the erect posture, with disuse of the fore limbs for locomotion and their application to industrial effort; in part from use of the organ for fulfilment of rational purpose. Intellectual activity, unexplained by organic functions, has given a new development to human organism, making brain the organ of mind, and effecting a combination of forces, physical and intellectual, found nowhere else in nature."

There are many who believe that the rational and moral nature of man has not been evolved in the same way as the bodily organism and the lower mental nature; and they will find pleasure in going through the mass of evidence brought forward in support of that view. "The grand distinction of human life," to again quote the author, "is *self-control in the field of action*," and in that fact lies the key to the elevation of mankind. To readers used to concise statements, the author's diffuse style will be annoying; but in spite of this they will find that the volume will considerably broaden their views of life, and show them the reality of processes not referable to protoplasm.

Dr. Reid's volume is somewhat similar to Prof. Calderwood's, inasmuch as it deals not only with man's physical evolution but also with his mental evolution. The work is divided into two parts: one dealing with the problem of evolution in general, and the second applying the conclusions arrived at to the problem of man's present evolution. Following Weismann, Dr. Reid holds that acquired traits, both physical and mental, are never transmitted, and he brings forward many original arguments in defence of his position and against the views of Mr. Herbert Spencer. Students of biology, broadly understood, and psychologists will find the first section of the volume well worth reading, and general readers will derive from it a fund of information on many biological problems of the present day. As to the second part, we think that the theory advanced therein is undoubtedly valuable. From the conclusion that men perish mainly by disease, the inference is drawn that man's present evolution must be principally against disease. To take an example: we are able to live in a climate which is fatal to the inhabitants of much the greater part of the world, while, on the other hand, the west coast of Africa is an unhealthy region for us. The explanation of this is, *pace* Dr. Reid, that our race, which is able to persist under conditions adverse to other races, has undergone an evolution in relation to tuberculosis fully equal to the evolution against malaria undergone by the West Africans; in other words, races become acclimatized by natural selection to the conditions of the areas in which they live. The immunity thus gained is held to result solely from inborn variations. Besides diseases there are agencies, such as alcohol, opium, hashish, and other narcotics, all of which assist in the elimination of the unfit. Dr. Reid exhibits the effects of each of these causes on "the present evolution of man," and points to the lessons they teach as to the directions of development in the future. We have read his work with pleasure, and pronounce it worthy the attention of all who are interested in the teachings and consequences of evolution.

Manual of Lithology. By Prof. Edward H. Williams, jun., E.M., F.G.S.A. (John Wiley & Sons: Chapman & Hall.) Illustrated. In this second and very considerably enlarged edition of a valuable manual of lithology, the principles of the science are treated with special reference to megascopic analysis. The engineer and prospector could hardly desire a more systematic and practical handbook to the rocks than this, and, in our opinion, no student should devote himself to the study of petrography before he is familiar with the facts herein contained. Work with the unaided eye (megascopic analysis) should always precede the microscopic analysis of mineral constituents of rocks; in other words, lithology is the natural introduction to petrography, spite of the separation brought about between them by the microscope. Before dealing with lithology proper, which treats of rocks as mineral aggregates, the author touches upon that branch of the subject—mineralogy—which is concerned with individual components, by devoting a chapter to rock-forming minerals. An excellent collection of definitions relating to the association in nature (geological), mineralogical and physical states of rocks, and a brief statement of theories of rock formation from fluid magmas introduce the section on primary or eruptive rocks. Secondary and metamorphic rocks are successively dealt with in two other sections of the volume. Finally there is a chapter on minerals as rocks, and one on the economic value of rocks; while six plates exhibit the megascopic structure of the surfaces of thirty-six rock specimens. To the student of structural geology, and to practical men, Prof. Williams' manual can be confidently recommended.

Insect Life. By Fred. V. Theobald, M.A., F.E.S. (Methuen.) Illustrated. This book, which is one of the University Extension Series, sets forth very clearly and concisely the chief characteristics and economic importance of the different orders of insects. It also deals with the life history and structure of many interesting species. Two useful appendices are added, the one on different ways of destroying insect pests, while the other comprises a list of the most important works on special groups of insects. Mr. Theobald's book will be found of great use to those who want to gain a general knowledge of insect life.

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BOOKS RECEIVED.

Text-book of Comparative Anatomy. By Dr. Arnold Lang. Translated by H. M. Bernard, M.A., and Matilda Bernard. Part II. (Macmillan.) Illustrated. 17s. net.

The Astronomy of Milton's "Paradise Lost." By Thomas N. Orchard, M.D. (Longmans.) Illustrated. 15s.

British Sea Birds. By Charles Dixon. (Bliss, Sands, & Foster.) Illustrated. 10s. 6d.

A Handbook to the Birds of Great Britain. By R. Bowdler Sharpe, LL.D. Vol. III. (Allen.) Illustrated. 6s.

Our Country's Butterflies and Moths. By W. J. Gordon. (Day & Son.) Illustrated. 6s.

Historical and Future Eclipses. By Rev. S. J. Johnson, M.A., F.R.A.S. New Edition. (Parker & Co.) Illustrated 4s. 6d.

The Composition of Expired Air and its Effects upon Animal Life. By J. S. Billings, M.D., S. Weir Mitchell, M.D., and D. H. Bergey, M.D. (Washington: Smithsonian Institute.)

A Laboratory Notebook of Elementary Practical Physics. By L. R. Wilberforce, M.A., and T. C. Fitzpatrick, M.A. (Cambridge University Press.) 1s.

James Clerk Maxwell and Modern Physics. By R. T. Glazebrook, F.R.S. (Cassell.) The Century Science Series. Illustrated. 3s. 6d.

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Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

ELECTROGRAPHY.

To the Editors of Knowledge.

Sirs,—I read Mr. J. W. Gifford's article on electrography in the April Number of Knowledge with great interest. I should, however, like to draw your readers' attention to the fact that the electrician Hertz, mentioned in this article, was not a Swiss but a great German professor.

He was born on February 22nd, 1857, in Hamburg, and after having studied in Munich and Berlin (under Helmholtz) he became, in 1885, Professor of Physiology in Karlsruhe, and followed Clausius in 1889 at Bonn, where he died on January 1st, 1894, after a short but brilliant career.

North Woolwich. E. Wohlwill.

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ZODIACAL LIGHT (?).

To the Editors of Knowledge.

Sirs,—Your correspondent, Mr. Lyon Browne, will find a very similar appearance to that seen by him on the 4th of March described as seen by Dr. Brauner, of Prague, on the 13th of the same month, in *Nature* for March 28th, except that Dr. Brauner saw five streaks instead of one. And if he will refer to Knowledge for 1883 he will find similar appearances described by Captain Noble and Mr. Bradgate as seen by them (at different hours) on the night of August 28th, 1883, and by Mrs. Harbin on September 21st, 1883, except that these appearances were in the eastern, not the western, horizon. I saw a similar appearance in the east on the 4th of September, 1885. The phenomenon appears to have been taken on other occasions for a comet or comet's tail by Mr. Eddie, at Grahamstown, and by Mr. Edwin Holmes; and a similar mistake seems to have occurred so far back as the year 1761, judging from the *Annual Register* of that year. By others (myself included) it has been mistaken for a meteor or meteor-track, but its real character has yet to be explained. Possibly it is more akin to the Aurora Borealis than to comets, meteors, or the zodiacal light. It would be interesting to know whether there were any electric or magnetic disturbances on the nights when it has been noticed, of which we may safely set down August 28th and September 21st, 1883, September 4th, 1885, and March 4th and 13th, 1896. It seems to appear in the east in autumn and in the west in spring, if we may judge from the few observations that I have been able to collect. Perhaps some of your readers may be able to add others.

W. H. S. Monck.

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To the Editors of Knowledge.

Sirs,—I also saw the phenomenon described by Mr. Lyon Browne in the April Number of Knowledge. It was about 8.55 p.m. when I first noticed an unusual streak of light in the west. I watched it with a field-glass for quite twenty minutes. At 9.20 it had become exceedingly faint and ill-defined, and a few minutes afterwards had disappeared. It appeared to me a broad column of light, sloping towards the south at an angle of about sixty degrees with the horizon. Its base was (as your correspondent states) about five degrees in width, and appeared to spring from a bank of clouds low down. From this base the light extended upwards about twenty or twenty-five degrees, tapering gradually to a point, which, however, was very faint and indefinite. The margins of the light were fairly distinct. The said margins appeared to be very slightly curved, so that the light had the shape of a spear-head, or, more exactly, the outline of the section of a thin double convex lens. Its brightness was considerable. It was *much brighter than the Milky Way*, and looked more like moonlight when it struggles through cloud or mist. I am not quite certain that it moved slightly towards the south, but I am quite sure that at nine o'clock its northern border towards the apex was nearly touching two bright stars near together and below the Pleiades, but that about ten minutes later it was two or three times its own diameter to the south of them. Now what was this light?

I see that someone writes to the *English Mechanic* confidently describing it as an "auroral streamer." I have seen Aurora frequently, but never like this. On the other hand I have never been able to see the zodiacal light, which is always described as very faint and difficult to observe, so that I could hardly believe I was actually beholding that difficult object. And yet its shape, position, and inclination?

Iron Bridge, Salop. T. Law Webb, M.R.C.S.
27th March, 1896.

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To the Editors of Knowledge.

Sirs,—I should like to say a few words in reference to the "unusual phenomenon" observed on March 4th, and described by Mr. W. L. Browne, jun., in your April Number. I feel no doubt in my own mind that it was an auroral streamer, an impression confirmed by two letters in the *English Mechanic*. My attention was called to it here at 9.15, shortly before it faded away, but it was visible for about an hour previously. Had I been able to watch it from the first I might have detected some motion. At 9.15 it was nearly due west, the sky being cloudless, with a little mist on the horizon. I find that it was noticed in other places in England, and that a discussion took place at the meeting of the Royal Astronomical Society on the 13th as to its nature. I may add, as confirming my own conviction, that it singularly resembled a beam of light which I observed last year in nearly the same position on March 13th, when Aurora was also visible in Scotland and the North of England—one observer stating that at 8 p.m. the whole of the northern sky was full of Aurora. Why these appearances were only seen in our more southern latitudes in the west instead of in the north is a question which requires explanation. It is possible that there may have been glows over the north horizon contemporaneously, but this locality is too much obscured by trees to observe them. E. Brown.

Further Barton, Cirencester.

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To the Editors of Knowledge.

Sirs,—The appearance described in Mr. W. L. Browne's letter in the April Number was seen here. We saw the streak of light, as he describes it, issuing from behind a dark cloud on the west-north-west horizon, bright enough to attract attention through a screen of trees, on March 4th. It faded in about ten minutes from the time we first noticed it; it was, however, 9.20, not 8.30, when we saw it. It was not so long as Mr. Browne describes it. I should have said that it did not extend so much as a third of the way to the zenith, but the upper part may have been hidden by cloud. The sides were well defined and parallel, but, as I remember it, it was slightly inclined to the horizon from north to south. One would have thought it a search-light, but for its coming from behind the cloud, and the fact that there was no place in that direction where such a thing could be. W. H. A. Cowell.

St. Edward's School, Oxford,
April 2nd, 1896.

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To the Editors of Knowledge.

Sirs,—Although the weather has of late hindered astronomical observation, I have seen the zodiacal light several times during March, and read with great interest Mr. Lyon Browne's letter in your April Number. It may interest your readers to hear that it was most distinct on March 30th, but it was fan-shaped, and not nearly so bright as when seen by Mr. Browne at Shrewsbury. It was quite distinct from 7.30 to 9.30, and stretched fully half-way to the zenith when viewed with the naked eye; and with the aid of my telescope I thought I could discern it even further. On the north-west horizon it was about five degrees in breadth, but increased greatly as it got nearer the zenith.

32, Primrose Hill Road, W. G. Buszard.
London, N.W.

[Observations which have come more recently to hand show conclusively that the remarkable light seen on March 4th by Mr. Lyon Browne and so many other observers was auroral in character. From the first it was quite clear that it was not a comet; it was seen too late in the evening to have been a "sun pillar," as some of the observations referred to by Mr. Monck may possibly have been; and though its direction, as described, coincided as nearly as we could expect with the axis of the zodiacal light, which was distinctly seen the same evening, yet its appearance was quite different from the faint, broad, lenticular-shaped glow which the zodiacal light usually presents. There was an unmistakable Aurora seen later in the evening, and some observers were able to follow out clearly the connection between the two. The instances of similar strange lights which Mr. Monck mentions were none of them coincident with large magnetic fluctuations, except that of September 4th, 1885; and even in that case the magnetic disturbance fell rather later than the observation of the light.—E. Walter Maunder.]

SUN PILLAR.

To the Editors of Knowledge.

Sirs,—The sun pillar was visible here at 6.20 p.m. on March 31st.

The sky was light red inclining to orange, and the noticeable feature in the column rising from the sun was that it was formed on (apparently) and was transverse to the long level bars of cirro-stratus crossing the western sky.

No cumulus was visible.

The column appeared slightly tremulous. It was more defined at the edges and slightly narrower than that figured by me in Knowledge, June, 1895.

On the following day there was a thick drizzle of rain.

Seasalter, Whitstable. (Rev.) Samuel Barber.

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To the Editors of Knowledge.

Sirs,—On March 27th a sun pillar was visible here from ten minutes past six until shortly after sunset. The sun was shining between cirrus clouds, and the pillar, of the same width as the diameter of the sun, shaded off gradually through similar clouds. Its colour was a faint yellow.

A brilliant appearance of the so-called "sun-dogs" was seen from several places in this locality on the same evening.

At the time, and throughout the following day, a cold north wind was blowing. Heavy rain fell during the night, but since the weather has been fine and dry.

Exeter. W. E. Besley.

WAVES.—V.

THE TIDE WAVE.

By Vaughan Cornish, M.Sc.

The attraction of the moon or of the sun is equally exercised upon all parts of a sheet of water of such size as the Mediterranean, so that scarcely any tide wave is raised there; but in the Pacific Ocean, which is the chief cradle of the tides, the attraction of, say, the moon, is at any moment appreciably different in different parts, and the waters heap themselves up into a long, low hillock, which follows the moon in her apparent motion from east to west, traversing the ocean at vast speed as a forced long-wave. Two such billows are formed by the moon in each twenty-four hours, for when the moon is on the opposite side of the earth the solid globe is pulled away from the waters, leaving them heaped up, so that the result is much the same as when the moon is overhead. The long, low, billows which are formed by the moon's action in the equatorial regions where the ocean girdles the earth, travel on as free waves into the higher latitudes, penetrating every open sea and channel. These free tide waves run under the action of the earth's gravity, almost exactly in the same way that the solitary wave travels on in a canal when the motion of the canal boat has been arrested. Like the solitary wave formed in canals the tide wave is a long wave, for the moon's attraction being practically equal at the surface and at the bottom of the sea, the motion of the water particles is the same at the bottom and at the surface. The motion of the water is mainly a backward and forward swing, the vertical motion being very small compared with the horizontal motion. The rapidity with which such a wave travels when left to itself—or rather to the force of the earth's gravity—depends upon the depth of the channel, because the deeper the channel the smaller is the quantity of water which has to be transmitted through each unit of cross section in order to maintain the hillock upon the surface. In the deep waters of the open ocean the height of the tide billow is very small—say, from one to three feet. As the wave approaches the shallowing slope of the shore the front of the billow is retarded while the hinder parts press on, and the height of the wave is thereby increased. The height of the wave is also increased when it reaches a narrowing channel in which the billow is laterally compressed. Thus the highest tides are not in the open ocean where the tides are generated, but in the distant channels, bays, and inlets, where the tide wave penetrates after the moon has left it to run its course. Once every twelve hours, as we have seen, the moon raises a billow and drives or drags it forward as a pulse of water in the southern oceans, much as the heart, in its rhythmic beat, drives the blood-pulse into the arteries. But, whereas the blood-pulse runs the whole length of the artery, and is lost in the capillaries before the next stroke of the heart sends out a second pulse, the tide wave, on the other hand, has not reached the most distant shores when the next succeeding pulse of water is set going by the moon. The tide wave of which the crest may round the Cape of Good Hope at noon, travels up the west coast of Africa and reaches the Azores about midnight. By this time it is followed by a second pulse, which is now rounding the Cape. It is four o'clock in the morning before the crest of the first wave has reached the entrance of the English Channel, where the shallower water makes it travel slower. It takes another six hours to run the length of the Channel, reaching the Straits of Dover at 10 A.M., where the height of the wave is considerable, owing, partly, to the narrowing of the Channel. Thus, at Dover the water rises twenty-one feet, and this occurs at Dover about six hours after the wave crest passed the Land's End. Now, the next incoming tide billow on its way from the Southern Ocean has not yet got as far as the Azores, and the water at the entrance to the Channel is at a low level—this being, in fact, the position of the trough between two succeeding tide billows. Therefore, when we have the water heaped up (and pent up, too, for the Straits are narrow) near Dover, the water being low at the other end of the Channel, the action of the earth's gravity sets a long wave travelling back from Dover towards the Land's End; and this is the ebb tide in the English Channel. The time which a free long wave takes to travel the length of the Channel being about six hours, the return wave will at 4 P.M. have emptied the Channel of nearly as much water as was sent in by the tidal billow.

This is just twelve hours since the last tidal billow arrived at the mouth of the Channel, and at this moment the next billow comes running in from the South Atlantic, and "the tide" again runs up Channel. Thus the natural period for the passage of a free long wave up and down the Channel coincides with the interval between two tide pulses. Were it otherwise—if, for instance, the tide were ebbing from Dover, and at the same time the crest of the succeeding pulse were, say, at Portland—the rise and fall of water in the Channel would be much less than is actually the case. As it is, what happens in the Channel can be well illustrated by sending a wave along a trough by tipping up one end, and keeping the wave going backwards and forwards by again gently tipping the same end of the trough just as the wave returns to where it started from. It will be noticed then that there is a considerable rise and fall of water at each end of the trough, with little horizontal motion there; at the middle point there is hardly any rise and fall, but a considerable horizontal swing of the water. The same thing happens in the Channel. The rise at Dover is twenty-one feet; at Portland the rise and fall is scarcely perceptible, but here are the strongest tidal currents, forming the well-known Portland Race, which rushes (eastward on the flood and westward on the ebb) past the rocky promontory, leaping and foaming over the "Ledge" in a wild turmoil of water, dreaded by the mariner, but fascinating to the watcher of waves—when he is on *terra firma*. We shall have more to say about the Portland Race in our next article, when we are dealing with waves in running water.

We traced the tidal billow on its rapid course up the South Atlantic as far as the south-western coasts of the British Isles. Here the wave divides, and while one part runs up the English Channel as we have described, and is nearly, though not quite, stopped at the Straits of Dover, the other half takes a western course, swings round the North of Scotland, and travels comparatively slowly—say forty miles an hour—along our eastern coasts in a southerly direction. It is this part of the original tidal billow which furnishes the greater portion of the wave which once in every twelve hours enters the tideway of the Thames. In this comparatively short tideway of, say, seventy miles, there is never more than one wave crest at a time, the free long wave running up to Teddington Lock and back again to the entrance of the tideway before the next tidal billow reaches the Nore. In a long tideway, such as that of the Amazon, the case is different, for there are at any moment a number of wave crests travelling up the channel. They enter the mouth of the tideway at intervals of twelve hours, and follow one another up the river as a train of "solitary" waves; but between each pair of crests is, not a flat surface, but a trough, which is the negative, or inverted, crest of the negative, or ebb, tide wave. Where the billows or hillocks are, the current runs up stream; where the hollows are, the water runs down stream.

Neglecting, at first, the effects of the shallowing of the river channel and of friction, we may represent by Fig. 2 the wave of flood tide followed by the wave of ebb tide, but necessarily with an exaggerated height; the arrows show the direction of the flow of water during flood and ebb tide. Let us deal with the tide in the Thames, and suppose an observer to place himself at London Bridge. When the point A is opposite to him it is slack water; when A has passed the current begins to flow up stream—slowly at first, and afterwards more quickly, the level of the water on the banks rising the whole time. When B, the crest of the wave, is opposite, it is high water at London Bridge, and the up-stream current is at its strongest. When high water has passed *the current continues to flow up stream*, but at diminishing speed, *the level of the water falling all the while*, until when the point C is opposite the post of observation slack water is reached. The current then turns, and flows down stream, slowly at first but gaining speed, the level of the water continuing to sink until the point D is opposite, when it is low water and the stream of ebbing tide is running its fastest. From that point the level of water begins to rise while the current continues to run down stream. When the point E is opposite the post of observation it is again slack water and the tide current is on the turn; the point E corresponds with point A, and the cycle of phenomena which we have described begins again.

The effect produced by the shallowing and narrowing of the river as we proceed up stream, and by friction with the banks and bottom of the channel, is to retard the progress of the front of the wave as it travels up stream while the hinder part of the billow presses on, so that the front of the billow becomes steeper than the back, much as in the case of the wind waves of the sea when they reach the shallowing slope of the shore. A very noticeable result of this shortening of the front part of the billow is that on the flood tide the interval between slack water and high water is shorter than it would be if the form of wave were as shown in Fig. 1, and that on the ebb tide the interval from high water to slack water is longer than the corresponding interval on the flood tide.

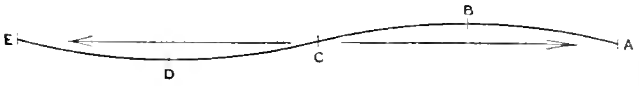

Fig. 1.

When the channel of a river narrows very rapidly the front of the tide wave becomes so short and steep that a *bore* is formed, in which, at last, we have the tide wave as a visible billow. In studying the tide waves of sea and ocean, and even of most rivers, we are at a disadvantage from the fact that the slope of the billow is so gentle and the length of the billow so great that the progress of the wave crest cannot be followed by the eye, and we are apt in actual observation to forget the invisible wave propagation while noticing the phenomena of rise and fall and of currents. This difficulty, which at first besets the study of the tides, is the converse of that met with in studying the wind waves of the sea, in which the progress of the wave crest fascinates the eye while the motions of the water as the wave crest passes elude the observation.

The River Severn affords a fine example of the bore, which is to be seen also in many other rivers which have a funnel-shaped estuary. When the channel of the river is very shallow at the sides, and bordered at low tide by broad flats of mud or sand, the phenomenon is particularly fine; the wave, which moves as an unbroken wall of water up the deep part of the channel, breaking in the shallow parts, and the water then rushes over the flat sands in a roaring surf. Our illustration (Fig. 2) shows the Severn Bore a few miles below Gloucester, at a place called Stonebench, where a ledge of rock projects into the stream and probably causes the breaking of the wave near the left bank of the river. The bore is not the whole of the front slope of the tide wave, for after the bore has passed the level of the water continues to rise, the current flowing rapidly up stream. At a distance of about six miles below Gloucester the rise of level has been observed to cease about one and a half hours after the passing of the bore. At this time the current is still flowing slowly up stream. In about a quarter of an hour the current turns seaward, running slowly at first but soon gathering strength, until it attains a speed seldom met with in other rivers.

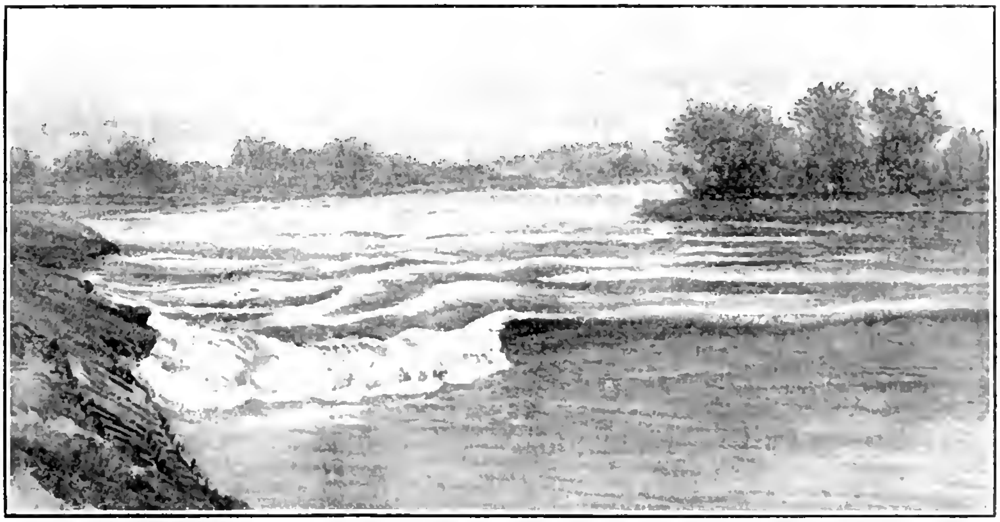

Fig. 2.—The Severn Bore from Stonebench.

The *ægre* of the Trent is another fine example of the bore in a tidal river.

Having now traced out the somewhat complicated connection between the rise and fall of water level and the direction of current in the tide wave of rivers, we are in a better position to explain the tidal currents of the English Channel, and their relation to the times of high and low water on the coast.

In mid-Channel the course of events is very similar to that in a river, viz., when it is high tide there the current is running its strongest up Channel; it continues to run up till half tide, then turns, and is running down Channel most swiftly at low tide. Close in shore, especially in bays, matters are very different. The front of the tidal wave as it runs up Channel is of course curved, for the sides of the Channel are shallow, and there the motion of the wave is retarded. Just as in the case of ordinary wind waves, the crest swings round and advances dead on shore. Hence, when the tide is flowing in the Channel the current *near the shore* is running towards the shore. At high tide, the crest of the wave being reached, the waters close on shore can flow no further, for they are stopped by the shore as by a wall; consequently it is slack water close in shore at high tide. After high tide the current here turns and flows off shore. At a position intermediate between mid-Channel and the shore the course of the currents is a compromise between these we have so far described. At low water the stream is down Channel; then, as the tide rises, the current is partly down Channel and partly shorewards. At half flood tide the current is directly towards shore; at high water directly up Channel, then partly up Channel and partly off shore; at half ebb directly off shore, and at low tide again directly down Channel: so that in the course of one complete tide the current flows towards every point of the compass in turn.

The work of the tides in the transport of sand and shingle, mud and silt, does not in its details come within our present scope, but a few points must be touched upon which serve to illustrate the matters we have dealt with in this article.

In tidal rivers mud and silt is deposited at each portion of the tideway in succession when slack water occurs there. In this respect the navigation of tidal rivers presents a disadvantage as compared with rivers which flow into non-tidal seas, in which the uninterrupted current carries away the mud and silt. This, however, is deposited off the mouth of the river, where the force of the current is lost; and in tideless seas, where there is no scour of coast tide-current to remove the deposit, the mouth of the river becomes choked.

Anything which tends to check the passage of a tide wave up or down a river has, generally, a bad effect upon the channel, increasing the deposit of mud. The removal of old London Bridge, with its numerous piles and broad foundations, considerably improved that part of the tideway of the Thames, by enabling the flood tide to flow up more freely and by increasing the scour of the ebb.

In the transport along the coasts of the sand and shingle which are formed by the action of the breakers, several circumstances concur to prevent the action of the tides from being simply a reciprocating removal and restoration of material, such as the oscillatory character of the tide might lead one to expect. Not only is the ebb tide not necessarily the exact reproduction of the flood tide, but the coasts are not symmetrical either in form or material with respect to the direction of flow of the tides. Material is in general scoured off the promontories, where the currents run strongly, so that no beaches are left, and is deposited at slack water (*i.e.*, at high tide) in bays and inlets. The transport is to some extent in both directions from a headland, but chiefly in the direction in which the tide runs most strongly, or in which the wind exerts most force (from west to east in the Channel, and from north to south on our east coasts). The prevailing trend of tidal transport on our southern and eastern coasts is well shown by the positions in which banks of shingle accumulate. Thus, in the Channel, we have the Chesil Beach to the west of Portland, and the shingle bank in a corresponding position at Dungeness; while, on the east coast, Lowestoft Ness grows southwards by the deposit of shingle brought from the north. In the same way, on the east coast, the accumulation of shingle has shifted the mouths of the Yare and the Ald several miles to the south of Yarmouth and of Aldborough. In the latter case the river runs for miles parallel to the sea, from which it is separated only by a bank of shingle. On our west coasts the direction of tidal transport is from south to north.

The principal sand deposits are situated differently from the great shingle banks, as we see, for instance, in the Channel, by the sandbanks near the mouth of the harbour of Poole, in Dorset, which are formed on the eastern and more sheltered side of the promontory called Purbeck Island.

BABYLONIA AND ELAM FOUR THOUSAND YEARS AGO.

By Theo. G. Pinches, M.R.A.S.,

Department of Egyptian and Assyrian Antiquities, British Museum.

THE cuneiform inscriptions of Babylonia and Assyria have thrown a flood of light upon the history of the countries in which they were written. That they would do so was to be expected; but they also incidentally restore the history of the nations around, and one of the powers of which their records constantly speak is Elam. Thus one of the important facts of the early history of Babylonia and Elam is that related by King Assur-banî-apli, of Assyria, who tells us that 1532 or 1632 years before his time (= 2180 or 2280 B.C.) Kudur-nankhundi, King of Elam, invaded Akkad or Babylonia, and carried off from Erech the image of the goddess Nanâ; and contemporary documents furnish us with the names of Simti-silkhak and Kudur-mabug, his son, Elamite kings who reigned in Babylon, probably at a somewhat later date. For other periods native records furnish some data, and the Babylonian Chronicle and Assur-banî-apli's history of his reign are of great value. Though the gaps are many, it must be admitted that satisfactory progress in restoring the lost history of Elam has been made.

No inscription, however, had revealed to the explorer in the realms of Assyriology the name of Chedorlaomer, of Genesis xiv. Kudur-Nankhundi and Kudur-Mabug had been found, but Kudur-Lagamar (or Lagamal), which would have been the Babylonian form of Chedorlaomer, was wanting. Not only was this royal name lacking, but those of Tidal and Amraphel, his companions, were absent too. The name of Arioch alone, of the four allied kings who went against Sodom, had been recognized in the inscriptions.

Yet Chedorlaomer, Tidal, and Amraphel were important rulers—powerful in the extreme, to come so far (all the way from Elam and Babylonia) to the valley of the Jordan, to defeat and subjugate again the nations of the district, which had rebelled against them. Was the story true, or merely a romance? Why did these names not occur in the extensive literature of Babylonia and Assyria?

It would probably be a difficult matter, even now, to answer all the possible questions that a well-armed critic might put; but we can at least say one thing, and that is that we are in a better position to answer them than we were a short time ago.

It came about in a very simple manner. Being on the look-out for historical texts, the writer chanced upon one of more than ordinary difficulty, which he decided to copy. It was a tablet of a late date, probably of about 350 B.C., and it was very mutilated; but one name shone out with an attractive clearness, namely, that of "Tudkhula, son of Gazza—[*]." Now, any Assyriologist would have had the thought that immediately occurred to the writer: Can this be the Tidal[†] of the Hebrews? The consonants all corresponded—it was the vowels alone that differed; but even these did not differ more than those of Tukulti-apil-êsarra do from the Hebrew (and Aramaic) form of the name Tiglath-pileser. Proceeding, therefore, hopefully, there were found on the same tablet the names Eri-[E]aku, probably Arioch, and Kudur-lakhmal, a name mentioned in close connection with Elammat or Elam, and therefore possibly Chedorlaomer.

It is true that there was not much to be learned from the fragment, but it proved to be, in any case, a text of the greatest importance. There is the usual number of references to killing which are to be found in the records of those ancient nations. Besides this, however, we learn that the son of Eri-[E]aku was called Dur-makh-îlāni, that some place was spoiled, and that (apparently) a flood invaded Babylon (or Babylonia) and the great temple called Ê-saggil (or Saggil) within the renowned capital. Then there is a statement to the effect that "the old man and the child [were slain] with the sword," and executions took place. Two lines after the mention of Tudkhula (or Tidal), son of Gazza—, it is stated that "his son (Gazza—'s, Tidal's, or another's) fell upon him with the weapon of his hand," and then "his dominion (?) [was proclaimed?] before the temple (of the goddess) Annunit."

Whether in consequence of these high-handed proceedings or not we do not know, but "[the King of?] Elam spoiled the city Akhkhēlal (?) and the land of Rabbāt," rendering [the land] "like heaps of ruins," and capturing,

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[*] The complete form of this name was, possibly, *Gazzani*.

[†] Properly, this name should be transcribed Tid'al, for a more ancient Tidghal. The Greek gives Thargal, a mistake for Thadgal.

in all probability, "the fortress of Akkad and the whole of Borsippa (?);" after which "Kudur-lakhmal, his son (probably the son of the King of Elam), pierced (?) his heart with the steel sword of his girdle," and afterwards, it is to be supposed, took the throne and "captured his enemy."

The discovery of another tablet which followed shed some light on the names, but did not give a very satisfactory sense. It referred, however, to the above-named Elamite prince, and seemed to state distinctly that he became King of Babylon:—

"[The gods ?] in their faithful counsel cared for Kudur-lakhgumal, King of Ela[m]. He descended, and the thing that unto them was good [he performed ?], and he exercised sovereignty in Babylon, the city of Kar-Dunias (=Babylonia)."

This passage gives an extra syllable to the name (Kudur-lakhgumal for Kudur-lakhmal), bringing it one degree closer to the Hebrew Chedorlaomer (Greek Chodollogomor), and rendering it probable that it is the same king. Of real history, however, this second fragment does not give much, partly on account of its imperfect state; but it refers to Dur-makh-ilāni, whose father's name is called Eri-ekua (a variant for Eri-Eaku, or Arioch, which the first text gives), and to certain letters which passed, in which he seems to emphasize his superior right to the throne of Babylonia (over that of Kudur-lakhgumal).

It was gratifying to find this second tablet, notwithstanding the imperfect nature of the text. The present writer then, with a view to rendering his translation as complete as possible by reference to other texts, proceeded to look through his copies for references to words, names, etc., and was agreeably surprised to find on another tablet the name Kudur-lakhgu—, who was called "the Elamite." The completion of this as Kudur-lakhgumal was, as may be imagined, the most natural thing possible, and an examination of this third inscription gave some very interesting items of ancient history.

Fig. 1. Babylonian Tablet. Obverse.

It is a text divided into paragraphs, and is written in poetical style, resembling, in some things, that of the Creation tablets, which are undoubtedly very ancient as to their composition. This new text, where it begins to be complete, speaks of someone (probably the Elamite whose doings form the subject of the tablet) who descended to Du-makh ("the supreme seat") like *Ura lā gamil* ("the unsparing pestilence"), and he saw there the temple, and spoke with the children (probably the officials) therein. He then sent a message to all his warriors, (saying) "Carry off the spoil of the temple, take also its goods, take away its image, break down its enclosing wall." "Against the god Ennun-dagalla" ("the guardian of the broad place") "the enemy pressed forward evilly." The god, clothed with light before him, flashed like lightning, and "the enemy was afraid." Nevertheless, he gave instructions to take the crowns of the god, and to "seize his hands" (probably instructions to carry the image out of the temple)—"he did not fear, he did not regard his life," but, notwithstanding this, "he did not remove his crowns." This practically closes the obverse (Fig. 1), the sense of the remaining lines being doubtful in consequence of the mutilation of the text.

The reverse (Fig. 2), which is divided into short paragraphs, continues the narrative after a gap which is probably considerable. The first complete lines tell us that "The enemy, the Elamite, devised evil, and the god Bel devised evil against Babylon." After referring again to the temple, the tablet says: "The enemy, the Elamite, took its goods——, the god Bel had displeasure towards his sanctuary (?)." After several lines in this same strain, in which the unfavourable attitude of the heavenly powers and the elements (*e.g.*, "storm and evil wind went round in the heavens") is referred to, a paragraph occurs in which the question is asked, "Who is Kudur-lakhgumal, the maker of the evils? He has gathered the barbarians . . . the people (?) of the god Bel, he has laid in ruin . . . by their side." "He set his face to go down to the land of Tiamtu" (probably by the Persian Gulf), then ruled, apparently, by a prince named Ide-Tutu. The writer of the tablet, however, again goes back to the misfortunes of the temples, etc., of his beloved country: "[The enemy], the Elamite, directed his yoke and set his face (to go) down to Borsippa . . . The princes he subjugated with the sword, he carried off the spoil of the temples, he took away and carried off to Elam their goods. . . ."

Such is, in short, the contents of these three interesting and remarkable, though mutilated, Babylonian texts. They lose much value by their imperfection—indeed, were they perfect they would probably present no difficulties to the historian, and but few to the translator. Badly preserved as they are, however, it is a matter of great satisfaction that time has spared them to us, for they throw light on a dark period, and one of great interest. Whether Kudur-lakhgumal (better transcribed, perhaps, Kudur-laghgumal) be really Chodollogomor or Chedorlaomer, and Eri-Eaku Arioch, time alone can decide: but the fact that the three names so closely resembling Chedorlaomer, Tudal, and Arioch all occur on the same tablet is, of itself, a great argument in favour of the identifications that have been proposed. That Kudur-lakhgumal, King of Elam, is the enemy, not the ally, of the King of Babylonia, is probably due to a change in the feelings and policy of the two rulers, and presents no difficulty, as far as our knowledge at present goes. In whatever manner, however, time may compel the student to regard the events these tablets refer to, there can be no doubt as to their real importance. The absence of any reference to an expedition to the valley of the Jordan is probably due to the mutilation of these clay records (one baked, perhaps by the Arabs who found it, and the other two unbaked), but may be due to the fact that they are written exclusively from a Babylonian point of view. They testify, as do other texts, Babylonian and Hebrew, to the power of Elam at a period which Babylonian chronology fixes at rather more than four thousand years ago.

Fig. 2. Babylonian Tablet. Reverse.

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THE FACE OF THE SKY FOR MAY.

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

Sunspots and faculæ are still diminishing in number and size.

Mercury is favourably situated for observation during May, being at its greatest eastern elongation (22°) on the **16th**. On the **1st** he sets at 8h. 54m. p.m., or 1h. 30m. after the Sun, with a northern declination of 20° 59′, and an apparent diameter of $5\frac{3}{4}''$, $\frac{8}{10}$ths of the disc being illuminated. On the **5th** he sets at 9h. 21m. p.m., 1h. 54m. after the Sun, with a northern declination of 22° 59′, and an apparent diameter of $6\frac{1}{4}''$, $\frac{67}{100}$ths of the disc being illuminated. On the **10th** he sets at 9h. 46m. p.m., or 2h. 10m. after the Sun, with a northern declination of 24° 32′, and an apparent diameter of 7·0″, $\frac{52}{100}$ths of the disc being illuminated. On the **15th** he sets at 9h. 57m. p.m., or two hours and a quarter after the Sun, with a northern declination of 25° 11′, and an apparent diameter of $7\frac{3}{4}''$, $\frac{4}{10}$ths of the disc being illuminated. On the **20th** he sets at 9h. 56m. p.m., or 2h. 6m. after the Sun, with a northern declination of 25° 3′, and an apparent diameter of $8\frac{3}{4}''$, $\frac{27}{100}$ths of the disc being illuminated. On the **25th** he sets at 9h. 42m. p.m., or one hour and three-quarters after the Sun, with a northern declination of 24° 19′, and an apparent diameter of 10·0″, $\frac{17}{100}$ths of the disc being illuminated. On the **30th** he sets at 9h. 16m. p.m., or one and a quarter hours after the Sun, with a northern declination of 23° 8′, and an apparent diameter of 11·0″, $\frac{1}{10}$th of the disc being illuminated. He is at his brightest about the **2nd** of the month. During May he pursues a direct path through nearly the whole of Taurus, being about 2° south of the Pleiades on the evening of the **2nd**.

Venus is too near the Sun to be observed, and Mars is, for the purposes of the amateur, invisible.

Jupiter is still a conspicuous object in the evening sky, but is rapidly nearing the west. On the **1st** he sets at 1h. 35m. a.m., with a northern declination of 20° 35′, and an apparent equatorial diameter of 37·0″, the phase on the *f* limb amounting to $\frac{1}{3}''$. On the **10th** he sets at 1h. a.m., with a northern declination of 20° 20′, and an apparent equatorial diameter of $36\frac{1}{4}''$. On the **20th** he sets at 0h. 26m. a.m., with a northern declination of 20° 1′, and an apparent equatorial diameter of $35\frac{1}{4}''$. On the **30th** he sets at 11h. 45m. p.m., with a northern declination of 19° 39′, and an apparent equatorial diameter of $34\frac{1}{3}''$. During the month he describes a direct path in Cancer, being rather more than $\frac{3}{4}$° south of the $5\frac{1}{2}$ magnitude star η Cancri on the **23rd**. The following phenomena of the satellites occur while the Sun is more than 8° below and the planet 8° above the horizon:—On the **1st** an occultation disappearance of the second satellite at 9h. 28m. p.m.; an eclipse reappearance of the third satellite at 11h. 42m. 46s. p.m. On the **2nd** an occultation disappearance of the first satellite at 9h. 50m. p.m. On the **3rd** a transit egress of the shadow of the second satellite and a transit egress of the first satellite at 9h. 26m. p.m.; a transit egress of the shadow of the first satellite at 10h. 42m. p.m. On the **8th** a transit ingress of the shadow of the fourth satellite at 10h. 5m. p.m., an occultation reappearance of the third satellite at 10h. 45m. p.m. On the **9th** an occultation disappearance of the first satellite at 11h. 47m. p.m. On the **10th** a transit ingress of the first satellite at 9h. 3m. p.m.; a transit ingress of the shadow of the second satellite at 9h. 7m. p.m.; a transit egress of the second satellite at 9h. 38m. p.m.; a transit ingress of the shadow of the first satellite at 10h. 16m. p.m; a transit egress of the first satellite at 11h. 23m. p.m. On the **11th** an eclipse reappearance of the first satellite at 9h. 48m. 14s. p.m. On the **15th** an occultation disappearance of the third satellite at 11h. 16m. p.m. On the **16th** an occultation disappearance of the fourth satellite at 8h. 43m. p.m. On the **17th** a transit ingress of the second satellite at 9h. 26m. p.m.; a transit ingress of the first satellite at 11h. 1m. p.m. On the **19th** a transit egress of the shadow of the first satellite at 9h. p.m.; an eclipse reappearance of the second satellite at 9h. 16m. 55s. p.m.; a transit egress of the shadow of the third satellite at 9h. 50m. p.m. On the **25th** an occultation disappearance of the first satellite at

10h. 14m. p.m. On the **26th** a transit egress of the third satellite at 9h. 20m. p.m.; a transit egress of the first satellite at 9h. 48m. p.m.; a transit ingress of the shadow of the third satellite at 10h. 7m. p.m.; a transit egress of the shadow of the first satellite at 10h. 55m. p.m.

Saturn is an evening star, and is in opposition to the Sun on the **5th**. On the **1st** he rises at 7h. 27m. p.m., with a southern declination of 14° 14′, and an apparent equatorial diameter of 17¾″ (the major axis of the ring system being 43¼″ in diameter, and the minor 15¾″). On the **13th** he rises at 6h. 34m. p.m., with a southern declination of 13° 58′, and an apparent equatorial diameter of 17¾″ (the major axis of the ring system being 43¼″ in diameter, and the minor 15½″). On the **27th** he rises at 5h. 33m. p.m., with a southern declination of 13° 42′, and an apparent equatorial diameter of 17½″ (the major axis of the ring system being 43″ in diameter, and the minor 15¼″). Titan is at his greatest eastern elongation at 10h. p.m. on the **2nd**, and 7h. 30m. p.m. on the **18th**. He pursues a retrograde path through a barren region of Libra.

Uranus is in opposition to the Sun on the **12th**, and is an evening star, but his great southern declination militates against successful observation in these latitudes. On the **1st** he rises at 8h. 14m. p.m., with a southern declination of 18° 13′, and an apparent diameter of 3·8″. On the **31st** he rises at 6h. 9m. p.m., with a southern declination of 17° 56′. He pursues a retrograde path in Libra.

Neptune has left us for the season.

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

The Moon enters her last quarter at 3h. 25m. p.m. on the **4th**; is new at 7h. 46m. p.m. on the **12th**; enters her first quarter at 6h. 21m. a.m. on the **20th**; and is full at 9h. 57m. p.m. on the **26th**. She is in apogee at 3h. p.m. on the **8th** (distance from the Earth, 252,050 miles), and in perigee at 11h. a.m. on the **24th** (distance from the Earth, 225,080 miles).

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Chess Column.

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

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solution of April Problem.

(C. A. Kennard.)

Key-move.—1. R to QBsq.

If 1. . . . K to Q4, 2. K to B3, etc.
1. . . . P to Q4, 2. R to K2, etc.

The "curiosity" lies in the fact that if White could make a waiting move there would be a second solution: for after 1. K to Q4, 2. P to Q4, and mates next move.

Correct Solutions received from Alpha, J. T. Blakemore, A. Walker, W. Willby.

R. P. Greg.—There is hardly enough variety in your problem, considering the force employed.

W. Willby.—It was certainly an unusual feat.

A. C. Challenger.—Many thanks for the problems, especially the three-mover.

W. M. A. E.—After 1. K to Kt2, P to Q4; 2. R to K2, K to Q6, there is no mate.

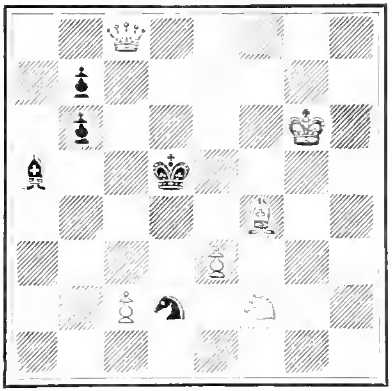
G. B. Fraser, A. E. Bramall, and A Norseman.—Your communications have been forwarded to our correspondent.

PROBLEMS.

By A. C. Challenger.

No. 1.

Black (5).

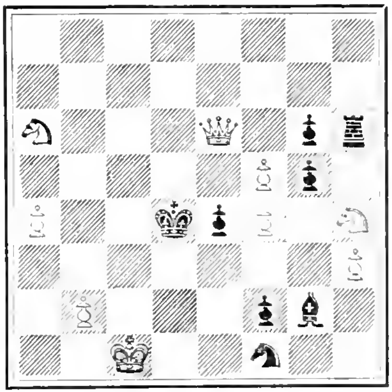


White (6).

White mates in two moves.

No. 2.

Black (8).



White (9).

White mates in three moves.

THE EIGHT QUEENS PROBLEM.

Some correspondents have sent us some remarks on this problem which may tend to explain the law which governs it.

Mr. W. W. Strickland shows that the paucity of solutions on a board of thirty-six squares (using six Queens) is connected with the fact that the solution is impossible when a Queen stands in the centre of one of the four quarters of the board. From other considerations he predicts that on a board of eighty-one squares there will be found only six essential methods of solving the problem. Perhaps one of our readers might care to verify this. Mr. C. W. Branch suggests the law which governs the convertibility or otherwise of the positions. He imagines a position set up on *nine* chess-boards placed in the form of a square. If, then, any piece on one of the outside chess-boards is in a line with any piece on the central board, the central position cannot be moved in such a direction as to cause the attacking piece to be brought on to the central board, unless such movement at the same time causes the piece attacked to disappear from the central board.

We regret that it is impossible to print the diagrams which accompany this ingenious explanation.

CHESS INTELLIGENCE.

The secretary of the newly established "Courts Chess Club" informs us that the club meets at 93, Chancery Lane. The members are mostly connected with the legal profession.

The Inter-University Chess Match was played at the British Chess Club last month, and resulted in a victory for Oxford. The following was the score:—

Oxford.		Cambridge.	
1. E. Lawton, capt. (Corpus)	1	W. V. Naish, capt. (Emm.)	0
2. E. G. Spencer Churchill (Magdalen)	1	G. Varley (Christ's)	0
3. H. G. W. Cooper (Oriel)	0	W. T. Quin (Caius)	1
4. H. N. Robbins (Corpus)	0	E. A. Crowley (Trinity)	1
5. R. A. Jenkins (Brasenose)	1	R. Battersby (St. Cath.)	0
6. G. Fraser (Corpus)	½	H. F. Parker (Emm.)	½
7. A. S. Ward (Balliol)	½	C. C. W. Sumner (St. John's)	½
	4		3

Mr. Robbins lost a game, which he should have won, by exceeding his time-limit. Cambridge are still seven matches to the good, out of the twenty-four played since 1873.

The score in the Steinitz-Schiffers match is:—Schiffers, 4; Steinitz, 6; drawn, 1.

Mr. H. W. Trenchard has just won a match with Mr. J. Mortimer, and drawn one with Mr. Herbert Jacobs.

The Annual Chess Festival of the Hastings Chess Club took place on March 16th to 19th. Messrs. Bird, Blackburne, and Teichmann gave simultaneous and blindfold performances, and there were the usual consultation games.

The Amateur Championship Tournament begins at the City of London Chess Club on April 20th. About the same time there will be a Masters' Tournament at Simpson's Divan.

In the Vienna Club Tourney the leading scores are now:—Englisch and Schlechter, 11; Marco and Weiss, 10½; J. Schwarz, 10.

The following game was played in the Universities' Match last month:—

"Petroff's Defence."

White. (G. Fraser, Oxford.)	Black. (H. F. Parker, Cambridge.)
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to KB3
3. Kt to B3	3. Kt to B3
4. B to B4 (*a*)	4. B to B4
5. P to Q3	5. P to Q3
6. B to KKt5 (*b*)	6. B to K3
7. B × B (*c*)	7. P × B
8. Kt to K2	8. Castles
9. Kt to Kt3	9. Q to Q2
10. P to KR3 (*d*)	10. Kt to Q5
11. P to B3	11. Kt × Ktch
12. P × Kt	12. R to B2
13. P to Q4	13. P × P
14. P × P	14. B to Kt3
15. Q to Q3 (*e*)	15. QR to KBsq
16. Castles QR	16. Kt to Ksq
17. B to K3	17. R × P
18. QR to Ktsq	18. P to B3
19. P to Q5	19. P to K4 (*f*)
20. Kt to B5	20. K to Rsq (*g*)
21. Q to K2	21. B × Bch
22. P × B	22. R(B6) × Kt
23. P × R	23. P × P
24. Q to Kt4	24. R × P
25. R to Bsq	25. P to KKt3
26. R × R	26. P × R
27. Q to Kt3 (*h*)	27. Kt to Kt2
28. Q to Kt2	28. P to K5 (*i*)
29. Q to Q2	29. Drawn.

Notes.

(*a*) An inferior variation of the Four Knights game. Black should reply 4 . . . Kt × P. The correct move is 4. B to Kt5.

(*b*) Inferior to 6. B to K3.

(*c*) Again bad judgment: for now his Knight can never enter at Q5, so that his Queen's Bishop is in a useless position, as Black will be able to escape from the "pin."

(*d*) Unnecessary. He might play 10. P to B3. On his next move it is too late, as he thereby gets a very weak doubled Pawn, which is speedily lost.

(*e*) He should make some attempt to defend the KBP by means of the QR and the King.

(*f*) So far Black has played excellently, but this mistake loses him all his advantage. He should play 19 . . . BP × P first.

(*g*) 20 . . . B × Bch would save a move if not more.

(*h*) 27. Q to Kt5 looks stronger; or Q to Kt2 at once. On his next move the obvious 28. R to Ktsq seems best.

(*i*) This move weakens all his Pawns; but in any case the game would probably be drawn.

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NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

Bound volumes of Knowledge, New Series, can be supplied as follows:—Vols. I., II., III., and VIII., 10s. 6d. each; Vols. VI., VII., IX., and X. (1895), 8s. 6d. each.

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Communications for the Editors and Books for Review should be addressed Editors, "Knowledge" Office, 326, High Holborn, London, W.C.

KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: JUNE 1, 1896.

CONTENTS.

THE NATURE OF THE X RAYS OF RÖNTGEN.

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

PROBABLY at no period in the history of science has so much research been concentrated on one particular part of the field of investigation as now, when in all the principal physical laboratories of Europe inquiries are being made into the effects and the probable causes of the remarkable new species of radiation labelled by one of the early discoverers X, or unknown. To able and well-directed efforts thus persistently made, "the rays" will no doubt soon be obliged to yield the secret of their origin and cause. In fact, already there are clear indications of the direction in which the truth may be discovered, and the researches of explorers in several widely separated countries are converging on one definite explanation of the source of this mysterious phenomenon. Opinions, however, amongst those competent to judge are still in many quarters widely different.

Recently amongst our neighbours the French, who have been active in physical research, a form of radiation has been brought to notice which differs from ordinary light and is different also from the rays described by Röntgen. This newly-found form of ethereal vibration appears to possess characteristics intermediate between those of light which affects our eyes and those associated with the X rays. Most people have seen in the shop windows, or elsewhere, yellow or canary-coloured glass, sometimes made into small trays or dishes. It possesses a peculiar fluorescent property, and when light of any colour whatever falls upon it, it glows with its own peculiar and weird phosphorescent yellowish light. This property of the glass is remarkably shown by placing a rod made from it in a dark room and forming a spectrum of some source of white light. When the rod is placed in the red or the blue part of the spectrum, it still persists in giving back its characteristic yellowish shimmer. The cause of this behaviour in the glass is the presence in it of salts of the somewhat rare metal *uranium*. Now, M. Henri Becquerel, in France, has been carrying out investigations on the nature of the radiation given out by various salts of uranium, and has shown the existence of radiation intermediate in character between that of light and that which probably causes the Röntgen effects. M. Becquerel made a fluorescent screen of thin crystals of the double sulphate of uranium and potassium, a substance which is very active in its phosphorescence. This phosphorescence or visible emission of light lasts a very short time, less than one-hundredth of a second: but the fluorescent screen appears to have also the power of giving forth invisible phosphorescent radiations. Light from the sun after passing through such a screen can cause the formation of an image on a sensitive film, although black paper or aluminium is interposed in the path of the solar radiations. Copper is, however, almost opaque to these radiations. Moreover, a film left in the dark with the phosphorescent screen almost touching it, shows intense images. These latter are not produced by any visible light, and must be due to the invisible phosphorescence. The persistence of the emission of these dark radiations from the uranium salt is most extraordinary. After being kept in the dark for a fortnight the screens formed from the salt emit their radiations with scarcely less intensity than when freshly exposed to light. These uranium radiations discharge electrified bodies just as Röntgen rays do: they also suffer the same sort of diminution in intensity as the rays of Röntgen on traversing a plate of quartz. Their action, however, has only about one-hundredth part of the intensity of that of the Röntgen rays. Various salts of uranium exhibit the same properties.

The special interest attaching to these experiments at present is due to the fact that M. Becquerel finds that the uranium radiations can be refracted and polarized. Now, this polarization proves that the radiation must consist of *transverse* vibrations; and as Röntgen radiation is similar in many respects, a presumption arises that the Röntgen rays themselves are caused by transverse vibrations in the ether. Recent work shows distinct evidence that the Röntgen rays can be reflected. These rays, then, possess some of the properties of ordinary light.

An Italian investigator, Signor Righi, finds that when a body charged with negative electricity is exposed to the action of Röntgen rays it loses its negative charge, which appears to leak away; and when longer exposed to the same influence it gains a positive charge instead. Invisible rays from the part of the spectrum beyond the violet exert a similar action, and there is thus shown to exist another property common to those two sorts of radiation.

Other observers have found that the light given out by phosphorescent bodies is able to penetrate substances which are quite opaque to ordinary light from the sun. Diffuse reflection of Röntgen rays seems to have been distinctly observed, and images of opaque objects have been produced by means of reflected rays when the sensitive plate on which the images were formed was screened from the direct action of the vacuum tube by means of a thick sheet of copper placed between the tube and the plate.

The Röntgen rays are probably of various wave-lengths, and are not analogous to light of one definite colour. The absence of any phenomena of diffraction does not, therefore, prove that they are not ultra-violet vibrations. Before diffraction experiments can be successfully performed a means must be found for sifting the Röntgen rays, and separating out the components differing in wave-length.

The evidence that irregular reflection of Röntgen rays occurs is accumulating, and, so far as can be judged at present from the results of the numerous experiments already carried out, it seems probable that this newly discovered form of radiation will turn out to be a form of transverse vibration in the ether of much smaller wave-length and more rapid than that which produces ordinary light.

It must be remembered that the visible vibrations constituting light have a range, from the dark red, or slowest, to the violet, or most rapid, of about an octave. Vibrations which are a little more than twice as rapid as those of red light do not affect our eyes. There is no reason to suppose that disturbances or changes in the ether many times as quick as those of red light do not exist. Some of these ultra violet vibrations have already been investigated and have become known, and it may well be that some still more swift and hitherto unsuspected vibrations have been manifesting their existence to us by the effects first noticed by Lenard and Röntgen, and since so diligently investigated by the numerous observers who have followed them.

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BRIEF DESCRIPTION OF THE ORCHID PHOTOGRAPHS.

By H. A. Burberry, F.R.H.S.

The accompanying illustrations are from photographs of a few specimens from the Right Hon. J. Chamberlain's collection of orchids.

Fig. 1 represents a specimen of *Cattleya mossiæ*, variety *Wagneri*, a very rare and most beautiful orchid. It is a native of Venezuela, and thrives best when grown in an intermediate temperature. The species as a whole is a richly and most varied coloured one. The variety *Wagneri* is the pure white form. The section to which this plant and *Cattleya mendelii* (to be described later on) belong is the "labiate" section, so named on account of the very large and beautiful lip, or labellum, which is a characteristic of the plants. All species belonging to this order have their pure white varieties, which are in all instances very rare and costly.

Fig. 2 is a specimen of *Cypripedium bellatulum*, a species coming from Cochin China. The flower is very striking, the ground colour being white and the whole densely spotted with brownish purple. The plant succeeds best in an intermediate temperature, and should be grown in a compost of strong loam mixed with limestone.

The genus *Cypripedium*, to which belong the so-called "lady's slipper orchids," is a very large and popular one, inhabiting both Asia and America. Those from the North of America are quite hardy. There is, moreover, one (*C. calceolus*) that is a well-known European species, and was once a wild plant in England, but has now become exterminated.

Fig. 3 is a very beautiful orchid coming from Burmah, and called *Dendrobium formosum giganteum*. The genus to which it belongs is a very large one, and species belonging to it are found scattered nearly over the whole of the continents of Asia and Australia. They are for the most part very warm-growing orchids, and the species here depicted always requires the warmest department and grows best planted in small pans suspended from the roof. It flowers during August and September. The flowers are pure white, with the exception of an orange blotch on the labellum, and are borne at the apex of the newly-formed pseudo-bulbs.

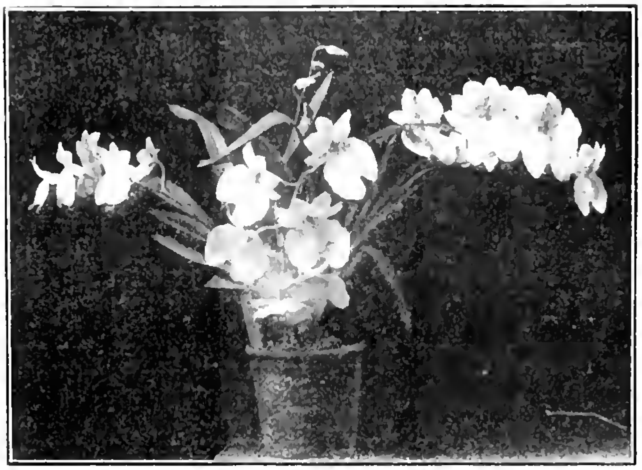

Fig. 5.—*Miltonia vexillaria.*

Cattleya mendelii, a specimen of which is shown in Fig. 4, belongs to the same very popular genus as the subject of Fig. 1. The genus was founded in honour of William Cattleya, of Barnet, Herts, who was a great lover of orchids in his day. *C. mendelii* is a very attractive and showy orchid, and is one of the most lovely of them all. The flowers are of great beauty and most delicately tinted, from light pink to a deep rose colour. Its native habitat is New Granada. The temperature most suited to its requirements is an intermediate one. It flowers in April and May, and grows best when planted in peat and sphagnum moss.

The genus *Miltonia* (named after Viscount Milton, afterwards Earl Fitzwilliam) is one containing several very beautiful orchids, some preferring the temperature of the warmest house, and others the intermediate house temperature. *M. vexillaria* —Fig. 5 — from New Granada, is one of the latter. It is sometimes known as the "standard-bearer orchid." It is one of the most showy and beautiful of the genus,

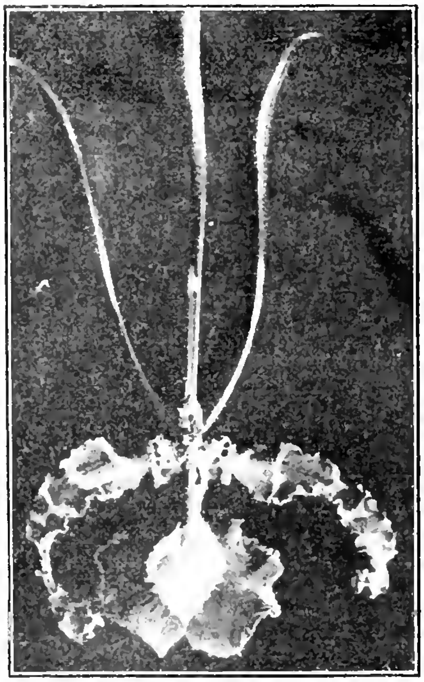

Fig. 6.—*Oncidium papilio.*

PHOTOGRAPHS OF ORCHIDS.

From the Collection of the Right Hon. JOSEPH CHAMBERLAIN, M.P.

Fig. 1.—Cattleya mossiæ, var. Wagneri.

Fig 2.—Cypripedium bellatulum.

PHOTOGRAPHS OF ORCHIDS.

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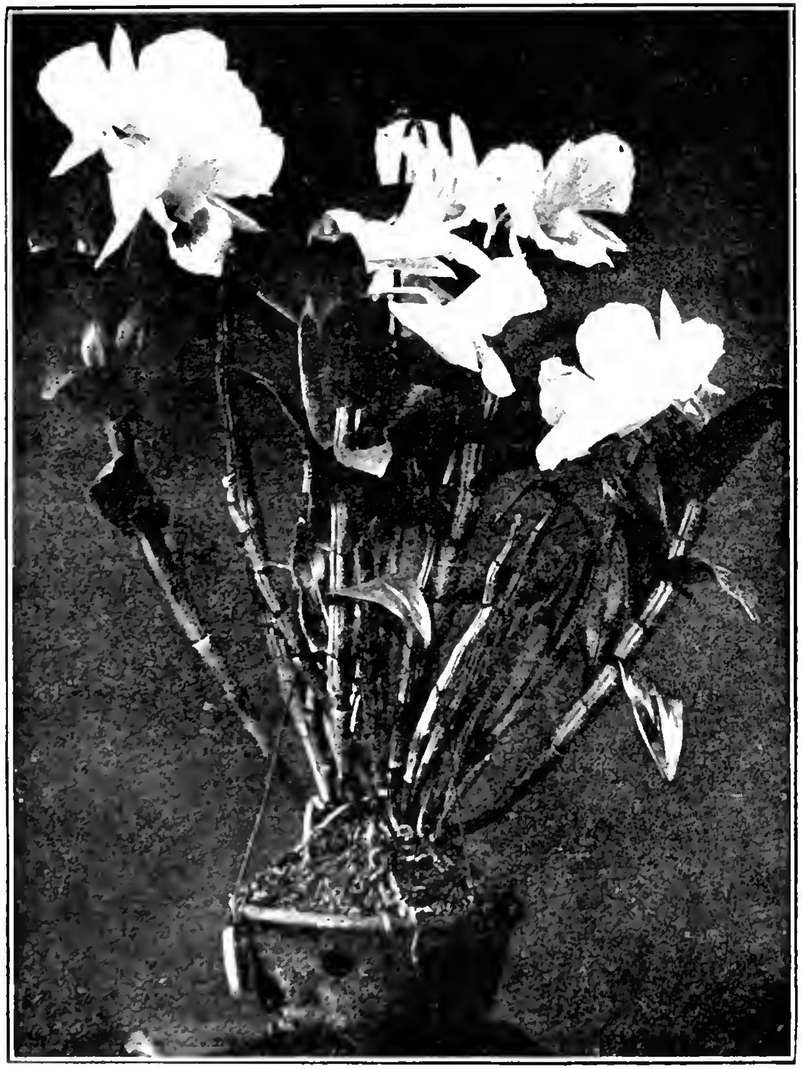

Fig. 3.—Dendrobium formosum giganteum.

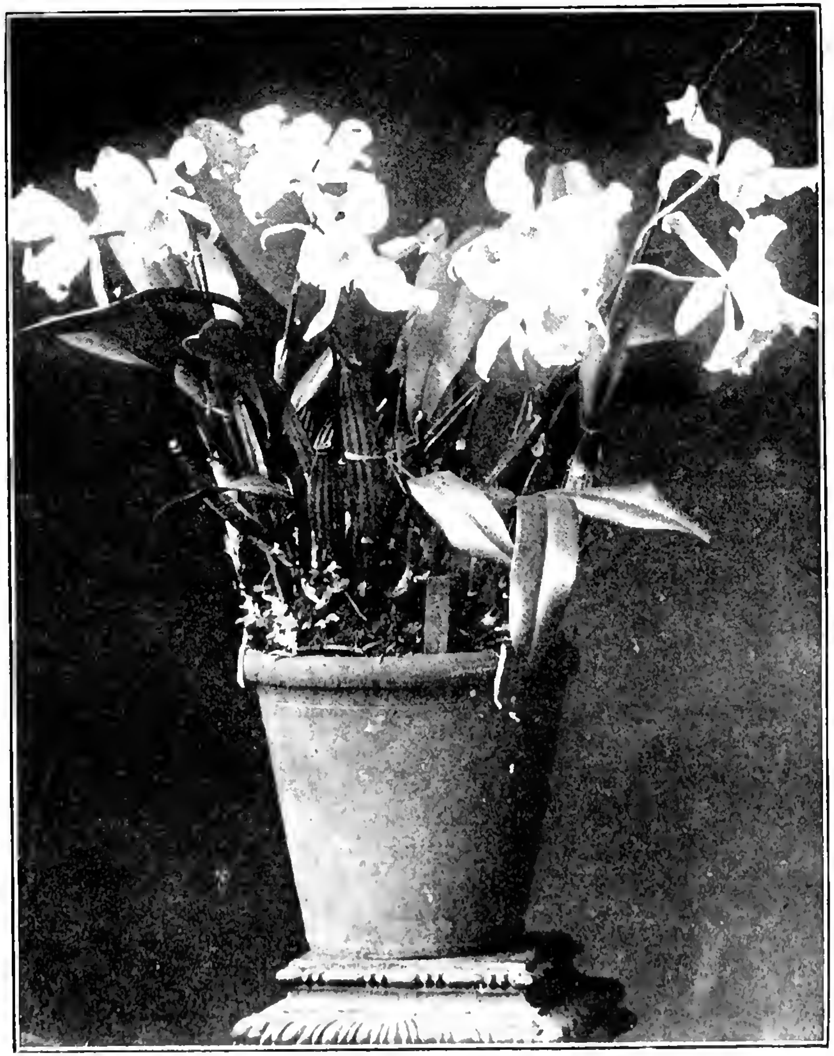

Fig. 4. Cattleya mendelii.

and if cultivated under proper conditions makes rapid growth. It is best grown in sphagnum moss and fibrous peat. There is great variety of colour, which varies from almost white to a very dark rose.

The genus *Oncidium* is a very large one, comprising over two hundred and fifty species, and inhabiting tropical America and the West Indies. Some are very cool-growing kinds, and require only the ordinary greenhouse in which to flourish, whilst others must have more warmth. *O. papilio* is one of the latter, and must have the warmest house. It is generally known as the "butterfly orchid," and it certainly resembles a large butterfly in shape. The flowers are pale golden yellow, barred with chestnut brown. It may either be grown fixed on a block of wood, or in a wooden basket planted in sphagnum moss and fibrous peat. It is a compact-growing plant, and the flower spikes (which are long and slender) are produced from the base of the last made pseudo-bulb, and the flower at its apex, one following the other in succession for several years.

[We are indebted to the Right Hon. Joseph Chamberlain, M.P., for his consent to reproduce, with Mr. Burberry's aid, a selection from his orchids.—Eds.]

◆

A GEOGRAPHICAL DESCRIPTION OF THE BRITISH ISLANDS.

By Hugh Robert Mill, D.Sc., F.R.S.E.

A SUGGESTION put forward in my paper in the January Number of Knowledge, on "Geography as a Science in England," that a complete geographical account of the British Islands might be compiled on the basis of the Ordnance Survey maps, has been received with considerable favour. It may not be out of place to summarize here the developments which have occurred, and to re-state the plan with the greater precision that lapse of time, the accumulation of fresh information, and the kindly criticism of friends have made possible.

I must, in the first instance, accord to Mr. J. Logan Lobley the credit of priority, not only in suggesting a complete scheme for the geographical description of the country, but in actually preparing such an account of a representative county. I was unaware of his labours in this direction when I brought forward my scheme and when I wrote a note on the subject in the March Number of Knowledge, and I am glad now to call attention to his excellent MS. account of the parishes of the county of Surrey, a work which I hope will soon be brought before the public. Mr. Lobley's work is on a somewhat larger scale than I would propose for use in the uniform treatment of the whole country, and it is in some respects treated from a different standpoint. But as work actually done it is of great value, and shows that the advantages of such descriptions had appealed very strongly to practical geologists. Prof. Seeley has also brought to my notice the fact that he has studied the country near London with his students for many years, and has in preparation a description of part of it from the point of view of physical geography. I dare say these are not the only instances of such work having been initiated; the more cases of the kind that have occurred, the more clearly does the importance of a general realization of the scheme appear.

The statement of a possible scheme submitted to the Royal Geographical Society on March 6th, and published in the *Geographical Journal* for April, 1896, may be repeated here in the hope that the range of criticism and suggestion may thus be extended.

The Chief Sources of Information.

(*a*) The basis of the description should be the topographical map of the Ordnance Survey on the scale of 1 : 63,360, or one inch to one mile. This, including the new survey of England, will be complete before the close of the present century. The sheets, measuring eighteen inches by twelve, contain two hundred and sixteen square miles of surface for England and Ireland; but the sheets for Scotland measure twenty-four inches by eighteen, and contain four hundred and thirty-two square miles. The map is in two editions, showing relief by hachuring and contouring respectively, and all sheets are graduated on the edge to single minutes of latitude and longitude, with subdivisions to ten seconds. In special cases the maps on the scale of 1 : 10,560, or six inches to one mile, would be referred to.

(*b*) The maps of the Geological Survey on the same scales supply in many cases the geological reasons for geographical conditions, and the memoirs to the various sheets, or on selected districts, usually give valuable summaries of the physical geography from the geological standpoint.

(*c*) The charts of the Hydrographic Department supply full details as to sea-depths along the coast, and as to depths of navigable rivers and a few lakes.

(*d*) The publications of the Meteorological Office, of the two Meteorological Societies, and of Mr. Symons (for rainfall), contain a great amount of information as to the climate of the British Isles.

(*e*) The Census reports give full particulars of the population of each registration district and of their occupations, a matter of great geographical importance; although I am not aware that the distributional relations of the Census have ever been fully worked out in the manner adopted, for example, by the United States Census Office.

(*f*) The reports of births, marriages, and deaths supplement the Census returns in many ways, and contain materials for statistical maps, including maps of the distribution of diseases as worked out by Dr. Havilland for the Lake District.

(*g*) The Board of Trade and other Government departments publish full accounts of exports, imports, and of internal transport, of mineral and agricultural produce and manufactures, all of which are capable of geographical treatment.

(*h*) The publications of such societies as the Royal Agricultural, the Archæological, the Statistical, the Institution of Civil Engineers, and many others, contain papers on subjects which may be profitably consulted; and there are numerous county histories and books on special aspects of geography from which help may be obtained.

(*i*) There are now several amateur photographic societies which make systematic collections of characteristic pictures of their own neighbourhood, such as that over which Sir Benjamin Stone presides in Warwickshire. Numerous local scientific societies are rendered accessible and capable of acting in concert through a committee of the British Association, many of the members of which are willing to act as skilled collectors of information.

The Plan of the Memoir.

Taking the one-inch map as a basis, the discussion and treatment would be on a corresponding scale. No doubt, by enlarging on each of the heads to be mentioned, a treatise of great length might easily be compiled for each sheet. My proposal is to aim at conciseness; as far as possible to touch only on essential matters, and to treat these exclusively from the geographical standpoint. A good deal of repetition would be avoided by the preparation of an introductory memoir describing the general features of Ordnance maps, explaining scales, the use of contour-lines, and map reading generally. This should also contain a statement of the principles of geography as applied to regional descriptions. The suggested memoir for each sheet would include :—

(a) *Index* of all names on the sheet, referring to them by latitude and longitude in areas of one minute by one minute, giving also the altitude (exact or approximate) in the case of hills, river sources, towns, villages, houses, etc., and the length of streams or portions of streams included.

(b) *Place-names.*—Notes on such of the place-names as present features of geographical interest.

(c) *Mean Elevation* of the sheet, with the areas between successive contour-lines, and statement of maximum and minimum heights.

(d) *Hypsographical Description.*—A general statement of the elevations and depressions of the sheet, mentioning their relation to the larger features of the country. Length of streams and their drainage areas.

(e) *Physiographical Explanation* with reference to the type of land-form in relation to geological structure, the position of the surface in the cycle of geographical development, the character of the soils and mineral productions, the local magnetic conditions, and the conditions of climate so far as these are dependent on position and configuration.

(f) *Vegetation and Agriculture.*—The approximate areas of woodland, moorland, pasture, arable land, and the leading crops. Local floras and faunas.

(g) *Political and Historical.*—The parish, county, and municipal boundaries. Historical sites, and events which depend on geographical conditions.

(h) *Geographical Description*, showing the relation of the human inhabitants to all the foregoing conditions, especially with regard to the sites of towns and villages, the distribution of population, the utilization of natural resources, and historical development of industries. Local vocabularies.

(i) *Illustrations.*—A few carefully selected photographs of typical scenery should accompany each sheet. Some sketch-maps and diagrams might also be included.

(k) *Bibliography*, giving titles of works relating to places contained in the sheet.

Several matters of very great importance cannot be included, because the facts to be ascertained would involve special surveys, *e.g.*, the variation of the force of gravity ; the seismic conditions ; hydrographic conditions involving the volume, speed, and normal seasonal fluctuations of all rivers—a subject which will acquire great economic importance in a few years ; and the ethnological description of the people.

Proposed Method of Execution.

(a) *Index.*—This requires simple mechanical compilation. It would vary greatly in length, some sheets having less than fifty names, others probably more than one thousand.

(b) *Place-names.*—The notes would be limited to (1) alternative names for places mentioned in the sheet, (2) corrections of spelling, (3) critical discussion of such place-names as are descriptive of geographical forms or positions, (4) discussion of names which can be traced by historical records sufficiently far back to throw light on prehistoric populations. The necessary information would be obtained from topographical and archæological works, from dictionaries of place-names, and from local students ; but the lists would require very careful editing by an expert, and must be strictly limited to cases concerning which there is no reasonable doubt.

(c) *Mean Elevation.* – The area between successive contour-lines on the map must be measured by the planimeter or by squared tracing paper, and the volume deduced by considering the mean inclination of the successive surfaces, which would also give the true area of the country as contrasted with the area projected on the plane of sea-level given on the map. The distortion due to the conical projection on which the map is drawn will probably be too insignificant to require notice ; if not, it must be allowed for. Check estimates might be made by Heiderich's method of drawing numerous equidistant profiles, and calculating the contents by Simpson's formula ; and also by marking as many actual elevations as possible on the map, and combining the arithmetical averages of each square inch, as in Karsten's method of estimating ocean depths. This work demands a considerable amount of skill and attention. It would be very suitable as an exercise and training for students, if any institution existed in this country where students could be induced to study geography seriously.

(d) *The Hypsographical Description* would in most cases be very brief. It should be written from the map, considering both hachures and contour-lines, and afterwards verified on the ground. The lengths of parts of rivers and their drainage areas would be treated in this description.

(e) *The Physiographical Explanation* would, so far as the geology is concerned, be simply a restatement of the "Physical Geography" section of the Geological Survey memoir, with such modifications as the modern views of the cycle of development of a land surface suggest. The character of the soils would, to a certain extent, be derived from the drift-maps of the Geological Survey, from notes of official or private geologists, and in some cases from local inquiries. The mineral productions would be described from the official returns. Climatic data would be derived from the publications of the Meteorological Office and of societies, supplemented in many cases by local information.

(f) *Vegetation and Agriculture.*—The areas of forests, parks, and moorland or commons would be measured on the six-inch Ordnance Survey maps, on which a distinction between different kinds of wood is made. The agricultural information would be got from official returns, the transactions of agricultural societies, and local inquiries ; while a knowledge of any peculiarities of local flora and fauna would be similarly obtained.

(g) *Political and Historical.*—The boundaries would be taken as shown on the map, referring to any important changes, such as the reports of Boundary Commissioners. Historical information would be sought from historical and archæological societies, and would be very stringently edited, so as to confine it strictly to those features and events of direct geographical importance.

(h) *The Geographical Description* would be the most important part of the memoir, and must be the work of a trained geographer, who, after studying the maps in the light of all the information referred to above, shall have made himself familiar with the ground. It would deal directly with the relation of the people to the land, showing the control exerted by geographical conditions on the sites of towns, on dwellings, occupations, the distribution of the people, the lines of communication, and, if data are forthcoming, on local character. Historical changes in the resources and industries of a region would be considered, to show in what degree they occurred in consequence of geographical changes, *e.g.*, the silting up of harbours, the destruction of forests, the discovery or exhaustion of minerals ; or in what degree they occurred in spite of geographical conditions, *e.g.*, the establishment of a gunpowder factory in an agricultural district, or the tunnelling of a hill by a new railway. Many of the more interesting relations to be discussed in this description are undergoing change, and unless they are soon studied and recorded the value of the work will be much reduced.

(*i*) *Illustrations.*—A sketch-map on the scale of, say, ten miles to the inch would be given, showing the area of nine sheets of the one-inch map, including the eight sheets which touch the sheet under consideration. A small index map on the outside cover could show the sheets contained in the whole country (England, Scotland, or Ireland, as the case might be). One or two characteristic profiles on a natural scale might be given, and a selection of views of characteristic scenery taken from a carefully chosen standpoint. It might be found possible in a few cases to give characteristic type-portraits of the people, and illustrations of the leading industries of the district.

(*k*) *Bibliography.*—All the books, articles, or references dealing with places referred to in the sheet would be recorded, so that a student could at once refer to all available original sources.

Probable Magnitude, Duration, and Utility of the Suggested Work.

The land area of the British Islands, excluding the Channel Isles, is estimated at one hundred and twenty thousand nine hundred and four square miles, which would correspond to five hundred and sixty sheets containing two hundred and sixteen square miles each, the size of the English one-inch sheets. On account of the irregularities of coast-line, the one-inch map of England contains three hundred and sixty sheets, that of Ireland two hundred and five sheets, and that of Scotland one hundred and thirty-one sheets of double size, corresponding to two hundred and sixty-two. The total number is thus equivalent to eight hundred and twenty-seven sheets of the usual size (eighteen inches by twelve); but of these twenty-seven at least are, so far as one can judge from the index maps, entirely blank, leaving eight hundred which would have to be considered. Of the eight hundred there are at least two hundred and fifty-eight which contain less than half their area of land surface. However, it seems to me that the advantages of having the memoirs in the form of a pamphlet corresponding to each sheet, and numbered in the same way, would be sufficient to make it worth while to face the prospect of eight hundred separate booklets. There might, in fact, be rather more, as the special sheets combined out of several to show the environs of important towns would naturally be included. The little books would be partly statistical and partly descriptive, and their aim would be to present the information in the most concise and systematic form. Possibly, wherever a sheet contained less than a certain area—say fifty square miles—of land, it would be found convenient to reckon it as part of its next neighbour. If the memoirs were printed in royal octavo form, the size of each might vary from eight to thirty-two, or possibly, in rare cases, to forty-eight pages. This is little more than a guess, but it illustrates the scale on which I think the work should be undertaken. The average length might be about twenty-four pages, which would give nineteen thousand two hundred pages for the whole work; this would correspond to twenty volumes of nine hundred and sixty pages. If the work were undertaken with a sufficient staff to turn out an average number of forty memoirs in a year, it would require twenty years for its completion; an increased staff would allow of the work being more quickly completed.

At the meeting when this scheme was discussed general approval of the principle was expressed by such authorities as General Sir Charles W. Wilson, late Director-General of the Ordnance Survey; Colonel J. Farquharson, the present Director-General; Mr. Clements R. Markham, President of the Royal Geographical Society; Mr H. J. Mackinder, Reader in Geography at the University of Oxford; Mr. E. G. Ravenstein; and Sir Benjamin Stone, M.P. There was, however, considerable divergence of opinion as to the proper unit of description, the majority considering that a political unit—the parish, hundred, or county—ought to be adopted.

The advantages of the map-sheet as a unit still outweigh those of the parish or county, in my mind, for a work on the scale and with the object that I have proposed. Once the description of the country is complete on the rigidly uniform plan suggested, it would be a very easy matter to prepare a series of county memoirs each of which could be worked up from the special point of view most important in the individual case.

The council of the Royal Geographical Society has appointed a committee to consider the practicability of undertaking the description of a specimen area as a sample of the whole and as a test of the character of the projected work. The complete work would prove very expensive for any private society, and from its national importance should, if undertaken at all, be carried out at the cost of the nation, under such expert supervision as would ensure continuity and steady progress. Whether this could be best attained by entrusting the work to the organization of the Ordnance Survey or to the Royal Geographical Society, or to a special Government department for geographical work, is a question that might be very profitably discussed. A geographical department would be a very useful adjunct to the scientific equipment of the Government, and could be utilized in many ways, not the least important being the co-ordination of the geographical data already copiously collected by Government departments, the work of which at present remains isolated and unprofitable.

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PROTECTIVE RESEMBLANCE IN THE NESTS AND EGGS OF BIRDS.

By Harry F. Witherby.

In a former article[*] a few cases of protective resemblance in birds were dealt with, and the accompanying illustrations furnish us with two further examples of the subject. Both engravings are from beautiful photographs by Mr. G. W. Burn Murdoch. The one of a long-tailed tit's nest is an excellent example of protective resemblance in the nest of a bird, while that of the oyster catcher's eggs is a good illustration of the subject in the eggs of a bird.

The long-tailed tit's nest is particularly difficult to distinguish from its surroundings, even in the photograph, where only the immediate surroundings are taken in. It may be well to briefly describe the builder of the nest before we go on to the nest itself.

The long-tailed tit (*Acredula caudata*) is a member of the family *Paridæ*, which contains some of our smallest and at the same time best known birds, which may be classed amongst the happiest and most lively. The long-tailed tit is in reality a very tiny bird, although its tail, which is longer than its body, gives it the appearance of being larger than it really is. The bird

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[*] See Knowledge, March, 1896.

is a resident and fairly common in the British Islands. Perhaps the most interesting point in its life history is in connection with the nest, which takes a fortnight to build and is a perfect work of art. In shape it is similar to that of a wren, being long and oval with a small hole in the side near the top.

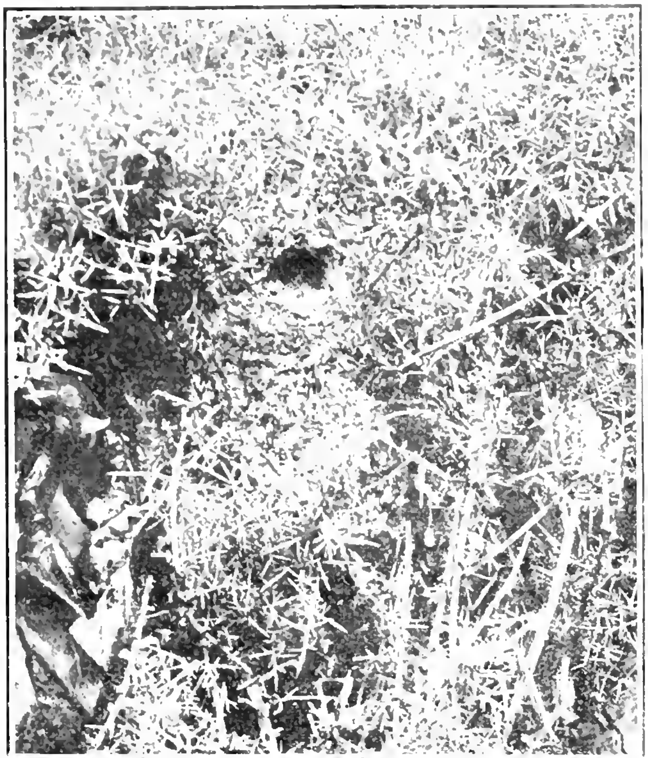

FIG. 1.—Nest of a Long-tailed Tit in a Gorse Bush.

This curious shaped nest has given to its maker the name of bottle-tit, and when the bird is sitting inside its long tail is turned over its back, and often protrudes from the entrance hole. The nest is made of moss and lichens, woven and cemented together with spiders' webs. The outside generally resembles its surroundings closely; when in a lichen-covered bush or tree it is often covered with silvery lichens, while, should the tree be mossy, the nest, too, is often mossy.

The bird does not, however, seem to understand to the full the protective advantages of this plan, for one found in a green holly bush was covered with white lichens, and was thus much more conspicuous than if it had been made entirely of green moss. Many species are noted for making their nests of materials akin to the surroundings; but one may always find exceptions where the bird has erred and the wrong material has been used.

The nest shown in the illustration was built in a furze bush and was covered with lichen. A few feathers can be seen peeping out of the entrance hole; this may be observed in almost every nest of a long-tailed tit, since the birds always line—or rather fill—the nest with feathers, and even add feathers after they have laid eggs. This, indeed, is very necessary to keep the eggs warm, for they are so numerous that they are one on the top of the other, and the tiny bird cannot possibly cover them all.

The oyster catcher (*Hæmatopus ostralegus*), the eggs of which are figured in the second illustration, is a widely different bird from the one with which we have just been dealing.

It inhabits our seashores all the year round in considerable numbers; in winter in flocks, while in summer it breeds more or less in small colonies. Although the eggs in the present case are a very good example of our subject, yet the breeding habits of the bird as a whole are not altogether consistent with protective resemblance. When the eggs are laid in a scoop in the sand or shingle they very closely resemble their surroundings both in ground colour, marking, and form. They are naturally difficult to find, too, in this position, and more especially because the bird makes a number of sham scoops round the tenanted one, presumably to mislead the ignorant. But the eggs are often laid in a shallow hollow in the rocks or in a scoop in the grass, and when this is the case they are comparatively as conspicuous as they are hidden when in the shingle. The reason for this curious change of habit is not quite apparent. It cannot be—at all events not in all cases—for want of shingle or sand in the locality, for they have often been found placed in the rocks when plenty of suitable shingle was available within a few yards. The shingle would seem to be their natural and original nesting place, not only because of the colour of the eggs, but because the birds always place stones, shells, or some such hard particles beneath the eggs when they are laid on rock or grass.

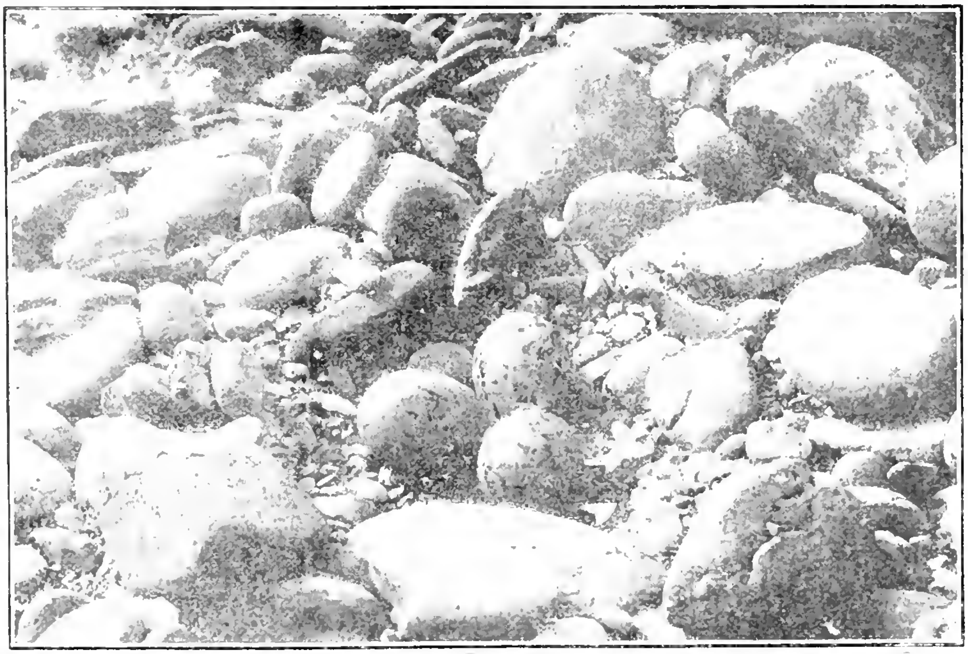

FIG. 2.—Eggs of an Oyster Catcher amongst Stones.

This, indeed, is one of the curious and seemingly contradictory facts with which nature abounds, and we cannot attempt a reason for it.

◆

SUN-SYMBOLS IN ANCIENT EGYPT.

By F. W. Read.

Among all the objects worshipped by the Egyptians the sun was the most honoured. It was he who furnished the type of the immortality of the human soul: as he sank daily behind the Libyan Hills and rose again daily over the Arabian Desert, so man, his creature, did not come to an end when he too passed westward to his grave in those same hills, but would rise again with the sun, his lord. To come forth by day, to triumph with the sun, is the object, again and again set forth, of the wonderful collection of religious writings called "The Book of the Dead." But the daily journey of the sun also gave rise to another kind of symbolism. Passing in triumph over the earth, he is its king; and to the pious Egyptian the Pharaoh was his representative, bearing all his titles, clothed with all his attributes, wielding all his powers. One of the titles of the Pharaoh was "Son of the Sun"; another was "Horus," and Horus was before all things a sun-god. On the beautiful statue of Khafra, the pyramid builder (about B.C. 3700), one of the oldest works of Egyptian art, the Hawk of Horus stands behind the king's head, spreading its protecting wings.

Although, in common with the moderns, the Egyptians sang the golden glories of the sun, the one thing that impressed them above all others was the fact that, wherever he went, he divided that over and through which he passed into two parts—the north and the south. When viewed in this light, heaven is "the two heavens," earth is "the two earths," and the space beneath the earth is "the double divine under-world," or "the double hall of Maat." The explanation of these phrases is to be found only in the fact of the sun's daily passage over all countries. As he passes over them he divides each into two, and therefore every country and every nome could be spoken of as "the two earths." Of course, Egypt among the rest might be described in this way, and it is possible that the expression sometimes has a double significance; but there is evidence that, down to the time of the Ptolemies at any rate, the distinction between "the two Egypts" and "the two earths" was well recognized by the learned class.

The pyramid texts, of which the first was discovered in 1880, and only recently published by Maspero, throw much light on this question, as they do upon nearly the whole of Egyptian mythology. In the pyramid built for King Teta (about B.C. 3300) we read: "Teta comes to the two heavens, Teta arrives at the two earths; Teta treads upon the herbage growing under the feet of Seb, he traverses the roads of Nut." The first part of this passage ought of itself to be sufficient to settle the meaning of the phrase "the two earths," since it occurs in connection with "the two heavens," and, obviously, "the two heavens of Egypt" would be absurd. But the second part takes us farther still; from it we see that the two heavens are equivalent to the goddess Nut (the sky), and the two earths to the god Seb (the earth).

This doctrine of duality, which has been briefly indicated, found expression in many ways, but chiefly in the titles of the king. The word "king" itself is expressed in Egyptian by *seten nat*, which, fully translated, means "king of the south and king of the north." Another common title, parallel with *seten nat*, is "lord of the two earths." The parallelism, indeed, is curiously exact, for, just as one could use "two earths" and "earth" interchangeably, so one could express the idea of king by either *seten* or *nat*—preferably the former, which from various causes acquired a pre-eminence.

A consideration of the other symbols of the same doctrine will take us a little deeper into the regions of mythology. Those who only know Horus and Set from the writings of Plutarch and his copyists will be surprised to learn that one of the most ancient titles of the Egyptian king is "the Horus and the Set." According to Plutarch, Typhon (Set) slays his brother Osiris, and Horus, the son of Osiris and Isis, defeats Set and reigns in his father's place. That some such story as this was told in Egypt during the Ptolemaic and Roman periods is highly probable, and some parts of it are demonstrably very ancient. At an early period we hear of a desperate fight between Horus and Set, but it does not seem to have had originally any connection with Osiris; and the combatants are at other times spoken of as friends and colleagues, and not at all as the deadly enemies described by Plutarch The king, as we have said, is called "the Horus and the Set," and sometimes the "Golden Horus and the Golden Set"; he is depicted standing between the two gods, who sometimes purify him with water, sometimes pour the symbols of life and power over him, sometimes instruct him in the use of arms. The two gods are spoken of as brothers having sovereignty over the two divisions of the earth; and that they are identical in character is proved by the use of the expression "the two Horus gods" as the equivalent of Horus and Set. The famous queen Hatshepsu (about B.C. 1600) says on her great obelisk at Karnak: "I bear the white crown (of the south), I am diademed with the red crown (of the north); the two Horus gods have united for me their divisions; I rule this earth like the son of Isis (*i.e.*, Horus), I am victorious like the son of Nut (*i.e.*, Set)." It will be seen that there are here three phrases in parallelism: first, the white and the red crowns; second, the two Horus gods; and, third, Horus and Set. The inscriptions known as "The Book of Hades," relating to the progress of the sun through the under-world during the night, contain two representations of a god with two heads, those of Horus and Set, who is called "the double-headed." In one case he stands on two bows (evidently another of the many symbols of north and south), and the text says: "The two bows bear the double-headed in his mystery; they direct Ra to the eastern horizon of heaven and they advance on high with him." Here we find Horus and Set not only conjoined in one person but actually identified with Ra (the sun-god), proceeding towards the eastern horizon of heaven and advancing on high. These and other texts point to the true interpretation of our pair of gods: they symbolize the northern and southern aspects of the sun and his dual sovereignty.

A much-damaged inscription which came from the ancient temple of Memphis, and which purports to have been copied from an older original by order of Shabaka, an Ethiopian king of Egypt (about B.C. 700), tells us of a fight between Horus and Set, which was brought to an end through the mediation of Seb, chief of the gods. Seb declared that there should be an arbitration between the belligerents, and summoned them to a mountain in the desert to the east of Memphis; each stood upon a hillock and there made peace, declaring the nome of An in which they stood to be the boundary of their territories. Seb then ratified the arrangement, and appointed Horus king of the north and Set king of the south. In this there is no allusion to the cause of the combat—no suggestion that Osiris had been slain, and it seems almost certain that the scribe who wrote the account to adorn the walls of the great Memphite temple was unacquainted with the legend of the enmity between Osiris and his brother Set, especially as the death of Osiris is mentioned in another connection in the same inscription. It may also be noted that the pyramid texts, though they speak continually of all three gods, and even occasionally refer to the contest between Horus and Set, never suggest that it was connected with the death of Osiris. We must conclude, then, that the Osirian myth, in the form in which Plutarch gives it, does not belong to the early ages of Egyptian history. Rather was the death of Osiris quite independent of the contest between the two Rehus (the name given by the Egyptians to a pair of gods, such as Horus and Set, Shu and Tefnut, Ra and Tehuti). It is not difficult to understand, however, how, in the process of amalgamation by which the Egyptian Pantheon was formed, the two myths would tend to coalesce and ultimately become fused. But that the new doctrine never altogether ousted the old is curiously illustrated by the position of Isis and Nephthys. Isis was the wife of Osiris, and Nephthys that of Set, and they ought, one would suppose, to be in antagonism; nevertheless, throughout Egyptian history they are the two beloved sisters who stand beside Osiris—the two weepers who mourn his death, and that of the dead man identified with him. This conception is clearly a survival of a much older mythology than that which the Greeks and Romans found in Egypt.

Fig. 1.—In the centre is the King Her-Hor; on the right of the picture are Nekhebit wearing the southern crown, and Horus offering the same emblem to the king; on the left are Uatchit and Set, respectively wearing and offering to the king the northern crown; over the king is the sun with the two snakes representing the sovereignty of the north and south.

How, then, shall we explain the fight? The most probable suggestion appears to be that it was invented to account for the divided sovereignty. When the "disease of language," mythology, had personified the two aspects of the sun, it was inevitable that stories should arise of how the double kingdom came into being. A fight, followed by the intervention of the great god Seb (or Tehuti, according to another version), and a division of the territory between the combatants, would at once commend itself to the good sense of the early Egyptian. Be that as it may: that the two gods did symbolize for many ages the sovereignty over the north and south is established beyond reasonable doubt. Later on, the antagonism which was originally represented as a mere fight for territory came to be regarded as an allegory of the eternal war between light and darkness, between the Nile and the desert, and even between good and evil. This last stage, which is supposed to have been arrived at under the influence of Persian ideas, was marked by the erasure of the name of Set from the monuments, and the substitution of other names for his in the religious papyri.

The duality of the Pharaoh's kingdom is expressed also by the two goddesses Nekhebit and Uatchit, who are represented usually by a vulture and a uræus, but sometimes by two vultures, sometimes by two uræi, sometimes by snake-headed vultures, and sometimes by winged snakes. From their continually receiving the same epithets as the southern and northern crowns (notably that of "mighty one of magical spells"), and also interchanging with the crowns in different copies of the same text, it seems reasonable to infer that they are in fact the crowns personified. Although this may be open to question, it is clear that Nekhebit and Uatchit are goddesses of the south and north. They usually wear the special crowns of their respective territories, they are represented standing on the plants emblematic of the two divisions, they are constantly depicted in close association with the two snakes depending from either side of the sun (who sometimes even bear their names), and they are also found in company with Horus and Set. One piece of sculpture seems to sum up the whole matter very effectively: the king is shown seated between the goddesses Nekhebit and Uatchit, each wearing her appropriate crown; beyond them, on either side, stand Horus and Set offering the two crowns to the king; beyond these again are written the speeches of the gods in making the presentation, and above is the sun's disc with the two uræi (*see* Fig. 1).

Here we must close this too brief sketch of the myths and symbols that gathered round the sun, and the Pharaoh as his image upon earth. To exhaust the subject would be well-nigh impossible, for, to the Egyptian, the sun was the one grand object of worship—the creator and sustainer of the universe; and concerning him, in his various personifications, myths innumerable were related.

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THE ROYAL SOCIETY OF PAINTERS IN WATER COLOURS.

It is to be noticed as a curious fact that in this exhibition the majority of the more important pictures are the work of artists well known to fame as painters in oil, illustrators, or designers; and to students particularly this fact would seem to be of some interest. Judging from the pictures themselves it is extremely difficult to find a satisfactory reason for this superiority on the part of those who have not made water-colour painting their specialty, for where this superiority is not maintained by a more ideal conception or truthful rendering of nature, it is to be found in the more prosaic qualities of technical skill.

On entering the gallery the attention is immediately arrested by Mr. J. M. Swan's "Jaguar and Macaw," in which we find a strength and freedom of colouring rarely attempted by one who makes water his only medium. Mr. George Clausen's "Tired Mower" is one of the most admired pictures here; yet the technique is poor, and the figure, though well drawn, is leaning on the scythe in an impossible manner. Mr. Clausen would certainly not have fallen into this error had he included modelling in his studies. Mr. Ernest A. Waterlow's little sketches are unsurpassed as truthful copies of nature; look, for instance, at "The Fields in June," a very lovely bit of sunlit meadows. In "Racing Nymphs," Mr. Weguelin gives us a delightful conception, in which fancy, draughtsmanship, and technical skill combine with equal merit. The works of Miss Clara Montalba, despite the repeated trick of composition and colour, are attractive beyond most of their compeers. The exhibits of Mr. Herkomer, Sir John Gilbert, Mr. Macbeth, Mr. David Murray, and Mr. E. J. Poynter, all hold a high place in this year's exhibition; and the same may be said of those sent by less well-known painters in oil. Mr. Walter Crane, one of our greatest cosmopolitans in the art world, sends one picture—"Britomart." Here, in places, we find the drawing weak, the modelling weaker, and the colouring none too pleasing; but behind all is the personality of Mr. Crane, with such a strength of conception and depth of artistic feeling, bred of wide sympathies, that the picture is one of the most striking and interesting in the gallery. Mr. Abbey—whose illustrations find the most devoted admirers in the old and new world—also sends one picture: a daring bit of composition, overstepping, in many ways, and with the best of results, the traditional bounds within which the water-colour school has found all possible requirements for the making of a good picture.

The exhibits of Mr. Carl Haag, Mr. R. Thorne Waite, Mr. W. Callow, Mr. E. Walker, and others, are, in many cases, equal in merit to those we notice above; but still the honours are held by those who have made their mark in some other branch of the kindred arts. And as to the reason of this? It is not stating the case fairly to say that the superior talent displayed is only what might be expected from artists of well-known high capabilities, for were not these same capabilities obtained, at least partly, by variations of the method of study? The greater understanding of his own language comes to him who is most intimately acquainted with that of others; and, similarly, the colourist can bring to bear on his canvas that knowledge which he can obtain only by his efforts on paper, and *vice versâ*.

We fear the general impression to be gathered from the above is the superiority of oils as a medium for the student; but we must point out that Turner and others used water for their closer studies, and found oil the better medium for the expression of their ideal. We might carry these inquiries into the other branches of the arts, and with less satisfactory results, for the more mechanical and less ideal the art, the more we find on the part of the workman a tendency to specialization.

Science Notes.

M. Lippmann has given a very interesting account of his experiments on colour photography before the Royal Society, and last month he also gave a discourse on the subject at the Royal Institution. He exhibited the pictures in natural colours which he has obtained, the vivid character of the tints being very striking. His earliest attempts were photographs of stained-glass windows, and his later work includes pictures of flowers, and landscapes showing the tints of brickwork and stonework, the green colour of leaves, etc. The method depends in principle on obtaining stationary light-vibrations in a sensitive film by means of a metallic mirror of mercury placed behind it. An interesting illustration of the length of waves of light was given by M. Lippmann in his lecture at the Royal Institution, when he stated that five hundred of the stationary waves of light, arranged in succession, can exist in a film of the thickness of ordinary note-paper. The dimensions involved may be realized by imagining a building of five hundred storeys, the height from base to roof, with its successive tiers, being comprised within the thickness of a sheet of paper.

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Observations made by M. Perrotin on Mount Mounier, at an elevation of about nine thousand feet above the sea, have convinced him that the period of the rotation of the planet Venus is equal to that of her revolution round the sun, the time of both being two hundred and twenty-five days or less. The observations were carried out in December of last year, and in February, 1896.

◆

"Ashtonian," writing from Ashton-under-Lyne, wishes to know (1) why the honey and pollen of poisonous plants like the foxglove are not detrimental to bees visiting the flowers; and, also, (2) the reason for certain of the ray florets of the daisy being tinged with red, while the rest are white.

(1) The nectar of a number of plants is poisonous—a quality shared also, no doubt, by their pollen. The principal constituent of honey is grape sugar; pollen grains can usually be detected in honey, and small quantities of other substances are present to which are due the peculiar colour, flavour, or fragrance by which special kinds of honey are distinguished. These substances sometimes impart narcotic or other deleterious qualities. Bees frequently fall out of gladiolus flowers in a state of helpless intoxication, and are therefore susceptible; but as the greater portion of the honey and pollen gathered by a bee is disgorged but little altered into the cells of the comb, only a small proportion of the poisonous principle can in most cases be absorbed into the insect's system. As, however, the larvæ are fed on honey and pollen, it is almost certain that bees must to some extent possess an immunity against poisons of this class.

(2) There appears to be a law of progressive colouration traceable in flowers, from the primitive yellow of the simpler blossoms through white, red, and purple to the deep blue of the highly specialized types. Most flowers are capable of reverting to the more primitive colours through which the species may be supposed to have passed in the course of its evolution, but they are apparently unable to give rise to an entirely new colour belonging to a stage of development to which the family has not yet attained. In the case of the daisy it is difficult to say whether the red at the tip of the ray florets is a new or a primitive colour due to reversion; the circumstance that the red appears at the extremities of the petals favours the view that it marks a new departure in the colouration of the species, for, as a rule, new colours appear at the outside, reversion tints at the centre of the blossom. But by cultivation the white ray florets may be converted into red, as in one variety of the garden daisy; and this fact accords fully better, perhaps, with the theory of retrogression. On this view the red tinge represents what once was the colour of the ligulate florets. Increase of light in many instances is known to intensify the colour of flowers.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

MIRA CETI.

To the Editors of Knowledge.

Sirs,—A maximum of ο Ceti, Mira, was predicted (*Companion to the Observatory*) for 1895, December 9th. But as its minimum occurred in October a search for it was not begun until late in November. Using a Lemaire field-glass of twenty-four lines, I succeeded in finding it definitely, December 6th, and thenceforward to date it was followed up assiduously without the loss of a single night upon which an observation of fair value could be obtained. The season has been unfavourable for such work, not only in this latitude but elsewhere throughout the States. The following estimates are the results of my best endeavours:—

1895.	Magnitude.	1896.	Magnitude.
December 6th	8·2	February 3rd	3·7
,, 9th	8·1	,, 4th	3·8
,, 11th	7·8	,, 9th	3·6
,, 14th	7·6	,, 10th	3·6
,, 21st	7·4	,, 13th	3·6
,, 26th	6·4	,, 14th, 15th, 16th	3·5
,, 28th	5·8	,, 21st	3·7
,, 30th	5·2	,, 25th	3·7
,, 31st	5·1	,, 28th	3·8
1896.		,, 29th	4·0
January 1st	4·9	March 1st	4·0
,, 3rd	4·7	,, 6th	4·1
,, 5th	4·5	,, 7th	4·3
,, 8th	4·0	,, 8th	4·2
,, 9th	4·1	,, 9th	4·3
,, 11th	3·9	,, 11th	4·4
,, 19th	3·5	,, 16th	4·6
,, 24th	3·7		

These figures show a maximum for February 15th, or a day or two before, and that the star reached this phase some sixty days later than the predicted date, and that its brightness was a magnitude less than the traditional light.

Comparison stars used:—γ Ceti, 3·60 magnitude; α Piscium, 3·9; δ, 4·2; V, 5·06; 66, 5·60; 70, 5·62; 71, 6·55; D, 6·62; H, 7·86; N, 8·12; all in Cetus.

R Leonis was again forty days ahead of the predicted maximum; magnitude only 6·4 January 10th.

David Flanery.

Memphis, Tenn., U.S.A.
18th March, 1896.

To the Editors of Knowledge.

Sirs,—On several occasions between the 7th and 26th December last I could just catch a glimpse of Mira Ceti with the naked eye by close watching and oblique vision. On the 29th December it was not thus visible to the naked eye, on account of the bright moonlight. Cloudy weather interrupted observations until January 6th, 1896, when Mira was readily visible to the unaided eye as a fourth magnitude star, being almost exactly equal with δ Ceti, and of a deep orange colour.

On January 10th and 11th it appeared to be a little brighter, and on the 18th I estimated it as but a little less bright than γ Ceti. Cloudy weather intervened until February 7th and 9th, when Mira was about equal with γ Ceti. After this it appeared to gradually decrease, and on February 23rd was about the same magnitude as δ Ceti.

Alta, Iowa, U.S.A., David E. Hadden.
March 16th, 1896.

SUN HALO.

To the Editors of Knowledge.

Sirs,—Last year I was with a party going through Palestine and Syria. On Saturday, the 20th of April, we stopped for luncheon at 11.30 a.m. on the plain a few miles outside of Damascus. After luncheon, at mid-day, we were suddenly surprised by a noticeable sight, which was very strange to us, and of which none of us could furnish an explanation; it was a triple rainbow. First, there was a complete rainbow all round the sun, with the usual colours, the red inside; second, to the south there was a partial rainbow, part of a circle, concentric with the circle round the sun, the red inside—this being evidently a reflection from the other; and, thirdly, there was another complete circle, but without the colours of the rainbow—just a broad plain ring, much like a lunar rainbow in appearance, this circle lying to the north, with an inclination to the west, though not quite north-west, its circumference running over the centre of the sun. All three were visible at the same time, and there was no rain. I should be glad to get an explanation of this curious phenomenon, and hope the matter will excite the interest of some readers of Knowledge. Helios.

[With regard to the optical appearance here described, the fact of the bow being *round* the sun, and the additional fact of the red colour being inside, are quite sufficient to determine the phenomenon as a halo; not a rainbow, but a bow generated by the direct transmission of light rays through ice crystals.

The other, *i.e.*, the second imperfect bow, also with red inside, was clearly enough another halo, as it had the sun also for its centre. The fact of the colours being similarly arranged also shows it to be a halo, which commonly has a red or an orange tint inside, with a bluish band *outside*. I take it, for this very reason, to be *not* a reflection, but a fresh halo with originating particles of a different refracting angle, and consequently of a different radius.

The circle resembling a lunar rainbow, which passed through the sun's disc, is, without doubt, a "halo of ninety degrees," an unusual form of halo, which owes its origin to the reflection of light from the pyramidal ends of snow crystals as they hang down towards the earth. A myriad of these, with a bright sun, produce an apparently continuous band which spans the heavens, the sun being in the circumference.—Samuel Barber.]

TIDE OF THE RIVER WYE.

To the Editors of Knowledge.

Sirs,—Would the October, 1883, tide on the Wye be the result of the Krakatoa eruption? The question only suggested itself to my mind while reading the fascinating paper by Rev. E. Rattenbury Hodges in the December, 1895, Number of Knowledge. The time distance between the eruption and the tidal rise would be between seven and eight weeks (August 27th to October 17th). Is this about the time the great wave would take to reach our shores? The tide was phenomenal. F. H. Worsley-Benison.

[In reply to Mr. Worsley-Benison's interesting question, I have no hesitation in saying that I cannot consider the Krakatoa eruption to have had anything to do with the high rise of the Wye in October, 1883, which was a *tidal* rise, the time of which, apart from its remoteness from the east side of the Indian Ocean, shows it to have been part of the great tidal wave due to lunar and solar influence.

A seismic wave is one caused by a volcanic eruption; although it may reach coasts at a great distance *if there is no intervening land*, it is non-coincident with the cosmic tidal wave.—J. Logan Lobley.]

THE APPROACHING TOTAL ECLIPSE OF THE SUN.

By A. Fowler, F.R.A.S.

Total eclipses of the sun have attracted great attention in all times, and are justly regarded as among the most impressive of natural phenomena. So much has been written in description of them that there are probably few readers who are not familiar with the general features of an eclipse, although, in the words of the late Mr. Hind, "no description could give an idea of its awful grandeur." The vast extension of pearly luminosity, surrounding the almost inky blackness of the moon, is certainly quite unique, and can be likened to nothing else.

On the 9th of August there will be a total eclipse, which will, fortunately, be visible from places comparatively near home, and a large number of British astronomers will take advantage of the splendid facilities offered for making the necessary journey. A few particulars as to the way in which the eclipse will be utilized by the various observers may, therefore, be of interest at the present time.

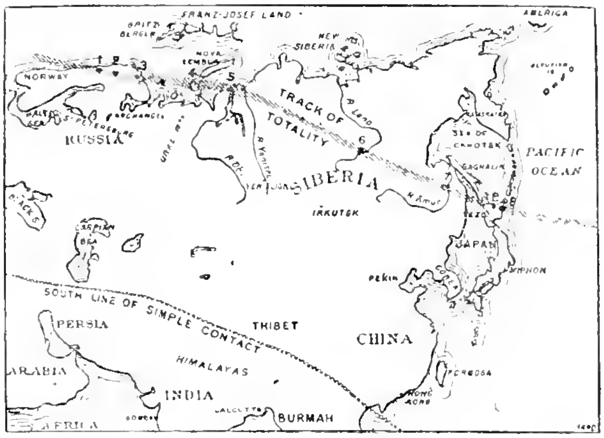

Fig. 1.—Track of Moon's Shadow, August 9th, 1896.

The line of central eclipse will pass through the North of Norway, Nova Zembla, Siberia, and Japan, as shown in Fig. 1, for which we are indebted to the editor of the *Journal of the British Astronomical Association*.* In Norway the most favourable station appears to be Vadsö, on the Varanger Fjord, and it is here that the greatest number of observers will await immersion in the moon's shadow. At this point the duration of totality will be about one hundred seconds, with the sun fifteen degrees above the horizon. Astronomically, Japan will furnish the best observing stations, but it is not sufficiently accessible to meet the requirements of many observers. Here totality will last more than two and a half minutes, and the sun will be much higher than in Norway.

Eight stations along the line of totality, indicated by the numbers in Fig. 1, will probably be occupied by various parties of observers.

(1.) Near Bodö there is certain to be a considerable gathering, although the conditions are not favourable to serious work.

(2.) Enontekis, Finland, has been selected by one of the expeditions of the Russian Astronomical Society, and by Prof. Glasenapp and L. G. Vuchikhovsky.

(3.) In the neighbourhood of Vadsö there will be one of the Government expeditions, including Dr. Common, Prof. Lockyer, and the writer; a large section of the British Astronomical Association, headed by Dr. Downing and Mr. Maunder; Dr. Copeland, the Astronomer Royal for Scotland; Sir Robert Ball; Mr. Evershed; M. Antoniadi, from M. Flammarion's observatory; and many others.

(4.) Nova Zembla has been chosen by the Russian Academy of Sciences and the Kazan Society of Naturalists.

(5.) At the mouth of the Obi there will be another section of the Russian Astronomical Society.

(6.) Olekminsk, on the Lena, will be occupied by the chief expedition of the Russian Astronomical Society, and by Prof. Voznesensky of the Irkutsk Meteorological Observatory.

(7.) A station on the Lower Amur has been selected by an expedition from the Pulkowa Observatory.

(8.) In the Island of Yezo, Japan, there will be a British Government expedition, consisting of the Astronomer Royal, Prof. Turner, and Captain Hills, R.E.; a French expedition under M. Deslandres; a party from the Lick Observatory, under Prof. Schaeberle; and another American expedition directed by Prof. Todd.

The duration of a total eclipse is so very brief that the utmost use must be made of every moment. Good organization is accordingly the keynote of success, and to this end a considerable amount of preliminary inquiry and discussion is essential. The arrangements for the Government expeditions have been made by a joint committee of the Royal and Royal Astronomical Societies, which has met at intervals during the last three years. The principal objects to be undertaken are to secure permanent and unbiased photographic records of the corona, and of the spectra of the various parts of the solar surroundings. Such records are considered the first duty of an organized eclipse expedition, but if instruments and observers be available the programme may be extended to include special pieces of research.

At the Japanese station the Astronomer Royal will employ the Thompson photoheliograph of the Royal Observatory, giving an image of the sun nearly four inches in diameter. It is not expected that the filmy outlying parts of the corona will be bright enough to impress their images on this large scale; but the very beautiful pictures obtained by Schaeberle in 1893 encourage us to hope that the finer structure of the inner corona will be depicted with almost telescopic minuteness.

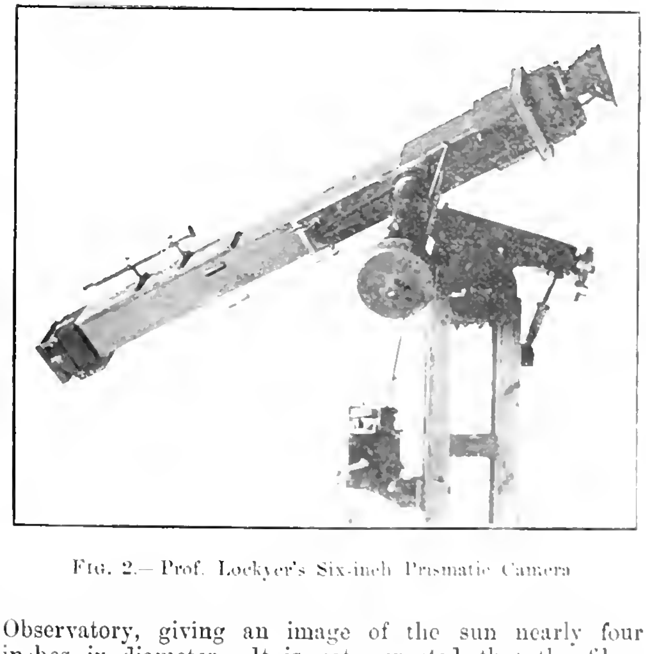

Fig. 2.—Prof. Lockyer's Six-inch Prismatic Camera

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* *See Journal B.A.A.*, p. 298.

Professor Turner will use well-tried instruments, which, although yielding pictures on a small scale, will give results strictly comparable in every particular with those of former eclipses. The images will be small and bright, and a special endeavour will be made to register the very delicate regions of the outer corona. One set of pictures will be on a scale of a half-inch to the sun's diameter, and another one and a half inches, the latter being enlarged by a "telephoto" lens.

At the Norwegian station the arrangements for photographing the corona will be in the capable hands of Dr. Common. Part of his outfit will probably consist of a modified Cassegrain reflector, giving large images of the corona; and other instruments which he will employ will give relatively small but bright images similar to those which Prof. Turner hopes to secure in Japan.

During the coming eclipse there will be a new departure in the instrumental arrangements for photographing the corona. In place of the equatorials which have almost invariably been employed up to the present time, the photographic telescopes will be fixed, and will receive the light of the corona after reflection from the mirror of a "cœlostat." The new instrument is an exceedingly portable form of heliostat which has recently been brought to the front by M. Lippmann. It consists simply of a mirror which is made to revolve on a polar axis in its own plane at the rate of one revolution in forty-eight hours, in the same direction as the apparent diurnal motion of the heavens. In a mirror so mounted the image of any celestial object whatever appears stationary, and a telescope pointed at the mirror in any direction will have a constant field of view.

The official observers, however, will not have the photographic field to themselves, although they will naturally have a monopoly of work which can only be done by large instruments. Many members of the British Astronomical party will make use of their cameras and telescopes, and Mr. Lunt will employ the three-inch photographic telescope with which he has been so conspicuously successful in stellar photography. The American observers in Japan will be chiefly occupied in photographing the corona on a large scale with objectives of long focus, and the same method will be adopted by the Russian observers at Olekminsk. Several ordinary cameras will be at work at the mouth of the Obi, and at Enontekis clock-driven cameras will be employed.

If the photographs of the corona are as successful as everyone desires, they should throw light on various points of solar physics. The larger pictures should especially enable us to learn something of the solar currents, "lines of force," or whatever it may be that determines the peculiar structure of the solar appendages. The distribution of coronal matter in different solar latitudes should also be revealed, and an investigation of its connection with the sunspot zones will become possible. Another point on which the photographs permit inquiry is the law of decrease in the intensity of the corona in passing outwards. Finally, if success is met with all along the line, it will be possible to determine if the corona changes its form in the interval of about one and a half hours intervening between the observations in Norway and Japan. It may be remarked, however, that previous experience does not favour the idea of such rapid changes.

In addition to the photographic records of the appearance of the corona, there will doubtless be many attempts at sketching. Chief among the workers in this field will be Mr. N. E. Green, a gentleman of high artistic ability, who is well known to the readers of Knowledge.

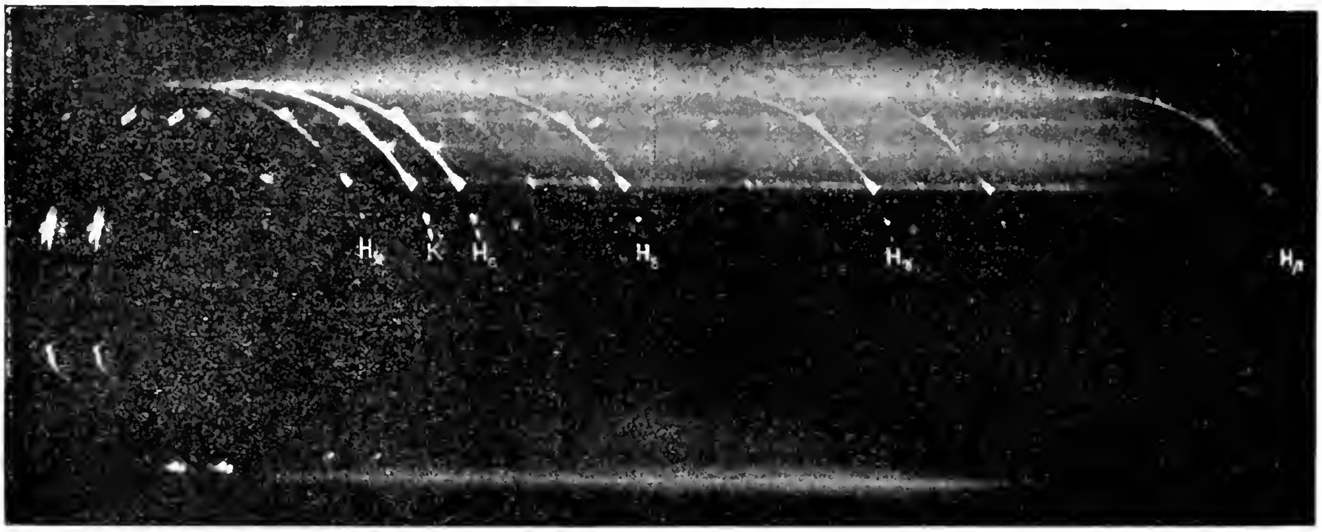

Fig. 3. Photograph of Eclipsed Sun, April 16th, 1893. Taken with Six-inch Prismatic Camera in West Africa by Mr. Fowler.

We now come to the spectroscopic part of the attack. The spectrum of every prominence, every part of the visible chromosphere, and of as many regions of the corona as possible is to be observed or photographed, in order that the duty of fully recording the phenomena shall be faithfully accomplished. It is true that the chromosphere and prominences can be investigated without an eclipse, but it would be unwise to completely neglect them in the belief that we perceive everything connected with them in our daily observations. At the same time, as the corona cannot yet certainly be observed at all except during an eclipse, and the lower reaches of the chromosphere only very imperfectly, it is to these features that attention will be chiefly directed.

For recording the spectroscopic appearances, instruments of two forms are employed—those which are provided with slits, and those which utilize the eclipsed sun itself as a virtual slit in the form of a ring.

The ordinary slit spectroscope may be used in either of two ways. It may be employed as an integrating spectroscope by simply directing the collimator to the moon's centre, or as an analyzing spectroscope by placing the slit in the focal plane of a telescopic objective or condenser. In the first case the spectra of corona, prominences, and chromosphere will all be superposed, so that in the absence of other evidence the spectra of the different parts could not be separated. The use of a condensing lens enables the observer to localize some particular region of the corona upon the slit, and its spectrum may then be studied apart from that of its neighbours.

Spectroscopes without slit or collimator were first employed for eclipse observation by Respighi and Lockyer, in 1871. The principle of this method is very simple. In an ordinary spectroscope the function of the collimating lens is to render parallel the rays proceeding from the slit; and the "lines" which one usually associates with spectra are simply images of the slit. If the ordinary slit be replaced by a circular one the spectrum lines become spectrum rings; indeed, the shape of the slit in all cases is reproduced in the "lines." The rays proceeding from the sun are already parallel, so that a collimating lens is superfluous, and the eclipse itself is at once the source of light and the slit. The eclipsed sun is in reality a number of independent slits: one—a complete ring—corresponding to the corona, and others of irregular form corresponding to the different parts of the chromosphere and prominences. Each "line" in the spectrum of a prominence is represented by a picture of the prominence, and if different vapours are unequally distributed these images will differ.

When the slitless spectroscope is employed for photography it becomes a "prismatic camera," and takes the form of a large prism placed in front of the objective of a photographic telescope. Such an instrument is shown in Fig. 2, and a photograph taken with it in Fig. 3, both of which we owe to the kindness of Prof. Lockyer. As a single exposure gives the spectrum of every part of the solar surroundings, the prismatic camera provides a very complete record of the spectroscopic appearances during an eclipse. For a considerable interval before and after totality the sky illumination is sufficiently reduced to show the chromosphere spectrum near the cusps of the crescent sun, and very valuable photographs may therefore be taken out of totality. Incidentally it turns out that the prismatic camera is the best possible instrument for photographing the solar prominences. This is illustrated in Fig. 4, which is an enlarged view of a group of prominences photographed in K light during the eclipse of 1893.

Fig. 4.—Prominences in K Light. Prismatic Camera, 1893.

Captain Hills has provided himself with a very fine slit spectroscope, having four quartz prisms and a condensing lens of four and three-quarter inches aperture, with which he hopes to photograph the spectrum of the corona. The instrument will be fixed on a horizontal base, and the rays of light from the eclipsed sun will be reflected into it by a heliostat of the ordinary form.

In Norway the principal spectroscope to be employed by Prof. Lockyer and the writer is a prismatic camera of six inches aperture, which was very successfully used in Africa in 1893. The instrument is mounted as an equatorial, and the arrangements provide for the exposure of a large number of plates in quick succession. An integrating spectroscope will also be employed by Prof. Lockyer.

We understand that Dr. Copeland will be armed with a prismatic camera, while Mr. Evershed will employ spectroscopes of both forms. The Russian party at Olekminsk will also be provided with a slit spectroscope arranged to photograph the coronal spectrum, and this method will probably be followed by M. Deslandres in Japan.

As the photographic plates cannot yet be relied upon to completely delineate the less refrangible parts of the spectrum under the special circumstances of an eclipse, they will be supplemented by visual observations. Mr. Maunder intends to use a slitless spectroscope to study specially the distribution and extension of the green ring corresponding to 1474 K, and it is hoped that other observers will similarly record the appearances of the yellow line of helium and the red line of hydrogen.

Apart from adding to our scanty knowledge of the undoubted coronal spectrum, and its possible variation from one eclipse to another, one of the chief points on which it is hoped that the spectroscopic work will enlighten us is the location in the sun's atmosphere of the vapours which produce the Fraunhofer lines. There is little doubt that the base of the chromosphere—the so-called "reversing layer"—is rich in bright lines, but the precise relation of these to the dark ones of the Fraunhofer spectrum is by no means understood.

Among the more special investigations which will probably be undertaken one may mention that Dr. Downing will make polariscopic observations, with the view of ascertaining the proportion of reflected to intrinsic light in the corona.

Photometric observations, having for their object the determination of the general brightness of the corona, will probably also be made at some of the observing stations, easy methods for doing this having been suggested by Mr. Maunder and Mr. Lunt. Mr. Crommelin has drawn attention to the desirability of recording the attendant phenomena, such as the mysterious "shadow bands," and some of the observers who have no telescopes will doubtless keep a look-out for such appearances.

The Russian observers at Enontekis will study the relation of the coronal spectrum to that of helium, and there is little doubt that M. Deslandres will endeavour to test the truth of his conclusion from the observations of 1893, that the corona shares in the general solar rotation. Prof. Voznesensky's object during the eclipse will be to investigate the meteorological effects which accompany the temporary obscuration of the sun's light and heat.

From what has been said it is evident that there will be no lack of observers during the forthcoming eclipse, and all friends of science will wish them the utmost success in the various researches undertaken.

PHOTOGRAPH OF THE CLUSTER MESSIER 24 CLYPEI.

By Isaac Roberts, D.Sc., F.R.S.

R.A. 18h. 12m., Decl. S. 18° 28′.

THE photograph covers the region between R.A. 18h. 9m. 15s. and 18h. 16m. 2s. Declination between 17° 49′ and 19° 2′ south.

Scale, one millimètre to twenty-four seconds of arc.

Co-ordinates, for the epoch A.D. 1900, of the fiducial stars marked with dots.

Star (·). D.M. No. 4861. Zone − 18°. R.A., 18h. 9m. 38s. Decl., S. 18° 11·1′. Mag., 6·8.

Star (··). D.M. No. 4886. Zone − 18°. R.A., 18h. 11m. 37·1s. Decl., S. 18° 30·0′. Mag., 6·7.

Star (.·.). D.M. No. 4896. Zone − 18°. R.A., 18h. 12m. 51s. Decl., S. 18° 39·6′. Mag., 7·3.

Star (: :). D.M. No. 4900. Zone − 18°. R.A., 18h. 12m. 56·4s. Decl., S. 18° 12·5′. Mag., 8·2.

Star (:·:). D.M. No. 4926. Zone − 18°. R.A., 18h. 15m. 28·7s. Decl., S. 18° 54·2′. Mag., 6·0.

The photograph was taken with the 20-inch reflector on August 14th, 1895, between sidereal time 18h. 57m. and 20h. 57m., with an exposure of the plate during two hours.

References.

The cluster is N. G. C., No. 6603; G. C., No. 4397; and h 2001.

Sir J. Herschel (G. C., 4397) describes the cluster as remarkable, very rich, very much compressed, round, and the stars of the 15th magnitude.

The photograph shows the cluster to be in shape somewhat resembling a horseshoe, with the open side pointing towards the *north preceding*, and the stars, both in it and in the regions around, are in lines and curves of various form. The stream of the Milky Way is well shown on the photograph, with dark spaces in which are few stars, and in some places none; the brightest star on the plate is only 6·8, and the faintest about 17th magnitude. The white line which is shown on the cluster consists of five or six stars so close together that their photo-images overlap; and on several other parts of the plate where the stars show an elongation, it is due to double or multiple stars.

There are doubtless many of our readers who possess a telescope which is equatorially mounted, and would like to examine visually those parts of the sky where are the marvellous groups and curves of stars which are shown on the annexed as well as on other photographs already published in Knowledge; and, in order to enable them to point their telescopes upon such objects, the application of the following simple methods will suffice.

Let us suppose that it is desired to determine the coordinates (right ascension and declination) of the centre of the small group of stars sixty-six millimètres from the *north* edge and eighty-five millimètres from the *preceding* edge of the photograph annexed: and also to ascertain what would be the diameter of a circle drawn on the photograph that would be equal to the field of view of an observing telescope, which we will assume to be five hundred and fifty-two seconds of arc in diameter?

Two questions are herein involved, and we will answer the second in the first order. The scale of the photograph is, as already stated, twenty-four seconds of arc to one millimètre, and the field of view of the observing telescope five hundred and fifty-two seconds of arc; the measured diameter, in millimètres, of a circle drawn on the photograph will therefore, obviously, be $\frac{552''}{24}$ = 23 millimètres. If we take, between the points of a pair of compasses, the radius 11·5, and with it describe a circle on a piece of paper; then cut out the interior and apply the vacant circle of twenty-three millimètres in diameter to any part of the photograph, it will, approximately, represent the telescopic field of five hundred and fifty-two seconds of arc in diameter; where, within a corresponding coincident area in the sky (if the telescope is of sufficient power to show stars down to about the 17th magnitude), all the stars shown on the photograph would be visible.

The other question—how to determine the co-ordinates of the positions of any star or other object shown on the photograph—will be answered in the following manner:—

First.—How to find the right ascension of the centre of the group of stars referred to above:—

The R.A. of the fiducial star (: :) = 18h. 12m. 56·4s.
,, ,, ,, (··) = 18h. 11m. 37·1s.

0h. 1m. 19·3s. = 79·3s.

(the difference in R.A. between them). We must now convert these 79·3 seconds of time into millimètres for measurement purposes, and that can readily be done by aid of the table annexed, which is computed to show the value of one millimètre, in seconds of time, at each degree in declination between the equator and the poles. The declination of fiducial star (: :) is 18° 12·5′ *south*; and by referring to the table we find the value of one millimètre at eighteen degrees from the equator to be 1·68 seconds of time in R.A., and therefore $\frac{79\cdot3\text{s.}}{1\cdot68\text{s.}}$ = 47·2 millimètres. Take this distance between the points of a pair of dividers; place one point on the centre of the fiducial star (: :) and extend the other point towards the *preceding* side; at the same time place a rule, having a fine edge, in *north* and *south* direction so as to bisect both fiducial star (··) and the disengaged point of the dividers.

The edge of the rule is then on the meridian (18h. 11m. 37·1s.) of the fiducial star (··); and whilst the rule is firmly held in this position, measure the distance of the centre of the group of stars herein referred to from it, which will be found to be 3·2 millimètres. Then 3·2 × 1·68 5·37 seconds of time, being the distance in R.A. of the centre of the group from the meridian of fiducial star (··), and 18h. 11m. 37·1s. + 5·37s. = 18h. 11m. 42·47s. is the required R.A. of the centre of the group.

Second.—To find the declination of the centre of the group:—

The declination of the fiducial star (··) is 18° 30·0′
,, ,, ,, (: :) ,, 18° 12·5′

0° 17·5′ = 1050″ of arc,

which is the difference in declination between the two stars; and since the scale of the photograph is twenty-four seconds to one millimètre, 1050″ ÷ 24″ = 43·75 millimètres. Take this distance between the points of the dividers, and place one point on the centre of fiducial star (··) and extend the other point towards the *north*: at the same time place the rule with its edge in the direction of a parallel of declination, and bisecting both fiducial star (: :) and the disengaged point of the dividers.

The edge of the rule is then in the parallel of declination of fiducial star (: :); and whilst the rule is firmly held in this position, measure the distance of the centre of the group of stars from it, which will be found to be 6·5 millimètres. Then 6·5 × 24″ = 2·6 minutes of arc, and by adding this quantity to the declination of fiducial star (: :) we obtain the declination required of the centre of the group: which is 18° 12·5′ + 2·6′ = 18° 15·1′. Refraction in this case will be a small quantity, but if required the correction for it can be made in the usual way.

The fiducial stars (··) and (: :) have been chosen in by ISAAC ROBERTS, D.Sc., F.R.S.

these illustrations because they are the nearest to the object the position of which is required, and it will be understood that the same result could have been obtained by using instead of them any other two of the fiducial marked on the photograph. The fiducial star (:·:) is Y Sagittarii, which is variable between 5·8 and 6·6 magnitude.

A Table

For converting the measured *Right Ascensions* of the Stars shown on the Photographs (which are to the scale of 1 millimètre to 24 seconds of arc) into intervals of time at each Degree in Declination between the Equator and the Pole.

Declination.	1 Millimetre seconds of R.A.	Declination.	1 Millimetre = seconds of R.A	Declination.	1 Millimetre seconds of R.A
0°	1·60	30°	1·85	60°	3·19
1	1·60	31	1·86	61	3·30
2	1·60	32	1·88	62	3·41
3	1·60	33	1·90	63	3·53
4	1·60	34	1·92	64	3·65
5	1·60	35	1·95	65	3·79
6	1·60	36	1·98	66	3·94
7	1·61	37	2·00	67	4·08
8	1·61	38	2·03	68	4·26
9	1·62	39	2·05	69	4·46
10	1·62	40	2·08	70	4·67
11	1·63	41	2·11	71	4·90
12	1·63	42	2·15	72	5·16
13	1·64	43	2·18	73	5·46
14	1·64	44	2·22	74	5·84
15	1·65	45	2·26	75	6·21
16	1·66	46	2·30	76	6·64
17	1·67	47	2·34	77	7·01
18	1·68	48	2·39	78	7·68
19	1·69	49	2·43	79	8·24
20	1·70	50	2·48	80	9·27
21	1·71	51	2·54	81	10·25
22	1·72	52	2·59	82	11·45
23	1·71	53	2·65	83	13·27
24	1·75	54	2·71	84	15·37
25	1·76	55	2·78	85	18·12
26	1·77	56	2·85	86	23·36
27	1·79	57	2·93	87	30·74
28	1·81	58	3·01	88	48·66
29	1·83	59	3·10	89	97·33

Editorial Note.—The August and September numbers of Knowledge, it is hoped, will contain illustrated articles on the Total Eclipse of the Sun. These articles will be written by Mr. E. Walter Maunder, F.R.A.S., who has arranged to visit Norway on board the *Norse King*, to observe the eclipse.

Notices of Books.

Popular Telescopic Astronomy. By A. Fowler, A.R.C.S., F.R.A.S. (G. Philip & Son.) Illustrated. 2s. There are many who would procure a telescope and direct it heavenwards, but they think that a small instrument is incapable of bringing good views within the vision of an observer. They forget that Galileo's telescope was no better than one which can now be purchased for a couple of shillings; yet he discovered with it the phases of Venus, the stellar constitution of the Milky Way, and four moons of Jupiter. Large instruments have their functions, but there is plenty of work for possessors of smaller ones, and, even if no remarkable discoveries are made, the increased knowledge derived from observation will bring untold satisfaction. With such a guide to the heavens as this of Mr. Fowler's, an observer will soon find his way about the constellations. Of orderly construction, clear composition, and trustworthy character, the book is an ideal companion for students beginning the outdoor study of astronomy. Less than twenty pages are taken up with descriptions by the guidance of which a workable two-inch achromatic telescope can be constructed; the remainder of the book is concerned with the sun, moon, planets, and stars. We confidently anticipate a successful career for a volume possessing all the features required in an introduction to observational astronomy.

An Introduction to the Study of Seaweeds. By George Murray, F.R.S.E., F.L.S. (Macmillan.) Illustrated. 7s. 6d. Many people, actuated by æsthetic considerations, collect and preserve seaweeds, and others do so because they like to possess collections, and think that algæ are as worthy objects of attention as postage stamps. The student is distinct from both these classes; for he collects specimens for the purpose of inquiring into their characteristics and discovering their relationships to one another. This book is intended for such seekers after knowledge, and it possesses all the attributes of a good text-book, being trustworthy, clear, and a true image of the present state of the subject treated. In the opening chapter, Mr. Murray gives an admirable review of the growth of knowledge of "the flora of the sea," and equipped with the facts therein contained students will be in a position to take a clearer and broader view of the subject than if they were launched at once among descriptions of species. A list of selected books and papers on marine algæ follows the introduction, and the remainder of the volume is taken up with descriptions of the various orders of the five sub-classes.

Our Country's Butterflies and Moths, and How to Know Them. By W. J. Gordon. Illustrated. (Day & Son.) Although an extraordinary number of books have been published during the last twelve months on the British lepidoptera, yet they are all quite different, and each one seems to have its use. The object of the book now before us is to provide a handy means for identifying specimens. It aims neither at classification nor at elaborate description. The chief means of identifying specimens by this book lies, therefore, in its illustrations. These consist of a thousand coloured examples by Mr. H. Lynn. Considering their number and the small size of the book these are good on the whole, but we fear that the novice will never be able to identify some of his specimens from them, the colouring in many instances being much at fault. The book is well arranged, however, and should prove useful to the young collector.

Furs and Fur Garments. By Richard Davey. (The Roxburghe Press.) Illustrated. This little book affords both interesting and instructive reading. It deals with the history of furs as garments from the earliest times up to the present, and dwells at considerable length on the fur garments worn by royal and noted persons of different countries and times. The history of the fur trade and of a good many of the fur-bearing animals is also included, as well as the mode of procuring and preparing the skins. The illustrations are excellent, and the book forms a valuable record.

The Artist. (Constable.) The May Number of this monthly is a positive triumph, whether considered from an artistic, literary, or technical point of view. Its motto seems to be "thoroughness." In its own line we do not know a better work, and it should be in the hands of all who concern themselves in art matters. The supplement, "The Harvest of the Studios," with its wealth of fine reproductions, makes this number a truly wonderful six-pennyworth.

SHORT NOTICES.

Principles of Metallurgy. By Arthur H. Hiorns (Macmillan.) Illustrated. 6s. The author's "Elementary Metallurgy" is already well known to students of the subject, and the present work forms an admirable sequel to it. Besides explaining the principles of metallurgy, and giving other valuable information, it expounds the views of modern metallurgists, and the methods of extracting various metals from their ores.

First Stage Mechanics. By F. Rosenberg, M.A. (Clive.) 2s. This work has been designed, we are told in the preface, to cover the requirements of the elementary stage of the Science and Art Department in the theoretical mechanics of solids. To this end the work is eminently successful.

Practical Inorganic Chemistry. By G. S. Turpin, M.A., D.Sc. (Macmillan.) Illustrated. 2s. 6d. This is a clear and practical guide to elementary chemistry.

Submarine Telegraphy. By James Bell and S. Wilson. (*Electricity.*) Illustrated. 1s. 6d. This book is composed of reprints of papers which were published under the heading of "Technical Telegraphy Papers" in *Electricity.* It should prove useful to telegraphists

Messrs. Wesley & Son send us a very full catalogue of valuable books which should be seen by every zoologist.

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BOOKS RECEIVED.

Artistic and Scientific Taxidermy and Modelling. By Montagu Browne, F.G.S., F.Z.S. (A. & C. Black.) Illustrated. 21s.

Introduction to the Study of Fungi. For the Use of Collectors. By M. C. Cooke, M.A., LL.D. (A. & C. Black.) Illustrated. 14s.

A Dictionary of Chemical Solubilities—Inorganic. By A. M. Corney, Ph.D. (Macmillan.) 15s.

A Compendium of General Botany. By Dr. Max Westermaier. Translated by Dr. Albert Schneider. (New York: Wiley. London: Chapman & Hall.) Illustrated. 8s. 6d.

The Elements of Physics. By E. L. Nichols and W. S. Franklin, Vol. I.—"Mechanics and Heat." (Macmillan.) Illustrated. 6s.

A Handbook of the Order Lepidoptera. By W. F. Kirby, F.L.S., F.E.S. Part I.—"Butterflies." Vol. II. Allen's Naturalist Library. (Allen.) Illustrated. 6s.

Handbook for the Bio-Chemical Laboratory. By J. A. Maudel. (New York: Wiley. London: Chapman & Hall.) 6s. 6d.

Milk: its Nature and Composition. By C. M. Aikman, M.A., D.Sc. (A & C. Black.) Illustrated. 3s. 6d.

Meteors and Sunsets observed at Lick Observatory in 1893, 1894, and 1895. (Sacramento: A. T. Johnston.) Illustrated.

Biological Experimentation. By Sir B. W. Richardson, M.D., F.R.S. (Bell & Sons.) 2s. 6d.

Notes on the Revised Latin Primer. By A. A. Ogle, B.A. (Relfe.) 1s.

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WAVES.—VI.

STANDING WAVES IN FLOWING WATER.

By Vaughan Cornish, M.Sc.

Waves of flowing water are the familiar surface corrugation of babbling brooks, rippling streams, mountain burns, the rapids of rivers, and the tide races of the sea. There are also most beautiful varieties of these waves to be seen where water cuts a channel through a sandy bed in making its way across the beach to the sea, as shown in Fig. 1.

If a stone too heavy for the current to move be thrown into a shallow, rapid, brook, the water rises in a heap over the obstacle, the forward motion of the water being checked, and an upward slope being given to the current, whilst on the lee side of the obstacle the water gathers speed as it slides along the downward slope of the billow, and falls below the proper level of the stream. If we watch attentively the course of events, we find that a second billow is quickly formed to leeward of the first, and then a third and a fourth, and so on; until the lengthening group of diminishing waves extends to a considerable distance down stream. Each wave crest maintains its position relatively to the stone, and from this comes the term *standing* wave, for there is apparently no bobbing up and down as in the stationary (*i.e.*, non-progressive) sea waves which may be seen near a vertical breakwater, or in harbours, or in docks. Sometimes, however, they are called stationary waves of flowing water, but standing waves is a more descriptive term. It is further to be noticed that although the wave crests are stationary relatively to the stone which produced them, yet they travel relatively to the water. The stone and the water are in relative motion, just as when a boat is tugged along a canal the boat and the water are in relative motion. A canal boat, if moving sufficiently quickly, is followed by a group of waves, each crest keeping its position relatively to the boat as long as the velocity of the boat remains the same. Most of the facts which are known about canal-boat waves may be applied directly to standing waves in shallow streams. If the stone which we used to form the group of standing waves be slowly rolled down stream by the force of the current, the group of waves moves with it. If, on the other hand, we attach a cord to the stone and drag it up stream, the group of waves travels up stream with the stone. If the velocity of the stream should slacken, the length from crest to crest of the waves to leeward of our stationary stone is diminished; if, on the other hand, the stream should swell, and flow more quickly, the wave-length is increased. The relation of wave-length to velocity is the same as in the case of canal-boat waves.

The differences of level in the standing waves are such as to balance the differences of horizontal pressure, the free surface of the water being a surface of uniform pressure. Thus the height of the first hillock of water depends upon the pressure of the stream upon the stone. It will be noticed in looking at the waves of rapid streams that their steepness is often much greater than that which is attained by wind-formed waves, and is comparable to the steepness of "steamboat waves." When a particle of water has been forced by the current to the summit of the heap which surmounts the stone, gravity pulls it down, and the inertia of the motion thus imparted carries it below its proper level, from which the hydrostatic pressure of the neighbouring water again raises it; and so the oscillation goes on, the amplitude diminishing at each swing. The particle, however, has a forward motion given by the current, as well as the pendular oscillation, so that at the end of the oscillation the particle is not in the same position as that from which it started. The pull of gravity causes the particle to occupy successively positions above and below the proper stream level. There is also an alternate backward and forward motion relatively to the current, as the current would be if the stream were allowed to flow uniformly without the interruption caused by the stone. The forward motion of the surface particle is retarded when it is above the mean level of the stream and accelerated when it is below the mean level. On the whole, therefore, the *wave motion* of the particle is the repeated description of a closed curve about the positions which it would successively occupy if flowing in the undisturbed stream. The actual motion compounded of current and wave motion of a particle on the corrugated surface of a stream is similar to the motion of the car of the switchback railway: slow, horizontal, on the top of the hill, gaining velocity on the downward slope, flying up the lower portion of the next hillock with the aid of the momentum gained in its fall, but with slackening speed as it rises; its velocity less than that proper to the stream at all points above the nodal line of the undisturbed level of the stream, greater than this at all points below the nodal line. That the general velocity of the stream under the troughs is greater than that under the crests, is sufficiently obvious from the fact that when a group of standing waves has been formed the current which flows is constant in quantity. Therefore the same amount of water passes per second across a shallow section (under the troughs) and across a deep section (under the crests).

If the stone be tugged up stream the length from crest to crest is greater than if the stone be at rest, for the velocity of the current relatively to the stone is increased. As the speed of the stone up stream is increased the wave-length continually increases, but the train of waves becomes shorter, as in the case of a canal boat, until, when the velocity of the stone relatively to the current is equal to the velocity of a free long wave in a channel of the given depth, there is no longer a train of waves but a single hillock accompanying the motion of the stone. When this state of things has been reached the vertical oscillation of the water particle is insignificant compared with the horizontal component of the motion. For shorter waves from stationary obstacles in ordinary shallow streams the motion is presumably elliptical or approximately so, the ellipse becoming more nearly a circle for shorter waves in deeper water. If we were to push our experiment of dragging a stone up stream beyond the critical velocity, the effect would be that the stone would leave the "solitary" wave behind it, the velocity of a free solitary wave being strictly limited by the depth of the stream. In this way a number of independent solitary waves might be produced on the lee side of the stone.

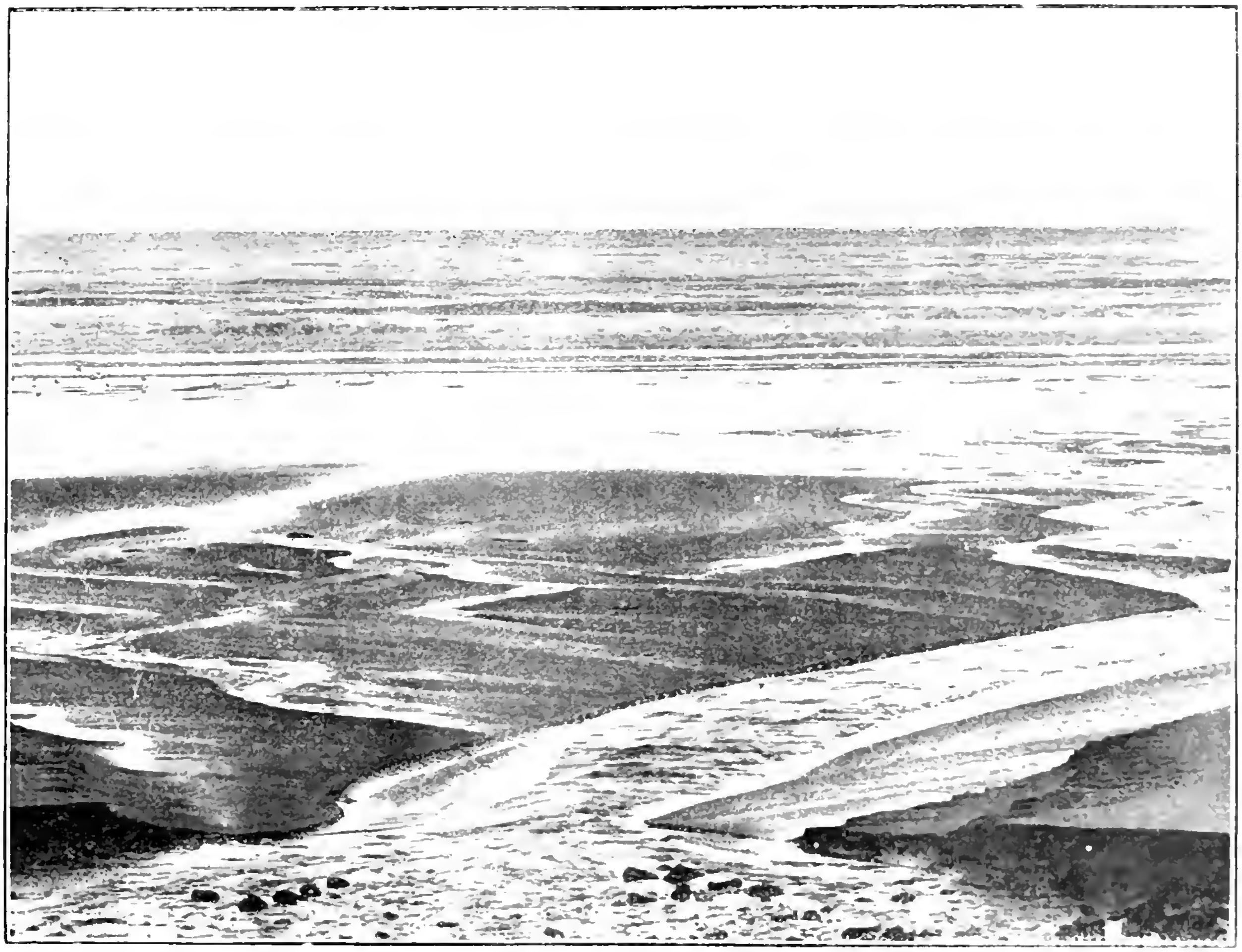

Fig. 1.—Rhossilby Bay. From a Photograph by Mr. F. H. Worsley-Benison.

If, on the other hand, we were to watch what takes place when the current rolls a stone down stream, we should find the wave-length shorter than in the case of a stationary stone, because the relative velocity of stone and current is diminished.

In all cases where a *group* of waves is formed, one wave making many, the energy travels slower than the wave: it falls behind the wave and makes another, so that the group lengthens, the tail of the group moving more slowly (relatively to the current) than the head, just as in the track of ships (*vide* Knowledge, March and April, 1896).

It will often be noticed that the first wave crest to leeward of a stone in a shallow stream (the first wave being that which has greatest amplitude) is a cusped or breaking wave, the cusp being, of course, on the up-stream side. This happens when the downward rush of the water on the lee side of the obstacle carries the water surface far below the proper level of the stream, so that under the trough the water is very shallow, and under the crest relatively deep. This is a similar condition to that of the breaker of the seashore the wave velocity in the crest is greater than that in the trough; the crest therefore gains upon the preceding trough and overhangs it with a trembling cusp. But the cusped wave to leeward of a stationary stone in a shallow stream does not usually fall bodily forward, as finally happens with the wave breaking on the beach, for it remains in the same depth of water Occasionally, however, when the current happens to be.

momentarily diminished, the cusped wave will roll forward and fall, like the breaker on the seashore.

In passing, it may be mentioned that the foam from the cusp of a standing wave is not ordinarily like the creaming froth of the sea breaker; the bubbles are coherent, well formed, and often of large size. Sometimes they may be seen rolling like glass marbles on the up stream slope of the cusped wave.

During the return of a breaker, when a current of water is running down the slope of the beach, one may, under favourable circumstances, see all gradations between the standing waves of running water and the ordinary waves of the sea, which are running waves in standing water. The best conditions are a moderately sloping beach and a long interval between the arrival of succeeding breakers. The stream made by the return of the breaker is constantly shallowing on the land side and becoming deeper on the seaward side. Hence, if the pebbles which are dragged seawards with the current, or any other irregularity of the bottom, should corrugate the surface of the stream, we may get a true breaker in running water: the back of the wave is accelerated (*i.e.*, is hastened shorewards) as the water deepens to seaward; the front of the wave is retarded as the water shallows on the land side; and at last the little breaker is stranded and falls flat upon the beach. More often than not the next incoming sea wave has arrived before this happens, and this gives a similar but more striking effect. This is the little breaker, which may be noticed on calm days and when the wind is off shore, of which the bottom seems to be tripped up by the heels—if one may be allowed the expression—the whole of the advancing ridge falling "flop" upon the shore. If the beach be sandy the water in this breaker is always yellow and turbid, even on a calm day when the ordinary breaker is clear and transparent.

If there happens to be a shoal close to the shore, standing waves may often be seen where a current is set up parallel to the coast in the channel between the shoal and the beach. This affords a good opportunity of watching running waves and standing waves on the same sheet of water; and the foam on the surface enables one to discriminate readily the two kinds of wave, for the foam in the current travels with the stream, passing over the standing waves, whereas the running waves pass the foam, leaving it behind them. The waves of running water are to be seen on the grand scale in the tide races, which run like rivers in the sea—sometimes, as off Portland Bill, with a velocity of six or seven knots. If the water be rather shallow, standing waves are caused by irregularities of the bottom, but this is not the only way in which they are produced. Anything which makes an extra pressure at any point in a stream gives rise to standing waves. They arise, for instance, where a current meets still water, as is the case on either edge of the rapid current which flows out through the opening in Portland Breakwater. When two currents meet at an angle, standing waves are also raised.

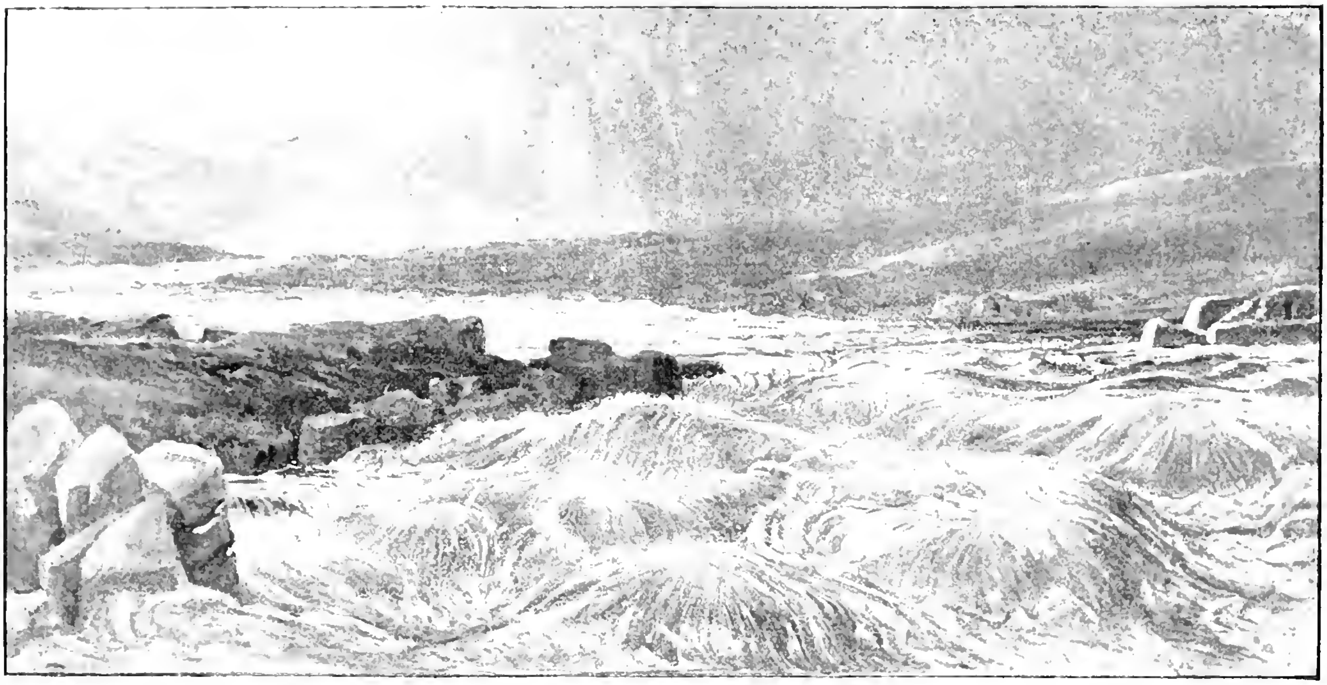

Fig. 2.—Rapids on the Tees. From a Sketch.

When the surface of the sea is agitated simultaneously with wind waves and standing waves, the result is a wild turmoil of waters almost impossible to follow with the eye or to analyze with the mind. The races and overfalls of the Channel are described with a certain rough picturesqueness in the "Sailing Directions for Pilots." The following account of Portland Race is from the twelfth edition of "The Pilot's Handbook for the English Channel":—"From about 2h. to 11h., F. and C. (or from the time of $\frac{1}{2}$ ebb to nearly the end of flood in Portsmouth Harbour), there is an outset from the West Bay, on the N.W. side of Portland, of nearly 9h. duration, which closely skirts the rocky shore, and gradually increases in strength as it approaches the Bill, where it acquires such velocity as to extend far beyond that point before it turns to the E., leaving a strong eddy between it and the land. Having assumed its E. course, it rushes 6 or 7 knots an hour, during springs, past the pitch of the Bill, leaping and foaming over Portland Ledge with great violence. . . . . During spring tides the agitation is so violent in the Race as to render it dangerous for small vessels; and in tempestuous weather, when the West channel stream is running to the eastward, the whole space between Portland and the Shambles is one sheet of broken water."

In the older "Sailing Directions for the English Channel" (1835), Captain White, R.N., gives a very explicit account of the causes which produce the standing waves in the principal races and overfalls of the Channel. The following passages are condensed from this book:—"Off Scilly, S.E. and South of St. Agnes Island, there is great rippling or overfall, between IV. hours flood and II. hours ebb, occasioned by the confluence of two streams of tide there at that period. . . . . Off the Lizard, south of the Stag Rocks, there is always an extensive rippling on both streams of tide; but this is chiefly occasioned by the unevenness of the ground. There is another extensive race, or rippling, to the S.E. of the Lizard (off Black Head), occasioned by the confluence of the tides. Off the Start there is considerable rippling, occasioned by the confluence of the fair-channel tide with the in-shore streams between Start Point and Dartmouth and within the Skerries. The Portland Race is caused by the rocky ledge which projects somewhat more than a mile in a southerly direction from the Bill; both sides whereof being remarkably steep, the consequent transition from deep to shoal water is very sudden. The overfalls off St. Alban Head are chiefly caused by the unevenness of the ground. The overfalls off St. Catherine and Dunnose are also partly caused by the various sudden transitions from deep to shoal water in that neighbourhood."

A group of standing waves may originate from a hole in the bed of a stream as well as from a hump on the bottom. It depends upon the velocity and depth of the stream whether the water will be raised or depressed over the hole; in a rapid shallow stream it is depressed over the hole. Hollows worked in the bottom of a stream flowing across a sandy beach frequently originate a train of standing waves. These holes are, I think, generally formed by the action of an eddy, or upward swirl in the water. The sand which rolls along the bottom of the stream keeps filling in the hole on the up-stream side, but the vortex scours away the sand on the lee side, so that the hole moves down stream. With it, of course, the group of standing waves to leeward moves down stream also. Another way in which standing waves are formed in these streams is by the convergence near the middle of the stream of ridges of water maintained by the pressure of the current upon the opposite banks. This gives rise to waves of very little lateral extension, but often of considerable height at their middle part. These likewise move down stream as the banks are continually eaten into by the currents. The most interesting thing about these groups of waves is that under each is a group of *sand waves*, which, when we look straight down upon the stream, are often more conspicuous objects than the corrugations on the surface of the clear water. Fig. 1 shows the kind of locality in which to study such sand waves, and the kindred phenomenon of Ripple-Mark. Fig. 3 shows a water wave and sand wave, the dimensions being from actual measurements. It will be noticed that the wave is deeper over the crests than over the troughs, the amplitude of the water waves being greater than that of the sand waves. In order to watch standing water waves carving ridge and furrow in a sandy bottom, I have strewn sand on the lee side of a stone fixed on the hard bottom of a stream. To the leeward of the stone were standing water waves, and as the sand was rolled down by the current it was rapidly carved into ridge and furrow of symmetrical form. In this case the stone was fixed, and the positions of the corrugations of the water surface were also fixed relatively to the banks of the stream. The grains of sand could be watched rolling rapidly over the furrowed bottom, but the ridges and furrows in the sand maintained their positions unaltered as long as the supply of sand was kept up. This means that the sand wave is travelling against the stream with the same velocity as that with which the sand grains travel with the stream.

In the case of sand waves under a group of standing waves which are moving down stream, the sand ridges move down stream also, keeping pace with the corrugations of the surface. The movement of the sand wave can be watched, and will repay the trouble of watching. If a small flat stone be dropped into a furrow or trough, it is speedily buried by the surface sand which rolls down upon it from the proceeding crest on the weather side. It is always the surface sand that moves, the lower layers having to be uncovered before they roll freely. Soon the stone is under the crest of a sand wave, presently it emerges on the up-stream side as the crest moves on. These are waves of *rolling* sand in which the top layer moves; but it is not always the same grains of sand which are at the top. The grains at the surface of the weather slope of a ridge are carried over to the trough, and are speedily buried by the grains of the next layer brought from the weather slope of the ridge; and so the motion of the ridge continues, the grains moving very quickly, but the form of the sand progressing slowly because the ridge contains many layers of sand grains. The down-stream movement of the ridges is the motion of the *group* of sand waves, and the velocity of the ridges relatively to the bank is the group velocity. Above the compact but mobile sand which forms these waves the water is clear: there is no flying or floating sand.

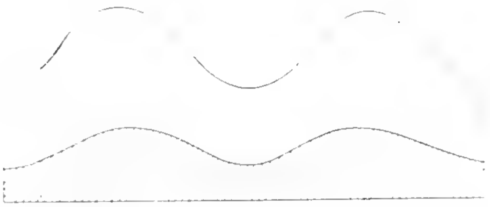

Fig. 3.—Waves of Flowing Water and Rolling Sand.

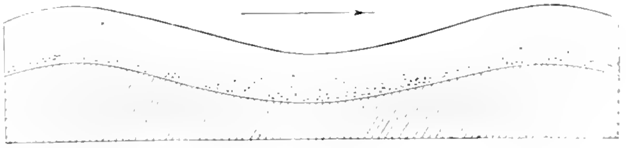

Fig. 4.—Waves of Flowing Water and Flying Sand.

Further down the stream, when the water is flowing strongly, matters are different. The stream gathers sand as it goes, largely by erosion of the banks, and, as we near the sea, the sand is looser. The sand flies along in a turbid current of sand and water, sometimes covered by clear water, but often rendering the whole stream turbid. At those places where the stream narrows and the waters rush together from the sides, or where two minor channels converge, or where pressure-ridges from impact of water with the sides of the channel meet, the water is thrown into standing waves, close under which sand waves are formed. These waves move *up stream*; yet their origin is generally in the action of the water upon sand which is constantly being carried down stream. Even if they originate from a stone firmly fixed in the bed the waves move up stream, though the head of the group cannot advance beyond the stone. It often happens that the condition which produced the corrugation of the water surface is annulled, leaving the group of waves still in existence, and the waves continue to move up stream. It is then interesting to note what happens to the first wave of the group which is exposed to the action of a straight-forward current. It continues to move up stream, the crest of water above and the ridge of sand below; but the sand ridge becomes lower and lower, its up-stream motion continuing, however, until the ridge has been quite scoured away. The first water wave has now disappeared, and the second sand ridge is exposed to the straight-forward current and is in like manner scoured away—persevering, however, to the end in its up-stream motion. Thus the whole group is obliterated, but for a time the sand ridges maintain the corrugations on the surface of the water. It is also to the sand waves, I believe, that the up-stream motion of both sand wave and water wave is due. We have here to do with flying sand, as I have said, and flying sand is also falling sand. There is a constant sand-rain falling through the water, and it is often possible to see quantities of sand dropping on the upper half of the weather slope of the ridges. Of course, the sand does not drop vertically; it falls very obliquely, for the downward motion through water is slow. Consider, then, as a first approximation, that the sand-rain comes down obliquely in straight lines. The weather slope of a sand hill, which is tilted up to meet the shower, is of course more exposed to the shower than the leeward slope; so that when there is much flying sand in the stream the sand ridge moves up stream, carrying with it the water ridge. When the up-stream waves extend the whole way across the channel, the path of the sand particles may sometimes be seen to be curved outward towards the edges of the stream, a motion which seems to help in building up the ridges at their two ends, and which probably assists to some extent the up-stream motion.

By examining the waves somewhat higher up the stream, it is often possible to hit upon the position where the waves are stationary; still higher up one may sometimes see very similar waves which are going down stream, in which the shower of flying sand is not sufficiently dense to maintain the ridges in place.

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A RARE METAL.

By T. L. Phipson, Ph.D.

At the beginning of this century the great Swedish chemist Berzélius discovered a new metal in some Norwegian rocks, and dedicated it to the mythological deity of the ancient Scandinavians, the god Thor, by calling it *thorium*: the mineral in which it was found was also called thorite.

It was at a period at which great activity was manifested in the search after new substances contained in rocks, minerals, and rare or precious stones. Chemists had not yet made much way into the mysteries of the organic world. They were not acquainted with the marvellous products which have since been derived from plants; animal chemistry was very little known; but a great insight was being obtained into the nature of the constituents of minerals, and ever since the middle of the eighteenth century discoveries of new metals were being made with astonishing rapidity.

During this extremely interesting period of scientific research, when men like Humphry Davy, Lavoisier, Klaproth, and Berzélius vied with each other as discoverers of the secrets of nature, considerable numbers of most curious substances were brought to light—metals which, to this day, are scarcely known, even by name, to the general public, and are still little enough known, indeed, to the most eminent of our modern chemists. Cerium, for instance, was found in a kind of granite rock in Sweden, glucinium in the emerald and beryl, zirconium in a precious stone from the East called jargon, and titanium in the black sand of some Cornish streams.

When a new substance is thus discovered, the thought that it may some day be applied to a useful purpose is generally quite absent from the mind of the discoverer. He is perfectly satisfied with the novelty of the discovery. Only those who pass their existence in a laboratory devoted to research can realize the intense interest with which every new property of these rare curiosities is studied. The book of nature is really more attractive than the finest pages of the greatest writers, and as its secrets are gradually revealed they rivet the attention more and more, quite independently of the possible application of these revelations to any particular art or industry. Nevertheless, it must be confessed that in these practical days such considerations are not always so entirely absent from the mind as they used to be.

It is needless, perhaps, to say that, of all the new metals which have come to light since the middle of the last century, very few have come to any extent into daily use. Hitherto, by far the most unpromising, perhaps, in this respect, has been the metal *thorium*, and its oxide *thoria*. It was found in a black, shiny mineral, resembling black glass, sticking in the Norwegian granite rocks, and afterwards in a few other stones of various colours, where its presence was thought to be accidental. It possessed no very striking properties. The oxide (thoria) is white, and forms white salts with acids; no colours are obtained with it. In fact, it was no more interesting in its chemical behaviour with other substances than common lime, to which it bears a good deal of resemblance. But it was very heavy, very infusible, and very rare; and it was certainly quite distinct from any substance which the crust of the earth had, as yet, yielded to the inquisitive searcher after new metals.

Thoria was first found combined with silica upon the little island of Loeven, not far from the small town of Brevig in Norway. It was discovered by a Swedish diplomatist named Esmarck, and handed to his friend, the chemist Berzélius, that he might analyze it and so find out what it was. In making this analysis Berzélius soon discovered that he was dealing with an entirely new substance. Some time afterwards the same new substance was found by the late Prof. Woehler, the celebrated chemist of Göttingen, and a pupil of Berzélius, in a stone from the Ural Mountains called pyrochlore, which is also found in Norway; and more recently it has been met with in another rare mineral called monazite.

It was soon seen to be extremely difficult to smelt the metal out of the oxide of thorium, as we get iron or copper out of their oxides, by heating it to a very high temperature with coal or charcoal. However, Berzélius did manage to get out a minute quantity of the metal by other means, and obtained it as a metallic powder, not unlike lead in colour and appearance. He found that when this metal was heated red-hot in the air it took fire, and burnt with a most extraordinary brilliancy. The light emitted was even more strikingly brilliant than that produced by the combustion of magnesium, which is at present so much used by photographers and makers of fireworks.

Now, this light-giving property of thorium is just bringing out this rare metal from the complete oblivion in which it has lain for nearly seventy years. Whilst we are writing these few lines search is being made in many parts of the world for stones, rocks, or sands which may perchance contain a certain quantity of this now precious substance, hitherto a mere useless chemical curiosity.

It has been found out, indeed, that of all the metallic oxides which have been tried on the so-called "hoods" or "mantles" that are placed around gas-flames in order to increase the light, thoria is by far the finest; and of recent years the manufacturers of these "mantles" for the incandescent gas-burners have created a brisk demand for thoria.

The consequence of all this is that, at various times during the last two or three years, *a pound weight* of this hitherto useless substance, thoria, has been freely sold at forty-five to fifty pounds sterling.

The incandescent light yielded by the "mantles" of thoria are enabling the street gas to rival the more expensive electric light; and employment in new fields is already being found for thousands of hands, thanks to the discovery, about seventy years ago, of a new substance, apparently of very slight interest, and long considered to be absolutely useless.

The minerals thorite, orangite, and pyrochlore, which all contain a large amount of thoria, are still very rare and expensive; but monazite has been found of late years in various parts of the world, and seems more plentiful, and as it generally contains about eighteen per cent. of thoria, it now forms the centre of a new and rising industry.

However, this mineral, monazite, is by no means common. It is rather heavy, weighing about five times its own bulk of water. In several regions of the United States and Canada, principally near Quebec and in North and South Carolina, it is met with in the sand and gravel which form the bed of small streams, the richest deposits being usually found near the head waters, among the detritus of gneiss rock and schists, where it is associated with several other minerals. In such localities it is either seen in pure crystals—ranging in colour from yellow to brown and yellowish green—sometimes as large as a grain of wheat or even larger, or as "monazite sand," in which minute crystals of the mineral are diffused or mixed with much ordinary sand and other worthless material. The principal district is North Carolina, the sands of which yield from two to four per cent. of monazite crystals. Similar sands are now being shipped from the coast of Brazil, which yield from one and a quarter to seven and a half per cent. of monazite. Some monazite sand also comes from Quebec. On the southern coast of Bahia it is found on a sandy beach of enormous extent, and is now being shovelled up from this beach into small vessels of some four hundred to five hundred tons and of light draught, and shipped to England or Hamburg. Norway is also supplying a certain quantity of the minerals thorite and orangite, which are very rich in thoria. About one ton weight per annum of these thorium minerals, representing seven thousand pounds worth of thoria, is the present output from the South of Norway.

Soon after the introduction of the new incandescent gas burners the demand for minerals containing thoria increased to a considerable extent. The first offered were the Norwegian thorite and orangite ores, which contained from forty to sixty-two per cent. of the rare oxide. At first the price paid for pure oxide of thorium was as high as fifty-three pounds for one pound weight avoirdupois; but it has since oscillated very much, and has sometimes been as low as seven pounds per pound, according as the output is more or less plentiful.

We have, perhaps, said enough to show that a new and highly interesting branch of industry has arisen in a most unexpected manner, from a chemical discovery which, at the time it was made, and ever since, has been generally regarded as one of the most useless and least promising, from a commercial point of view, in the whole annals of scientific research.

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SERTULARIAN POLYPIDOMS; OR "HORNY CORALLINES."

By P. L. Addison, F.G.S., Assoc.M. Inst.C.E.

THE heaps of tangle which lie at high-water mark along our coasts contain a variety of objects it would be almost impossible to catalogue, but which, with certain exceptions—such as cabbage stalks, old boots, and the like—are all of more or less interest to the naturalist. The principal mass of the tangle consists of a great variety of seaweeds, ranging from the thick stems of the common bladder-wrack to the most delicate fronds of the *Griffithsia* and *Cladophora*. Clusters of egg-cases of the whelk, like balls of sea foam that have been petrified, egg-cases of the skate, defunct starfish, sea-urchins, and small crabs are among the first objects which arrest attention. All these have an attraction of their own, but it is to the remains of a much less conspicuous class of marine animals that we now wish to draw the reader's attention. These are the polypidoms or polyparies of the zoophyte family *Sertulariidæ*: small, graceful, branching, tree-like objects, which are usually found in the tangle in great variety after a storm. They are often mistaken for seaweed by the casual observer, and were formerly considered to belong to the vegetable world. They are frequently called "corallines," or "horny corallines"; but the popular names must not allow them to be in any way associated with the common coralline (*Corallina officinalis*), which is a true but very remarkable form of marine alga.

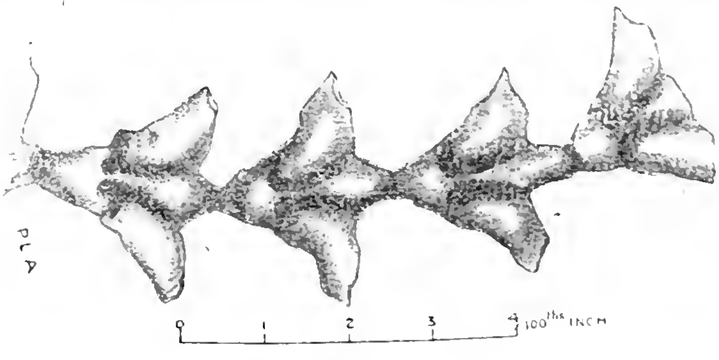

Fig. 1.—*Sertularia gracilis.*

With the help of a small pocket magnifier it may easily be seen that along each side of the stem and branches of the polypidom are arranged minute cup-like projections, placed alternately, or opposite to each other, according to the species of Sertularia to which they belong. In the allied Plumularia the cups are on one side of the stem and branches only.

Sertularian zoophytes are very similar in bodily structure to hydra, or fresh-water polypes; but differ in their mode of life, inasmuch as they live in colonies, constructing and inhabiting the horny polypidoms already mentioned. The active part of the body of the animals is contained in the polype cells, and is provided with a mouth surrounded by fine contractile tentacles. These are extended in the sea-water, and wave about in search of tiny particles of food, which are conveyed to the mouth, and passing direct into the body are there digested and assimilated.

The lower part of the body of each polype is prolonged through the base of the cup into the tube or cœnosarc running through the stem and branches of the polypidom, and is thus united with the common body, to which each polype contributes a share of nourishment through the assimilation of food in its own body. Under such conditions it would be quite possible for many members of the sertularian colony to live for a certain length of time through the exertions of their brother polypes without troubling to collect food for themselves.

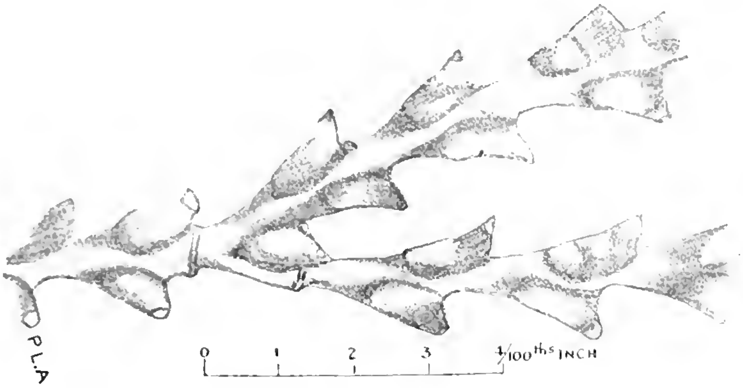

Fig. 2.—*Sertularia argentea.*

The system of growth and reproduction in the sertularian colony is as follows: new polype buds arise from the cœnosarc of the stem and branches of the polypidom and enlarge its horny substance into beads or globules. As the buds develop, their horny cases open and form cups, each one of which contains a fully developed polype.

Sertularia, though differing in certain points, are generally considered to be the modern representatives of, and closely allied to, the graptolites, so common and found in such variety in the lower and upper Silurian formations.

Figs. 1, 2, 3, and 4 are reproductions of microscopic drawings of characteristic sertularian polypidoms, showing the different form and arrangement of the cells which formerly contained the living animals; and, in order that the dimensions of these structures may be easily determined, we have added a scale of one one-hundredth of an inch to each drawing. But this is not enough to convey any idea of the delicate structure of the polypidoms or of the vast number of polypes that formed the colony. With the hope of making this more clear, we have taken some of the branches of *Sertularia argentea* (Fig. 2), and find that they contain one hundred and seventy-eight cells, and that the weight of these naturally dried fragments is ·0001 of a gram, or about one five-hundredth part of a grain. The tree-like polypidom from which these were taken is nineteen centimètres (about seven and a half inches) in length, and its weight is ·123 of a gram.

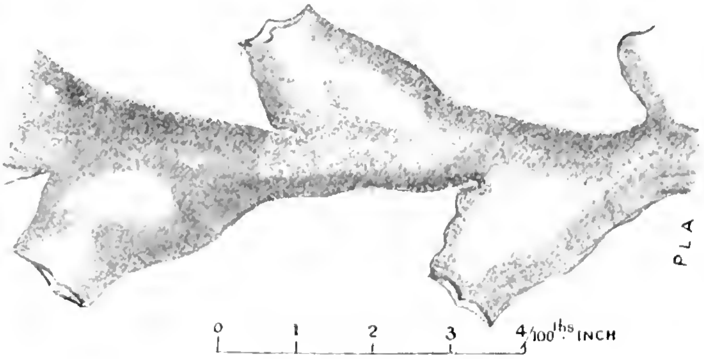

Fig. 3. *Sertularia abietina.*

We are therefore confronted with the fact that the whole colony—and this specimen is by no means a large one, weighing when dry less than two grains—must have consisted of nearly fifty-five thousand individual polypes.

In preserving these objects for future reference it is enough to mount them dry in shallow cells formed by thin vulcanite or zinc rings. They should first be thoroughly washed in warm water and then allowed to become perfectly dry. The cell and cover-glass should be heated over a spirit lamp, so as to destroy mould spores without injuring the specimen, before it is hermetically sealed. Balsam and balsam and benzole mounting often tend to over-clarify these objects when examined under transmitted light; and air bubbles which form in the cœnosarc and polype cells—even when great care is exercised to avoid their occurrence—give a false impression of the structure of the polypidom. It is true that these difficulties may be overcome by the use of an air pump; and if it is desired to examine the objects under polarized light, it is necessary that a much more elaborate

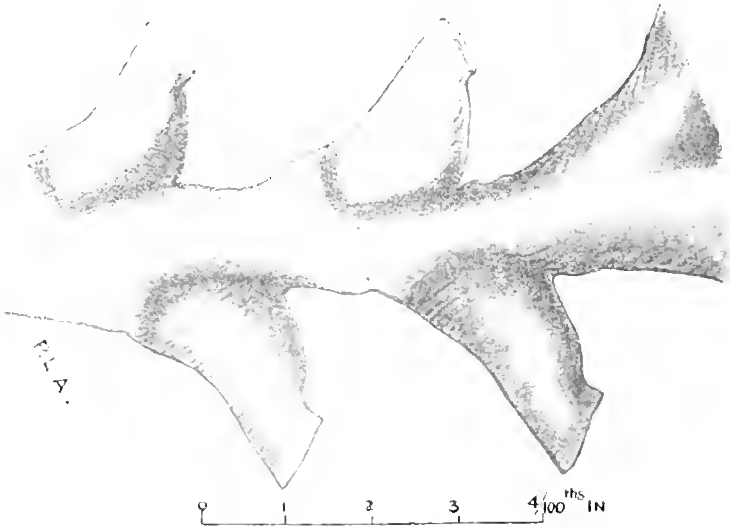

Fig. 4.—*Sertularia pinaster.*

system of mounting should be resorted to than that we have suggested as being sufficient for ordinary observation and recognition of species.

What power of instinctive inclination endows these simple and minute animals, and induces each species to constantly adhere to a particular design in the formation of its abode—why each member of a colony seems to be thoroughly educated in the work it has to perform while helping to build a branch of the polypidom so that it may exactly coincide with all the others—is one of the deeply hidden mysteries connected with the lower forms of animal life.

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THE FACE OF THE SKY FOR JUNE.

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

SUNSPOTS and faculæ are rapidly diminishing in size and number.

Mercury is an evening star during the first week of the month. On the **1st** he sets at 9h. 2m. p.m., or 57m. after the Sun, with a northern declination of 22° 34′, and an apparent diameter of 11½″, about $\frac{8}{100}$ths of the disc being illuminated. On the **4th** he sets at 8h. 41m. p.m., or 34m. after the Sun, with a northern declination of 21° 39′, and an apparent diameter of 11¾″, $\frac{3}{100}$ths of the disc being illuminated. He is in inferior conjunction with the Sun on the **10th**, and after that becomes a morning star. On the **26th** he rises at 3h. p.m., or about three-quarters of an hour before the Sun, with a northern declination of 18° 44′, and an apparent diameter of 9½″, about $\frac{2}{10}$ths of the disc being illuminated. On the **30th** he rises at 2h. 47m. a.m., or about 1h. before the Sun, with a northern declination of 19° 30′, and an apparent diameter of 8½″, $\frac{28}{100}$ths of the disc being illuminated. During the first week in June he pursues a short retrograde path in the eastern border of Taurus, and during the last week a short direct path in the same quarter.

Venus is invisible, and Mars, for the observer's purposes, is in the same condition.

Jupiter is an evening star, but is so near the Sun that we only continue his ephemeris during the first three weeks of the month. On the **1st** he sets at 11h. 41m. p.m., with a northern declination of 19° 34′, and an apparent equatorial diameter of 34¼″. On the **8th** he sets at 11h. 16m. p.m., with a northern declination of 19° 16′, and an apparent equatorial diameter of 33¾″. On the **18th** he sets at 10h. 41m. p.m., with a northern declination of 18° 47′, and an apparent equatorial diameter of 33″. While visible he describes a short direct path in Cancer, being about ¾° north of δ Cancri on the **10th**. The following phenomena of the satellites occur while the planet is more than 8° above and the Sun 8° below the horizon:—On the **2nd** a transit ingress of the first satellite at 9h. 27m. p.m., an occultation disappearance of the second satellite at 9h. 31m. p.m., and a transit ingress of the third satellite at 9h. 57m. p.m. On the **4th** an eclipse disappearance of the first satellite at 10h. 3m. 5s. p.m. Jupiter will be occulted by the Moon on the evening of the **14th**. The disappearance will occur at 9h. 52m. p.m., at an angle from the north point of 113° (reckoning from N.E. to S.W.), and reappear at 10h. 43m. p.m., at an angle of 293°. The four bright satellites will also be occulted.

Saturn is an evening star. He rises on the **1st** at 5h. 16m. p.m., with a southern declination of 13° 38′, and an apparent equatorial diameter of 17½″ (the major axis of the ring system being 43″ in diameter, and the minor 15″). On the **10th** he rises at 4h. 34m. p.m., with a southern declination of 13° 30′, and an apparent equatorial diameter of 17¼″. On the **17th** he rises at 4h. 4m. p.m., with a southern declination of 13° 26′, and an apparent equatorial diameter of 17″ (the major axis of the ring system being 42¼″ in diameter, and the minor 11¾″). On the **30th** he sets at 1h. 4m. a.m., with a southern declination of 13½°, and an apparent diameter of 16¾″. During the month he pursues a retrograde path in Libra, being less than ¼° south of μ Libræ (5¼ magnitude) on the **30th**. μ Libræ is an exceedingly beautiful double star (5½, 6¼ magnitudes), the components being 1½″ apart.

Uranus is an evening star, but owing to his great southern declination is not well situated for observation. On the **1st** he rises at 6h. 5m. p.m., with a southern declination of 17° 56′, and an apparent diameter of 3·8″. On the **30th** he rises at 4h. 6m. p.m., with a southern declination of 17° 41′. During the month he describes a very short retrograde path in Libra, without approaching any naked-eye star.

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

The Moon enters her last quarter at 8h. 2m. a.m. on the **3rd**; is new at 8h. 43m. a.m. on the **11th**; enters her first quarter at 11h. 41m. a.m. on the **18th**; and is full at 6h. 53m. a.m. on the **25th**. She is in apogee at 8h. a.m. on the **5th** (distance from the Earth, 251,430 miles), and in perigee at 4h. p.m. on the **20th** (distance from the Earth, 229,000 miles).

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Chess Column.

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

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of May Problems.

(A. C. Challenger.)

No. 1.

1. Kt to K4, and mates next move.

No. 2.

Key-move.—1. Kt to Kt4.

If 1. . . . K to K6,	2. Kt to B2ch, etc.
1. . . . P × P,	2. Kt × Pch, etc.
1. . . . Kt to Q7,	2. Q to Q5ch, etc.
1. . . . Kt (or P) to K6,	2. Q to K5ch, etc.
1. . . . K to B4, etc.	2. Kt to B2, etc.

Correct Solutions of both problems received from H. S. Brandreth, H. S. Quilter, G. A. F. (Brentwood), Alpha, and W. Willby. Of No. 1 only, from A. E. Whitehouse, J. W. Bilbrough, J. M'Robert, and A. S. Coulter.

Solutions received too late for acknowledgment from J. M'Robert (two-mover in March Number), and G. A. F. (Brentwood), (April problem).

J. W. Bilbrough.—Have you considered the defences—1. . . . P × P, and 1. . . . P to K6?

A. G. Fellows.—Many thanks.

G. G. Beazley.—If 1. Kt to Kt4, B to B6 is the defence.

H. H. Q.—"Meminisse juvat."

W. Willby.—We quite agree with your criticism.

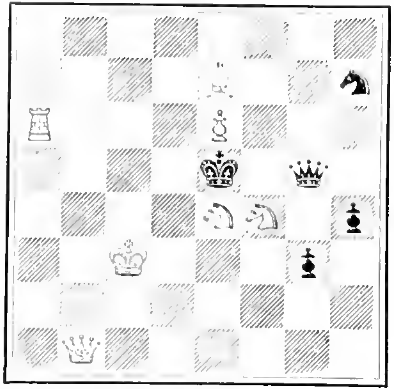
A. Bumpus (Loughborough).—Please send full address. The names of some correspondents who wrote in reply to your challenge were forwarded to you, and returned through the dead-letter office.

W. J. Ashdown.—Many thanks; just too late for this month.

PROBLEM.

By A. G. Fellows.

Black (5).



White (7).

White mates in two moves.

This problem obtained the first prize in the tournament of the *Irish Times*. Mr. Fellows informs us that it is his ninth success.

CHESS INTELLIGENCE.

The tournament of the Vienna Club, after a protracted contest, resulted finally as follows: 1. Max Weiss; 2. C. Schlechter; 3. B. Englisch; 4. G. Marco. Herr Schlechter lost only one game out of more than twenty, but he drew quite half his games. The *Standard* states that a quadrangular tournament for the championship of Vienna has been arranged between the four prize-winners mentioned above.

The Whitsuntide meeting at the Craigside Hydropathic, Llandudno, begins on May 27. The competitions are the same as at the last meeting. Mr. E. O. Jones is the present holder of the Challenge Cup.

Surrey have this year come out at the head of the South-Eastern section of the Counties Chess Union. This is naturally the strongest of the four sections, and the winners should have no difficulty in securing the Cup.

In the tournament in progress at Simpson's Divan the leading scores are: R. Teichmann, won 5, lost 1; L. Van Vliet, won 3, lost 1; R. Loman, won 5½, lost 2½; H. Lee, won 3½, lost 1½. There are eight other competitors, including Mr. Bird.

A Masters' Chess Association has recently been formed; its object, apparently, is the playing of matches with the leading clubs and with foreign teams. Mr. Lasker is president, *pro tem.*, and Mr. Tinsley, secretary.

The match between J. W. Showalter and E. Kemeny resulted in a victory for the former player by seven games to four, with four games drawn. Mr. Kemeny is a Hungarian resident in the States.

The final score in the Steinitz-Schiffers match was: Steinitz, 6; Schiffers, 4; drawn, 2. The last game was drawn by mutual consent, as it could not affect the result. M. Schiffers has considerably increased his reputation by the excellent stand made against his formidable opponent.

The Championship of Scotland has, as usual, fallen to Mr. D. Y. Mills, who won all his five games. The veteran G. B. Fraser was a good second, and Mr. W. N. Walker third. Should Mr. Mills win again next year, the Challenge Cup will become his property.

The game below is a good example of Mr. Teichmann's skill. It was played in the Hastings tournament last August.

"Queen's Gambit Declined."

White. (A. Burn.)	Black. (R. Teichmann.)
1. P to Q4	1. P to Q4
2. P to QB4	2. P to K3
3. Kt to QB3	3. Kt to KB3
4. Kt to B3	4. P to B3
5. P to K3	5. B to Q3
6. B to Q3	6. QKt to Q2
7. P to B5	7. B to B2
8. P to QKt 4	8. P to K4
9. P×P	9. Kt×KP
10. Kt×Kt	10. B×Kt
11. B to Kt2	11. Q to K2
12. B to K2	12. Castles
13. Q to B2	13. B to Q2
14. Castles	14. QR to Ksq
15. QR to Qsq	15. B to Ktsq
16. Kt to Ktsq	16. Kt to K5
17. Kt to Q2	17. P to B4
18. B to Q4	18. Kt to Kt4
19. B to Q3	19. P to B5
20. K to Rsq	20. Q to B2
21. Kt to B3	21. Kt×Kt
22. P×Kt	22. Q to R4
23. R to KKtsq	23. R to B2
24. Q to K2	24. B to K4
25. B to B2	25. R to B3
26. B×B	

Black mates in four moves.

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NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

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KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: JULY 1, 1896.

CONTENTS.

THE SUBMERGED FORESTS OF THE WIRRAL, IN CHESHIRE.

By Henry O. Forbes, LL.D., F.R.G.S.
Director of Museums to the Corporation of Liverpool.

THE pedestrian proceeding along the Cheshire shore from the mouth of the Mersey to that of the Dee, will, when about half-way along, find his progress interrupted by the walls of the ancient castle of Leasowe, the residence till quite recently of the Cust family. It is an interesting structure and worthy of a visit, if for nothing else than the fine view over the Wirral—as the interesting country between the two rivers is termed—to be had from its tower. It is said to have been built by a Lord Derby in the reign of Elizabeth as a residence during his visits to the races annually held at Leasowe, when it was known as "Mock Beggars' Hall." Before it was dismantled of its contents a few months ago one of its chambers was panelled and roofed with fittings of the famous Star Chamber in Westminster Palace, purchased and brought here on its demolition. This interesting interior has, we believe, been transported back to London to the family's town residence.

On the walls of the staircase there hung, till the same recent period, equally interesting and much more ancient objects of interest. These were the almost perfect skull of the great primigenial ox (*Bos primigenius*), some fine antlers of the red deer (*Cervus elaphus*), and bones of the short-horned ox (*Bos longifrons*). They were all dyed black from their long repose in the vegetable mould of the forest in which they roamed, over part of which the castle now stands. And who may dare to say that these same kine may not have sheltered under the very oak trees out of whose disentombed boles the black furniture of the library and seats in the hall were made?

All along the seaward front of the castle a strong shelving embankment of masonry, against which the sea washes at high tides, protects the site on which the castle stands from the action of the waves. On the top of this embankment our itinerant palæontologist may rest with pleasure on a fine day, and, while surveying the mercantile fleets that are ceaselessly passing in and out of the estuary of the Mersey, watch the thousand islands of sand and mud as they rise above the water with the receding tide, the results of erosion and redistribution which are modifying the coast-line.

Fifty years ago the sea was half a mile distant from the castle front, and no embankment was required, for a broad rampart of sand hills protected it. Since then the horizontal action of the sea has encroached far on the land, and to the eastward of the castle has removed long lines of this blown sand, and, but for its masonry embankment, that edifice must long ago also have been washed away. The observant traveller, sitting at very low tides on its south-west end and looking westwards along the coast, would see extended between the water's edge and the sandhills behind, a rough dark expanse of shore, stretching towards Hoylake village, which must arrest his attention and induce him to visit it. From the embankment he would walk along to Dove Point upon the sandhills, and descend from them upon a *bed of sandy peat*, protruding from beneath its æolian covering, whose edge, denudated by the sea, is about two feet in thickness. On the surface of this bed he may, if he be alert and fortunate, collect *Lymnæas* and other fresh-water shells, bones of deer, horse, and other recent animals, as well as articles of Norman, Saxon, and Roman manufacture, besides the flotsam and jetsam of the innumerable wrecks that since Roman times have been continually washed upon it. This *soil-bed* is evidently, he would perceive, the last surface of the land before it was covered by sand. His next descent would lead him upon a *bed of peat* underlying the soil-bed; and a foot lower he would find himself traversing a *clay bed*, through which, where it has been denuded, *another peaty surface* comes in view, with protruding stools, two to three feet in height, of thick forest trees—alder, willow, birch, elm, fir, and oak—whose roots still spread down into the soil in which they grew, their stems lying prostrate in all directions. There is no mistaking this for anything but a forest in ruins. Its denuded edge measures about three feet in height, and Fig. 1, from a photograph taken—as are all the others which illustrate this paper—by Mr. Charles A. Defieux, of Liverpool, affords an excellent idea of its appearance. Another downward step brings the investigator on a second layer of blue clay some thirty inches in depth, overlying the peaty *débris* of a *lower forest*, whose fallen stems recline by the side of their own still undisturbed stumps, whence the roots can be traced stretching down, as when they lived, unto yet a lower stratum of clay, in some places of red sand covering the clay, full of pebbles and boulders inscribed with striæ that tell their own story. This lower forest bed has, within the past thirty years, suffered much by marine denudation, and has quite vanished from many places where it used to be distinctly visible. In Fig. 1 its site would occupy the light triangular area in the centre of the right-hand side of the illustration.

Beneath the boulder clay are encountered no rocks newer than the red marl of the Triassic, formed at the beginning of the Mesozoic Age. "After the deposition of the red marls," says Mr. G. Morton in his excellent geology of the country round Liverpool to which the reader is referred for fuller information—"at the termination of the Triassic, there is a great blank in the geological history of the country round Liverpool. Whatever formations may have been deposited afterwards, no record of them now remains, for denuding agencies were in action, and not only swept them away," but ground down much also of the Trias, Permian, and Carboniferous strata. Fig. 2 exhibits a view of the denuded surface of the Triassic lower pebble beds in Middle Hilbre Island (lying in the entrance of the estuary of the Dee, and only a few miles from Dove Point), and the peculiar current-bedded strata of which these rocks are composed.

FIG. 1. The Submerged Upper Forest Bed, near Dove Point, Cheshire, showing Stratification and Result of Wind-Erosion on Sandhills. From a photograph kindly supplied by Mr. Charles A. Defieux.

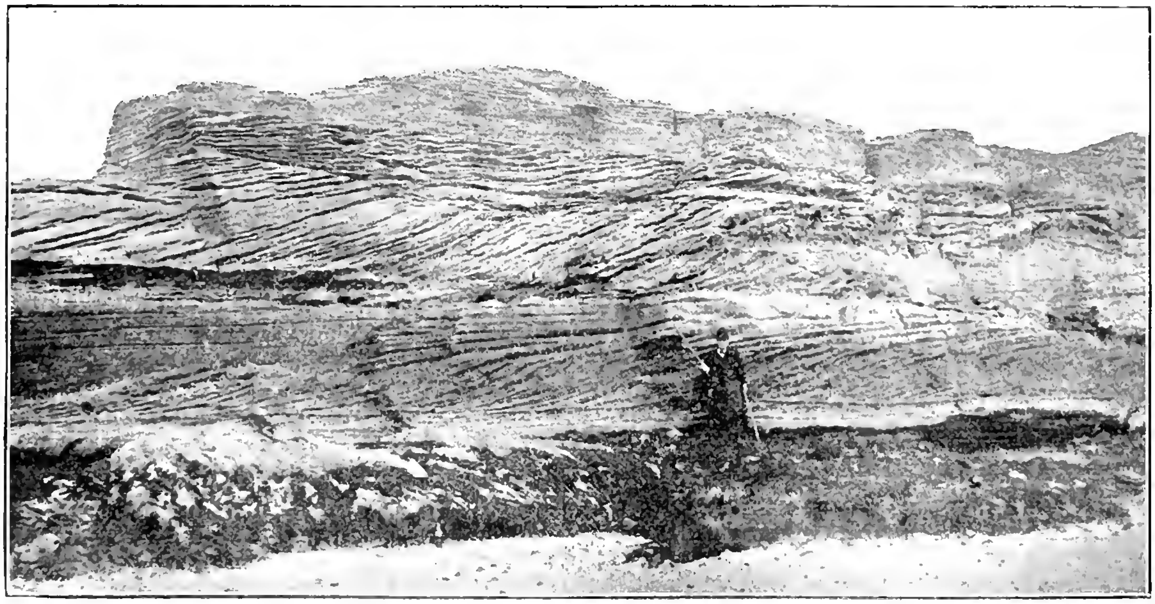

FIG. 2. -The Current-Bedded Strata of the Lower Pebble Beds, Middle Hilbre Island. From a photograph kindly supplied by Mr. Charles A. Defieux.

Upon this undulating country, which presented much the same surface contours as now—except that the hills were somewhat higher—there came to be laid down by the ice-foot in the fulness of time, all over the district, a thick blanket of clay studded with blocks, borne from the South of Scotland and the North of England on the submergence of the Wirral, to at least some hundred and fifty feet, during the latter part of the Glacial Epoch. Upon the re-elevation of the land at the close of that dreary period there grew up, by-and-by, the extensive forest whose remains form the lower bed described above. Under its trees there harboured the wild boar, the wolf, the red deer, the urus, the short-horned ox, and perhaps the Arctic bear and the Irish elk. After flourishing for ages this forest, becoming water-logged through subsidence, was engulphed by an upgrowth of peat, and slowly perished as if by a malignant cancer. This peat bed being in turn buried over by sea-silt and laminated clay containing numerous marine shells, formed for a time, after its elevation, a hospitable surface for the seeds of various trees, and was in due time once more liveried with alder and elm, fir and oak trees, larger in size and more densely set together than in the lower forest, but sheltering a much diminished fauna. "There seems," says Morton, "to have been a successive growth of forest trees, until the drainage became intercepted and peat accumulated and formed the upper portion of the bed. It seems that the trees had gradually fallen, and that the most recent broke off near the ground in consequence of rotting in the wet peat surrounding them."

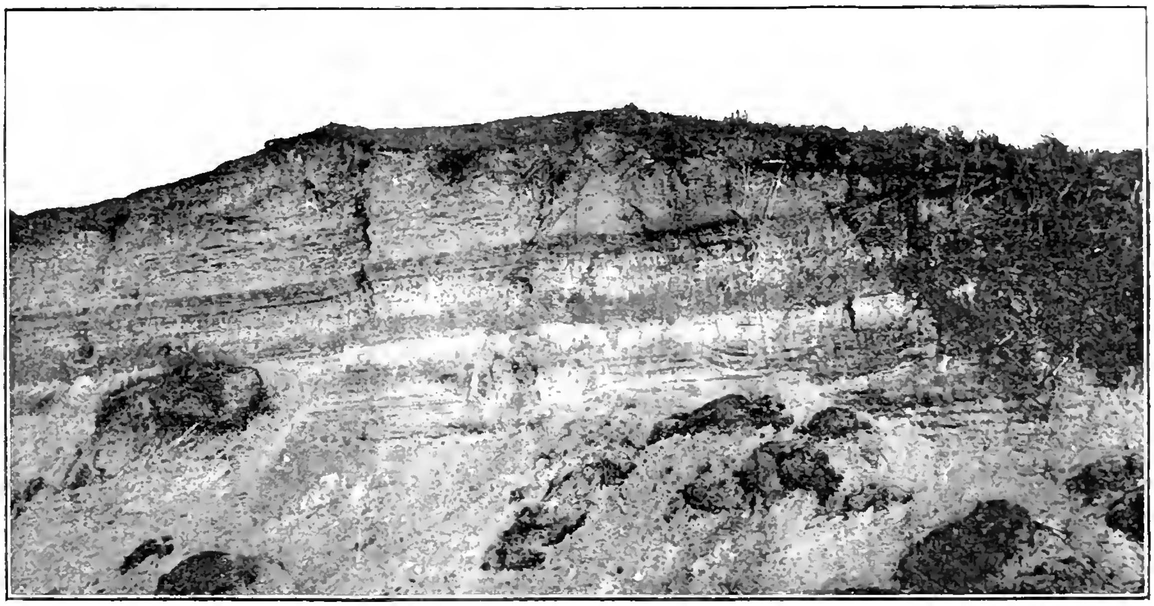

Fig. 3. -The Æolian Bedding of the Sandhills near Dove Point From a photograph kindly supplied by Mr. Charles A. Defieux.

Borings, excavations for docks, and the sinking of wells in many parts of the district on both sides of the river have revealed the existence below the present surface of the ground of one or both of these buried forests. Beneath what was earlier in the century known as Wallasey Pool (now the great Birkenhead dock) the more ancient forest lies buried, and from it fine heads of the urus (*Bos primigenius*) and *Bos longifrons* (besides fragmentary human remains) have been recovered, probably from the very spots on which they died. Along the estuary of the Dee the lower peat and forest bed has been seen lying on the boulder clay. Along the northern coast from the mouth of the Alt River, near Formby, where remains of the urus and the Arctic bear have been found, and along the same side of the Mersey estuary, the younger forest bed has been identified. The extensive excavations for the Manchester Ship Canal traversed the same ancient forest. So that from the Alt to the Dee, and from an unknown distance seaward, then extending inland up the valleys of these rivers "as far as the Ince and Helsby marshes and the mouth of the River Weaver," the country was clothed with trees, which, after flourishing for ages, were gradually and slowly covered over—as at Dove Point, where our illustration, Fig. 2, is taken—by beds of blue and yellow marine silt as the shore continued to slowly subside. Upon this silt another band of peat accumulated through the stoppage of the natural drainage by subsidence, and over it again was laid down the remarkable peaty *soil-bed* above described.[*] Imbedded in the latter are the shells of fresh-water molluscs which formerly lived in its surface-pools, the remains of mammals—sheep, dog, and horse—not found in the older forests, and the Saxon and Roman antiquities already referred to. Most of these antiquities belong to the thirteenth century, and there are some who hold the opinion, according to Mr. Morton, "that some great flood or disaster occurred at the close of the fourteenth century, for very few articles have been found belonging to the period immediately succeeding it." It is remarkable that at the end of the thirteenth century there did take place a great invasion of the sea, which destroyed the Abbey of Stanlow, situated between Ellesmere Port and Ince. "I am fully convinced," says Mr. Mellard Reade, "that all the changes that have taken place since the Roman occupation have arisen from the *horizontal* encroachment of the sea and the erosion of the post-glacial land surfaces." Since then there has been neither elevation nor subsidence.

Topmost of all rests the blown sand, which in some places, especially to the north of the Mersey, forms dunes forty to one hundred feet in height and three miles in width along the shores of Lancashire and Cheshire. Fig. 3 gives a nearer view of a portion of one of these accumulations lying behind the forest bed seen in Fig. 1, to show its æolian stratification.

The lower peat and forest beds rest very often directly upon the boulder clay, or upon a *drift sand* re-formed out of it; and they date, therefore, from after the Ice Age. The fauna of that time appears to have been richer in

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[*] For an account of the formation of peat mosses the reader is referred to a very interesting series of articles by Sir Edward Fry, on "British Mosses," in Knowledge, December 1st, 1891, and subsequent numbers.

numbers and more important in species when compared with that which inhabited the Wirral when the trees of the upper forest bed were flourishing, or roamed over it in later days to the present time. It was, however, vastly poorer in species, and these altogether meaner, when considered beside the grand Ungulates and imposing Carnivora that animated the district in pre-glacial times, and whose bones have been preserved in the caves of North Wales. Mr. Morton, who gives a list of the species whose bones have been found in caves sealed up beneath undisturbed beds of boulder clay, enumerates the cave lion, the spotted hyæna, the Arctic bear, the badger, the wild cat, the Irish elk, the reindeer, the wild boar, the woolly rhinoceros, the mammoth, the elephant, and the hippopotamus. On the threshold of one of these caves, and beneath the boulder clay, a flint flake found purposely fashioned proves that man shared the country, and, no doubt, contested possession of these rock shelters with some of the remarkable fauna which Britain could then boast of, and which has vanished for ever through, among other influences, the increase of population and the revolutionary march of the ploughshare.

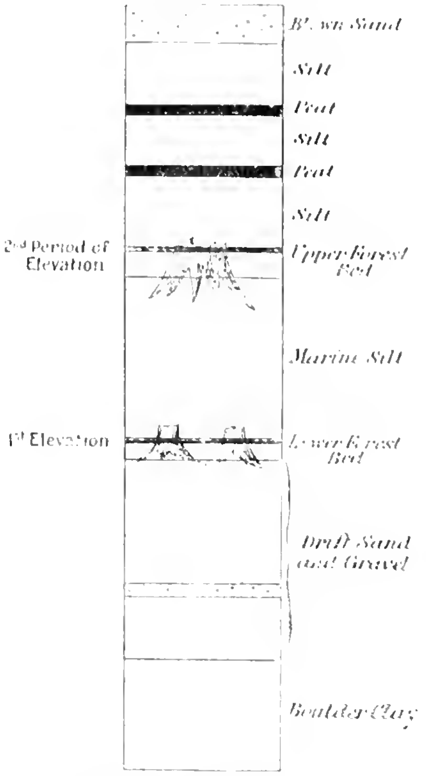

Fig. 4.—Section of the Strata over and under the Forest Beds.

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ALUMINIUM: ITS HISTORY, MANUFACTURE, AND FUTURE.—II.

By Samuel Rideal, D.Sc.Lond., F.I.C.

At the present time it may be said that all the aluminium brought into the market is the product of three factories, viz., the Pittsburgh Reduction Company of Pittsburgh and Niagara, the Aluminium Industrie Actien Gesellschaft of Neuhausen on the Rhine, and the Société Electrometallurgique Française of Froges in France. The aluminium company which has been at work in England for some years past has found that the chemical process used by them and devised by Mr. Castner cannot compete successfully with the newer companies, all of which manufacture aluminium by electrolytic processes. Quite recently a new company, under the name of the British Aluminium Company, has been formed in this country with the object of manufacturing the metal by an electrolytic process, and considerable progress has already been made by them.

These various electrolytic processes differ only very slightly, and depend for their success chiefly on the economic production of electrical energy. In America the Falls of Niagara, in Switzerland the Schafhausen Rhine Fall, are utilised, whilst the British Aluminium Company have acquired the water rights of the Falls of Foyers in Scotland. Although the cheap production of electrical energy has thus hastened the development of these large industrial undertakings, it must not be forgotten that about the year 1887 Chas. M. Hall, in America, by his discovery that alumina would dissolve in a molten bath of cryolite and fluorspar, rendered its utilisation in this particular industry feasible. He found that from such a bath a sufficiently strong current of electricity caused all the impurities to separate, and pure aluminium from the dissolved alumina was liberated at the negative electrode. The melted fluorides remain undecomposed if due precautions are observed, so that it becomes possible by feeding the bath with alumina to obtain a continuous separation of aluminium. The electrolysis of the alumina is brought about when the electromotive force is equivalent to 2·1 volts, whilst upwards of four volts are required for the decomposition of the fluorides. The composition of the flux is so adjusted by the third patent of Hall that it has, when molten, a specific gravity which is slightly lower than that of the metal, so that the latter, as soon as it is liberated, falls through the molten mass to the bottom of the electrolytic cell, and is thus prevented from being in contact with the air and so being altered by oxidation.

The Hall process is the one adopted by the Pittsburgh Reduction Company. In order to obtain the pure alumina for the electrolytic bath, native beauxite has to undergo a preliminary treatment. This consists in igniting it gently with soda ash, and in this way producing sodium aluminate, which is next treated with sufficient hot water to just dissolve it. Oxides of iron, silica, and other impurities remain undissolved, and the clear decanted solution of the aluminate is then decomposed by carbonic acid gas, obtained by the combustion of coke. The precipitated hydrated alumina is thus obtained pure, and on drying is ready for the bath, whilst the carbonate of soda simultaneously formed is available for a fresh portion of beauxite. The vessels in which the electrolysis is effected consist of iron pots lined with powdered carbon, and are connected with the negative terminal from the dynamo. To the bath of molten fluorides about one-third of their weight of alumina is added. The positive electrodes consist of blocks of compact carbon dipping into the molten mass, and, as already mentioned, the current used is of comparatively low voltage, so as to prevent the decomposition of the fluorides. Each machine produces at Niagara a direct current of two thousand five hundred ampères at one hundred and fifteen volts, and is obtained by transformers from a two thousand five hundred volt alternating current. The amount of energy required to produce one pound of aluminium is about five horse-power hours. The aluminium is liberated in globules which sink to the bottom of each of the iron pots, and there collect into a large molten "button." The first portions, being impure, are removed; the remainder is drawn off at intervals by a syphon, without interruption of the current. Alumina is added from time to time as the decomposition proceeds, so that the process is practically a continuous one. Chloride of calcium is occasionally added to render the bath more mobile and to prevent clogging. During the process the positive carbon electrode is oxidized to carbonic oxide, and has to be renewed from time to time. Theoretically, thirty-six parts by weight of carbon are required to produce fifty-four parts of metallic aluminium—thus:—

$$Al_2O_3 + 3C = Al_2 + 3CO;$$

but, practically, one pound of carbon is consumed per pound of aluminium formed, and this quantity is obtained per hour from each pot. The pots themselves and their linings last for months of continuous work. Unlike many industrial processes, there are no bye-products or slag, and there is no volatilization of the metal. The Pittsburgh works are only about half a mile from the Niagara Falls, so that the current is obtained directly from the mains of the Niagara Falls Power Company. This current is alternating, but it is converted into a direct one and its voltage is lowered by transformers at the works. The aluminium produced in America is of high comparative purity, the average percentage of the metal being ninety-nine and upwards. The chief impurities are silicon and iron, and its commercial value is now about thirty-five cents per pound.

In Switzerland and France the process adopted is that which was patented by P. L. V. Héroult. As to the priority of these patents, it is interesting to note that the cryolite process was first proposed by Henderson, an Englishman, in 1886, but he never put his process into practice. The Hèroult process, as will be seen from the following description, is based on exactly the same principle as that involved in the patents taken out by Hall, although both these inventors worked independently of one another, and about the same time applied for the American patents; but on investigation it was found that Hall had produced the first aluminium on February 23rd, 1886, whereas Hèroult named only the date of his French patent of April 23rd, 1886.

Héroult's first French patent deals with the production of pure aluminium. He places a mixture of alumina and cryolite in a carbon crucible surrounded by a larger one, the space between the two being filled with graphite. The positive electrode consists of a thick carbon rod which dips into the molten mass. A current of three volts is used by this inventor, but in other respects the process is similar to that of Hall.

By slight alterations in the working of the process it can be made available for the production of aluminium alloys. This consists in using a negative electrode of the metal—say copper—with which it is wished to form an alloy, when, as the current passes, the aluminium alloy is regularly formed, and collects as a melted button at the bottom of the crucible. It would seem that Héroult hardly realized the importance of his invention towards cheapening the production of pure aluminium, as at this time he gave his chief attention to his alloy patent. This was acquired by the Société Metallurgique Suisse, at Neuhausen, and proved so satisfactory that the firm at once decided to use it for the manufacture of aluminium bronze on a very large scale.

The usual bronze contains forty-two per cent. of aluminium, and from it, by the addition of copper, alloys of different grades are produced in ordinary smelting furnaces. In 1888 the Société Electrometallurgique Suisse was converted into the present Aluminium Industrie Actien Gesellschaft, and the bronze plant was then augmented so as to yield one thousand kilos of bronze daily. Encouraged by the success of Hall's process in America, Héroult, in conjunction with Kiliani, returned to his original process for the production of the pure metal, and soon succeeded in so improving his process that the Neuhausen company were enabled to erect additional plant, which already turns out five thousand five hundred pounds of commercially pure aluminium daily, and the new process has now almost entirely superseded the alloy process. In 1888 the Société Electrometallurgique Française, at Froges, acquired the right to use the Héroult patents, and has since had a daily output of three thousand kilos of alloy, and has produced some fifty thousand kilos of pure aluminium per annum.

The British Aluminium Company, to which reference has been made, has only been in existence a short time, but has already erected plant at Larne for the treatment of their deposits of Irish beauxite, and are engaged upon the erection of reduction works at the Falls of Foyers and of metallurgical workshops at Milton. It is difficult, however, to predict the direction in which this English industry will develop, as at present no information has been published as to which electrolytic processes are to be employed. The statement of the chairman of the company that "the natural advantages of the Strath were even greater than those of Niagara, for the fall of water to Loch Ness was very much greater," remains to be proved.

Sufficient has been said to show that since the Paris Exhibition of 1855 the progress in this particular industry has been enormous, but a few statistics as to the total output may not be out of place.

According to Richards, the world's production up to 1892 was only two million five hundred and eighty-six thousand pounds; but in 1893 one million four hundred and seventy-four thousand pounds were produced, and in 1894 two million two hundred and forty-four thousand pounds. Last year the American output has been estimated at eight hundred and fifty thousand pounds, and it is believed that the production of the present year will reach over two million pounds, as the Pittsburgh Reduction Company will have ready by the 1st of June plant capable of making ten thousand pounds per day.

This increase has been accompanied by a reduction in the price, so that from being, as at one time, a luxury, and used as a cradle for the Prince Imperial of France and as a helmet for the Crown Prince of Denmark, aluminium can now be found in most houses. Amongst the many uses to which it is at present applied may be mentioned the following: military equipments, as water-bottles, spurs, sword handles, helmets, and horseshoes; naval purposes, torpedo-boats and yachts being made of it for lightness; bicycles; vehicles, autocars, etc. (an aluminium cab is running in Paris); aerial machines; besides numerous smaller articles of domestic use, and especially surgical and scientific apparatus. It will be seen that all these different uses indicate a great future for the metal, especially as, of the more common metals, iron, zinc, nickel, and copper are at present the only ones which are cheaper than aluminium.

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SOME CURIOUS FACTS IN PLANT DISTRIBUTION.—III.

By W. Botting Hemsley, F.R.S.

STILL continuing on insular floras, I would say something about the Tristan d'Acunha group in the South Atlantic, in latitude 37°, and longitude 12° W.; and St. Paul and Amsterdam Islands, in the Indian Ocean, in almost exactly the same latitude as Tristan d'Acunha, and about 77° 30′ E. longitude, or in round numbers five thousand miles distant, with no land intervening in the same latitude. The history of botanical discovery in these islands is so intensely interesting that one is tempted to dwell on it; but I must be content to give the reader a taste only. The Tristan d'Acunha group consists of three islands only a few square miles in extent, yet one of them towers to the height of eight thousand feet. The main island has had a small population for some years. Amsterdam Island is larger—some six miles across—but rises only to a height of two thousand seven hundred and sixty feet. St. Paul is smaller, and less than eight hundred and fifty feet high.

Both are uninhabited. Sir George Stanton, a member of Lord Macartney's embassy to China, was probably the first Englishman who brought dried plants from these two groups of islands. This was a century ago. For what is known of the vegetation of the smaller islands of the Tristan d'Acunha group we are wholly indebted to the late Prof. Moseley, of the *Challenger* expedition.

These islands support a much more luxuriant vegetation than those in higher latitudes to which I have referred ; but here, as there, it is composed of few species, thirty-eight being the total in Amsterdam and St. Paul Islands, half ferns and lycopods and half flowering plants, and fifty-five in the Tristan d'Acunha group, whereof twenty-nine are flowering plants and twenty-six ferns and lycopods. The composition of the floras of these islands is exceedingly curious, for although the majority of the endemic species belong to genera that may be termed cosmopolitan, the bulk of the vegetation of these two groups of islands, five thousand miles apart, consists of *Phylica nitida* (Rhamnaceæ), a shrub or small tree, and a reed-grass, *Spartina arundinacea*. The latter is closely allied to a South American species, but hitherto it has only been found in these islands. In stature it is very different from our British species, which, I may add, is a widely spread seaside plant, not only in Europe, but recurring in North America and South Africa, the nearest land to Tristan d'Acunha. Inaccessible and Nightingale, the smaller uninhabited islands of the Tristan group, are almost covered with *Spartina arundinacea*, relieved here and there by clumps of the *Phylica*. This reed grows five to six feet high, and in such dense masses as to be impenetrable, except in the tracks made by penguins, prodigiously numerous colonies of which it shelters. It is equally abundant and luxuriant, in some parts, at least, of Amsterdam Island. In St. Paul it occurs in scattered clumps only.

The genus *Phylica* is allied to the buckthorns, and is represented in South Africa by upwards of thirty species ; in the Island of St. Helena by one endemic species ; by one or two in Madagascar ; and by *P. nitida* in Tristan d'Acunha and Amsterdam I., which also inhabits the mountains of Bourbon and Mauritius. It is the only woody plant in the former islands bigger than the common crowberry, and it forms woods in the main island of the Tristan d'Acunha group and in Amsterdam, though it does not exist in the fifty miles distant St. Paul. I have mentioned the crowberry (*Empetrum nigrum*) because this British shrub, which is diffused all round the temperate and cold zones of the northern hemisphere, is represented in the extreme south of America, in the Falklands, and in Tristan d'Acunha, and nowhere else in the world, by a variety scarcely differing from the northern plant except in having red instead of black berries. Several other peculiarities in these remote insular floras offer problems in the distribution of plants not easy of solution ; but some remarks I have to make on this point must be deferred. More than a third of the flowering plants and ferns of the two groups of islands under consideration are endemic. Of the remainder, some, especially the ferns, are of wide range ; others are common to the New Zealand and the South American regions, as well as the intermediate islands whose vegetation I have already described ; others, again, are partly common to the South American region and the islands, partly to the New Zealand region and the islands—*Pelargonium australe*, for instance.

The question how these and other remote islands became more or less clothed with vegetation is a most interesting one, and one that has been discussed and answered in a variety of ways. Few persons believe in a special creation, but the existing vegetation may be the remains of a former more extensive flora, and the islands themselves remains of a former continent ; or it may have been derived from other countries, conveyed by birds, oceanic currents, and other agencies, and the islands themselves may be comparatively recent upheavals of the ocean bed.

In Knowledge for December, 1895, is an illustrated account of the appalling and disastrous eruption which desolated the Island of Krakatoa and neighbouring countries in 1883. The island was torn and rent, and what was left of it was covered with a layer of cinders and pumice stone from one to sixty mètres in thickness, which was, of course, at first of such intense heat as to utterly destroy all animal and vegetable life. A spot of such absorbing interest has naturally attracted the attention of all who have passed within view of it, and it was actually visited by a botanist (Dr. Treub) three years after the great eruption. His observations teach us how an absolutely barren island may become covered with vegetation.

The island, as the destructive forces left it, is about three miles across, and has an altitude of two thousand five hundred feet. One side presents an almost perpendicular wall to the sea, and the other side slopes steeply to the shore. Its situation in the Sunda Straits is twenty miles from Sumatra and twenty-one from Java ; and the nearest point where there was terrestrial vegetation is the Island of Sibesie, ten miles distant. When Dr. Treub visited the island in 1886 he found the elements of a new flora, which he studied on the spot, afterwards publishing the results in detail.

The beginning of this new flora is the most instructive phase to study. Cinders and pumice stone do not suggest fertility ; but it is astonishing what moisture and chemical action will do, and how one class of plants prepares the matrix for others of higher organization. On this unpromising medium the spores of filamentous algæ (chiefly species of the universally dispersed genus *Lyngbya*), carried thither by the winds, were the first to germinate, causing in their development a certain amount of disintegration. Individually these organisms are microscopic, but they multiply prodigiously, and form a green, film-like, gelatinous tissue over the surface on which they grow. The action of these organisms on the volcanic stratum, and their own decay, formed a medium in which the spores of ferns, brought by the currents of air, germinated and developed into plants. In this early stage of the new vegetation of Krakatoa, Dr. Treub observed eleven species of ferns, and some of them were already common. In their turn the ferns prepared the soil for plants of a still more complex organization, namely, flowering plants belonging to various families. At the time of Dr. Treub's visit plants of this class were quite rare, though fifteen species had already established themselves. These consisted partly of seaside plants, whose seeds were undoubtedly floated to the island and were cast ashore by the waves, and partly of plants whose seeds were either dropped by birds or carried thither by winds. Eight species were found on the mountainous interior of the island. Those on the seashore were all plants that have a very wide range in similar situations in the tropics, and are among those which first take possession of coral islands. The seeds of most of them have been proved by actual experiment to bear immersion or "flotation" for a long period in salt water without losing their vitality. Last year Dr. Treub visited Europe, and on his homeward voyage passed within view of the island, which, as he informed the writer, was then again covered with vegetation. This is a most instructive lesson in the natural distribution of plants, on account of its being the result of actual observation. There are records of seeds being conveyed very much longer distances by oceanic currents and afterwards germinating; but here we have an instance of the complete renewal of a flora. In addition to plants growing on the seashore, Dr. Treub collected seeds or fruits of seven other species of flowering plants, including those of a screw-pine and the coconut.

The preponderance of ferns in remote volcanic islands is characteristic. In Ascension, for example, there is a dozen species of ferns and three of lycopods, against less than half a dozen certainly indigenous species of flowering plants; and the latter are comparatively rare. It should be remembered that in all these comparisons plants introduced by human agency are left out of consideration. The aboriginal flora of St. Helena comprised, so far as is known (some being now extinct), thirty-eight species of flowering plants and twenty-seven species of ferns and lycopods. In the Tristan d'Acunha group the numbers are twenty-nine and twenty-six respectively. In the small flora of Juan Fernandez there are forty-four species of ferns. The relatively large Bourbon Island, near Mauritius, has two hundred species of ferns, as against eight hundred species of flowering plants. The large proportion of ferns is easily accounted for by the fact that there is probably no limit to the distance fern spores are carried by the wind, and they are produced in such prodigious quantities that they are likely to reach the smallest and most remote islets.

I do not like to encumber an article of this description with too many botanical names, but so many persons know ferns that I feel justified in giving the names of those which had established themselves in Krakatoa three years after the great catastrophe. They are:—*Gymnogramme calomelanos*, *Acrostichum scandens*, *Blechnum orientale*, *Acrostichum aureum*, *Pteris longifolia*, *P. aquilina*, *P. marginata*, *Nephrolepis exaltata*, *Nephrodium calcaratum*, *N. flaccidum*, and *Onychium auratum*. These ferns are nearly all of wide distribution, and nearly all in cultivation. It will be seen, too, that the common bracken (*Pteris aquilina*), one of the most widely diffused ferns, is among them.

GREEK VASES.—III.

B.—BLACK-FIGURED VASES.

By H. B. Walters, M.A., F.S.A.

In resuming the history of Greek vase painting, we have now to trace the course of development in a town that always played an important part in the history of the minor arts in Greece, and, consistently with its position as second only to Athens in commercial importance, may be regarded as second only to that city in the reputation of its fictile products. We refer to Corinth, which, from its geographical situation, was well suited to be one of the principal centres of Greek trade, while yet another circumstance contributed to its success in this particular branch. The soil of the surrounding country is composed of a whitish clay of peculiar excellence, which was employed not only for home products, but also to a great extent for exportation. Even Athens, favoured as it was in the possession of excellent clay in its immediate neighbourhood, sometimes made use of that of Corinth.

The first indication we have in Greek literature of a school of art at Corinth is in the account of the chest of Kypselos, which was set up by the family of that tyrant in the temple of Hera at Olympia about 600-580 B.C. From the minute description of this wonderful work of art given by the traveller Pausanias, we may gather that the carvings on the sides of this chest were very similar in style and range of subject to those on many existing Corinthian vases. At the same time the chest of Kypselos, regarded in the light of the evidence from vase paintings, must belong to a very highly developed stage of Corinthian art, and it will now be necessary to trace the preliminary steps which led up to it.

There is a small class of vases, mostly found at Corinth, of which the British Museum possesses the most notable example, all of diminutive size, but characterized by an extraordinary delicacy of execution. These vases are generally regarded as the earliest products of Corinthian ceramic art, and are known as Proto-Corinthian. The subjects which occur on them are of a comparatively simple nature—battle scenes, hunting scenes, and figures of animals, executed with marvellous minuteness. The shapes and method of decoration of these vases point to the influence of Oriental metal-work—an influence which made itself most strongly felt in the art products of Chalcis, in Eubœa; it has therefore been supposed that this group of vases belong rather to Chalcidian than Corinthian art, as there was undoubtedly a close connection between the two places. They appear to date from the seventh century B.C.

We must now, however, turn to the large number of vases the Corinthian origin of which is free from all doubt. It is true that examples are found in great quantities not only at Corinth, but in Bœotia, Rhodes, Italy, and other points of Greek civilization; but even if made on the spot where they have been found, the connection with those from Corinth is far too close to allow of any supposition other than that they are the work of Corinthian artists residing in that place.

In the earlier Corinthian vases Orientalism reaches its zenith. The surface is usually so crowded with rosettes and similar ornaments that the ground-colour almost disappears, and the general effect to the eye, both in colour and design, is that of rich Oriental embroidery. Fantastic monsters seem to have been directly chosen for their fitness to fill in spaces (as we see in some of the early sculptures found on the Acropolis at Athens). The ground is a clear yellow, varying in tone from cream to orange, on which the figures are painted in black with a purple pigment added for details; while a great fondness for incised lines is also noticeable. It is necessary to call attention to these two points, because they form a most salient feature of the black-figured vases.

In the repertoire of subjects we see a steady development, from the simple vegetable ornament to the elaborated scene from mythology. The steps are as follows: (1) vegetable ornament; (2) single animals; (3) animals in friezes, or heraldically grouped; (4) single human figures; (5) friezes or groups of human figures; (6) scenes of hunting or battles; (7) scenes from Greek mythology, or connected with the worship of Dionysos. Among the animals the lion is a principal favourite, and fantastic monsters are very popular, especially the Sphinx, Siren, and winged fish-tailed deities. We now first find names inscribed over the figures, and this is a matter of special importance as regards Corinthian vases, owing to the peculiarity of the alphabet employed, and the fact that the use of certain letters or forms of letters enables us to date many vases with tolerable certainty. These inscriptions range from about 650 to 500 B.C.

Before the growing sense that human action is the most appropriate subject for the vase painter, Orientalism begins to give way; the animal shapes, it is true, still encumber the field, but are for the most part restricted to friezes bordering the design, of which they thereby gradually cease to become an integral part. The face is now generally rendered in silhouette, sometimes in outline, and the practice grows up of distinguishing female figures by the application of white for flesh tints; this afterwards became universal as long as the black-figure period lasted.

Another feature with which we now meet almost for the first time is that of artists' signatures; two are known to us on Corinthian vases, one of which is found on a specimen of a remarkable series of painted plaques discovered on the Acropolis of Corinth in 1879. Most of them bear dedications to Poseidon, and many also have representations of this god with his consort Amphitritê. On several specimens are representations of mining, of the potter's art, and other occupations of daily life. The inscriptions are important as dating these plaques between 650 and 550 B.C. They were hung up as votive tablets in a temple of Poseidon, the guardian deity of Corinth, and had been collected in a rubbish-heap like the Naucratis fragments mentioned in the last article.*

The favourite shapes of Corinthian potters are, in the earlier examples, the aryballos and alabastos, kylix, pyxis, and cotyle (Fig. 1*b*)—viz., small oil flasks and two-handled cups; but in the later stages the larger shapes, such as the amphora, crater, and hydria, come into general use; also the oinochoë. The later specimens are usually made of red clay, and are, in fact, little distinguishable from the earlier Athenian examples. It is an open question whether the Athenian vases were influenced by Corinthian, or the reverse; but, probably, both views contain a measure of truth. A wider field is now opened to the subjects, which include scenes from the Trojan legends or the exploits of Herakles. Names from mythology are frequently inscribed over the figures of banqueters, warriors, or huntsmen, or ordinary scenes from daily life, in order to intensify the interest or to give a sort of idealized picture of everyday events.

Fig. 1.—(*a*) Cup (Kylix) of so-called Cyrene Fabric, representing a Sacrifice, one-fourth original. (*b*) Cup (Cotyle) from Corinth; two Sirens confronted; one-fourth original. (*c*) Plate (Pinax): Warrior blowing Trumpet: one-fourth original.

We must now retrace our steps once more to discuss a fabric of especial interest and importance, though represented by comparatively few specimens (see Fig. 1*a*). These vases are, almost without exception, of the shape known as *kylix*, or goblet, and the designs are painted, in lustrous black, on a thick, creamy slip, with purple and incised details. From a technical point of view they represent the same stage as the older Corinthian fabrics, but the drawing shows a great advance, while the mythological repertoire is comparatively large. They are generally attributed to the first half of the sixth century. One of the most remarkable specimens is in the Library at Paris, and represents Arkesilaos II., King of Cyrene on the north coast of Africa (580-550 B.C.), weighing out bales of the plant silphium (asafœtida). This plant was a product of the country, and a great source of revenue to the kings of Cyrene; it is represented on many of the coins. Another example in the British Museum (unfortunately, much injured) represents a female figure holding branches of silphium, surrounded by flying male and female figures. It has been most ingeniously shown that this figure represents the Hesperid nymph Cyrene, while the other figures are the Boreades (who bring the fertilizing north wind) and the Harpies (who guarded the Garden of the Hesperides). All this is very strong evidence for the presumption that these vases were manufactured at Cyrene, although it is true that none have been found there; there is also a close connection in technique with Naucratis, where, indeed, the last-mentioned vase was found.

We must now turn our attention once more to Athens, a city that is destined not only to supplant Corinth as the chief centre of ceramic art, but gradually to oust all other fabrics from favour or absorb their excellencies in its own, and to retain this monopoly unquestioned for two centuries. The impetus to this productiveness was given by the extraordinary advance of art and culture under the beneficent rule of the tyrant Peisistratos and his successors (565-510 B.C.). The immediate result of this development was to attract artists from all parts of Greece, and in the Athenian sculpture and vases of this period we are able to trace a marked influence of Peloponnesian art.

The museum at Florence possesses one of the most remarkable existing specimens of Greek pottery in the shape of a large vase (of the shape known as crater) found near Chiusi in 1844 by M. François, from whom it is always known as the François Vase. This vase bears the signature of two Athenian artists, to this effect: "Ergotimos made me, Klitias painted me"; and it is usually attributed to the middle of the sixth century. The

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* See Knowledge for April

alphabet in which the inscriptions are written clearly shows its Athenian origin, but there are several characteristics which betray Corinthian influence.

The British Museum and that at Berlin possess two similar vases, but of inferior size and merit, the principal subject on each being the birth of Athena from the head of Zeus. This was originally a Peloponnesian legend, and it is interesting to note that one of the figures on the Berlin vase is inscribed, "I am Hermes of Kyllene," referring to a mountain in Arcadia on which that god was especially worshipped. Further, the word Kyllene is spelt with an initial "Q," a letter which only occurs twice in Attic inscriptions, but is common in Peloponnesian alphabets.

From this time onwards the history of Athenian vase painting is one of continuous and rapid development. One noteworthy result of this development is in the shapes employed, which in the earlier periods show an extraordinary variety. But the shapes in common use by Athenian potters may be limited to perhaps a dozen or so, and of these only five may be said to enjoy anything like popularity. These are the amphora (by far the most popular of all), the hydria (three-handled pitcher), oinochoë (wine jug), lekythos (oil flask), and kylix (goblet). Several of these shapes pass through successive phases of development which are of great assistance in a chronological classification. We may take the amphora and kylix as best illustrating our purpose. The earlier examples of the amphora are obviously Corinthian in type, and have a thick body, more or less egg-shaped, running up without marked division into the neck, and thick cylindrical handles. The whole vase is covered with black varnish, except a panel on either side in which is the design. Another variety is chiefly represented by the Panathenaic amphoræ, which we shall discuss later, which have a very short neck and converge below to a very small foot. The later examples have a high cylindrical neck strongly set-off from the body, which has a high flat shoulder. In these the black varnish is only applied on the mouth, foot, and handles (which are formed of three parallel ribs), the whole of the vase being left red, except for the figures, and highly glazed. The early kylix has a high stem, and the upper part of the bowl is set at an angle to the lower, forming a band for the designs; in the next stage this angle becomes more obtuse, and the band is narrowed by a broad stripe of black varnish round the lip; finally the angle is replaced by a continuous outward curve, and the foot becomes shorter and thicker.

The technique of the black-figured vases is marked by two notable features, the first being the red clay of which the vases were manufactured, which was found in such abundance in the plains of Attica; its hue is due to an oxide of iron. This red clay is admirably suited for taking a glaze—an essential preliminary to the process of painting on such a material. The second feature is the black, varnish-like pigment which was used, not only for filling in the contours of the figures and for the decorative patterns, but also for covering the mouth, foot, and handles.

Two accessory colours are employed, purple and white; the latter mostly for the flesh of women, for the hair of old men, or for the long garment worn by the charioteer. It is noticeable that at first purple is by far the more popular of the two, being used in large masses, and even for the flesh of men in many cases; but in the later black-figured vases its use is largely discountenanced, and is at most employed for small details such as the folds or patterns of a dress. The incised lines, again, play a very important part in the technique of these vases. They are made with a hard-pointed tool of bone or iron while the clay is still moist, the outlines of all the figures being traced first, and the designs then filled in with black varnish. The next process was the addition of incised lines for the inner markings and finer details, after which the vase was sent to the furnace, and finally the purples and whites were added and a second baking completed the process of production.

Throughout this period a steady advance in drawing is noticeable, although in one direction there is a somewhat deplorable tendency to affectation and mannerism, which shows itself both in the drawing and in extravagant use of ornament. Another feature is one which is more or less common to all archaic art, but is especially noticeable in these vases—viz., the tendency to give tapering extremities to human figures, and this at times runs quite to extravagance (*see* Fig. 2).

Fig. 2.—Corintho-Attic Jug (Olpè), with Hunter returning from the Chase. "Minute" style: one-third original.

The treatment of drapery is interesting, and may be regarded as a fair indication of date. The chiton, or long garment ordinarily worn by women, is at first straight, with rigid stripes of purple on black; then patterns are incised or painted in white on the black; the waist is generally very small, and bound tightly with a broad girdle. By degrees the lines of the folds take an oblique direction, as if to indicate motion: while an upper garment, the himation, or mantle, is now introduced with marked effect in the direction of oblique flowing lines or angular falling folds.

Another important feature of black-figured vases is the treatment of decorative patterns, which in this period become almost stereotyped. Thus on the amphoræ certain patterns are always employed to decorate certain parts of the vase; again, on the kylikes, in the latest development, a large eye is always painted on either side of the handles, this particular object being chosen, probably, as best adapted to the space. Again, it seems to have been almost a rule at one time to decorate the interior of a kylix with a full-face head of the Gorgon Medusa, not painted in black on a red ground, but left in the red clay while the whole of the surrounding surface is black. It will be seen that this is practically the method of the succeeding red-figure style; and it has been supposed that this treatment of the Gorgon head was one circumstance which led to the evolution of that method.

We come now to what is, perhaps, the most important, and certainly the most interesting, aspect of the Athenian black-figured vases, namely, the subjects painted on them. These may conveniently be divided into six classes, as follows:

1. Representations of myths connected with Olympian deities, such as the birth of Athena from the head of Zeus.
2. Representations of Dionysos and his attendant Satyrs, Mænads, etc.
3. The labours and exploits of Herakles.
4. Subjects taken from the Homeric poems or other sources dealing with the tale of Troy.
5. Other mythological subjects, such as the exploits of Perseus and Theseus.
6. Subjects taken from daily life, such as athletic contests, battle scenes, etc.

It should be noted that this classification of subjects holds good throughout the history of vase painting—at least with some slight modifications; but it is in the period with which we have to deal that the subjects present the greatest and most varied interest, owing chiefly to the prevalent fondness for myth and legend. In the later periods the human interest tends to predominate.

Fig. 3.—Athenian Amphora, with Dionysos and Eyes; one-third original.

In the mythological scenes the most remarkable feature is the adoption of certain fixed compositions of figures or types; a scheme of design for any given subject, once adopted, becomes conventionalized, and is adhered to with only minor variations, which do not affect the main design. An example of one of these types is given in Fig. 4. In all representations of the Judgment of Paris the same grouping of the figures is employed, but variety is introduced by omitting Paris or one of the goddesses.

Among the favourite subjects with vase painters of this period are: the combat of the gods and giants, the birth of Athena (*see ante*), Peleus wrestling with Thetis, Theseus slaying the Minotaur, Herakles conveyed by Athena in her chariot to Olympus, and contests in which that hero took part, such as his encounter with the Nemean lion, with the triple-bodied monster Geryon, or with the Amazons.

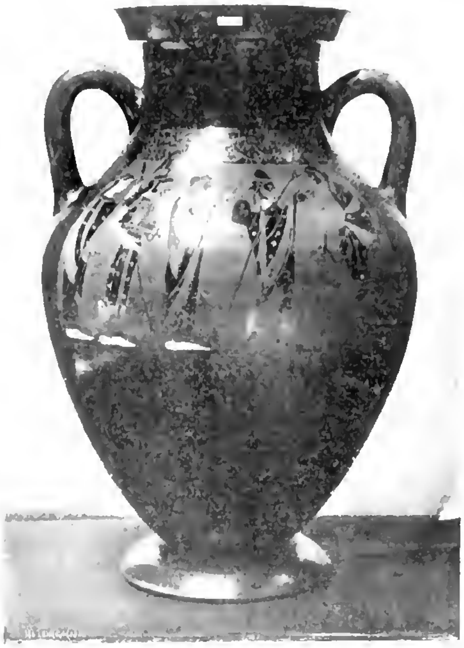

Fig. 4.—Amphora, with Judgment of Paris. Athenian Fabric; about one-fifth original.

Only one instance of a historical scene is known on the black-figured vases—on an amphora in the Louvre, which represents Crœsus, King of Lydia, seated on his funeral pyre and pouring a libation. The story is told by Herodotos. We may also recall the cup described on page 152, with Arkesilaos of Cyrene weighing out the silphium.

Among the scenes from daily life an interesting subject is seen on a number of hydriæ (pitchers) which indicates the use to which this particular vase was put. A building is depicted containing a fountain or spring, at which girls are seen filling their hydriæ, while others bring theirs up to be filled or carry them away on their heads. On one example in the British Museum (*see* Fig. 5) the famous well of Callirrhoe at Athens is depicted; on another possibly that of Peirene at Corinth.

A most important class which must here be mentioned, is formed by the Panathenaic amphoræ, or vases given as prizes in the games at Athens in honour of Athena. On one side is always depicted a figure of the goddess herself; on the other, the contest for which the prize was given. Usually the vase is inscribed, "I am a prize from the games at Athens." It is interesting to note in connection with these vases that the black-figure method was adhered to on them, for religious reasons, down to the end of the fourth century B.C.: that is, as long as they continued to be made, although on other vases this method was given up at the beginning of the fifth century.

Another class of vases which for religious reasons preserved the old style of painting through the fifth century has come to light in recent years, on the site of the temple of the Cabeiri at Thebes. The Cabeiri were mystical deities about whom very little is known; but it appears that ribaldry and grotesque caricature played a considerable part in their religion, and probably burlesque representations of myths were performed as part of the rites, and were further depicted on the vases dedicated in the temple, as on most of these vases we find caricatures of mythological scenes, such as Circe offering the magic potion to Odysseus.

A new development of technique towards the end of the sixth century is seen in a class of vases with white ground instead of red—a method which is supposed to have been introduced by the artist Nikosthenes, a man of considerable fertility of invention, who also introduced a new form of amphora. In several vases signed by him the clay is covered with the creamy white slip which is characteristic of the class of which we are speaking. Some specimens of this group are very effective, but they are generally of small size.

Fig. 5.—Athenian Hydria (Pitcher), with Girls drawing Water at the Fountain of Callirrhoe; about one-fifth original.

It will be necessary to add a few words on the other Athenian artists who during this period left their signatures on their productions. They fall roughly into three or four classes: (1) the earliest group, at the head of which stand the artists of the François Vase described in a previous page, Klitias and Ergotimos; (2) the so-called minor artists, the chief names being Glaukytes, Tleson, and Xenocles; (3) the artists of the "affected" or "minute" style, such as Exekias and Amasis; (4) the artists who combine the black-figure and red-figure methods, Pamphaios, Nikosthenes, and Andokides. This classification is roughly chronological.

The "minor artists" in a way may be regarded as the forerunners of the great vase painters of the succeeding period, as they turned their attention almost exclusively to the decoration of the kylix.

In the next paper we shall see how the humble efforts of the "minor artists" led by degrees to the beautiful creations of their successors. In the present stage we find the decoration limited to one or two small figures on either side of the exterior, or a single figure, while many bear nothing but the signature of the artist or some appropriate motto, such as "Welcome and drink deep," or "So-and-so is fair." On the later unsigned kylikes the decoration becomes very rude and careless, although more attention is paid to choice of figure-subjects than by the "minor artists."

The artists of the "affected" style appear to be descendants of those who produced the so-called Peloponnesian vases, to which we have referred in connection with the François Vase. The same tendency to minuteness and richness of detail, to tapering extremities of human figures, and delicacy of form and outline, is here visible, in conjunction with more advanced power of drawing and knowledge of technique. Still, the result is quaint rather than pleasing, although it must be remembered that this tendency to over-refinement and richness is characteristic of the end of the archaic period in all branches of Greek art, and the result of a tendency which is swept away by the wave of athleticism and simple idealism which spread over the cultured Greek world in the fifth century.

It must, however, be reserved for the next article to treat of the causes which led to the change of artistic methods under Nikosthenes and his contemporaries, and the results which were brought about by that development.

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COMETS OF SHORT PERIOD.

By W. E. Plummer, M.A., F.R.A.S.

We have now to consider that large class of interesting comets which, moving as they undoubtedly do in elliptic paths of comparatively short period, have been seen once and then disappeared as completely as if their paths had been parabolic. Evidently this class of objects offers two riddles for solution. Why were they not seen before? And why have they never been seen since? The latter question does not, however, apply with the same force to those recently discovered comets which have not yet completed one revolution since they were first seen. It will be desirable to put these new comets in a class by themselves, and trust that time will prove them to be well-regulated members of the solar system. They cannot be said to have discredited themselves as yet, and the only suspicious circumstance connected with some of the members is, that they bear, in some of the elements of their orbits, a great family likeness to others that have had their chance of being repeatedly visible in our telescopes, and have not availed themselves of their full opportunities. We will give this list first, and make a few comments upon the more suspicious, and for this reason, possibly, the more interesting members of the group. The order of arrangement is again that of increasing mean distance from the sun.

Ordinary Designation of the Comet.	Period in Years.	Date of last Perihelion Passage.	Approximate Date of next Return.	Aphelion Distance in Terms of Earth's Distance.
1894 V. E. Swift	5·863	1894, Oct. 12	1900, Aug. 23	5·111
1892 V Barnard	6·304	1892, Dec. 11	1899, April 1	5·396
1890 VII. Spitaler	6·381	1890, Oct. 26	1897, Mar. 11	5·063
1892 III. Holmes	6·904	1892, June 13	1899, May 9	5·112
1889 V. Brooks	7·072	1889, Sept. 30	1896, Oct. 26	5·449
1895 II. Swift	7·19	1895, Aug. 21	1902, Oct. 30	6·150
1894 I. Denning	7·373	1894, Feb. 4	1901, June 19	6·129
1889 VI. Swift	8·534	1889, Nov. 29	1898, June 12	6·298

Here we have eight comets introduced into the system in the short space of six years—on the average, more than one annually—and yet the total number of elliptic comets of approximately this period is only about thirty, including those that are lost and some whose periodicity is very uncertain, owing to defective observations made in the last century. Evidently, if this rate of increase was only approximately correct, the number now known should be far greater. Some in this catalogue, it is true, have been very faint objects, and would probably have passed undetected in days when telescopes were smaller or searchers fewer in number. Still, as pointed out in my article in the February issue, this suggestion does not altogether explain the frequency with which elliptic comets are now met with. Another very obvious suggestion presents itself. Is it possible that these objects are not all independent? May not some of the older and lost comets take upon themselves new shapes—move along strange and unrecognized paths under the influence of planetary perturbation, exerted upon them at some period in their career subsequent to our observation of them?

In this question we have implicitly two suggestions: the possibility of identity and the possibility of intimate connection between comets, arising presumably from having sprung originally from one parent stock; for it is necessary to bear in mind that other causes than planetary perturbation may be operative. We have seen Biela split itself into two sections, and the dichotomized comet pursue a bifurcated path. It may not be possible to demonstrate the cause of this disruption with certainty, though the behaviour of other comets, particularly the perplexing and inexplicable changes in brilliancy which they present to us at successive returns, and even while under observation, suggests that it was more probably due to some mechanical agency within itself than to any external force. In this particular case of Biela the two separated portions kept near each other, and came up to perihelion together within a day; but had the operating cause been greater, it is easy to imagine that a longer space of time would have separated the return of the two fragments, which, pursuing paths wider asunder, would have been submitted to different effects of perturbation, and the other elements of the orbit would have differed proportionately. Or suppose, the disruptive force being the same, several revolutions had been completed without the possibility of observing the comet; the disconnected portions would have separated more and more at each successive return, till it is quite possible only one of the components would have been seen. In the great comets of 1843 I., 1880 I., and 1882 II., we appear to have an instance of more violent disruption, in which one may suggest that some giant comet, carrying in itself greater forces, and consequently greater opportunities for producing catastrophe, has so violently dismembered itself that its several portions arrive at perihelion separated by years. The history of cometary astronomy contains so many surprises that it is almost impossible to reject any hypothesis as absolutely untenable, and it is unfortunately too easy to throw out suggestions that it is impossible to put to the test of experiment or efficient analysis. For instance, it is generally accepted now, with more or less certainty, that comet tails are due to a form of energy (electrical repulsion is the usual form the explanation takes) acting from the sun in a sense contrary to that of gravitation. But recent photographs of comet tails have indicated a shattering and discontinuity incompatible with a force regularly and continuously operative; and though this irregular structure may be explained by actual encounter with some asteroid, it is not impossible that the origin of disruption was present at the birth of the tail itself.

The only point that is here insisted upon is this: that while planetary perturbation, acting under laws that are perfectly understood and can be submitted to mathematical analysis or arithmetical calculation, is undoubtedly a great factor, either in the introduction of fresh cometary matter into the solar system or in controlling cometary matter that entered the solar system with the velocity due to parabolic, or approximately parabolic, motion, it is not necessarily the only force that can be invoked or employed as a working hypothesis. The suggestion of hypotheses without submitting them to adequate test is, perhaps, a confession of ignorance and an attempt to hide it; but the criteria applied by astronomers and mathematicians in this particular connection rarely give a certain and unambiguous result. The conditions of the problem are so varied, the opportunities of escape so numerous, the labour of absolute test so onerous, that we are too often obliged to accept a half answer, and console ourselves with the hope that time will fight in our favour by adding fresh observations and increasing the accuracy of the deductions. But time frequently introduces a fresh and complicating factor, without by any means removing the old perplexities.

As a good instance of the difficulties to be overcome in answering the question of a comet's origin, we may take the first item on the list (1894 V. Swift) and endeavour to understand the interesting problem it offers for solution and the means it supplies for that solution. On November 21st, 1894, Mr. E. Swift, the son of Prof. Lewis Swift, well and honourably known in connection with cometary discovery, picked up a faint comet at considerable southern declination. It had passed its perihelion and was growing fainter, but was moving northward, which slightly improved its chances of observation, and Prof. Barnard was able to follow it with the large refractor of the Lick Observatory till January 25th. We have, therefore, two months' intermittent observation of a faint nebulous patch by a few observers, no two of whom are likely to agree on the same precise point for measurement, to say nothing of the possibility of an alteration of shape. Yet out of these observations, which cover so small an arc of an ellipse which requires six years to complete its revolution, the entire curve has to be constructed. Such procedure puts the *ex pede Herculem* principle to its fullest stretch. Nevertheless, as soon as a few observations permitted the first rough determination of an orbit, M. Schulhof announced unhesitatingly that it was the lost comet of De Vico, that had previously been seen once, and once only, in 1844. If this conjecture be well founded, evidently the comet has no right to a separate place on the list, any more than any other comet which may have been missed at one or several returns and subsequently recovered, of which examples were given in February. On what grounds, then, had M. Schulhof based his assertion?

The observations of the comet of 1844 had been submitted to a very critical discussion by the late Dr. Brunnow, and though the orbit was to some small extent uncertain the elements were fairly trustworthy, and resembled those of the parabola that Schulhof had computed from the first observations that had come to hand. It may be as well to mention here that this is the course uniformly pursued by computers. A parabolic orbit is first derived because the labour of computing elliptic elements is far greater, and to obtain accuracy comparable with that labour the elements should be based on observations extending over a longer period than is required to give fair accuracy in the case of parabolic motion. So complete was the resemblance between the new parabola and the old ellipse that Schulhof at once, without waiting for additional observations, assumed a period very nearly that which Brunnow had assigned for the 1844 comet, and re-computed elliptic elements which subsequent care and additional information have not materially improved. Here is the first link in the chain of evidence, namely, that the motion of Swift's comet can be represented by elements whose period is suggested by that of De Vico's comet. But fifty years is a long time, and many alterations more or less serious must be expected to take place in the pure elliptic motion of a comet which runs very nearly in the plane of the ecliptic, and must cross and recross the orbits of Mars and Jupiter several times, with the chance of approaching those planets more or less closely. To compute the perturbations of a comet for fifty years is a task which, though it would effectually remove the objection, is not lightly to be undertaken; and to enter upon such an enquiry we want what we have not got—either very accurate knowledge of the elements in 1844, or the present condition of things in 1894. Errors accumulate with the time. Dr. Brunnow had assigned 5·5 years for the period of De Vico; Schulhof preferred 5·8 years for Swift. So far as these figures go, at each return the error would be increased by three-tenths of a year. But mathematical analysis has been able to indicate the direction that perturbations will take without the labour of actual calculation, and it has been demonstrated by M. Callandreau that in the case of a comet having a small inclination to the plane of the ecliptic, and moving about the sun in the same direction in which the planets revolve, the action of the planets will continually tend to increase the longitude of the perihelion and diminish that of the node. Fortunately the means were at hand to settle this question. Le Verrier had believed that the comet of 1844 was the reappearance of one that had been seen in 1678. If this be the case, the fact that it lay dormant, so to speak, for so many years is typical of its more recent behaviour; but in investigating this question Le Verrier had carried back the perturbations and supplied elements for various dates in its past history. We are simply concerned in the motion of the perihelion and the node, and for these Le Verrier gives

	Longitude of Perihelion.	Longitude of Node.
For 1799	334° 24′	135° 18′
,, 1811	338° 24′	118° 29′
,, 1844	342° 31′	63° 50′

while M. Schulhof's hastily computed element gives

For 1894	345° 20′	43° 41′

Here we have clearly exhibited the direct motion of the perihelion and the retrograde motion of the node, tending to complete the train of evidence in favour of identity. But the argument is not yet complete. Dr. Brunnow's elements showed that De Vico's comet should approach Jupiter towards the end of 1885. Dr. Schulhof's elements show that the 1894 comet was actually near Jupiter in 1885-86, and this might well explain the alteration of the period from 5·5 years to 5·8 years.

At this point Prof. Chandler, whose name is so well known in connection with the variation of geographical latitude, took up the subject; and after having improved the elements by incorporating Prof. Barnard's latest observations, computed the perturbations of the comet back to the time before the last approach to Jupiter occurred. It is not possible to compute these perturbations with absolute certainty, because the unavoidable errors in the elements do not permit the distance of the comet from Jupiter—on which, of course, the amount of disturbance depends—to be determined with accuracy. The result of his calculations, however, is to show that all the elements have a tendency to approach those that Dr. Brunnow assigned in 1844, when brought up to the same date. These are given side by side. In the first column are Brunnow's elements brought up to 1882; in the second the most probable elements that can be assigned before the very considerable perturbations by Jupiter were effected; in the third the most trustworthy elements Prof. Chandler could derive from the inadequate materials at his hand.

	Brunnow.1882.	Before Perturbation, 1886.	Actual Orbit, 1894.
Arc between perihelion and node	278° 49′	283° 7′	296° 34′
Longitude of node	64° 23′	60° 24′	48° 41′
Inclination to ecliptic	2° 55′	2° 58′	2° 58′
Eccentricity ...	0·61765	0·60282	0·57190
Nearest approach to sun	1·1864	1·2548	1·3920
Period in years	5·466	5·615	5·863

Here the agreement is very satisfactory and gratifying, since the greater part of the observed difference between Brunnow's orbit (1844) and Chandler's (1894) has disappeared.

There still remains the question, Will time fight on our side, and by adding fresh information remove any shadow of doubt which hangs over the question of identity? Evidently, if we should see the comet again six years hence, we could get a very accurate idea of the mean motion, and so trace back the path of the comet with greater certainty. We have, however, to face the fact that in 1897 a still closer approach to Jupiter is certain; and Mr. Chandler, in summing up the probability of the new conditions under which the comet will find itself, says: "I am inclined to anticipate that, with the present appearance, our acquaintance with this interesting body will unfortunately be brought to an end. The present perihelion distance will probably be changed by Jupiter in 1897 to one considerably beyond the orbit of Mars, so that unless a favourable reversion of the change in brilliancy which apparently took place between 1844 and 1894 should occur, it will in all likelihood hereafter be invisible; at least until, at some future approach to the critical point of disturbance near longitude 165°, simultaneously with Jupiter, it shall be thrown into a path in which, near perihelion, it will be again in reach of our telescopes."

I have dealt with this comet at length because it offers a typical instance of the difficulties and of the degree of success that attend inquiries of this nature. The history contains all the uncertainties that arise from imperfect knowledge of the actual path in which the comet is moving at the time of observation, the laborious nature of the arithmetical calculations involved, and of the uncertain element that lapse of time introduces. There is, it is true, another test, easy of application, known as "Tisserand's criterion;" but this test, for reasons which I shall hope to explain hereafter, is peculiarly apt to speak with uncertain sound. I have not introduced it here, though applicable, for its use can be better illustrated in the case of some of the other comets of which mention has been made in the first paragraph. In the case of De Vico's comet, here considered, it will be admitted that the final result appears gratifying; but no light is thrown on the further interesting question of actual identity as opposed to an intimate connection. In the present state of our knowledge, or of our ignorance, of the internal constitution of comets, it is not possible to apply mathematical analysis. The problem presents itself simply as one of disturbed elliptic motion, and the interest turns on the ingenuity with which various astronomers have successfully encountered and overcome the intricacies of the subject.

PHOTOGRAPH OF THE REGION OF THE SPIRAL NEBULA MESSIER 33 TRIANGULI.

By Isaac Roberts, D.Sc., F.R.S.

THE photograph was taken with the Cooke five-inch lens on the 14th November, 1895, with exposure of the plate during two hours and fifteen minutes. The centre of the plate is about R.A. 1h. 28m., declination north $30^\circ\ 7'$; and the area of the sky covered is 8·1 degrees from north to south and 6·1 degrees from *preceding* to *following*, the nebula being at the centre.

Scale, one millimètre to one hundred and twenty-one seconds of arc.

Sir J. Herschel (N. G. C., No. 598; G. C., No. 352) and Lord Rosse (*Observations of Nebulæ and Clusters of Stars*, p. 20) record many observations made by them of this spiral nebula, and by the aid of their large instruments, used with great skill and perseverance, they accomplished all that was possible in the way of descriptive matter and delineation to present the object in an intelligible form to astronomers. It is no adverse reflection upon their work if they did not succeed in the accomplishment of their object, for such is the vast area of the nebula, the complexity of its structure, and the faintness of parts of the nebulosity, that the best efforts by eye and hand could not possibly delineate it.

The photograph shows the nebula to be about sixty-two minutes of arc in length from *north following* to *south preceding*, and thirty-five minutes in breadth from *south following* to *north preceding*.

There are two large, very prominent spiral arms, with their respective curvatures facing north and south, and the curves are approximately symmetrical from their extremities to their point of junction at the centre of revolution, where there is a nebulous star, of about tenth magnitude, with dense nebulosity surrounding it—elongated in north and south directions. Involved in this nebulosity are three bright stars and several faint nebulous stars; the two arms are also crowded with well-defined stars and faint nebulous stars with nebulosity between them, and it is to the combined effect of these that the defined forms of the arms are due. There are also subsidiary arms, less well-defined, trending towards the centre of revolution, which are constituted of interrupted streams of faint stars and nebulosity intermingled together.

There are detached outliers of nebulosity with many small well-defined stars as well as nebulous stars involved in them; also isolated nebulous stars on the extreme boundaries of the nebula.

The larger photograph taken with the twenty-inch reflector simultaneously with that here annexed shows more clearly the details referred to, but the area of the sky delineated is limited to four square degrees.

In studying these photographs the question is very naturally presented to us, What is the cause that produced this vast stellar and nebulous whirlpool in space? Two answers may be suggested:—(1) An explosive disruption of a large body; (2) collision between two bodies moving from opposite directions. The colliding bodies might be two stars, two nebulæ, or two meteor streams; and if we judge by the widely scattered vortical distribution of the star-like and nebulous matter shown on the photographs, it is very probable that the collision of two streams of meteorites would be the cause.

Many other spiral nebulæ have already been photographed, and the appearance of each of them would well fit into the hypothesis suggested by Prof. Lockyer of the collision of streams of meteoric matter.

Notices of Books.

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Remarkable Eclipses, by W. T. Lynn (Edward Stanford, 6d.), is apologetically presented by the author as but "a little one." Here the apology is scarcely appropriate, for many readers would gladly see a larger work, tracing and explaining the allusions to astronomy in ancient and mediæval literature, from Mr. Lynn's pen. Mr. Lynn roughly divides the book into two periods—first, that of those eclipses which took place prior to A.D. 1715, the year when the prominences were first seen; the other, that of those subsequent to that date. The first authentic recorded eclipse he dates as recently as B.C. 776, as found in the "*Sto-King*," which is Mr. Lynn's free rendering of the title of the Chinese chronicle the "*Shu Ching*." But according to a series of papers on "Some Astronomical Records in Ancient Chinese Books," published in "The Observatory" in 1895, a noteworthy eclipse took place at An Yi Hsien on October 22nd, 2136 B.C., from 10 to 12.30 in the daytime, which may therefore surely be allowed a place in eclipse history. Mr. Lynn has long been known as a first authority on ancient eclipses, and the first portion of this his most recent work ably sustains his reputation. The latter part is the most lucid and accurate compendium of the results of modern eclipses that we have seen in such small compass. On page 38, however, he has been led into error on one point. Speaking of the eclipse of 1878 he says, "The corona was smaller and less brilliant than in those of the last-mentioned eclipses"—*i.e.*, 1869, 1870, and 1871. This was scarcely the case. As to its form, it was indeed of a most strongly marked minimum type, but it was of unusual extent and more than average brilliancy. These are the only corrections we note in a most readable and convenient little manual, the low price of which should certainly secure it a large sale.

Historical and Future Eclipses. By Rev. S. J. Johnson, M.A., F.R.A.S. (Parker & Co.) Illustrated. 4s. 6d. We are sorry not to be able to accord Mr. Johnson's book by any means unqualified praise. It is in effect a second edition of "Eclipses, Past and Future," published by the same author in 1874, and to which a small supplement was added in 1889. As it originally appeared the book had very considerable merits. It passed in brief but sufficient review nearly all the more important eclipses of the past, and gave some interesting particulars of a large number of eclipses to come. But in a second edition, published after an interval of almost a quarter of a century, we expect to find not merely all the information of the first edition, but also its errors corrected and its general character improved. The reverse is the case. The information given in the original work concerning the eclipses of 1896 to 1900—those most important to us just now—is not expanded but expunged. The misprint of "Ophinchus" for "Ophiuchus"—excusable, perhaps, in a first edition—is developed systematically throughout the present book. The physical details respecting the sun and planets, meagre enough in the earlier volume, remain nearly in the same condition, no sustained attempt having been made to bring them up to date; whilst the last page of the book repeats a long-exploded idea. The new matter is not always correct. Oppolzer's "Canon" is stated not to give solar eclipses in the southern hemisphere. Curiously enough, whilst the particulars of the eclipses close at hand are wholly eliminated, and those relatively near are often much shortened, the list of future eclipses is carried up to 2491, several centuries further than before. In short, a work with much to recommend it, and which, with a little

PHOTOGRAPH OF THE REGION OF THE SPIRAL NEBULA MESSIER 33 TRIANGULI

care in revision, could have been rendered faultless, has been but little altered after twenty years' interval, and then often for the worse.

A Contribution to our Knowledge of Seedlings. By the Right Hon. Sir John Lubbock, Bart., M.P., F.R.S. (Kegan Paul & Co.) Illustrated. 5s. This—the seventy-ninth volume in the well-known International Scientific Series—is an abridged edition of a larger work published under the same title. It is described upon the title-page as a "popular edition," but this must only be taken in a comparative sense, for no one unfamiliar with botanical phraseology could properly understand the contents. Readers who have received that preliminary education will, however, be interested in Sir John Lubbock's attempt to throw light upon an important stage in the life-history of plants. The forms of many interesting cotyledons are described and figured, and explanations are offered why cotyledons differ from the subsequent leaves and from one another. In a previous work on "Flowers, Fruits, and Leaves," the author gave an account of the causes which determine the form and structure of seeds and fruits. The present work, with its many suggestive ideas, forms a worthy companion to its forerunner.

Minerals, and How to Study Them: a Book for Beginners in Mineralogy. By Edward Salisbury Dana. (New York: John Wiley & Sons. London: Chapman & Hall.) Illustrated. Students of mineralogy are not very numerous, but this volume should certainly be the means of adding to their ranks. Written by a master of the subject, and with the desire to encourage those who wish to learn about minerals, the volume admirably supplies the wants of elementary students. Many guide-books to fields of scientific knowledge fail to point out the pitfalls and difficulties which are always liable to crop up in practical work, and which frequently discourage beginners. But this is not so in Prof. Dana's work. By clear descriptions he lights the way of the student; and while he directs attention to this or that point of interest in the form, structure, or other characters of minerals, he gives, where necessary, a caution as to sources of error in an experimental examination. The arrangement of matter is excellent. Sections on forms of crystals and kinds of structure, physical characters, chemical characters, and the use of the blow-pipe, form nearly one-half of the book; the remainder is concerned with the description of mineral species and the determination of minerals. Numerous illustrations, most of them new, are distributed through the book, and these, with the lucid text, make up a volume which will cultivate powers of observation, and excite interest in a neglected science.

Discoveries and Inventions of the Nineteenth Century. By Robert Routledge, B.Sc., F.C.S. Eleventh Edition. (George Routledge & Sons.) Illustrated. When a work has reached its eleventh edition it is almost beyond the effects of criticism. Little need, therefore, be said about the volume before us except that it contains a good general account of engineering achievements and scientific discoveries, written in a style "understanded of the people," and liberally illustrated. Some parts of the book have been brought up to date much more thoroughly than others. Thus the statement that "the number of observed bright lines in the iron spectrum has been since [that is, since Kirchhoff] extended to four hundred and sixty, and yet each is found to have its exact counterpart in a dark solar line," is behind the times, for nearly two thousand iron lines have been identified in the solar spectrum by Rowland. Several other cases of imperfect revision have been noticed in glancing through the book; but, taken as a whole, the new edition of the work deserves to be as successful as previous ones.

Heating and Ventilating Buildings. By Prof. Rolla C. Carpenter. (New York: Wiley & Sons. London: Chapman & Hall.) Illustrated. Would that all the tradesmen who call themselves plumbers and hot-water engineers had to give evidence of familiarity with the contents of this book before they were permitted to practise. The general principles of heating and ventilation are usually outside the knowledge of workers with lead and solder, and even in technological classes they are neglected in order to hurry on to applications. Prof. Carpenter gives satisfactory accounts of principles of ventilation, the nature and properties of heat, the radiation of heat, and similar matters, before describing the methods of application to the erection of systems of heating and ventilating. By so doing he shows that he knows the value which purely scientific facts possess for the self-styled "practical men," who often despise knowledge of which the industrial bearing is not apparent. With the clear and concise introductory chapters as a foundation, the reader of the work will be able to follow intelligently the descriptions of various practical methods and systems employed in heating and ventilating buildings. Steam and hot water systems, heating with hot air, with exhaust steam, and with electricity are all considered, and practical directions for their construction and installation are given. Throughout the book the information is sound and practicable. We offer our congratulations to Prof. Carpenter at having produced a splendid general treatise on a branch of engineering little studied in this country.

SHORT NOTICES.

The National Geographic Magazine (U.S.A.). (London: E. Marlborough & Co.) Issued from Washington as the organ of the National Geographic Society of America, this excellent monthly may now be obtained in London or Paris.

The Interchangeable Index. (Spink & Son, Piccadilly.) This is a most ingenious invention for the cataloguing of all kinds of collections. The method is simplicity itself. The desired narrative is written upon specially prepared slips, which are then inserted in the pages of a quarto volume, having slits already cut to receive them. The slips are of various sizes, and are of course interchangeable, so that perfect alphabetical order is at any time possible by the simple process of inserting your latest addition in its proper place and then moving the others the necessary spaces forward. Of the smaller slip, the volume before us will take no less than 480.

The Condition of Working Women and the Factory Acts. By Jessie Boucherett and Helen Blackburn. (Elliot Stock.) This little book is an interesting plea for the direct representation of women in the construction of factory legislation, which the writers consider to be unduly oppressive to the interests of working women.

Theatre Panics and their Cure. By Archd. Young. (Andrew Elliot, Edinburgh.) This is another attempt to deal with the terrible dangers arising from a panic in theatres and other buildings when crowded with people. Mr. Young's ideas are admirably illustrated in a series of plans by Mr. Thomas F. Paterson.

The Observer. (Edward F. Bigelow, Portland, Conn.) The editors are to be congratulated upon their energetic attempt to further the cause of popular work in nature studies.

Roman "First Brass" Coins. By Leopold A. D. Montague. (C. H. Nunn, Bury St. Edmunds.) A cheap guide to the Roman brass coinage, and very useful to collectors.

Messrs. Macmillan & Bowes send us a catalogue (No. 257) of valuable books on mathematics and astronomy from the libraries of the late Mr. Arthur Cowper Ranyard and Prof. Henry J. Stephen Smith.

We notice that Mr. R. Kanthack, of 18, Berners Street, London, has been appointed sole agent in the United Kingdom and Colonies for Messrs. C. A. Steinheil Sohne, the famous astronomical instrument makers of Munich.

BOOKS RECEIVED.

Mars. By Percival Lowell. (Longmans.) Illustrated. 12s. 6d.

The Indian Calendar. By Robert Sewell and S. B. Dikshit. With Tables of Eclipses visible in India. By Dr. R. Schraur. (Swan, Sonnenschein.) 31s. 6s.

Miscellaneous Papers. By Heinrich Hertz. Translated by D. E. Jones, B.Sc., and G. A. Schott, B.A., B.Sc. (Macmillan.) 10s.

Water Supply. By W. P. Mason. (New York: Wiley. London: Chapman & Hall.) Illustrated. 21s.

A Dictionary of the Names of Minerals. By A. H. Chester, E.M., Ph.D., Sc.D. (New York: Wiley. London: Chapman & Hall.) 15s.

Press Working of Metals. By Oberlin Smith. (New York: Wiley. London: Chapman & Hall.) Illustrated. 12s. 6d.

Chemistry in Daily Life. By Dr. Lassar-Cohn. Translated by M. M. Pattison Muir, M.A. (Grevel & Co.) Illustrated. 6s.

A Manual of Mending and Repairing. By C. G. Leland. (Chatto & Windus.) Illustrated. 5s.

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Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

SEA SICKNESS: A MECHANICAL REMEDY.

To the Editors of Knowledge.

Sirs,—Some years ago, when crossing the Irish Channel on board a passenger steamer, with a very rough sea, it occurred to me that as the motions of the vessel produced sea sickness, it might be possible to so utilize such motions as to prevent that disagreeable malady.

The vessel has three kinds of motion: a rising and falling motion of the entire vessel; an oscillatory motion longitudinally about its centre of gravity; and a transverse rolling motion.

Without going into the technicalities of these motions, I may say that I treated the longitudinal motions as having a tendency to drive matter, centrifugally, towards the head and stern, and the rolling motions as having a similar tendency to drive matter outwards from the centre of such motions.

Now, the entrance to the stomach is on the left side of the body, the œsophagus end, and the exit is on the right side, the pyloric orifice; and my experiment consisted in utilizing the longitudinal motions so as to keep the food *in* the stomach, and utilizing the rolling motions so as to assist the natural operations of the œsophagus in propelling the food towards the pyloric orifice. This I effected by selecting a couch arranged in a line with the keel: lying with my head *towards* the engine room, and lying upon my *left* side. The experiment was entirely successful, and I have always adopted it in rough seas, when a suitable berth could be obtained. The pitching and rolling of the vessel had the desired effect of aiding the retention of the food, and the rising and falling of the entire vessel was immaterial, and did not in the least interfere with my comfort. The experiment cannot be carried out with berths arranged athwart-ship. Thomas Moy.

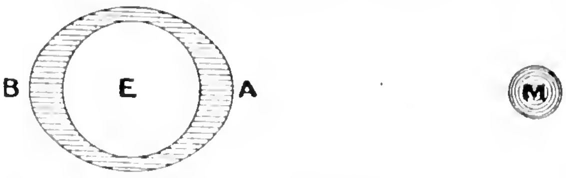
WAVES.

To the Editors of Knowledge.

Sirs,—Allow me to make a remark about Mr. Vaughan Cornish's article on the "Tide Wave" in the May Number of Knowledge.

I find as explanation for the secondary tide formed by the moon that the solid globe (that is, the earth as a whole) is pulled away from the waters, leaving them heaped up; in other words, the earth is pulled out of its orbit, in which it revolves once a year round the sun, and undergoes a daily deviation (not a monthly one, which it actually does), whilst the waters on the opposite side of the earth are not subject to that deviation, because they are not sufficiently attracted. That the attraction is less powerful on the opposite side is quite true, but the conclusion I draw from this fact is different from that drawn by Mr. Cornish.

The large circle E represents the earth, the smaller M the moon, and the shaded part round E the water surrounding the earth, A and B being two points diametrically opposite on which there is high tide at the same time. The attraction of the moon accounts for the waters being heaped up at A, as the liquid mass is more subject to that attraction than the solid earth. But is the earth itself as a whole pulled away from its orbit in a daily deviation? Observation teaches it is not. So the solid globe cannot actually be drawn away, and there must be another reason for the water bulging up at B. The attractive power of the moon is much smaller at B than at A, owing to the greater distance; and therefore the centrifugal force, which arises from the daily revolution of the earth round its axis, has the same effect at B as the attraction of the moon has at A—that is to say, owing to the centrifugal force the waters at B try to get away as far as possible from the centre of the earth, and cause the same bulging out that takes place at A.



I do not profess to have given in the above quite an exact and correct statement of the facts. It seems to me, however, more plausible than the theory of the solid globe being pulled away from the waters. E. Wohlwill.

TIDE OF THE RIVER WYE.

The second paragraph of Professor Logan Lobley's note upon this subject in the last number of Knowledge (at page 130) was incorrectly printed. It should read as follows: "A seismic wave, or one caused by a volcanic eruption, although it may reach coasts at a great distance if there is no intervening land, is non-coincident with the cosmic tidal wave."

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ABOUT DEATH RATES.

By Alex. B. MacDowall, M.A.

We live in an age of sanitation. In the course of a generation the conditions of life have in some ways been sensibly improved. It is a well-known fact that the death rate has declined. This result has naturally been an occasion for much—perhaps excessive—jubilation. There are sanguine spirits who seem to see in the near future a complete victory over all the ills that flesh is heir to.

It is not so generally known that this improvement in the death rate is not an all-round one; that is to say, it holds good only, as we may put it, for the earlier half of life. The death rate of middle-aged and elderly people has increased. I will illustrate this with a diagram (Fig. 1).

This relates to males, in England, of different age-groups, viz., 0 to 5, 45 to 55, 55 to 65, and 65 to 75. The first dotted curve shows the variation in the death rate of children. By a smoothing process the general course of the curve is brought out more clearly in the continuous curve, each year-point of which represents an average of ten (*e.g.*, that for 1848 the average of 1844 to 1853). Here we find a marked decline from about 1865.

When we come to the age-group forty-five to fifty-five, however, we encounter a general rise in the death rate; and the next two decade-groups (for which only the smooth curves are given) are of the same type.*

With regard to the omitted age-groups, the earlier ones, to thirty-five, all show a decline, and generally from the

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* Each of these curves, or curve-groups, it will be seen, has its separate scale, and that of *a* is different from those of *b*, *c*, and *d*.

outset. The group thirty-five to forty-five, as also the two groups over seventy-five, show little change in the final result.

This rise in the death rate of adults—amounting, in those three groups, to about six, twelve, and seven per cent. respectively from first to last—presents an important problem in sociology.

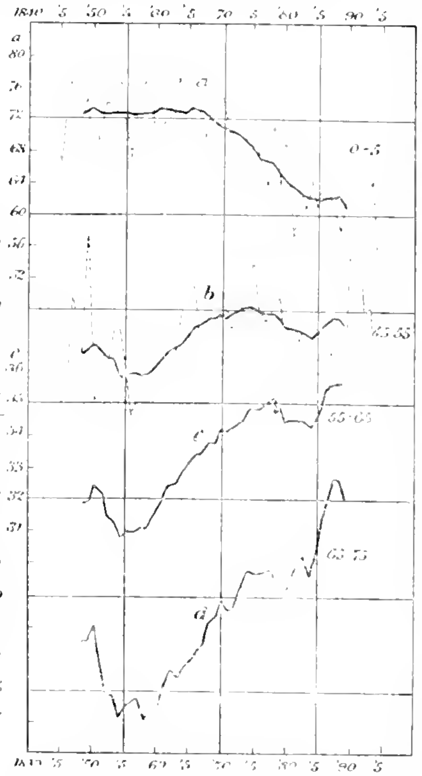

Fig. 1.—Death Rates of Males in different Age-groups (England).

The great world of London presents many startling contrasts in the conditions of life. It is not wonderful to find the ravages of death much more severe in one part than another. Here are two curves (upper part of Fig. 2) showing the history of the death rates of East and West London since 1851. Not only is the death rate of the Western District considerably under the other (say three to five in one thousand), but the improvement is greater and more continuous. The Eastern death rate rose in 1866 to 34·0 through the visitation of cholera, which chiefly affected East London; three-fourths of the total of deaths (three thousand six hundred and ninety-six) taking place in Eastern parishes. In 1854—another cholera year—the difference in mortality of the two districts was much less.

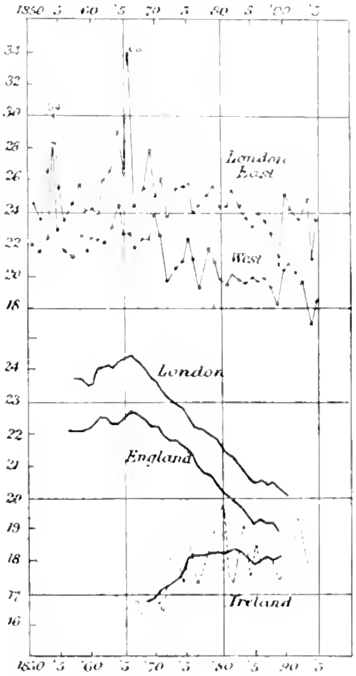

Fig. 2.—Death Rates (London, England, and Ireland)

It might possibly surprise some people to hear that the death rate for Ireland is generally less than that for England and Wales. We must remember that the population is more largely rural. In the lower part of Fig. 2 (dotted curve) is shown the course of the Irish death rate since 1864, and it is smoothed in the continuous curve (as before). Above are the smoothed curves of the death rates in England and in London. While the two latter curves have been going down almost continuously since 1866, the Irish curve shows an upward tendency from about the same date, followed by a nearly stationary condition since about 1875.

Here are the first and last figures of these smoothed curves:—

London	1857, 23·8;	1890, 20·1
England ...	1857, 22·1;	1889, 18·9
Ireland	1868, 16·8;	1889, 18·2

It is interesting to compare the death rates of various European countries through a series of years. Here (Fig. 3) is a group of curves showing the actual variations for England, Scotland, Belgium, Prussia, Austria, and France (each with its separate scale).

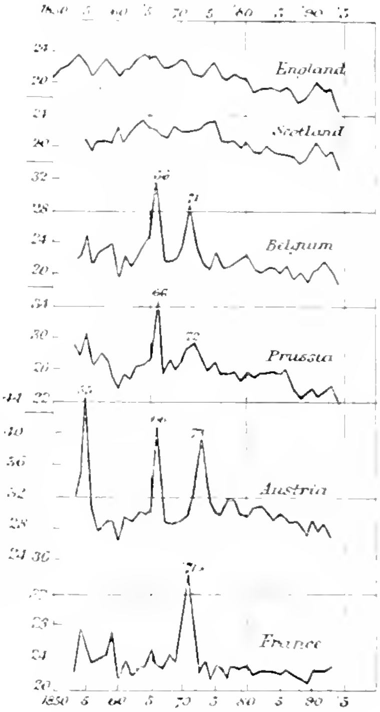

Fig. 3.—Death Rates in some European Countries.

There are some very conspicuous years in some of these curves, accounted for chiefly by cholera, or war, or (as in the case of 1866, in Austria and Prussia) by both.

In the general trend of most of these curves one may detect a considerable similarity. Thus we may make out by the eye, or by smoothing methods, a long wave rising from about 1860 to a crest something like a decade later, followed by a long downward slope, interrupted latterly, in some cases, by mortality from influenza. It would appear as though some common cause (possibly of climatic nature) were at work giving rise to this general uniformity of variation.

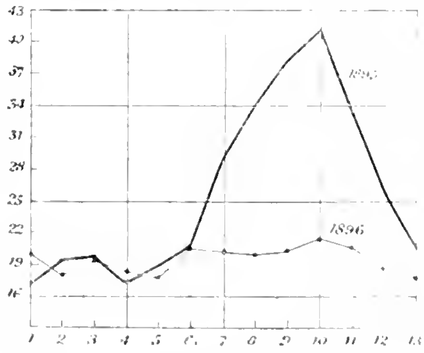

Fig. 4.—Death Rate in Weeks of First Quarter of 1895 and 1896 (London).

We have had a striking instance lately of the effect of cold and mild winter weather on our mortality. The first quarter of 1895 was intensely cold; the first quarter of 1896 very mild. Here is a diagram (Fig. 4) showing the London death rate in the thirteen weeks of those two quarters. In the fifth to the tenth week of 1895 the rate quickly rose till it was over forty; whereas in the first quarter of 1896 it did not reach twenty-two. The influence of temperature on health and life, however, is a question of no little complexity.

THE FOLDINGS OF THE ROCKS.

By Prof. J. Logan Lobley, F.G.S.

Although most observers of nature are fully cognizant of the inclination or "dip" of the stratified rocks, and well know that oblique beds seen in an exposure or section of these rocks are but parts of great folds, yet few are aware of the extent to which the sedimentary rocks have been disturbed from their original horizontality. It may even be said that few geologists, to whom rock-foldings are familiar, realize the aggregate magnitude, much less the momentous significance, of the plications of the stratified rocks. It may, therefore, be useful to present a few facts to bring home to the mind the vast extent to which the once horizontally deposited strata, forming the exterior rind of the globe, have been folded and plicated since they were completed sheets of rock.

Cultivated, verdure-covered, or wooded land so generally forms the surface, and conceals the underlying beds from observation in almost all generally known regions, that exposures of the rocks beneath the surface have to be sought for; but yet they are sufficiently numerous to reveal the general structure of the ground beneath us. Natural sections are seen in mountain precipices, torrent ravines, banks of rivers, and cliffs of the sea coast; while mining, quarrying, well sinking and boring, and road and railway engineering, with its excavations and tunnelling, supply many and most valuable artificial sections.

Although these exposures of the rocks forming the exterior crust of the earth show in many cases horizontal or only slightly inclined strata, yet so many present to view highly inclined beds, and these in so many widely separated parts of the world, that, in the words of Sir Archibald Geikie, "we may readily perceive that the normal structure of the visible part of the earth's crust is one of innumerable foldings of rocks." The examples that follow must, therefore, be regarded merely as typical illustrations, and not by any means as an exhaustive list of those that have been observed.

Our own country of England affords many remarkable examples of highly inclined and folded rocks. In Shropshire the Cambrian rocks of the Longmynd Hills are actually vertical, with beds of conglomerate in which the longer axes of the pebbles are upright; and so it is evident that these massive beds are but remnants of enormous folds, the upper parts of which—the crowns of the arches as it were—have been entirely removed. Such is also the case in the Isle of Wight, where, at both the east and the west end of the island, the stratification of the Chalk may be seen by the lines of flints to be almost vertical. In other places the rocks, though not so nearly vertical as in the above-named localities, are yet very highly inclined. In the Vallis Valley, near Frome in Somersetshire, the Carboniferous Limestone is at a very high angle—about seventy degrees—but overlaid by Jurassic rocks that are almost horizontal. The grand section of the Carboniferous Limestone in the gorge of the Avon below Bristol shows a dip of forty degrees throughout the whole section, which is fully a mile in length, giving the thickness of the formation. In the Mendip Hills the compression of the horizontal extension of the rocks by folding has been estimated to be as much as half of its original length. In many localities, too, the rocks are so plicated that they can only be called contorted, the bendings being so numerous in a small space and the angles so acute. Such are the Purbecks of Lulworth, in Dorsetshire, and the Lias of some sections in the Midlands. The remarkable Silurian inlier in the midst of the Dudley coalfield, forming the Wren's Nest, is but the summit of a fold of Wenlock Limestone that rises through the Coal Measures. Of large but less acute foldings there is an example to the west of the Malvern Hills, where the Wenlock Limestone is in a great synclinal that passes under the Ludlow, which at Ledbury becomes an anticlinal; and in the same county of Hereford the remarkable "valley of elevation" at Woolhope gives a conspicuous anticlinal of Upper Silurian rocks. A very fine example of folding, showing both the synclinal and anticlinal fold on a large scale, is presented by the London Basin and the great valley of the Weald to the south, London being over a synclinal of the Chalk which rises to the south and forms the North Downs that overlook the great Weald Vale, through which passes from east to west an anticlinal axis from which the beds dip to the north and south.

In Wales the examples of inclined and folded rocks are almost as numerous as the sections, both North and South Wales being formed for the most part by greatly folded Palæozoic rocks. A remnant of a vast synclinal fold of Caradoc rocks forms the upper part of Snowdon, in North Wales, and a great anticlinal of Ludlow rocks gives the Alt Fawr and Corw-y-Fan of Brecon, in South Wales; while marvellously contorted rocks, most acutely bent, may be seen at Holyhead Island, opposite the South Stack. Rock foldings and acute plications are as conspicuously displayed in Scotland and Ireland. Indeed, in some parts of Scotland there is seen an actual inversion of strata, the beds being bent back on themselves. On the coast of Berwickshire the Silurian rocks are highly contorted, and so also are the rocks near the Old Head of Kinsale, in Ireland.

When the English Channel is crossed the rock foldings are found to be on a still greater scale in surface extension than is indicated by the observation of British rocks alone. Along the whole distance, from Westphalia on the east to Somersetshire on the west, and even further, to South Wales, the Palæozoic rocks are folded in a succession of synclinals and anticlinals; and in the Ardennes, forming part of this line, enormous masses of these folded rocks have been removed by denudation, yet hills approaching mountains in elevation are left which are the remnants of the original vast plications. In the Eifel district of Germany the Devonian rocks are greatly plicated, and of the same age are the rocks forming a great anticlinal in the Department of the Sarthe, in France: while Silurian rocks show foldings on an extensive scale in Bohemia.

Those who have travelled by the railway from Macon to Geneva may remember the rock foldings displayed by the cuttings along the base of the Jura range of mountains. These foldings of the Secondary rocks in the Jura are, or have been, regularly alternating synclinals and anticlinals, though now showing much denudation, which in many cases has transformed the synclinal folds into elevations and the anticlinals into depressions. But when the Alps themselves are reached, rock folding is on a truly stupendous scale. Even to the ordinary tourist, the precipitous side of the Rhigi towards Lake Lucerne shows, by the inclined beds there conspicuously displayed, the enormous uptilting and folding to which the Alpine rocks have been subjected; and at the southern end of the same lake, near Fluelen, highly plicated rocks will arrest his attention. It is, however, by the perforation of the main axis of the Alps by the great tunnel of the St. Gothard that we have become acquainted with rock folding in perhaps its greatest manifestation. Thus it has been found that the rocks forming the central portions of this great mountain range are mainly the vertical portions of vast plications, and at Andermatt and Airolo these rocks rise in a fan-shaped manner which gives actual inversions of strata. This enormous folding is found to be the prevailing character of the Alpine rocks from the northern side of Switzerland to the plains of Lombardy. The summit of the Great Ruchen, ten thousand feet above sea-level, affords another example of a former vast fold having left as its witness a remnant of vertical beds; and on both sides of the great mass of Mont Blanc, in the Val de Chamouni and the Val Ferret, are vertical Jurassic rocks which are but the remains of a fold that has extended over the rocks forming the summit of the monarch of the Alps. A grand example of inversion of strata is seen in the Glarnish Alp, where the beds are folded, as has been said, even as we might fold carpets. In the extreme north of Europe, too, both in Norway and the Ural Mountains, the Palæozoic rocks are found to be folded on a most extensive scale, giving in some places quite vertical strata, though overlaid by horizontal beds of recent geological age.

As in Europe so in Asia, the mountainous regions exhibit flexures on a grand scale, with Palæozoic rocks that are but the remnants of vast folds, in some of which, as in Baltistan in the Himalayan region, the plications have been sufficiently extreme to quite reverse the original sequence of the beds. Far to the south of the Himalayas, too, in Mysore, the rocks have been greatly folded, and so far denuded as to leave but remnants of their original plications. In Asia, however, not only are the Palæozoic and the Secondary rocks folded on a great scale, but Tertiary strata are so too. The Eocene rocks of Afghanistan and Beluchistan give the broken and denuded anticlinal valley of Chumarlong, and the anticlinals at Tungar and the Deka ridge. Again, to the east, the great folds of the Tertiary rocks form anticlinals on both sides of the River Jhelum, with synclinals so elevated as to give peaks and ridges forming lofty mountains, as the Murree Ridge; while Mount Mianjani, on the west of the great vale of Kashmeer, nearly ten thousand feet, is also formed by folded Tertiary rocks. The great Eocene Limestone, called the Nummulitic Limestone, is in great flexures in the north-west of India, which rise in the Balket Mountains to six thousand feet above sea-level, and in the Sievalik Hills the still newer Sandstones are greatly folded.

Though the mountainous regions of Africa have not yet been sufficiently explored to afford geological details, and many of the highlands are volcanic, yet we have abundant evidence of great folding of the rocks in that continent also, both in the north and the south. As was shown in Knowledge, page 51 of the present volume, the auriferous rocks of the Transvaal Witwatersrand are highly inclined, and are but remaining portions of great folds. In the north of Africa, and forming a large part of the main range of the Great Atlas, are grey Shales having a nearly vertical position. Of these rocks Mr. George Maw says they are pre-Cretaceous, and "their almost vertical position appears connected with one of the several upheavals that have affected the chain." Metamorphic rocks, having a dip of from fifty degrees to eighty degrees, form hills in the immediate neighbourhood of the city of Morocco.

The great western continent of America tells the same tale of enormous rock foldings. Although in North America there are great areas formed of rocks but little folded, yet in Canada, near the eastern coast, Palæozoic rocks, conformably overlying the Laurentian, have been much folded and even contorted; and in the neighbourhood of Lake Superior there is a natural arch of rocks formed by an anticlinal, the interior rocks having been removed by water erosion. In Colorado both the Palæozoic and the Secondary rocks are so upheaved as to be almost vertical, being parts of great folds, and in the Mosquito range there are reversed folds. In Texas there are synclinal troughs, the bases of once enormous folds; and in New Mexico the Carboniferous rocks are quite vertical, and in places even folded on themselves.

The rocks of the more eastern parts of the United States are also greatly folded. Indeed, so enormous has the plication been in the Appalachian Mountains, that Prof. Claypole estimates the compression of the original horizontal extension of the Appalachian rocks by subsequent folding to have been from one hundred and fifty-three miles to a present breadth of sixty-five miles. In Virginia and South Carolina the rocks are greatly folded, and in Massachusetts and Vermont the same phenomenon is conspicuous, vertical strata being displayed in the former of these two States.

In South America there is a magnificent display of folded and uptilted rocks, the Silurians, nearly vertical, rising to about twenty-five thousand feet above sea-level at the summit of the Andes; and the Devonians and Carboniferous rocks forming great folds or parts of folds, chiefly synclinals, at lower levels, the latter giving to the west of Lake Titicaca a wonderful series of upturned edges. The Peruvians and Secondaries of the Andes exhibit similar phenomena.

Nor is rock folding on a great scale wanting in the Australasian continent. In the Ballarat district of Victoria the Lower Silurian rocks have been so greatly folded that the strata are often nearly vertical; while in Gipps Land, in the same colony, the Devonian rocks are highly inclined, and in the Cape Otway district there is an enormous anticlinal fold of Mesozoic rocks.

Many other remarkable illustrations of rock folding might be given; but those now cited will suffice to conclusively show that the rocks forming the outer rind of the earth's lithosphere have been subjected at various times and at various places to enormous lateral pressure, that has folded, plicated, and crumpled them previous to the production of the present surface features. The discussion of the cause of this pressure must be left for a future occasion.

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WAVES.—VII.

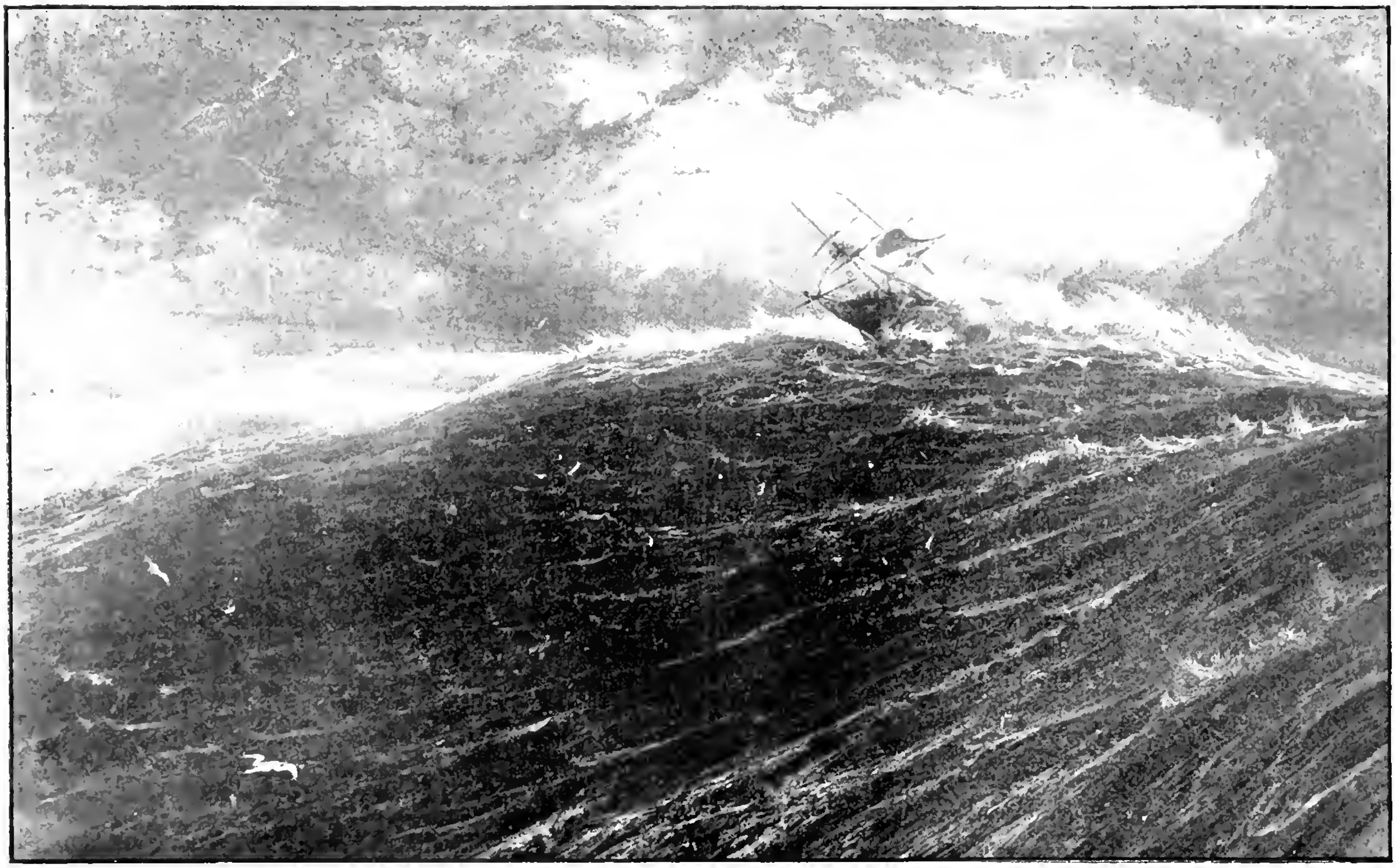
THE ARTISTIC STUDY OF WAVES.

By Vaughan Cornish, M.Sc.

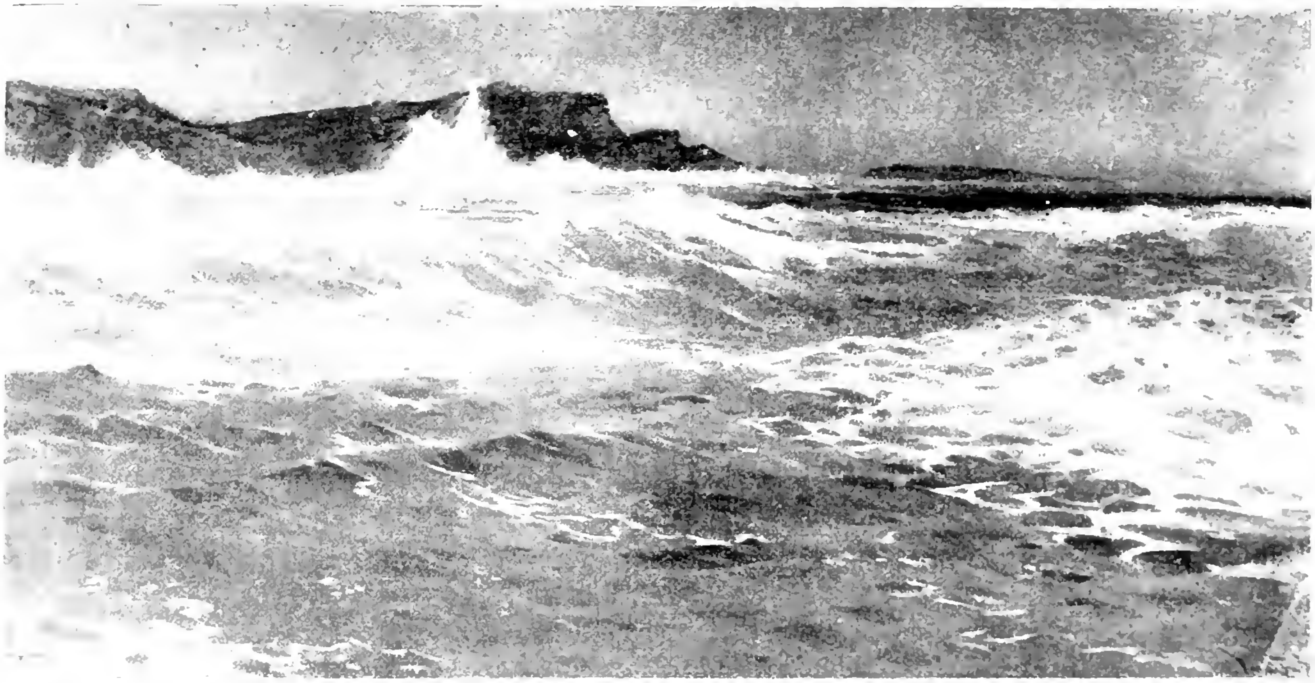
A GOOD sea-piece always makes a pleasing picture, and the foundation of a good sea-piece is correct drawing of the water, showing the form and indicating the motion of the waves. Instantaneous photography reproduces with absolute fidelity the form of the water surface as it would appear to the eye if illuminated, say at night, by a lightning flash. Such an instantaneous illumination makes moving objects appear at rest, and this is apt to be the effect of photographs of the sea. When watching the waves under ordinary conditions, the sense of movement is probably due, in part at least, to the persistence of impressions upon the retina, several impressions received at successive moments being simultaneously present. To reproduce this effect in a picture the phases represented together upon the canvas should be nearly but not quite simultaneous.

I propose to examine a number of sea-pieces which are to be seen in the London galleries at the present time, in order to show how the artists have rendered the forms of waves. Taking the National Gallery first, which contains some excellent examples of the old Dutch sea painters, I find in Van der Welde's picture, "A Gale" (No. 876), a good representation of short rough waves quickly raised by a brisk wind in shallow sea. The profile of several successive waves, concave on the lee, and curving over, perhaps *a little* too much, on the weather side, should be noticed. The same aspect is shown in some of Bakhuizen's pictures, but not so well.

In the Turner Gallery are many famous sea-pieces. He likes to perch a boat precariously upon an isolated mound of water. This may be a way of indicating the toss and tumble of the sea, but the balanced rhythm of the undulation is thereby lost. "The Shipwreck" (No. 476) is an instance of this, in which there is a great heap of water on the right-hand side, and nothing to balance it on the left. However, such is the aspect of sea waves which Turner chooses to represent, and one would bow to genius and pass on if these great unbalanced billows were at all like the waves of the sea, but they are not. The fluid has more the consistency of tar—it is some slow viscous fluid tossed into great heaps. Take, for instance, No. 813: "Boats in a Stiff Breeze off the Coast." The height of the waves is nearly half the length from crest to crest; and in "Spithead" (No. 481) the slope of the waves is about forty-five degrees. The wind has raised the waves, but gravity has no power to bring them down again and the breeze has no force to drive them forward. On the other hand, the wild sea towards the horizon in the picture of "Calais Pier" (No. 472) is very fine; but it is generally the waves in the background which are Turner's best. His breakers (in No. 496) are as bad as his deep-sea waves. If anyone doubt his eyes when looking at these pictures, deeming his visual memory too unreliable to justify him in finding fault with a master's work, let him go straight from the Turner Gallery to the Chantrey pictures and the Prescot Hewett Gift pictures at South Kensington, and test his impressions by examining some of the finest wave pictures in the world. On students' days at the National Gallery one cannot but regret to see so many artists copying sea-pieces in which the sea is badly drawn, when really good studies of waves are to be found so near at hand.


An Indiaman in a North-Wester off the Cape of Good Hope. From a picture by Mr. Wm. Daniell, R.A.

There are some half-dozen wave paintings at South Kensington which at once bring the real thing before one. Perhaps, as a study of waves, the best of all is "A Grey Day at Sea," by Sir Francis Powell (No. 121 in the Prescot Hewett Gift). In this picture I note the following points of careful observation accurately rendered, most of which are missed even in the average of good sea-pieces. The waves run from right to left before a strong wind, and in the foreground on the left we see the back or weather slope of the first of a train of waves. This slope is much less steep than that of the lee side of the next on-coming wave. It is driven by the onward rush of the wind, instead of being supported and heaped up by the wind eddy, as are the leeward slopes. Again, on the weather slope the rushing wind tears at the water, raising new waves upon the slope of the billow. In another moment the top of the wave will break and the pressure of the wind will be relieved. The lee slope of the next on-coming wave is in comparative calm, sheltered in the eddying wind; but the surface of the steep slope, though smooth, is covered with a thin network of transparent foam; and here the artist has shown great power of observation. The foam was left when the preceding wave passed this point. The crest of the wave broke, streams of water-drops flew out, streaking the back of the wave and giving it a "ropy" look. This is not actually shown, for it happened a second or two before the time represented in the picture, but the painting is so good that we can reason backwards from it. This ropy appearance is seen on a small scale at a certain stage in the splash of a falling drop, and is shown in a drawing in Mr. Worthington's admirable papers on that beautiful phenomenon. The streaking of the back of the wave indicates the presence of little ridges and furrows, which (as well, perhaps, as the larger ridges and furrows due to cross waves) give rise to a vast number of whirlpools on the back of the breaking wave. The foam of the breaking crest, left behind as the wave rushes on, is whirled round in the vortices. The vortices are always formed in pairs, each pair consisting of a right-handed and a left-handed whirl. The foam is collected round the edges of the whirls, and particularly where the whirls approach one another, and a thin transparent network (for the bubbles have burst, leaving only a thin film) is formed, the meshes of the net being oval, for the circles are drawn out into ovals by the forward motion of the water. This, I think, is how the floating film of foam assumes the characteristic and wonderfully persistent form which is so well indicated in Sir Francis Powell's picture.* Again, there is a tendency to form a *knife edge* along the crest of all billows (whether of water *or of sand*) which are forced at their crest by the co-operation of a forward current and a backward eddy, as is the case with the storm waves of the sea and with ripple-mark in sand. The knife edge is shown on the billows to the right hand of the picture in exactly the proper way, for the artist has shown the sharp edge without falling into the mistake of making the top of the wave too thin. In a more distant part of the same billow we see the spraying "white horses," just where the crests of the cross waves give to the main billow a height too great for its forward velocity; and the upward as well as forward motion of the spray is just indicated. In fact, a mass of detailed observation has been accurately embodied, and perhaps condensed, in this small picture, and the result is far finer than that of any attempted emphasis by way of exaggeration. When I look at this picture I see the storm itself; and soon, as each true detail starts out clear before me, I feel the stinging spray and breathe the rasping air.



"Where the wild Atlantic surges Rush with headlong race to shore."

From the water-colour painting by Mr. Reginald Smith, in the Royal Academy Exhibition of 1895. (By kind pe[illegible] Artist.)

Among the larger works in the adjoining rooms, "Britannia's Realm," by Mr. John Brett, shows a great stretch of blue sea covered with the little waves raised by a light zephyr. The scale of the picture is a part of its merit, for it is only by including a multitude of waves upon the canvas that an artist can fully convey the rhythmical effect of a repeating undulation. Mr. Vicat Cole's "Pool of London," which is placed next to this picture, gives a fine rendering of the restless waters of a tidal river where wind conflicts with current. "Their Only Harvest," by Mr. Colin Hunter, in the next room, brings out well the cross waves which generally traverse the larger undulations of the sea. The rendering of this effect, emphasized by a low light, is characteristic of this artist's pictures. Mr. G. H. Andrews' water-colour drawing, "A Storm in the North Sea," takes in only two of the great storm billows; but the flanks of these are themselves carved into waves of a not inconsiderable size. The effect of a squall, with

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* There is another point to be noticed about the effect of vortex motion upon the appearance of water: it gives a stretched or oily look to the surface; probably, as has been suggested to me, because the surface is renewed from below too rapidly for ripples to form. This stretched look is often noticeable on the back of the breaker, especially in a ground swell, and it deserves the attention of sea painters. The most familiar example of the appearance produced by vortices is the swirling wake behind a rudder. Another example is the wake left outside the edges of the paddles of a steamer. A sharp edge introduced in running water will generally give it. The effect may often be noticed also in a swirling river.

driving rain, upon the surface of the water, is excellently done. The picture is a genuine study of a storm at sea, which is, of course, much more rarely painted than the storm waves as seen from land. The late Mr. William Daniell is one of the few painters who has represented from personal experience the storm waves of the open ocean. Fig. 1 is a reproduction of his picture, "An Indiaman in a North-Wester off the Cape of Good Hope," reproduced from a fine print in the British Museum. The immense velocity of these very long waves is finely indicated in the billow which rushes from right to left, having just raised the ship to its summit. This artist was too much given to exaggeration to be quite satisfactory as a sea painter: his waves are often ridiculously steep besides being too high; but this picture has the merit of conveying an impression of the great length and speed of ocean waves.

The Academy of 1896 has a large number of sea-pieces of varying degrees of merit. Perhaps the best study of waves is No. 1161 in the Water-Colour Room, by Mr. Reginald Smith: "Where the wild Atlantic surges rush with headlong race to shore," which is reproduced from a photograph in Fig. 2. We are looking towards the coast, and see the sloping rounded backs of the rollers, whose long undulating crests extend far to the right, rank upon rank charging irresistibly along. In this picture the network film of foam is very well rendered. In the left lower corner only does the drawing fall below excellence. In Mr. John Fraser's picture, "Newhaven" (405), in No. V. Gallery, the heaving of the waves near a vertical wall has been skilfully preserved, while all trace of forward motion has been properly suppressed. In Mr. J. C. Hook's pictures (Nos. 48 and 279) the water is so smooth as to give little scope for wave drawing on the scale adopted; yet a careful examination shows great mastery of the forms and motion of the sea. Mr. Wm. J. Callcott has put plenty of movement into the sea in "Smeaton's Lighthouse on the Eddystone" (No. 411), but he makes the common mistake of representing, in the foreground of the picture, two waves which are back to back, running away from one another instead of following in procession. Mr. C. Napier Hemy's "Through Air and Sea, through Scud and Spray," is one of the best wave studies. The light coming through the top of the wave on the left indicates the thinness at the crest, which, from its position, could not be shown by the drawing. The action in the picture seems to cease abruptly in the right-hand corner, which is a pity. In "Volunteers for a Boat's Crew" (917), by Mr. T. Somerscales, there is wild white water lit by sunshine in the distance, and a sluggish sea under a black cloud in the foreground. The effect of contrast is fine, but I think the drawing has been to some extent sacrificed for the sake of this effect; there seems too much wind in the picture for the nearer waves to move so sluggishly. There are a number of sea-pieces in this year's Academy which I cannot criticize because they have no drawing, and this applies to several pictures by distinguished sea painters, who have not taken the trouble to draw the forms they know so well. For complete disregard of drawing in sea-pieces, however, the most notable collection of examples I have seen is in this year's Paris exhibitions.

For good book illustrations of waves I may refer to Mr. Robert Leslie's charming "Waterbiography." All his illustrations of the sea are worth studying. Mr. Leslie knows the sea too well either to slur over the drawing, or to attempt an increased effect by exaggerating the forms of waves.

Of wave phenomena, other than the wind-raised waves of the sea, artists take but little note. I have met with hardly any attempt to represent a train of standing waves in a rapid stream, except in one picture in the Luxemburg Gallery, and that is not successful. Ship waves are sometimes done, the earliest attempt that I am acquainted with being in Turner's well-known picture, "The Fighting Téméraire towed to her Last Berth." In a fine picture now at Versailles, "Arrivée de l'Escadre Russe, Toulon, 13 Octobre, 1893," by M. Paul Jobert, the curved and stepped front of the echelon ship-waves is well shown.

Photographic views of waves consist for the most part of studies of big breakers on rocky coasts, with clouds of flying spray, and, sometimes, masses of curdled foam. Mr. Worsley Benison's "Westby Series" of photographs are the finest studies with which I am acquainted. One of these is reproduced in our full-page illustration. There is no sea painter, however skilful, who would not find much to repay him in the careful study of such photographs. Above all, the foam is rendered as no painter ever rendered it: not merely the thin film of foam of which I have already spoken, but the thick white froth of the breaker line, which looks by daylight like whipped cream, but by moonlight is changed to molten silver. This difference of aspect, I think, is due to the circumstance that in moonlight we only get a surface, and therefore a metallic, reflection; whereas the sun's stronger rays pierce into the curdled masses and then struggle up again into the air, thus imparting the translucence which gives to foam its look of lightness.

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THE FACE OF THE SKY FOR JULY.

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

The Sun's disc is now comparatively free from spots. Conveniently observable minima of Algol occur at 0h. 5m. A.M. on the **5th**; at 8h. 54m. P.M. on the **7th**; and at 10h. 36m. P.M. on the **27th**.

Mercury is visible as a morning star during the first three weeks of the month. He rises on the **1st** at 2h. 44m. A.M., or 1h. 6m. before the Sun, with a northern declination of 19° 44′, and an apparent diameter of $8\frac{1}{4}''$, about $\frac{3}{10}$ths of the disc being illuminated. On the **4th** he rises at 2h. 30m. A.M., with a northern declination of 20° 28′, and an apparent diameter of 7·6″, being at his greatest western elongation ($21\frac{1}{4}°$) at noon. On the **8th** he rises at 2h. 34m. A.M., or 2h. 20m. before the Sun, with a northern declination of 21° 30′, and an apparent diameter of 7″, about one-half of the disc being illuminated. On the **11th** he rises at 2h. 35m. A.M., or 1h. 24m. before the Sun, with a northern declination of 22° 11′, and an apparent diameter of $6\frac{1}{2}''$, about $\frac{6}{10}$ths of the disc being illuminated. On the **16th** he rises at 2h. 45m. A.M., or 1h. 20m. before the Sun, with a northern declination of 22° 54′, and an apparent diameter of $5\frac{3}{4}''$, about three-quarters of the disc being illuminated. On the **21st** he rises at 3h. 7m. A.M., or 1h. 2m. before the Sun, with a northern declination of 22° 46′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{87}{100}$ths of the disc being illuminated. After this he approaches the Sun too closely to be conveniently observed. While visible, Mercury passes through the eastern portion of Taurus into Gemini, being near η Geminorum on the evening of the **11th**, and μ Geminorum on the evenings of the **12th** and **13th**. He is at his

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* The following explanation has been given of the smoothing of the sea by rain. The rain does not penetrate, but, driving water down before it, mixes up parts of the sea water the momentum of whose oscillation is in opposite directions, thus annulling the rhythmic swing of wave motion.

BREAKERS ON A ROCKY COAST,

greatest western elongation (21¼°) on the **4th**, and in superior conjunction with the Sun on the **31st**.

Venus is in superior conjunction with the Sun on the **9th**, and Mars is, for the observer's purposes, invisible.

Jupiter is now too near the Sun for satisfactory observation.

Saturn is an evening star, setting on the **1st** at 1h. A.M., with a southern declination of 13½°, and an apparent equatorial diameter of 16¾″ (the major axis of the ring system being 41″ in diameter, and the minor 14⅓″). On the **9th** he sets at 0h. 28m. A.M., with a southern declination of 13° 20′, and an apparent equatorial diameter of 16½″. On the **18th** he sets at 11h. 49m. P.M., with a southern declination of 13° 22′, and an apparent equatorial diameter of 16½″ (the major axis of the ring system being 40¼″ in diameter, and the minor 14″). On the **22nd** he sets at 11h. 34m. P.M., with a southern declination of 13° 23′, and an apparent equatorial diameter of 16½″. On the **29th** he sets at 11h. 6m. P.M., with a southern declination of 13° 27′, and an apparent equatorial diameter of 18¼″ (the major axis of the ring system being 39½″ in diameter, and the minor 13¾″).

Iapetus is in inferior conjunction on the **1st**, and at his greatest western elongation at 9h. 30m. P.M. on the **21st**. He is almost stationary in Libra throughout the month.

Uranus is an evening star, but owing to his great southern declination is not well situated for observation. On the **1st** he rises at 4h. 2m. P.M., with a southern declination of 17° 41′, and an apparent diameter of 3·8″. On the **30th** he sets at 11h. 2m. P.M., with a southern declination of 17° 37′. He is almost stationary in Libra throughout the month.

Neptune does not rise till after midnight at the end of the month.

Shooting stars are fairly numerous in July, but twilight interferes with observation. There is a well-marked shower near δ Aquarii towards the end of the month, the maximum being on the **28th**. The radiant point is in R.A. 22h. 40m., south declination 13°.

The Moon enters her last quarter at 1h. 23m. A.M. on the **3rd**; is new at 7h. 35m. P.M. on the **10th**; enters her first quarter at 4h. 4m. P.M. on the **17th**; and is full at 5h. 45m. P.M. on the **24th**. She is in apogee at 3h. A.M. on the **3rd** (distance from the Earth, 251,150 miles); in perigee at 6h. P.M. on the **15th** (distance from the Earth, 229,200 miles); and in apogee at 10h. P.M. on the **30th** (distance from the Earth, 251,280 miles).

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Chess Column.

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

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solution of June Problem.

(A. G. Fellows.)

1. Kt to B6, and mates next move.

Correct Solutions received from Alpha, J. M. K. Lupton, G. A. F. (Brentwood), Arthur S. Coulter, A. C. Challenger, W. Willby, W. V. Popham, H. H. Quilter, H. S. Brandreth, and J. T. W. Claridge.

Correct Solutions of May Problems, received too late for acknowledgment last month, from J. M. K. Lupton and E. W. Brook.

F. Welch.—1. Kt to K4, Kt × Kt, 2. P to B4 mate, and other variations; 2. Kt to B6 mate is threatened.

G. G. Beazley.—If 1. Kt to Q2, Q × B, and there is no mate.

H. Le Jeune.—Is Kt to B5 a misprint for Kt to B6?

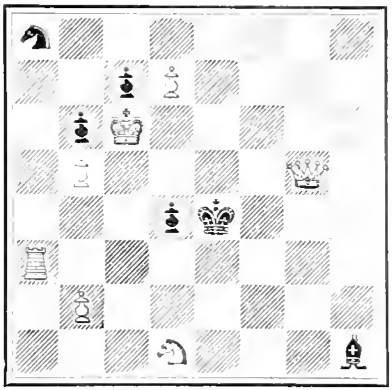
A. C. Challenger.—Many thanks. Your compositions are always welcome.

W. J. Ashdown.—Thanks for your interesting communication printed below.

PROBLEM.

By A. C. Challenger.

Black (6).



White (7).

White *compels Black* to mate in two moves.

Mr. W. J. Ashdown has sent the following interesting communication on

THE EIGHT QUEENS PROBLEM.

The Queens Problem on a board of sixteen squares has two solutions, namely (using the German notation), A2, B4, C1, D3, and A3, B1, C4, D2. Let diagrams of these two positions be placed one overlapping the other to the extent of six squares—that is, with the top left-hand square of the A3 diagram resting on B2 square of the A2 diagram, being a Knight's move downwards. The three Queens must be removed where overlapping occurs, and this is a rule to be observed throughout.

The position now obtained may be placed on an extended board, the Queens occupying squares B6, C8, D3, E7, F4, and within a rectangle of thirty squares. This rectangle with its five Queens may be called the "initial position," as all the solutions of the Eight Queens Problem are derived from it. Let the board be extended indefinitely upwards and to the right, and a second "initial position" placed upon it, with the corners of the rectangle resting on squares F10, F5, J10, J5, being two Knights' moves to the right. The two rectangles will then overlap four squares, and the Queen thereon must be removed. The four added Queens are at G10, H5, I9, J6. This may be called the "doubled position."

The Queen's stride being limited to seven squares on the ordinary board, the eighth square in any direction is "out of range," and additional Queens can, therefore, be placed at A1, D11, G2. This at once gives seven solutions of the problem. Thus, the sixty-four squares, from B9, B2, to I9, I2, contain the solution α, and the others are:—

Sixty-four squares from A8 to H1 contain solution β.
" " C9 to J2 " γ.
" " B10 to I3 " δ.
" " C11 to J4 " ζ.
" " B11 to I4 " ι.
" " C10 to J3 " λ.

Any arrangement whatever of Queens, where all are kept out of each other's range, will possess this property, namely, that every set of x^2 squares within it that includes x Queens will be a solution of the x Queens problem—where x equals the number of squares in the side of the board—but "out of range" will vary according to the length $(x-1)$ of the Queen's stride.

Take solution α, and remove the right-hand "initial position," and notice what squares are available for Queens in substitution for those thus removed. The only other vacancies are at H9 and I5, and two Queens there will give solution θ.

Similarly, solution ζ—the left-hand "initial position" being removed (restoring the missing Queen at F8)—with substitutions at C7 and E4, will give solution η.

At first sight there would appear to be no connection between the symmetrical solution shown on page 24 and the above. But let one of the "doubled positions" be superimposed on another, and one of them rotated half-way round (through 180°), using the meeting point of D5 and E4 as centre of rotation. The rule as to omitting all Queens where overlapping now occurs must be observed, and the symmetrical solution ω will be at once obtained, being the central part of this position. The reason for the symmetry is thus ascertained. It is a little curious that if a board of twenty-five squares, with its unsymmetrical solution (A3, B5, C2, D4, E1), be treated in this way, the turning point being easily seen, the solution ω for a board of sixty-four squares will be arrived at.

Take this position ω (page 24, second column) as a fresh starting position, and transfer it two squares to the right. This will throw two Queens off the board, but the one on the fifth rank comes on again at A5. The other, in being brought on to the third rank at H3, pushes H1 to B1 (the only available square), and the solution κ is obtained.

Let this solution κ be another starting position, and transfer it three squares upwards and one to the left. This will throw four Queens off the board, but the two now on the C and F files produced will at once come on again at C1 and F2. The two others, which should come on again at D3 and H8, find both those squares "covered," and have to be satisfied with D8 and H3. This gives the remaining solution ε.

The last five solutions read thus on the ordinary board:—

θ ... A5, B7, C2, D6, E3, F1, G8, H4.
η ... A4, B8, C1, D5, E7, F2, G6, H3.
α ... A4, B6, C8, D2, E7, F1, G3, H5.
κ ... A5, B1, C4, D6. E8, F2, G7, H3.
ε ... A4, B7, C1, D8, E5, F2, G6, H3.

The twelve absolutely distinct positions admit of rotation, bringing each of the four sides in turn to the top, and giving forty-eight changes. There are two repetitions arising from the symmetrical position, and the number is reduced to forty-six. All these can be turned over from right to left, making a total of ninety-two. The number of distinct ways of actually arranging the Queens so as to solve the problem *on the board* is twenty-four, and no one of these positions can be changed to any other without moving the Queens to other squares. But from the twenty-four positions the remainder of the ninety-two can be obtained by simply turning the board and Queens *en bloc*.

The application of the above principles to boards of other dimensions might produce some interesting results.

Mr. Ashdown sends also an ingenious automatic diagram for producing positions on a forty-nine-square board. The height of the diagram is seven squares, but the board is unlimited in its extension towards the right. Placing Queens on A7, B3, and H7, and taking these squares as starting points, lines of Queens are constructed sloping *downwards towards the right*, each Queen being the distance of a Knight's move from its neighbours on the same line. Thus, the first position is A7, B3, C6, D2, E5, F1, G4. Now omit the A file and substitute the H file, and a fresh position is obtained. This process, which is available whenever the height of the board is $(6a + 3 \pm 2)$ squares—*i.e.*, for boards of five, seven, eleven, thirteen, etc., squares—may be continued until the positions repeat themselves.

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CHESS INTELLIGENCE.

Mr. E. O. Jones has again won the Challenge Cup of the Craigside, Llandudno, meeting.

The Nuremberg International Tournament is fixed for July 20th. It will conclude on August 6th. The prizes are very valuable, and all the leading players except Dr. Tarrasch are expected to compete.

A match of one hundred players a side, representing the north and south sides of the Thames, took place on May 9th, at the Cannon Street Hotel. The northern representatives were victorious by 57½ to 42½.

On May 15th a team of eight players of the City of London Club, by no means their best team, succeeded in drawing a match against the newly-established Divan Association. The merit of the performance will be apparent from the fact that the latter team consisted of E. Lasker, I. Gunsberg, R. Teichmann, J. Mason, L. Van Vliet, S. Tinsley, A. Guest, and R. F. Fenton.

Entries for the *Brighton Society* Two-move Self-mate Tourney should reach the Chess Editor, 101, Queen's Road, Dalston, N.E., before November 1st. Three prizes are offered, and the adjudication will be by experts.

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NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

Bound volumes of Knowledge, New Series, can be supplied as follows:—Vols. I., II., III., and VIII., 10s. 6d. each; Vols. VI., VII., IX., and X. (1895), 8s. 6d. each.

Binding Cases, 1s. 6d. each; post free, 1s. 9d.

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Index of Articles and Illustrations for 1891, 1892, 1894, and 1895 can be supplied for 3d. each.

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KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: AUGUST 1, 1896.

CONTENTS.

HYGROSCOPIC SEEDS.

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

HYGROSCOPIC movements depend mainly on changes in the humidity of the atmosphere. Air of any given temperature is only capable of absorbing a definite amount of aqueous vapour: when that amount is present the air is said to be saturated, and evaporation ceases. As the temperature rises in arithmetical progression, the quantity of vapour which the air is capable of retaining is found to increase in a geometrical ratio; hence evaporation mounts up rapidly as the temperature rises; hence, also, when two saturated currents of different temperatures mingle, they are no longer able to retain as much vapour as they did separately, and precipitation consequently occurs in the liquid form. Barometric pressure also affects evaporation; the rate diminishes as the pressure increases. Since these atmospheric conditions are so liable to change, the rapidity with which evaporation takes place must be subject to incessant fluctuation.

As it is the superficial layer alone which furnishes vapour, the rate at which any body yields up its water to the atmosphere depends on the extent of surface which it exposes. The force of adhesion must also be taken into account. A porous body like charcoal condenses atmospheric vapour even at ordinary temperatures; deliquescent salts, too, abstract water from the air. The nature of the surface exposed to the air is also of importance: even the thinnest film of oil or grease prevents, or, at least, greatly reduces, evaporation. Water holding substances in solution also evaporates more slowly than when perfectly pure. These considerations show that the equilibrium of humidity depends on a number of circumstances which must vary in different bodies and at different times in the same body.

Organic bodies containing water very commonly increase or diminish in size as the proportion varies. From their peculiar structure some tissues retain water tenaciously: others readily part with it to the atmosphere. There are, also, great differences in their powers of reabsorption, some being unable to recover their lost moisture, even when it is presented to them in a liquid state, while others speedily imbibe what they lost in drying. Substances such as wool, hair, and feathers are extremely sensitive in this respect, especially if perfectly free from oil or resin; they respond to very slight atmospheric changes and are described as hygroscopic.

Organized structures are rarely, if ever, homogeneous: it therefore frequently happens that one part of an organ contracts or expands more rapidly than the rest. In this way tensions arise within the organ causing it to split, or the organ may alter its shape and exhibit motion. Hygroscopic phenomena are further complicated on account of the intricacies of microscopic structure. A violin string is rendered slacker if moistened, whereas a rope tightens. In the former the molecules of water are apparently introduced chiefly in the direction of length; in vegetable fibres they go rather to increase the thickness. The effects of imbibition are augmented in cellular tissue by endosmose. As the quantity of fluid contained in a closed cell increases the elastic cell-membrane becomes distended and the volume of the cell is enlarged. The range of expansion arising from turgescence is, however, inconsiderable in comparison with the expansion caused by simple imbibition; moreover, turgescence can only occur in closed and thin-walled cells. The cells of which wood is built up have open pores; any change of dimensions must therefore be brought about entirely by imbibition or desiccation taking place in the perforated cell-walls. In cartilaginous or collenchymatous tissues the greatly thickened cell-walls contain a large proportion of water; they contract strongly in drying and swell very much from imbibition.

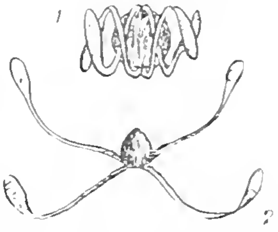

Fig. 1.—Spores of Equisetum. 1. In dry state. 2. With Elaters expanded after moistening (magnified).

Of hygroscopic action we have a familiar example in the warping of unseasoned timber, where the bending is caused by the younger sap-wood on the one side contracting at a different rate from the older heart-wood on the other. Hairs and fibres are especially prone to bend and twist as they dry. Every angler knows how catgut unbends and straightens when put into water. Advantage is taken of this property in the simple old-fashioned weather-glass alluded to in Cowper's lines:—

> "Peace to the artist whose ingenious thought
> Devised the weather-house, that useful toy!
> Fearless of humid air and gathering rains
> Forth steps the man."

Good weather is indicated by the appearance of a small female figure at one door, rain by the figure of a man coming out at the other. The figures are attached to a support suspended by a fibre of catgut, which twists and untwists according to the state of the atmosphere. The instrument is really a hygroscope or hygrometer indicating the humidity of the air, and the figures are made to swing round by hygroscopic action. The proportion of moisture present in the atmosphere can be ascertained with far greater precision, however, by means of the wet-bulb hygrometer or by Daniell's dew-point hygrometer.

Fig. 2.—Fern Spore-Case, showing Annulus (enlarged).

Fig. 3.—Legume of Bird's-foot Trefoil after dehiscence, showing the twisted Valves.

The dehiscence of seed capsules is brought about by the contraction of their outer walls, and this often takes place in such a way that the seeds are violently expelled, as in the ripe pods of the broom, vetch, and bird's-foot trefoil. At the moment of dehiscence each half of the legume or pod suddenly twists itself, scattering the seeds with great force. The fruit of the common dog-violet is of interest; each of its three valves, when the fruit opens, has a double row of seeds. The valves are boat-shaped; in drying they contract till the seeds are so closely jammed in and the tension becomes so great that the slightest touch causes them to be shot up into the air. The seed vessel of Veronica, on the other hand, remains closed in dry weather, but opens and discharges its seeds in wet. The application of moisture also causes the stellate capsule of Mesembryanthemum to open up. Instead of opening to allow of the escape of its seeds, a many-seeded fruit may become broken up into indehiscent pieces, each containing a single seed. The fruit of the dead-nettle, called a carcerulus, splits up in this way into four little nutlets. In some of the Labiatæ, such as self-heal, *Prunella*, the nutlets are retained within the calyx, which remains closed while the weather is fine; rain, however, causes the sepals to open up and the nutlets are discharged. The fruits of the Geraniaceæ, or cranes'-bills, are also schizocarps, as these splitting fruits are called. These plants are named from the long beak or carpophore of their peculiar fruit. To this beak the five one-seeded carpels at first adhere, but when ripe their basal portions separate from it and curve upwards. At the same moment each carpel splits open along its inner edge, and by the suddenness of the movement the seed is projected out to a distance of some feet. A few species have indehiscent carpels, which themselves spring away from the carpophore. This is what happens in the stork's-bill, *Erodium*, a rather common plant belonging to the geranium family. The fruit of Erodium is, perhaps, the most interesting of all the hygroscopic class. When it springs away from the carpophore in the manner just described, the carpel of Erodium is seen to have a long slender filament or awn, which is in the act of curling upon itself. After the carpel alights its awn continues to curve and twist for a minute or two, until at last it acquires a corkscrew form and comes to rest. As long as the awn is kept dry it does not change, but if moistened with a drop of water it immediately begins to straighten out, and in the course of a very few minutes becomes quite straight. Two or three long slender hairs near the base of the awn keep the carpel in position, with its sharp point directed obliquely into the soil. If now, as in all probability is the case, the upper extremity of the awn presses against some object which affords a point of resistance, the moistening, in consequence of the untwisting and elongation of the awn, forces the point of the carpel down into the earth. Should the soil after a time get dry, the awn will once more assume its corkscrew condition; but instead of the seed being drawn up by this shortening of the awn, the latter is itself drawn down, for the seed holds on and keeps all it gains, its point being barbed like a harpoon. The chances are now that the upper extremity of the awn has been applied to a new point of resistance, so that the next rain will send the seed still deeper into the soil, and so on with every succeeding change of weather. The awn in some species is feathered at its extremity, the more certainly to secure that it shall press against a resisting object when it begins to unwind. Species of anemone and clematis have awned seeds or achenes capable of burying themselves in this manner. The feather-grass (*Stipa pennata*) has the same peculiarity; we have found its seeds stuck deep in the ground like so many darts. Seeds of this description, several of which have been used in the construction of hygroscopes, may literally be said to screw themselves into the earth. The grains of the barren oat and some other grasses have hygroscopic awns by means of which they move about from place to place. During damp weather a heap of these grains disperse themselves in a most surprising manner, marching off in various directions like so many flies. In other cases, as in the common vernal grass and one or two others, the seed trips about in quite fantastic style. Many aristate grains and seeds appear, however, to be adapted for dispersion through animal agency. Even in such cases the hygroscopic property is useful; it enables the seed to burrow into fur or wool the better to ensure its transport. A remarkable splitting fruit is that of *Hura crepitans*, called the "monkey's dinner-bell" because its woody carpels when quite dry separate suddenly with a noise like the report of a musket. The common wood-sorrel has the testa or outer coat of its seed elastic; if touched, this suddenly ruptures, and the core of the seed is projected to some distance. The hairy cress (*Cardamine hirsuta*) is a well-known example of an elastic fruit. If the ripe siliqua be touched, its two valves quickly curl up and the seeds are shot out all around. The pod of *Impatiens*, or "touch-me-not," behaves in the same manner.

Fig. 4.—Fruit of Stork's-Bill (*Erodium cicutarium*), the Carpels still attached to the Carpophore.

Fig. 5.—Carpel of Erodium. 1. Dry condition. 2. After moistening.

A sharp line can hardly be drawn between hygroscopic movements and those due to turgescence. Of the latter the squirting cucumber furnishes an illustration. When the fruit breaks away from its stalk, the seeds, along with the watery contents, are shot out as from a syringe. Turgescence aids in the dispersion of a number of fungi. The mortar-fungus (*Sphærobolus*) projects its sporangium very much in the way a shell is thrown from a mortar. The globular sporangium retained by the outer membrane of the peridium is pressed from behind, till the tension suddenly ruptures the membrane and the sporangium is forcibly expelled. The rose of Jericho, a small annual found in sandy places in Syria, has the curious habit of curling itself up into a ball; the rootlets become detached from the dry earth, and the plant is rolled along the ground by the wind. On reaching a moist spot the plant unfolds, its pods dehisce, and the seeds are sown. From this remarkable habit *Anastatica* has been called the "resurrection plant." Placed in a basin of water it at once expands. Anastatica belongs to the order Cruciferæ, but an Australian grass (*Simplifex*) and a Brazilian club-moss possess the same curious wandering habit. From the examples now given it will be seen how widespread is the employment of hygroscopic agency throughout the vegetable kingdom wherever the distribution of seeds or other reproductive bodies is in question. With the exception of the wind, no agency is more in requisition for the dissemination of plant-germs. But notwithstanding this, hygroscopic agency seems to play only a subordinate *rôle* in the distribution of plants. We have but to consider how limited is the range of this force to see that the hygroscopic property is of value chiefly in conjunction with other and more efficacious agencies.

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THE LIME.

By Geo. Paxton.

> "Above waves wide the linden tree:
> With humming bees the air is thrilled."
> Mrs. Howitt.

The lime or linden tree (*Tilia europæa*) deserves to be held in much respect by all botanists, if for no other reason than that the great father of botany, Linnæus, derived his name from it.

Independent of all associations, however, the lime is much esteemed for its own sake; it grows to a very large, handsome tree, and in favourable situations lives to an old age. A fine lime has been called "one of the most imposing specimens of the vegetable kingdom."

This tree used to be the favourite for avenues—indeed, there are few old English parks, or European cities, that cannot boast of their avenues of limes; lately, however, it has fallen into disfavour, either on account of its shedding its leaves so early in autumn or because a less formal style of landscape gardening is now the fashion.

The lime is indigenous to the middle and north of Europe, and is supposed to have been introduced to our island by the Romans. It is quite common, all the varieties having long since been naturalized. It grows generally with a straight stem (fluted in old trees), has smooth bark (Fig. 1) and dense foliage; it is a very quick free grower, and stands transplanting exceedingly well, even when of good size.

The tree grows to a height of from seventy to one hundred feet with a girth often over twenty feet, and is less suited to stand the smoke of towns than the plane, elm, and some others.

The leaves, which usually appear in May, are heart-shaped, lop-sided, and beautifully toothed along their margins. The flowers, small and of a greenish colour, are generally borne three or four together on a curious leaf-like bract; they have a sweet perfume and overflow with honey. The seeds or fruit succeeding are small spherical capsules, which, however, seldom ripen in this country (Fig. 2).

One great peculiarity of the lime is the mass of twigs or "adventitious" branches which often surround the bole, and which give the tree a grace and beauty quite its own. In some avenues these twigs are quite a feature, in spring their red-tinted points look like bunches of coral, which give place to the tender green of the opening leaves. These at this season hang vertically downwards, and are more gracefully tapered towards the apex than later, when they increase in breadth. Two other peculiarities of this tree are the density of its foliage and the immense quantity of sweet-smelling honey-producing flowers which it bears; it consequently receives the industrious attention of the bee—the honey being of a pale colour and excellent quality. On the Continent the lime is much grown for its shade; indeed, even in this country we know of fewer greater pleasures than to spend the long hours of a hot July day reclining in the grateful shade of a large lime, drinking in the sweet odour and listening to the hum of the bees sounding though its branches.

In the middle ages "divine honours" were sometimes paid to this tree. Pliny tells of its "great repute" and "thousand uses." Shields (more important in those days than now) made of its wood were said to deaden the blow of a weapon better than those of any other kind of wood. The bark was a common writing material. Evelyn mentions that a book written on the inner bark of the lime "was brought to the Count of St. Amant, Governor of Arras, 1662, for which was given eight thousand ducats by the Emperor." Alas! there are no such emperors now.

The wood is of a pale yellow or white colour, close grained, soft, light, and smooth, and not readily attacked by insects. It cuts with great ease, and admits of much sharpness in details, and is consequently much used by the carver.

Many of the fine carvings in Windsor Castle, Trinity College Library, Cambridge, and Chatsworth House, are of this wood. It is also used by cabinet makers, piano makers, and for toys, boxes, and the like. One of the most important uses of the lime, however, in the North of Europe is that of supplying material for making ropes and mats. These mats are made from the tough but flexible inner bark or bast of the tree, and are much used in garden work; indeed, as many as fourteen million of them,

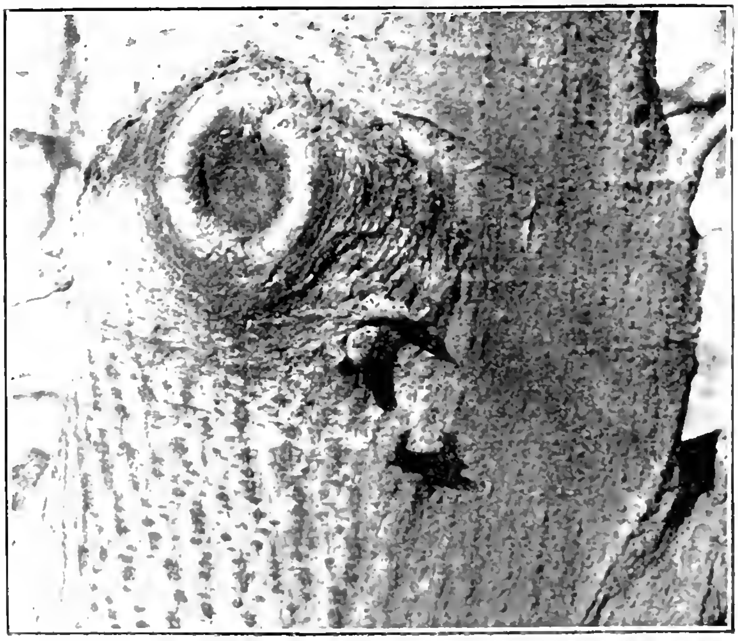


Fig. 1.—Bark of the Lime Tree.

each about two yards square, are annually imported into Great Britain, chiefly from Archangel.

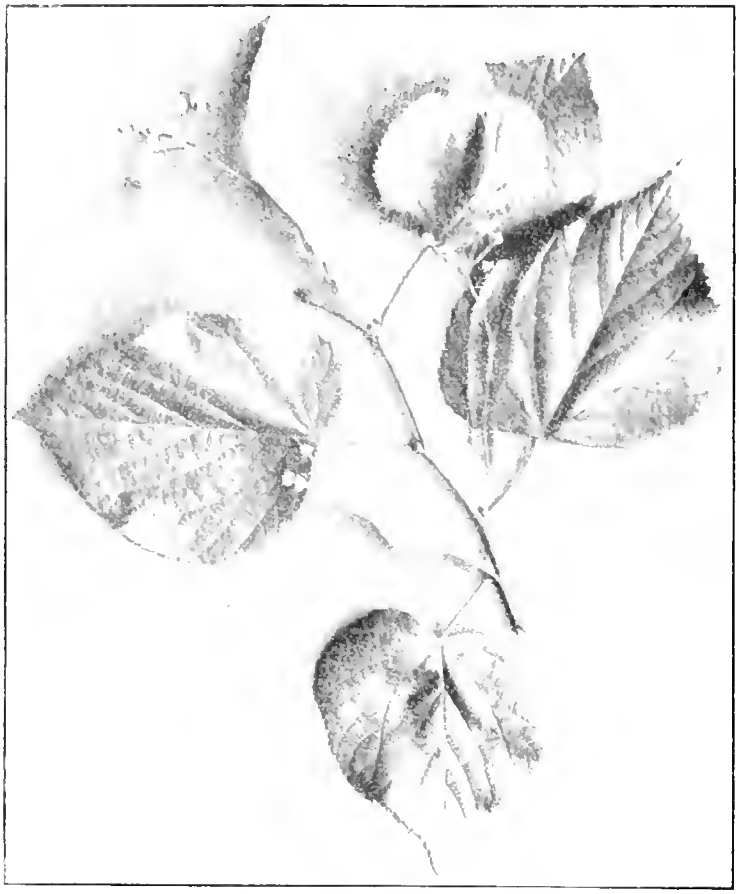


Fig. 2.—Leaves and Seeds of the Lime Tree.

During the struggles of the Swiss and Flemish to recover their liberty it was their custom to plant a lime tree on the field of every battle they had gained. Some of these still remain, and have been the subjects of many ballads. One planted at Fribourg in 1176 was standing in 1831, and then measured, according to Loudoun, twenty-three feet nine inches in circumference. Another, near the same place, supposed to be nearly a thousand years old, has a trunk thirty-six feet in girth. A famous tree at Neustadt, in Würtemberg, with a stem nine feet in diameter, has given that town the name of Neustadt *an der Grossen Linden*. At Reinhardtsbrun a lime in vigorous health measured, in 1895, twenty-five feet nine inches five feet from the ground, and has a clear bole of fifteen feet.

Autumn brings new grace to the lime as the foliage turns to yellow—in some years clear as the green of spring, but, alas! even more fleeting. It is to be regretted that this tree is one of the first to lose its leaves; indeed, almost before we have time to realize our brief summer we see them begin to fall. In spring or early summer the lime is at its best, and it is evidently to that time Mrs. Browning refers when she pays it this graceful tribute:—

"Here a linden tree stood bright'ning
  All adown its silver rind;
For, as some trees draw the lightning,
  So this tree, unto my mind,
Drew to earth the blessed sunshine
  From the sky where it was shrined."

ENGLISH COINS.—II.

By G. F. Hill, M.A.

The effect of the Norman Conquest on the English coinage is almost imperceptible, and any change that took place was apparently for the worse. Under William I. and II. (whose coins have to be dealt with together, as no satisfactory distinction between the two monarchs has been arrived at) the number of types is numerous, and the facing bust of the king (Fig. 1: PILLEM REX ANGLOR; reverse, MAN ON CANTVLBI, a Canterbury penny) now begins to be very common. The silver of these coins is of about the same fineness as that of our coins of the present time. From this time the style of the coinage deteriorates rapidly, until, under Stephen, it reaches its lowest point. The coins of this period are, however, interesting for the reason that, besides Stephen and Matilda, several other persons who were conspicuous in these troubled days are represented by coins. Thus we have coins of Eustace and William, sons of Stephen; of Henry de Blois, Bishop of Winchester, and Stephen's illegitimate brother (Fig. 2: HEN[RIC]VS EPC; reverse, [STEP]HANVS REX); of Robert, Earl of Gloucester, the illegitimate son of Henry I.; and of Roger, Earl of Warwick.

On his accession Henry II. found the coinage in a bad state. During his reign some uniformity was brought into the system, the number of types being simplified and a single superintendent being appointed who was responsible for the whole of the coinage. In 1180 an important issue took place, which consisted of what are known as "short-cross pennies," from the double or voided cross not reaching to the edge of the coin, which is the uniform type of the reverse. These coins all bear Henry's name, although they were in part issued in the reigns of Richard I. (Fig. 3: HENRICVS REX; reverse, STIVENE ON LVN, a London penny) and of John. Neither Richard nor John struck English coins with his own name. The short-cross pennies lasted until 1247 or 1248, when, to prevent the too prevalent practice of clipping the coins, the cross was lengthened. This was not the only innovation made in this reign.

In 1257 an attempt was made to introduce a gold coinage, which had been inaugurated five years before by the coining of the first "florin" in Florence. Henry's gold pennies (each worth twenty silver pennies) were not a success. They are excessively rare. The probability is that being of pure gold they were speedily melted down (Fig. 6: HENRIC REX III; reverse, WILLEM ON LVNDE). Another innovation was the placing of III, or TERCI(us), after the king's name. Curiously, this very sensible reform was not followed out by later kings, and the numerals do not appear again after the king's name until the time of Henry VII. The only lasting change made by Henry III. was the introduction of three pellets in the angles of the cross; these pellets occur constantly until the time of Henry VII., and only finally disappear under James I. It has been suggested that they gave rise to the three balls adopted by money-lenders as their sign.

The coins of the first three Edwards are difficult to distinguish. By this time the voided cross has given place to the cross pattée, *i.e.*, broadening towards the ends. (Fig. 4: EDW R ANGL DNS HYB, *i.e.*, Dominus Hyberniæ; reverse, CIVITAS DVREME. On this coin the mint-mark, a small cross moline at the beginning of the legend, is noticeable as being the sign used by Bishop Beck, who filled the see of Durham from 1283 to 1310.) Edward I. and Edward II. limited their actual coinage to the silver penny and its half and quarter; but the third king of this name made a far-reaching change by the introduction of a splendid series of gold coins, as well as by striking fourpenny and twopenny pieces (groats and half-groats) in silver. In 1353 Edward struck gold florins worth six shillings, with half-florins and quarter-florins. These, however, being valued too high in terms of silver, failed, and were withdrawn. The "noble," of six shillings and eight pence (the origin of our lawyer's fee), issued in 1344, was a greater success, though, perhaps, a less beautiful coin. Fig. 8 represents the florin, of which only two specimens are known; the king is seated, facing, a leopard on each side of the throne, fleur-de-lys strewn over the field. On the reverse is the motto: IHC (*i.e.*, Jesus) TRANSIENS PER MEDIVM ILLORVM IBAT. The legend (Luke iv. 30) was supposed to be a charm against thieves, and thus appropriate to the coinage. The half-florin and quarter-florin bore heraldic types (a leopard bearing a banner with the arms of France and England, and a lion standing on a "cap of maintenance," the field strewn with lys). The noble is represented by Fig. 9. Here the king is shown in a ship, with sword and shield bearing the royal arms. The reverse, like that of the florin, is purely decorative, and bears the same motto (with or without the addition of AVTEM after the first word). The origin of the obverse type is uncertain, the only plausible suggestion being that it has reference to the naval victory of Sluys, won by the English four years before these coins were issued. The half-noble was similar in type to the noble, but the quarter bore the shield of arms alone; the half with the motto, DOMINE NE IN FVRORE TVO ARGVAS ME, the quarter with EXALTABITUR IN GLORIA

In 1351 the penny was fixed at eighteen grains, and groats and half-groats were issued. The groat bore two circles of inscription on the reverse, the outer containing the motto, POSVI DEVM ADIVTOREM MEVM, the inner the mint name (in the case of Fig. 5, CIVITAS LONDON). Before the Treaty of Bretigny, in 1360, Edward calls himself King of France on his coins; from 1360 to 1369 he is Lord of Aquitaine (DNS HYB & AQT, Lord of Ireland and Aquitaine, on Fig. 5); after 1369, when the treaty was broken, he again claims the title of King of France. The half-groats are very similar to the groats, and the pennies are still of the type introduced by Edward I. The coinage which was thus established by Edward III. remained materially unaltered for more than a century, and his gold coinage was so fine that it was largely exported abroad. Under the impression that the wealth of a country was measured by the amount of gold it possessed, the English legislated time after time against the exportation of gold coin, but to no effect. Not only were the coins themselves exported, but imitations of all kinds were made on the Continent, varying only in legend or in some small heraldic detail. The next change of importance in the English coinage was due to Edward IV. In 1465 this king issued a new noble worth ten shillings, and a new coin worth six shillings and eight pence to fill the place of the old noble, which had risen in value. These nobles (which were also called "royals" or "ryals") differ from the old coins in having a rose on the side of the ship, and a rose on a sun in the centre of the reverse; a banner with E also flies from the poop of the vessel (Fig. 12). The half-noble is similar, but the quarter bears on the obverse the shield alone, with E, a rose, a sun, and a lys around it. The rose on these coins is, of course, the white rose of Edward's family, while the sun is explained by the story that before the battle of Mortimer's Cross, in 1460, Edward's victory was portended to him by the appearance in the heavens of three suns (mock suns?). The angel, or angel-noble, was so called from the type of the obverse, which was the archangel Michael subduing Satan (Fig. 7). On the reverse was a ship, carrying a cross between E and a rose, and on its side a shield. The motto was a lame hexameter: PER CRVCEM TVAM SALVA NOS XPE (*i.e.*, CHRISTE) REDEMPTOR. The angelet, or half-angel, is similar in type to the angel itself. As in the case of Edward III.'s coins, a great number of the coins of Edward IV., especially the ryals, circulated and were imitated abroad; specimens exist with the countermark of foreign States, such as Dantzic, upon them.

The accession of the Tudors may be said to mark the beginning of a new era in the English coinage. The execution of the pieces is in every way worthy of the young Renaissance, and the coinage from Henry VII. to Elizabeth has never been surpassed in England for decorative beauty and magnificence. Henry VII. introduced the sovereign, so called from the representation of the full-length figure of the king (Fig. 16). On the reverse were the royal arms in the centre of the Tudor rose. This fine piece, which weighed two hundred and forty grains (our present sovereign weighs one hundred and twenty-three and a quarter grains), was worth twenty shillings of the time, or two ryals. Henry also issued a ryal from which the rose was absent on the obverse, while the reverse is fully occupied by the Tudor rose with a shield bearing three lys in its centre. In silver, Henry VII. introduced an important coin, the shilling, weighing one hundred and forty-four grains, and equivalent to twelve pennies. On these pieces (Fig. 10) the number (VII or SEPTIM) is once more added to the king's name, and the bust appears in profile, being no longer a merely conventional representation but a real portrait. While most of the pennies are of the usual kind, it is interesting to note the recurrence on some of them of the sovereign type. The coinage continued to improve under Henry VIII., and coin was still exported from England in large quantities, since gold was rated at a higher value abroad than in this country. To prevent this it was proclaimed in November, 1526, that the sovereign should be current at twenty-two shillings and six pence, the angel-noble at seven shillings and six pence, and the other denominations proportionately. New coins were also issued, the most interesting being that which was known from its type (the George and Dragon) as the George noble (Fig. 11). We have also at this time the new gold denominations of the crown, of five shillings, and its half, and the quarter-angel. The silver coinage offers several points of interest. One of the counts in the indictment against Wolsey was that "of his pompous and presumptuous mind he hath enterprised to join and imprint the cardinal's hat under your arms in your coin of groats, made at your city of York, which like deed hath not yet been seen to have been done by any subject within your realm before this time." It should be borne in mind that it had long been the custom for bishops to place their mark on pennies issued by their authority (compare No. 4); but it would seem that Wolsey had ventured to place his mark and initials on the larger coins issued, at York, by the king's and not by his own authority. Several groats and half-groats exist with T W to right and left of the shield of arms, and the cardinal's hat beneath it. From the time of Henry VIII. the shield in some form or other is present on almost all English coins. The cross, which had been the chief feature of the English coinage since the Conquest, was first omitted on the shillings of Henry VIII.

The interest of Edward VI.'s coinage lies chiefly in his silver. In this metal he issued crowns, half-crowns, and sixpences. The sixpence, like the shilling, bore a crowned bust, sometimes in profile to the right, sometimes facing; the crown and half-crown bore the king on horseback to the right. Two great practical improvements in the English coinage are to be imputed to Edward VI.—the introduction of dates and values on the coinage, although this is limited at first to a few denominations.

We may pass over the coinage of Mary with a mention of the fact that, after her marriage with Philip II. of Spain, she struck half-crowns with the head of Philip on the reverse, and shillings with her own and Philip's heads confronted (Fig. 18). This type inspired the well-known couplet in Hudibras:

> "Still amorous, and fond, and billing,
> Like Philip and Mary on a shilling."

The coinage of Elizabeth is exceedingly plentiful. Besides adding some new smaller denominations, she made various material alterations in the coinage. The new denominations were the threepence, three halfpence, and three farthings. We illustrate here only the halfpenny (Fig. 11, with the Tudor portcullis) and farthing (Fig. 13, with ELIZABETHA R in a monogram, crowned). The most important innovation of Elizabeth's in the process of coinage to be chronicled is the introduction of the use of the mill.

Until the sixteenth century coins had been struck with a hammer; this slow method was now partly superseded, at first in Germany, then in other countries, by a machine put in motion by hydraulic wheels, and hence known as a mill. The use of the word "milling" to describe the roughened edge of modern coins is inaccurate, and the milled coins of Elizabeth and her successors can only be distinguished from the hammered by the greater neatness of the workmanship (Fig. 19 is a milled half-sovereign of Elizabeth). For some reason the new process was only employed for a limited number of coins, and the hammer was not finally superseded by the mill until the time of Charles II. (1662).

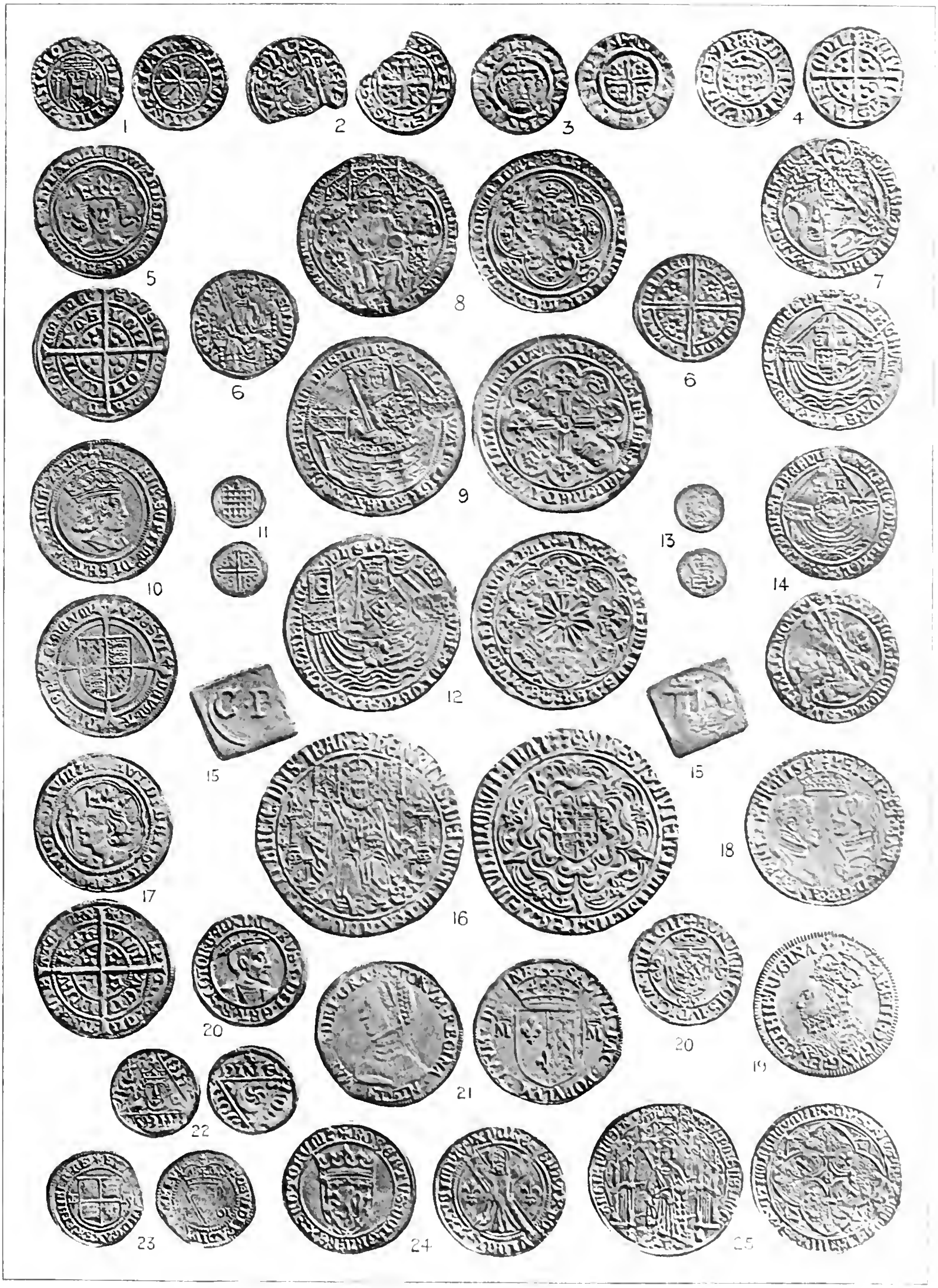
To the time of Henry VIII. the English coinage had maintained a very high level of purity, which accounts for the constant exportation of English money to countries where the coinage had become debased. For the sake of a little immediate profit, and perhaps to prevent this constant exportation, Henry issued gold and silver coins of a base quality, and his example was followed by Edward VI. and Mary. Elizabeth, however, was wise enough to see the badness of the system, and called in all the base coin. She seems, however, to have thought it good enough for Ireland, for it was passed over to that country.

The issue of so many small denominations in Elizabeth's reign is evidence of the general desire for small change. There exist patterns made under Elizabeth for copper coins, but it was not until the time of James I. that an official copper coinage was issued. Meanwhile the want was partly supplied by the issue of private tokens. These were given in change, and when, say, twenty-four farthing tokens of the same kind had been collected, the person who issued them would redeem them by payment of sixpence in coin of the realm. A private token coinage seems to have existed as early as the fifteenth century, but the nature of the tokens then used is involved in some obscurity. It is not, in fact, often certain whether the known leaden pieces of the fifteenth and sixteenth centuries were tokens or merely counters used for reckoning. Between 1590 and 1600 Elizabeth granted permission to the city of Bristol to issue city tokens, all private tokens being called in. A specimen issued early in the seventeenth century is illustrated here (Fig. 15: obverse, C B, for Civitas Bristol; reverse, the city arms).

The coinage of Scotland, which commenced in the reign of David I. (about 1124), was at first an imitation of the English coinage. It can hardly be said to have been important before the time of David II. (1329-1371), who imitated the gold nobles of Edward III., and also issued groats and half-groats, in addition to the smaller denominations which had been introduced by his predecessors. The groat here illustrated (Fig. 17: obverse, DAVID DEI GRATIA REX SCOTORVM; reverse, DOMINUS PROTECTOR MEUS & LIBERATOR MEUS; in inner circle, VILLA EDINBVRGH) was struck at Edinburgh. The stars which here take the place of the balls in the English coins are characteristic of Scottish silver coinage from William the Lion to Robert II. Like the Continental coinage of these times, that of Scotland—which was in close relation with France—was of a very inferior quality, and caused many complaints in England. The influence of France may also be seen in the first Scottish gold pieces of an original character, viz., those issued by Robert III. These are the St. Andrew crowns or lions, with a crowned shield bearing a lion rampant on the obverse, and a figure of St. Andrew on the reverse (Fig. 24: XPC, *i.e.*, Christus, REGNAT XPC VINCIT XPC IMPERAT). In style and legend these coins remind us of the French coins of the period. We must pass over the numerous and various issues of the successors of Robert III., mentioning only the fine "bonnet-piece" of James V. (Fig. 20: reverse, HONOR REGIS IVDICIVM DILIGIT), to the time of Mary Queen of Scots, whose portrait may be seen on the testoon of 1561 here illustrated (Fig. 21: reverse, S'LVVM FAC POPVLVM TVVM DOMINE, arms of France half effaced by those of Scotland), which was struck after the death of Mary's first husband, Francis. In spite of the union of the crowns, the coinage of Scotland remained distinct from that of England until the union in the reign of Anne.

The Irish coinage may be dismissed very briefly. None is known between the time of Æthelred II. and that of John, who, both as Governor of the island and as King of England, struck a series of coins. His regal coins have triangles on both sides; on the one containing the bust, on the other the sun, moon, and stars (Fig. 22: obverse, IOHANNES REX; reverse, ROBERD ON DIVE, a Dublin penny). More interesting, however, than the coins of John himself are the silver "Patrick farthings," reading PATRICII on one side, and DE DVNO or CRAGF on the other. These were struck at Downpatrick and Carrickfergus by the Earl of Ulster and Governor of Ireland, John de Curcy (whose name occurs on some in place of the mint name), between 1181 and 1189. The Irish coinage of Edward IV. was very extensive, but of no particular interest. The Irish harp first appears on the coins of Henry VIII., which are of very poor metal. Elizabeth's Irish silver was also base; but this ruler introduced a coinage of actual copper pence (Fig. 23: obverse, ELIZABETH D' G' AN' FR' ET HIBER' RE', with E R at the sides of the shield; reverse, POSVI DEV' ADIVTOREM MEV', with the harp crowned and date 1601), and halfpence of similar types. No gold was ever struck for Ireland.

As rulers of various parts of France, the English sovereigns, from Henry II. to Henry VI., struck considerable series of Anglo-Gallic coins. Among the most interesting are those issued by Edward the Black Prince,



ENGLISH, SCOTTISH & IRISH COINS

one of whose *pavillons* (struck at Bordeaux) is all that we have space to illustrate here (Fig. 25: obverse, EDwardus PrimOGeNitus REGis ANGLiæ PriNCepS Aquitaniæ; reverse, DOmiNus AdIVTOr & ProTECTOr MEus & In IPsO SPerAVIT COR MEVM. Burdigalæ).

APPRECIATION OF MUSICAL PITCH.

By Dr. J. G. McPherson, F.R.S.E., *late Mathematical Examiner in the University of St. Andrew.*

Dr. McKendrick, the Professor of Physiology in the University of Glasgow, lately brought before the Royal Society of Edinburgh a remarkable case of the early appreciation of musical pitch. His attention was drawn to the wonderfully accurate ear of John Baptist Toner, a boy of four and a half years of age. From the photograph shown us we could see that he was a smart and intelligent boy; he seems quite healthy and cheerful. His parents are both young and musical. His father excels on the organ and piano, and has studied musical harmony; his mother sings well, and loves music; but no other member of the family, collateral or ancestral, is known to be of a musical turn of mind.

John used to watch his father playing on the piano, and when two years of age would by himself finger the keys. Shortly before Professor McKendrick saw the boy, John had been told by his father the names of the notes on the piano. The exact notes left a lasting impression on the boy's mind. He acquired the names of the white keys in two or three minutes, and that over the whole keyboard. Next day he picked up the black keys in the same short space of time. The impressions seemed photographed on his memory, for when any note, white or black, was struck, he would instantly name it, though his back was turned to the instrument.

Professor McKendrick examined the boy in his father's house, so as not to disturb him by a change of associations. The professor struck notes here and there on the piano, when the boy could not see the keyboard, and John named them as soon as he heard the sound, without any hesitation or mistake. Not only so, but when the professor struck any two notes at random on the keyboard, the boy named them accurately at once. The boy even went the length of naming three notes when simultaneously struck by the professor on any part of the keyboard, commencing at the highest note and coming downwards in the naming of them. The boy's attitude during the experiment was leaning over the sofa at the other side of the room from where the piano stood, with his back to the instrument; and it was the professor who struck the keys. The piano was at concert pitch. Dozens of experiments accurately answered satisfied the professor that the boy had a remarkably acute ear for appreciating the different notes.

It was the concert pitch notes that were fixed in John's memory; for when, on another occasion, he tested the boy's ear with a set of Koenig's forks, he gave different names to the notes. These forks are lower than concert pitch, and the boy would give the name of the note corresponding to the concert pitch note. When a fork at concert pitch was struck, the boy would at once name the exact note with which his ear had been familiar. The notes seemed to be as accurately marked in his mind as the words of a verse of poetry. The boy accurately named the sounds as they corresponded to his standard. Thus he had acquired a standard of pitch fixed by his father's concert piano, and he remains true to that standard in all circumstances. If the professor named a note within the compass of the child's voice, John at once sang it correctly at concert pitch, as immediately after tested by striking the corresponding key on the piano.

John was then taken to the house of the professor to have his skill tested on the piano and organ there. The Bechstein piano and American organ were both at concert pitch. The boy was at first a little diverted from the necessary concentration of mind by the changed associations; but after a time he settled down and answered with perfect accuracy all the notes and groups of two and three notes simultaneously sounded on these instruments, although his back was turned to them.

This remarkable case is quite different from the tonic sol-fa system. In the latter the keynote is given three times, and the pupil is then expected to sing to words or to the syllable *la* any part in a psalm or hymn tune in the tonic sol-fa notation not seen before; and many thousands of children can do this easily. But there the keynote is given—quite a different test from that given to John Toner. This boy had no key or reference note given to him to guide and steady him in his search after particular notes. In his case the pitch is appreciated directly, and where he has had no musical training whatever. He had the standard and main key fixed in his mind. Of course for two years and a half the boy had been frequently touching the keys of the piano and listening to the corresponding sound; that was, so far, an education in the variety of notes. But it was only a short time before the professor saw him that he was told by his father the names of the white notes and the black notes. Moreover, the boy detects the notes within the whole range of the piano.

Professor McKendrick noticed the peculiarity in the boy's discrimination of the three notes simultaneously sounded. John always mentioned first the one highest in pitch, and he seemed to "feel about," as it were, for the other notes; but he invariably named them accurately within a quarter of a minute. The severe strain of three notes told on him, for after a time he would make mistakes, as if his little brain had not been able to retain the three impressions with sufficient distinctness to fix them accurately. When fresh, however, he invariably answered with correctness. The lowest note of the piano was struck by the professor and the boy could not name it correctly; but it was ascertained that that note was out of tune. The boy asked his father to name the notes in the same way, and laughed when mistakes were made, naturally wondering why his father could not do what to him was so very easy.

Dr. McKendrick directed attention to the importance of this case in connection with the question of "tonal fusion and analytic powers." In some cases a quick "ear" can, after long training, discriminate the several notes struck in this way, but many skilful musicians are deficient in the faculty. "One can hardly resist the conclusion," he says, "that it is a gift dependent on the delicacy of the ear and the part of the brain that receives auditory impressions, and that each note of a given instrument has, to such an individual, an undefinable quality or colour by which it is identified."

Professor Edgren, of Stockholm, gives some remarkable instances of the marvellous ease with which young children acquire the discrimination and expression of sounds before they can speak. Reyer brought over a nine-months-old child which accurately repeated the notes sounded on the piano. Stumpf's child sang the scales exactly at the age of fourteen months. The son of a compositor, Dvorak, of Prague, sang, when only a year old, the "Fantinitza-marsch," with its nurse. When eighteen months old it sang the melodies of its father, which he accompanied on the piano. But these curious cases are quite different from the marvellous discrimination of young John Toner.

WAVES.—VIII.

CAPILLARY WAVES.

(With information upon Breaking and Spraying, and upon the Use of Oil at Sea.)

By Vaughan Cornish, M.Sc.

A SHIP on her course leaves a wave track behind, whilst in front there is scarcely any visible disturbance except the foaming surge at the bow. It is otherwise with a small body moving slowly through the water, which makes the principal disturbance in front. If, when walking slowly by the edge of a pond, one trails his walking stick in the water, little ship-waves of the familiar pattern follow in its wake, but in front of the stick there is a novel appearance not seen with the ship. This is an arrow-head pattern of wavelets or capillary waves, such as is shown in Fig. 1, the pattern moving as a whole through the water, preserving its position relatively to the stick. The pattern is seen even better with a fishing line, especially if the line be kept nearly vertical by a weight: the ship waves behind are not so conspicuous with the smaller body, but the pattern of wavelets in front is better defined. The appearance is seen equally well when fishing from a river bank or from a boat slowly drifting on a smooth sea. All that is necessary is that there should be a slow relative motion of, say, a half to one mile per hour between the obstacle and the water; dozens of ridges can then be counted in front of the fishing line. When the motion is more rapid the pattern closes up, and at the same time the angle of the arrow-head becomes sharper. On slowing down again the arrow-head flattens out, until at a very slow speed, about nine inches per second, the obstacle is preceded and followed by one or two nearly straight parallel ridges separated by intervals of about two-thirds of an inch. This phase is difficult to catch, for if the motion becomes ever so little slower the ridges vanish altogether, the surface of the water being smooth and unwrinkled. About nine inches per second is the lowest velocity possible for a wave of water, and there is one definite wave-length, about two-thirds of an inch, corresponding to this speed. As soon, however, as the speed of the moving body is decreased, two sets of undulations of different wave-length accompany the body, and it therefore appears that for any speed greater than nine inches per second there are two wave-lengths, one greater and one less than two-thirds of an inch. The latter are the wavelets or capillary waves (which Lord Kelvin calls ripples) which form the fore part of the visible wave pattern of a small moving body. Those furthest in front are the shortest, the wave-length increasing as we go backwards through the pattern. These wavelets which run by capillarity move quicker the shorter their wave-length. Waves which run by gravitation move quicker the longer their wave-length. The wave of minimum velocity is controlled equally by the two forces of gravitation and capillarity. Wavelets a little shorter are mainly controlled by capillarity; waves a little longer are mainly controlled by gravity; and if the wave-length is much shorter or much greater than two-thirds of an inch, the one or the other force has complete control. Clerk Maxwell treats the case of a small body moving slowly through water in the following manner. In front of the body the relative velocity of the water and the body varies from V, the velocity of the body, where the fluid is at rest, to zero at the cutwater, where the fluid is forced to move with the body. The waves produced by the body roll away from the cutwater until they reach distances from it at which the relative velocity of the body and the fluid is equal to the several velocities corresponding to the wave-length of the several disturbances. Nearest the body is the wave of minimum velocity. Now what does theory indicate that there should be in front of this, where the relative velocity of the water and the body is greater? *Theoretically* there is a double series of undulations—capillary waves and gravitation waves, the former getting shorter, the latter getting longer, the further they are in front of the body. *Practically* we do not notice the gravitation waves in front, because they are too flat, whereas the little wrinklings of the capillary waves are rendered conspicuous by the play of light and shadow upon their steep sides. The wave of minimum velocity diverges least on either side of the path of the moving body, and at a distance on either side it is the most conspicuous part of the pattern. When the body moves quickly, even though it be small, the amplitude of the disturbances is so much increased that the gravitation wave nearest the body becomes steep enough to be conspicuous. This corresponds to the great bow wave of a steamer. Now these gravitation waves drop their energy behind them, as was explained in the article upon the force of the waves, so that the bow wave makes a group of waves behind it, and these are the waves which follow in the track of the ship although originating in front. Directly in the wake of the ship or moving body they appear as a procession of waves following the ship, each keeping its place relatively to the ship. Their outer border on either side of the ship's path is a series of short billows, stepped back one behind the other *en échelon*, as described in the article upon ship waves. Each line of the capillary waves, on the contrary, presents an unbroken front—a continuous arrow-head. This, I suppose, indicates that the energy of the capillary waves does not lose itself in the depths of the water, but keeps in the skin of the liquid: that is to say, the surface film of capillary thickness. If this be so, the form of the wave front of the capillary waves created by a moving body is readily explained. Let us think for a moment of the pattern formed by the drops falling from the blade of an oar when swung back slowly

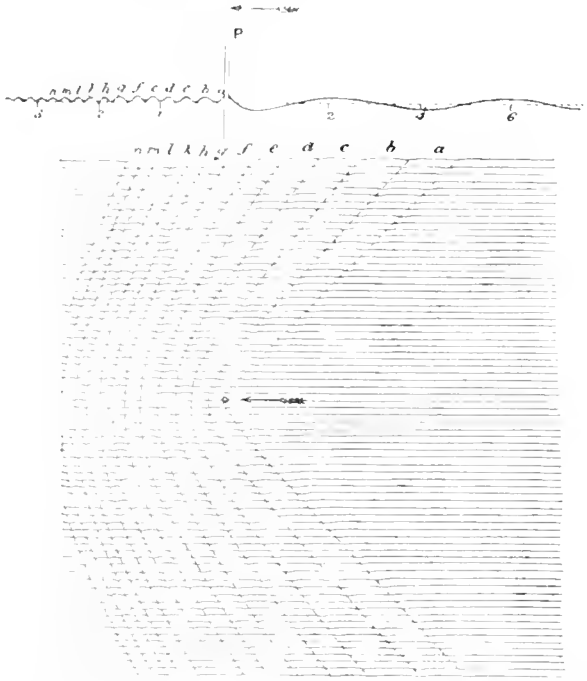


Fig. 1.—The Wavelet Pattern, after Scott Russell. (The Section shows also the Waves on the lee side which are omitted from the Plan.)

for a stroke. The wavelets from the falling drops ring out thus (Fig. 2), and the dotted line shows the arrow-head wave-front which would be produced if the disturbance were continuous instead of intermittent.

The arrow-head pattern of diminishing wavelets is a decorative tracery of singular delicacy worth knowing for its beauty, apart even from its scientific interest. The pattern can be seen on the up-stream side of every pebble which raises a wave in a brook, and on the lee side of every small wave raised by the wind on a calm sea, or on a river, lake, or pond. In front of the breast of a duck, when swimming quietly, the broad pattern is visible; and the little ducklings show it almost better, for they cannot swim fast enough to obliterate the pattern. Those insects from whose feet the water shrinks so that they stand in little holes, make an arrow-headed track when they dart about on the surface of a pond.

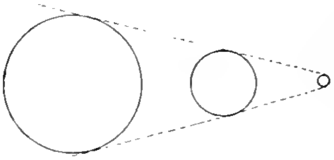


Fig. 2.—The Arrow-Head.

Capillary waves are also formed by other means than those which give the arrow-headed pattern, as, for instance, when a catspaw of wind suddenly darkens the surface of still water, covering it with fairly uniform wavelets, the wrinkled surface smoothing itself once more the moment the gust has passed.

An exquisitely fine pattern of stationary wavelets is seen on the water in a finger-glass when the wetted finger is drawn round the rim so as to cause the glass to vibrate and emit a musical note. The vibrating prongs of a tuning-fork in the same way will produce minute wavelets, which are finer in pattern the higher the note. A special device for showing capillary waves was recently exhibited by Professor Boys at the Royal Institution. A circular glass dish with vertical sides is placed upon a whirling table, and the surface of the whirling water is touched with the point of a needle. The arrow-head takes the form shown in Fig. 3, the wavelets vanishing towards the centre where the velocity is less than that of the slowest wave. Anything which diminishes the tightness of the skin of the water will enable the wave pattern to extend nearer to the centre, for when the surface is not so taut, less force is needed to wrinkle it and the corresponding velocity is less. A little soap added to the water has this effect. The skin of alcohol is not so tight as the skin of water, and if the basin be filled with alcohol instead of water and the vessel be started whirling, the capillary wave pattern appears sooner than with water, and the wavelets are longer from crest to crest. The same is the case with wavelets in mercury, for although mercury has a tight skin the liquid is so much heavier than water that the force required to propagate a wave is provided by a slower motion of the liquid. Capillary waves on liquid metals such as mercury (or molten aluminium) are very beautiful owing to the perfection of the surface reflection.

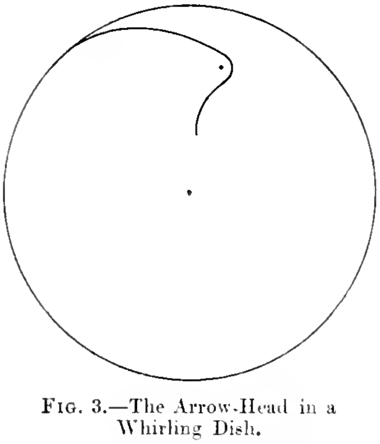


Fig. 3.—The Arrow-Head in a Whirling Dish.

The force called "capillary," which gives a liquid a tight skin, requiring an appreciable force to wrinkle or ruffle it, is due to the strong attraction exercised between the neighbouring particles of a body, and between those parts of different bodies which are so close that, to our senses, they appear in actual contact. At very small distances attraction can be very much stronger than is accounted for by the *law* of gravitation—the law which states that attraction is proportional to the square of the nearness. This law appears to hold good from the greatest distances down to, say, the hundredth or the thousandth of an inch, but at much closer quarters the law no longer holds. Not that any new agency necessarily comes into play, but that the law of its action is changed. Perhaps, as Lord Kelvin has pointed out, if we could locate each molecule we should be able to account for the increased attraction at close quarters, simply by the arrangement of the discontinuous matter. A spot may be so hemmed in by the contiguous molecules that their attraction is far greater there than that of all the distant parts of the body, however large it may be. It is this which constitutes the strength of materials.

Obviously, the conditions with regard to such short-distance actions must change abruptly at the surface of a body. Indeed, the surface of a solid body is the boundary of a universe, on the two sides of which are two different laws of being. At present, however, we are concerned with the surface of a liquid. If Fig. 4 represent a vessel containing a liquid and its own vapour, the horizontal line representing the surface of separation, and if we consider the attractions upon a particle C of all other particles which are very near to it; we see, in the first place, that as there are fewer particles above than below (the vapour being less dense than the liquid), it will require work to carry the particle C into the upper part of the vessel. This is a familiar fact; energy is taken up, *e.g.*, in the form of heat, when a liquid is made to evaporate. Secondly, to pull C down into the depths of the liquid will similarly require the supply of external energy, because the attraction of all particles below the dotted line is as nothing compared with the attraction of the neighbouring particles in the thin film above the dotted line. On the whole, therefore, there is a resultant force along the surface of the liquid, which makes the surface behave something like a stretched sheet of india-rubber, for it always tries to shrink so as to make itself as small as possible. It requires force to wrinkle it because wrinkling increases the extent of surface; and, if the compulsion be withdrawn, the crests fall smartly down, and the troughs jump nimbly up; inertia carries crest and trough past the middle line, vibration goes on with diminishing amplitude, and presently the surface comes to rest. This is the vibration of a capillary wave, surface tension wave, or ripple.

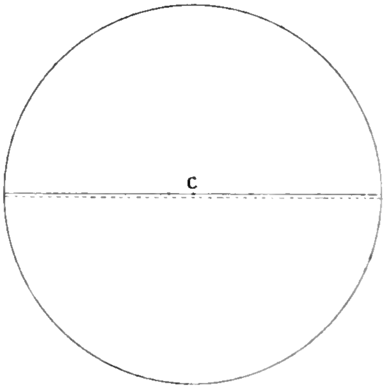


Fig. 4.—The Surface of a Liquid.

It is the shrinking of the surface which makes liquids tend to form spherical drops, the sphere being the figure of smallest surface, and therefore the proper equilibrium figure of a liquid. In practice one seldom sees a perfectly spherical drop, because gravitation towards the earth tends to pull it out of shape, the more so the larger the drop. Thus a large hanging drop has the shape shown in Fig. 5 —very much that of an india-rubber bag filled with water. If one gently taps a bough on which the dewdrops hang, each one trembles, the larger ones more slowly than the little ones, for the total shrinking force of the elastic skin is proportional to the area of the surface; but the attraction of the earth depends upon the mass of the drop, which is proportional to the volume. The quivering of a soap-film is more quickly brought to rest owing to the deadening action of the air, which presses upon it from both sides.

Fig. 5.—A Pendent Drop.

The elastic skin which capillarity provides accounts for the regularly repeating form of a water jet which has received some slight lateral displacement when issuing from a nozzle. As Lord Rayleigh points out in describing his beautiful researches upon liquid jets, the recurrent form of the jet is due to vibrations of the fluid column about the figure of equilibrium, superimposed upon a general progressive motion. Since the phase of vibration depends upon the time elapsed it is always the same at the same point in space. The distance between consecutive corresponding points of the recurrent figure (*the wave-length*) is proportional to the velocity. In fact, the recurrent broadening and narrowing of a jet in which at the outset some slight lateral disturbance has occurred, is comparable to the series of stationary crests and hollows to leeward of an obstacle in a shallow stream, but caused by capillarity, not by gravity. When a water jet breaks up into drops, owing to capillarity the drops strike against one another; and such is the elasticity of the skin of a water drop that, instead of amalgamating at collision, the drops fly apart almost as if they were billiard balls, and to this is due the scattering of the jet. Anything which helps the drops to cohere at collision diminishes the scattering. This is the effect produced by electrifying the spray, when the drops, cohering, fall in a steady, rattling shower—like the rain in a thunderstorm, says Professor Boys, whose "happy thoughts" flow as readily as those of Mr. Burnand himself.

The pressure of wind and eddy upon either side of the higher billows in a rising sea causes the tops of the ridges to burst into spray. The least additional resistance on the lee side makes these forced waves break more violently, the masses of broken water which are flung bodily forward being dangerous to vessels, especially the smaller craft. This danger may be, to a great extent, avoided by diminishing the capillary shrinking of the sea's surface by the use of oil. When a drop of oil is placed upon water there are three surfaces—the water-air surface, the oil-air surface, and the oil-water surface. To these three surfaces there correspond three stretching forces. If no two of these be greater than the third the oil remains in a lens-shaped drop, as is the case with the oily drops (which should not occur) upon hot soup, hot water having a much smaller surface tension than cold. In the case of cold water the tension of the water-air surface is greater than the sum of the tensions of the other two surfaces, and the oil cannot remain in a thick drop, but is dragged out into an inconceivably thin film, and spreads with surprising rapidity over a great space of water. So much of the sea as is covered with oil has no longer a powerfully capillary surface, but a feebly contractile oil surface, and there is no longer the same liability of breaking and spraying. The waves are as high as ever, but smoothly crested and comparatively harmless. Not much oil is required,[*] for there is no object in having a thick film; half a gallon an hour is said to be sufficient for a large ship. It is best applied from a canvas bag punctured in one or two places and hung over the side. When lying-to in a heavy sea the bag should be hung out to windward. When drifting under shortened sail the oil may be fed to leeward, so that the ship drifts into quiet water. When a vessel is in tow, oil fed over the stern of the tug is very useful in preventing the sea from breaking against the convoy.

The surface tension and the density of water being known, the force required to wrinkle the surface can be calculated. The pressure of the air being known, the velocity can be calculated which must be given to the lower layers of the air in order that their motion should wrinkle the surface, nothing like friction (*i.e.*, the mutual engagement of rough surfaces) being supposed to occur. This requisite wind velocity is calculated by Lord Kelvin to be 12·8 knots, which, of course, is very much greater than that which is found by observation to suffice for rippling the surface of the sea. It appears, therefore, that a part of the work of raising waves is due to something of the nature of friction. This fluid friction is supposed to be due to diffusion. When air and water are in contact, air is always dissolving in water and water is always evaporating into air. In a closed vessel the water soon saturates the air-space with moisture, and the water soon absorbs as much air as it can hold. This does not mean, however, that nothing goes on afterwards; there is a continual interchange, but evaporation and absorption proceeding at equal rates no further change is observable. So it is with the air and the sea: molecules of the gases of air are continually dashing into the water and remain there—for a time at least—and molecules of water are continually flying up into the air. When the air is blowing strongly over the surface of the water each particle of air as it dashes into the sea helps to impel the water forward; the driving wind not only presses forcibly upon the water but drags at it almost as a harrow, digging with its teeth, scratches the soil along.

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AN EXPEDITION TO DISCOVER HOW CORAL ISLANDS GROW.

By E. W. Richardson.

FIFTEEN years ago Darwin, finding surface investigation and dredging insufficient to determine with certainty the origin and genesis of coral atolls, expressed in a letter to Alexander Agassiz the wish that some rich man would have borings made in some of the Pacific and Indian atolls, and bring home cores from a depth of five hundred or six hundred feet for examination. For nine years this idea lay dormant in the minds of scientific men, but six years ago it took shape, and a committee of leading geologists and biologists was formed by the British Association to carry it out. Professor Bonney was appointed chairman and Professor Sollas secretary to this committee. The British Association appealed to the Royal Society, which readily supported the scheme. A large sum was voted from the Government Grant Committee, and another by the Royal Society from its own funds. Professor Anderson Stuart, of Sydney, N.S.W., has given great help, and it was through his efforts that the Colonial Government was

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[*] A shoal of sprats makes a smooth patch of oily water which tells the fishermen of their whereabouts.

induced to lend drill and steam plant to the value of two thousand five hundred pounds. The New South Wales Government also supplied skilled workmen, and contributes towards the wages of those in charge of the machinery.

After some five years' preliminary preparation and hard organizing work, an expedition to carry out Darwin's wish, and to discover by boring the origin of a coral atoll, was formed. The expedition is in charge of Professor Sollas, who is well known as having devoted special attention to coral formations. The other members of the expedition are Mr. John Stanley Gardiner, B.A., whose work as a biologist is considered of great promise, and Mr. Charles Hedley, of the Australian Museum, who, besides being a naturalist, is an artist, and will make all the drawings and sketches for the expedition.

The Government have placed H.M.S. *Penguin* at the disposal of the expedition, for the purpose of carrying the *personnel* and plant from Sydney to the scene of operations and back. The *Penguin* started on May 1st, and next month will probably be bringing the members of the expedition back. The island chosen for investigation is Funafuti, the largest isle of the atoll of that name, which forms one of the group of the Ellice Islands. These coral isles are situated in latitude 9° south, longitude 180°, and almost due north of Fiji. Funafuti is a typical atoll, being a chain of thirty-five islets encircling a large central lagoon about ten miles long by five wide. The chief island—and that on which the expedition is located—is about four miles long by half a mile wide, and it is nowhere higher than from eight to nine feet above the sea level. The island, which is under British protection, is covered with cocoanut trees, and supports a peaceful population of four hundred natives, nominally Christian.

Professor Sollas' instructions are simplicity itself; he is "to investigate a coral reef by sounding and boring," and is to do so with a mind quite unbiassed as to the various rival theories of coral-reef formation. The drill which does the boring is faced with black diamonds, which will cut through anything. The diameter of the drill is four inches. Seeing that the coral polype has never been recorded as living at a greater depth than ninety feet, it will only be necessary to bore to a depth of six hundred feet, and if that depth be reached the chief object of the expedition will have been attained. At the same time it is an open secret that Professor Sollas intends to go as far down as one thousand feet, if possible, and thus solve beyond a doubt the point to be cleared up.

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Science Notes.

Mr. T. Ruddiman Johnston has projected a most interesting and instructive aid to the study of geography in the shape of a huge terrestrial globe, having a diameter of eighty-four feet, and showing the earth's surface on a scale of about eight miles to the inch. Every geographical feature of any importance will be found on the proposed globe, several sections of which have been already constructed under Mr. Johnston's patent, and these may be seen at 21, Pall Mall.

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A correspondent writes: "I have heard that the 'perch' land measure of sixteen and a half feet, derived from *pertica* (Lat.), 'a rod,' had its origin in the long goads used in former times to goad on the ploughing oxen, which subsequently came to be used as land measures. Can any of your readers inform me if there is good authority for this statement?"

From investigating the cases in which death caused by electricity has occurred, whether by the accidental passage through the body of a powerful current used in industrial processes, or by the designed passage in cases of execution by electricity, the conclusion is reached that usually death by electricity is due to the excitement of the nervous centres, producing stoppage of respiration and syncope. Brown-Séquard and D'Arsonval are of this opinion. In many cases where artificial respiration is employed, a man apparently killed by electricity or lightning can be resuscitated. A man struck by lightning should be treated like one apparently drowned.

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Notices of Books.

Mars. By Percival Lowell. (Longmans.) 12s. 6d. "A steady atmosphere is essential to the study of planetary detail, size of instrument being a secondary matter." So Mr. Lowell begins his book. "With regard to work on the planets, the important point about an observatory is not so much what is its lens as what is its location." These are his closing words, and it is to his realization in his observing station of the condition which he presents in these two sentences, coupled with the steady determination to study Mars as long and as continuously as it was possible, that won him the remarkable success which he has recorded in the most interesting and striking volume now before us.

Mr. Lowell's "Mars" marks an epoch in the study of our planetary neighbour. There can be no doubt of that. As certainly as Mr. Green's true and beautiful designs, in 1877, established a record then, not since surpassed in their own line—as certainly as the discovery of the canal system by Prof. Schiaparelli marked a little later a new period—so Mr. Lowell's work advances us further still; and the marvellous, the almost incredible result is presented to us that, from actual observation of a planet some forty or fifty millions of miles away, we have a strong *primâ facie* case made out for the recognition of the actual handiwork of intelligent beings. Of mere speculation and surmise we have, of course, had, in the past, volumes by the score. This is different. It would, of course, be absurd to speak as if Mr. Lowell's presentment of his case amounted to a mathematical proof; that cannot be expected. But he certainly makes it what we may fairly term "reasonably probable' that in the "canals" of Mars we have the evidence of the work of skilled and trained intelligences—of engineers and mathematicians, in fact—and it is not too much to say that this is an achievement of the most astonishing kind.

The book is written in a style both bright and clear, and we feel sure that our readers will be grateful for being induced to read it. To our own mind the most valuable part is the clear demonstration of the progress of the effects of season on Mars. In the chapter on "Atmosphere," however, a reliance is placed on differences of measurements of diameter of too minute a character to merit much confidence until very fully confirmed by independent observations in other oppositions. But, as a whole, the book stands as a remarkable record of a most successful attempt to extend our exploration of Mars.

British Sea Birds. By Charles Dixon. (Bliss, Sands, & Foster.) Illustrated. 10s. 6d. Mr. Dixon is an energetic and constant writer on ornithology. The subject of this volume has so often, and especially of late, been discussed and written about, that there really seems nothing fresh to say. Indeed, it is difficult to find a use for this book.

It is not arranged in a way to be of any use as a book of reference, and is scarcely popular enough to be of general interest. We must therefore take it as a book merely of passing interest to bird lovers, and as this it makes very pleasant reading, and brings back to our minds many a day spent with the birds and the sea.

James Clerk Maxwell and Modern Physics. By R. T. Glazebrook, F.R.S. (Cassell.) "Century Science Series." 3s. 6d. Mr. Glazebrook, in his preface to this short memoir of Clerk Maxwell and his work, expresses the fear that his attempt to explain to non-mathematical readers the problems attacked by the great investigator, "without the aid of symbols is almost foredoomed to failure." In this we cannot agree; for it is by no means impossible, while avoiding the exact reasoning expressible only by mathematical symbols, to describe in words at least the nature of the problems attacked, and the conclusions to which they lead. Unfortunately, this attempt has somewhat overtaxed Mr. Glazebrook's skill. The earlier part of the book, dealing with the life of Clerk Maxwell, is brightly written and intensely interesting. The anxiety of the child to know the "particular go" of everything around him made his manner somewhat eccentric, and gained for him among his schoolfellows the nickname "Dafty." This eccentricity developed later into a genius for mathematics, in which study Clerk Maxwell easily eclipsed all his schoolfellows. And in 1846, when he was barely fifteen years of age, his genius was displayed in a communication to the Royal Society of Edinburgh, "On the Description of Oval Curves, and those having a Plurality of Foci." It is interesting to observe that mathematical ability, like musical genius, is almost always of early development. It was thus with Lord Kelvin, whose jubilee has just been celebrated.

J. Clerk Maxwell

From *James Clerk Maxwell and Modern Physics.*

An unfortunate misprint occurs over and over again in Mr. Glazebrook's book, wherever the ratio of the specific heats of gases is touched on. It is when the number 1·33 is given as the theoretical ratio between the specific heat of an ideal gas at constant volume and at constant pressure, instead of the correct number, 1·66. And this misprint has the result of rendering obscure the whole explanation of Clerk Maxwell's reasoning. It is especially to be regretted that confusion is thus introduced into a subject which it is most difficult to expound in popular language.

Clerk Maxwell must have been an ideal teacher for those who possessed the will and the power to learn. The secret of the success in teaching at Cambridge is contained in a sentence of his introductory lecture: "The student who uses home-made apparatus, which is always going wrong, often learns more than one who has the use of carefully adjusted instruments, to which he is apt to trust, and which he dares not take to pieces."

The biographical part of Mr. Glazebrook's book ends with chapter vi., and chapters vii. to x. are devoted to an exposition of Maxwell's researches. The account of his experiments on vision is clear and essentially accurate; but it is unfortunately otherwise with his account of Maxwell's share in the development of the kinetic theory of gases. For example, while the conclusion is correctly drawn that the specific heats of all gases are inversely proportional to their densities, Mr. Glazebrook adds: "This is the law discovered experimentally by Dulong and Petit to be approximately true of a large number of substances." To anyone who knows the subject, Mr. Glazebrook's meaning, though obscurely expressed, is clear enough. He would say that the specific heats of elements are inversely proportional to their atomic weights, and that these may be taken (though with many exceptions) as proportional to the densities of the elements in the gaseous state. But, as it stands, a much fuller explanation is required to make the passage intelligible. The account of Prof. Bolzmann's theorem of degrees of freedom, on page 139, is quite unintelligible; nevertheless it is not impossible to express its main features in popular language.

It is very difficult, too, to derive any clear idea of Clerk Maxwell's theories of electricity and magnetism from Mr. Glazebrook's words; and yet the main features might have been expressed so as to be understood partially by the half-scientific public.

It is with regret that we write in this deprecatory vein, for the task which Mr. Glazebrook has set himself is a praiseworthy one, and it is a pity that his book cannot be unreservedly praised.

Artistic and Scientific Taxidermy and Modelling. By Montagu Browne, F.G.S., F.Z.S. (A. & C. Black.) Illustrated. 21s. Some years ago Mr. Browne brought out a very useful book on the subject dealt with in the present volume, which is, however, much more advanced and elaborate. With this book in his possession the collector should be able to preserve and mount, either artistically or scientifically, any specimen which he may possess or obtain. Mr. Browne treats, in the most clear and practical way, of the ways of collecting, skinning, preserving, modelling, casting, mounting, and grouping of mammals, birds, insects, fish, and reptiles, and of the tools and preservatives most useful for these purposes, besides the methods of modelling and casting of rocks, trees, and flowers. When we add that the author has had long personal experience as curator of a large museum, we are sure that no further commendation on our part is needed. That this is the best and most useful book on the subject ever published is undeniable.

BOOKS RECEIVED.

The Story of Electricity. By J. Munro. (Newnes.) Illustrated. 1s.

Observations de l'Eclipse Totale du Soleil du 16 Avril, 1893. Par M. H. Deslandres. (Paris: Gauthier-Villars et Fils.)

Modern Optical Instruments. By Henry Orford. (Whittaker & Co.) Illustrated.

Things New and Old. Book VII. By H. O. Arnold-Forster. (Cassell.) Illustrated.

Results of Meteorological, Magnetical, and Solar Observations at Stonyhurst College. By Rev. W. Sidgreaves, S.J., F.R.A.S.

The Old Light and the New. By Wm. Ackroyd, F.I.C. (Chapman & Hall.) Illustrated. 1s. 6d.

Physics for Students of Medicine. By Alfred Daniell, M.A., LL.B., D.Sc. (Macmillan.) 4s. 6d.

The Law of the Symmetry of Composite Flowers. By W. W. Strickland. (Malton: R. S. Smithson.) Illustrated.

Text-Book of Zoology. By Dr. J. E. V. Boas. Translated by J. W. Kirkaldy and E. C. Pollard, B.Sc. (Sampson Low, Marston.) Illustrated.

A Geographical History of Mammals. By R. Lydekker, B.A., F.R.S., etc. (Cambridge University Press.) Illustrated. 10s. 6d.

The Evolution of Bird-Song. By Charles A. Witchell. (A. & C. Black.) 5s.

A Concise Handbook of British Birds. By H. K. Swann. (Wheldon & Co.) 3s. 6d.

Rheumatism. By T. J. Maclagan, M.D. Second Edition. (A. & C. Black.) 10s. 6d.

Vorometric Revelation. Written and compiled by J. Abner for the Author, A. A. North. (Authors' and Printers' Joint Interest Publishing Co.) Illustrated.

Plants of Manitoba. A Series of Chromolithographs. (Marcus Ward.) 10s. 6d.

The Biological Problem of To-day. By Prof. Dr. Oscar Hertwig. Translated by P. C. Mitchell, M.A. (Heinemann.)

The Universal Law of the Affinities of Atoms. By J. H. Loader. (Chapman & Hall.) 2s. 6d.

Wayside and Woodland Blossoms. Second Series. By Edward Step, F.L.S. (Warne.) Illustrated. 7s. 6d.

What it Costs to be Vaccinated. By Joseph Collinson. (William Reeves.)

Practical Radiography. By H. Snowden Ward, F.R.P.S. (Dawburn & Ward.) Illustrated. 1s. 6d.

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Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

TIDAL WAVES AND THEIR CAUSE.

To the Editors of Knowledge.

Sirs,—I have long been of the opinion, so well expressed by Mr. Wohlwill in the July Number of Knowledge, that the usual explanation given of the coincident occurrence of high water at the antipodes is unsatisfactory.

Could not a theory of the tides be formulated more in accordance with the facts and known dynamical laws? In the received theory our earth's solid nucleus is supposed to be completely submerged beneath an exaggerated ideal ocean, in which a tidal wave is supposed to follow continuously in the wake of the moon, without any interruption whatever, this again being followed by another tidal wave in the same hypothetical universal ocean at the antipodes, the two waves always occupying the same relative position to each other and to the moon, and consequently completely and continuously circumnavigating the globe as our satellite apparently does from east to west.

But what are the actual facts? The terrestrial waters only partially cover the solid earth, and are irregularly divided by the two principal masses of the dry land—the continents of the Old and New Worlds—which extend north and south of the Equator almost to the Poles, so as to effectually act as two great barriers to the continuous movement of any tidal wave from east to west in the wake of the moon. The general effect of this alternate exposure of continent and ocean to lunar influence is that vibratory motion of the latter characteristic of the tides, each antipodal oceanic basin oscillating backwards and forwards twice during the time that the moon makes a single uninterrupted apparent revolution round the earth. The real tide caused by the moon is the primary wave that immediately follows that body. This wave, being unable to follow the moon in her entire circuit, ebbs and again flows back upon the terrestrial barriers before-named, which stretch north and south of the Equator, as a secondary tide, whilst the moon pursues her course beneath the horizon. It is easy to see that a primary wave in the Atlantic will flow in the same direction as a secondary wave in the Pacific, and *vice versa*, so that we may sometimes get a simultaneous production of high water at the antipodes as the effect of the general arrangement of the great continents and oceans.

In a brief letter like this it is, of course, only possible to deal with the problem in a very crude and imperfect manner. But I am certain that if the geographical relations of land and water were to be taken into consideration instead of being totally ignored, a much more correct theory of the mechanism of the tides than the one at present accepted could be constructed upon sound dynamical principles.

Halifax. H. A. Cookson.

P.S.—Sir R. Ball, in his work on "Time and Tide," tells us that it is still "a moot point whether high water or low water should be represented beneath the moon, supposing the ocean to be vibrating with ideal tides"—which is equivalent to admitting that the theory is very far from being a complete solution of the problem. Mr. Proctor goes even further, and says that "the theory of the tides remains yet to be satisfactorily established:" and that "although the received theory explains the statical equilibrium of a tidal wave, the dynamical conditions of the problem cannot be thus explained."

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To the Editors of Knowledge.

Sirs,—I cannot altogether follow Mr. Wohlwill's argument in the July Number, but I agree with him that Mr. Cornish is inaccurate.

The usual popular explanation that has been handed on from book to book for several generations is to the effect that the moon draws up the water into a heap on the side of the earth nearest to itself, while it pulls the earth away from under the water on the remote side of the earth.

On this hypothesis the sheer direct *lifting* power of the moon causes the tides to arise, and their position would be such that the two opposite high tides would be always in a line with the moon if there were no land to interfere with the free motion of the water. Mr. Cornish seems to have accepted this theory almost in its entirety.

Now, from the mathematical theory of the tides (see Airey, Brinkley, Abbot, etc.) we learn that they are produced solely by the *tangential* action of the moon, *i.e.*, tangentially to the earth. This consists in an acceleration (or retardation) of the rotation of the watery shell of the earth acting through alternate quadrants, as the earth, with its oceans, rotates under the moon. Further, it is demonstrated that theoretically (*i.e.*, if there were no obstructing continents) *low water* would be found almost directly in a line with the moon at any given moment.

The whole subject of tide-production is an abstruse one, requiring the higher mathematics for its investigation, and is really incapable, apparently, of being described in homely language. But this does not warrant the use of simple language, if it is to be done at the cost of sheer misstatements of scientific truths.

There would surely be a great future for the man who will discover a handy, accurate, and intelligible account of the cause of the tides without using mathematical phraseology!

(Rev.) C. Robinson, B.A.

Willow Road, Birmingham,
July 1st, 1896.

[*Pace* Mr. Wohlwill and Mr. Robinson, I did not say, either that the earth is pulled away from its *orbit* or that the raising of the water is due to a *direct* lifting power.—V.C.]

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To the Editors of Knowledge.

Sirs,—The subject which is mentioned in the correspondence of the July Number of Knowledge, the formation of the ocean tides, is one on which we of the general public are sadly in need of fresh instruction and guidance. I have endeavoured, by looking up author after author of those within my reach, to obtain an authoritative explanation of the manner in which the great tides are produced; but I find them discordant one with another, and unsatisfactory or insufficient in themselves. Each explanation is based on one or more of the following ideas or theories, of which the most prevalent is the first one:—

(1) The suction theory. According to it, the moon (and the sun, but for brevity sake I will omit it), having more power over the waters nearest her than over the earth as a whole, draws them up—sucks them up in fact—into a heap under her; the action is described as direct, and is referred to as natural and requiring no elucidation. The authors would seem to have gone back to the old times when we all believed that the "sucker" in the pump drew the water up; and they fail to see that the tidal power of the moon, being almost infinitesimal compared to the earth's gravity force, could raise towards herself in direct opposition to gravity neither a particle of water, nor a grain of sand, nor any portion of matter, small or large.

(2) Closely connected with the "suction" is the "slip" theory. It is used to account for the secondary tide; the solid earth is said to be drawn away from the waters on the side farthest from the moon, and in fact to slip through the water moonwards, leaving a bulge of the ocean behind it. Unfortunately for the theory, the solid earth and the water are held together by a bond many million times stronger than the power which the moon can exert to separate them.

(3) One of my authors rests the explanation solely on the "weight" theory. The difference of the moon's attraction on the various parts of the water *tends* to separate them in the larger portions of the sphere, and to compact them at the quadratures; that tendency asserts itself by change of weight in the water, which results, through gravity, in rising and sinking, *i.e.*, in the tide bulges and depressions.

Two other writers eke out the "suction" by the "weight" theory, and one uses the latter idea as if he believed that light bodies have in themselves a power of ascension. None of them descend to the application of the idea; if they did they would readily perceive its inadequacy to do more than to help slightly the formation of the tide bulges. Our oceans are but a few miles in depth, but, in order to account for a rise of only three feet in their height, a depth of water of between three thousand and four thousand miles would be required.

(4) One—perhaps the greatest of my "authorities"—treats the tides as a case of "perturbation," similar to that to which heavenly bodies, such as the moon and the earth, are subject in their revolutions. But, however true that idea may be in the result, it is impossible to identify the course of action of the ocean, tied down as it is by gravity to the earth, with that of bodies moving freely in space.

(5) A great encyclopædia describes the force originating the phenomenon, but stops short cautiously at its *tendencies*, and omits to trace for us the course of its action, saying, "Thus we see that the tidal forces tend to pull the water towards and away from the moon, and to depress the water at right angles to that direction."

I note that most of the authorities recognize the existence of nothing but "force" in the case; that is to say, an agency like gravity, acting on each molecule of matter. The molar result of the action of "force" on matter, namely, "pressure," is considered only in one of its manifestations, "weight." The idea that the "tidal forces" of the moon acting on the water might produce "pressure" in a direction other than the vertical, does not seem to have been taken up by them. They have set themselves the difficult task of explaining to us the action of "force" on water without the aid of hydrostatics. J. Creagh.

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BILLOWS.

To the Editors of Knowledge.

Sirs,—From my earliest childhood I have always observed the rhythmic succession of maximum developed waves, with intervals of quiescent water, which I always attributed to the rhythmic gusts in light blows, and to the rhythmic paroxysms of violence always observable in heavy gales.

I have ever been impressed, during storms, with the regularity of this motion in heavy rolling, and have often taken its time, which I always find to be every twenty minutes—that is, three times in every hour; this rhythmic oscillation, with some five, six, or seven seas, then easy steaming. Some call these largest waves "tenth waves," but they are nearer "fiftieth" in such gales.

When the sea rises in tempests, and the exits leading out on deck have to be battened down, the passenger vouchsafed on deck by the captain imagines that the waves are the highest possible; but they are only the highest at that particular time and phase in that particular storm. So the gallant Scoresby thought when he measured what he believed to be the highest billows.

My good friend Captain Atkin, of the Cunard Steamship Company, related his experiences in the heaviest hurricane which he ever met on the North Atlantic some five winters ago, the like of which he does not desire ever again to run into. From his bridge—a coign of vantage not possessed in Scoresby's time—with the steamer in the trough of the sea, he observed the crests of the tremendous surges considerably higher than the top of the funnel, and but little below the masthead. Again, a well-posted American sea captain, lately returned from a passage around the Cape of Good Hope, using Dr. Scoresby's method, measured mountainous billows of the type of Mr. Daniell's realistic and ideal picturing on page 164 of your last issue, on the South Atlantic, from fifty-eight feet up to seventy-two from trough to crest; but he did not get the distance from crest to crest, or their velocity. H. P. Curtis.

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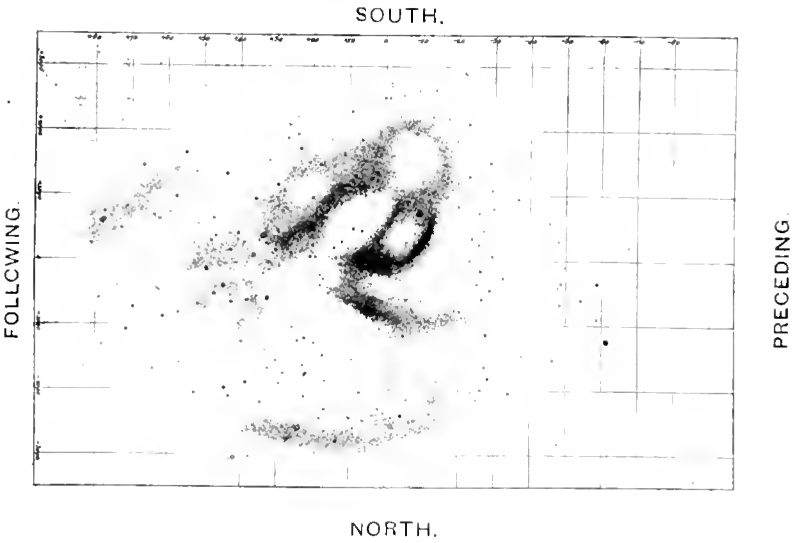
SEA SICKNESS.

To the Editors of Knowledge.

Sirs,—I followed Mr. Moy's advice recently, and secured a berth lengthwise of the steamer, whereon I lay carefully on my left side, with my head towards the engine room. The cabin was amidship, and the engine room aft, so my

M 8 SAGITTARII. Enlarged from a Photograph by Prof. K. D. NAEGAMVALA, taken May 18-19, 1895, with an exposure of 2 hours 40 minutes.



M 8 SAGITTARII. Reduced to approximately the same scale as the above, from the engraving by Sir JOHN HERSCHEL, Plate I. of the "Cape Observations."

head was towards the stern. I was dreadfully ill that journey.

Returning next day by another steamer I again followed the directions, but on this occasion the cabin was aft and the engine room amidship, so my head was towards the bow. This time I was much better, but there was very little sea on.

As engine rooms vary in position they are no guide, and I want to know which way of the ship is the right one.

A Landsman.

[We have shown our correspondent's letter to Mr. Moy, who says that "A Landsman" appears to prove the correctness of his theory and experiment, which, in Mr. Moy's case, was tried on a paddle steamer, in which the engines and boilers were amidships, and the position of the centre of gravity was therefore clearly amidships. In "A Landsman's" first experiment he appears to have been on a screw steamer, with the engine room well aft. If loaded, the centre of gravity would be a little abaft the centre of the vessel, and the position of his berth would render inoperative the effect arising from longitudinal oscillation; a berth much further forward would have effected his purpose.—Eds. K.]

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NOTE ON A PHOTOGRAPH OF THE NEBULA M 8 IN SAGITTARIUS.

By Prof. Kavasjee D. Naegamvala, M.A., F.R.A.S.

This nebula was very carefully examined by Sir John Herschel in the years 1836 and 1837, during his voluntary exile at the Cape of Good Hope. It has been fully described on pages 14-16 of the Cape *Observations*, and a half-page drawing of it has been assigned the place of honour in the plates.

Sir John Herschel describes it in the following words:—

"Its brighter portion may be described as consisting of three pretty distinct streaks or masses of nebula of a milky or resolvable character, arched together at their northern extremities so as to form some resemblance to the arches of an italic letter *m* very obliquely written, and this is the aspect under which it strikes the eye on a cursory view. On closer attention these streaks are seen to be connected and run into each other below (or to the south) by branches and projections of fainter light, and to form three distinct basins, insulating oval spaces—one entirely, the others comparatively dark. Northwards, a great effusion of faint nebula runs out, insulating a larger and more ill-defined basin of great extent and irregular form, which in some measure communicates with the best defined and darker of the three oval spaces already spoken of."

The stars, both of M 8 proper and of the cluster h 3725 just following it, are involved in the nebula, and Herschel has counted and assigned places to one hundred and eighty-six stars, ranging in magnitude from six to sixteen, in the region involved. Almost every one of these stars can be recognized on the photograph taken with an exposure of two hours forty minutes.

The nebulosity, however, impressed on the plate is much more extensive than that portrayed by Herschel, and the star 7 Sagittarii, shown as being absolutely free from any nebulosity in the drawing, is distinctly surrounded by nebulous matter in the photograph. This difference in visually recognizing the extent of the *nebulous* matter may very likely be due not only to the continuous action of the photographic plate, but also to the difference in the focal ratios of the two instruments employed. Sir J. Herschel's reflector was of eighteen and a quarter inches diameter and twenty feet focus, giving a focal ratio of a little over 1:13, while the focal ratio of the reflector employed for photographing was only 1:7·4.

An exposure of about four hours, in my opinion, would involve 7 Sagittarii in the same common nebulous envelope as M 8 and h 3725. This view is further supported by a photograph taken with one hour's exposure with an old portrait combination by Ross of two and a quarter inches diameter and about seven inches back-focus, in which the nebulosity completely extends right beyond 7 Sagittarii.

But the chief point of interest centres in the nucleus of the nebula, which, in the words of Herschel, "is decidedly not stellar, and resembling much more that of the nebula in Andromeda than any other I (Herschel) can call to mind as a term of comparison." Presumably, therefore, he had most carefully observed this nucleus, and delineated it faithfully with his great skill. In the drawing the nucleus is shown decidedly *concave* towards the *following* side, but it is as much clearly *convex* in the photograph.

The photograph taken with an exposure of two hours forty minutes has the stellar images not quite circular; but another, taken with an exposure of one hour thirty minutes, has stellar discs much more perfect, and on it, too, the nucleus is distinctly *convex* towards the *following* side. The photographs are mainly in agreement with Herschel's drawing; but to what cause could be assigned this gross discrepancy in the form of the nucleus is a question on which I cannot presume to enter.

The photographs were taken in the principal focus of a sixteen and a half inches reflector, of one hundred and twenty-two inches focal length.

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STOCK-TAKING OF THE VARIABLE STARS.

By Lieut.-Colonel E. E. Markwick, F.R.A.S.

The advance in the discoveries of variable stars, both by photography and direct observation, is proceeding so rapidly that it seems desirable to take stock or count of those very interesting bodies and see how we stand at present. It is evident that the theory or theories of the variable stars must hold an important place in the larger theory of the universe. If we can interpret correctly what is going on in a star or sun, this will be the key to similar phenomena occurring in countless other suns; and hence we are gaining an insight into a part, and an important part, of the interior economy of the universe of worlds.

This was not so in the past. The variable stars (there being then comparatively few known) were looked upon rather as peculiar cases or exceptions, the great multitude of stars being regarded as absolutely unchangeable. But now the number of the variables is so considerable, and the phenomena connected with them, as shown by the spectroscope, are so extremely complicated, that the attention of astronomers is being more and more directed to them.

Some years ago Dr. Gould announced his opinion that "a very large proportion of the fixed stars exhibit fluctuations of brightness"; and although at present, either with photometers or photography, regular variation of less than half a magnitude is exceedingly difficult to prove, still the progress of the optical and mechanical arts may in the future give us the means of detecting with certainty variation so small as the one-tenth of a magnitude.

The study of variable stars, in the matter of variation of light only, does not, like other branches of astronomy, require very elaborate apparatus to detect variation of half a magnitude or over. For the brighter stars it would seem that the unassisted eye is still the best photometer. Then from the fifth to the seventh magnitude the binocular or field-glass is a very excellent means of research, while for stars below the seventh magnitude the telescope must be called into use.

Hence this is a study peculiarly applicable to amateurs, many of whom take it up to become practically professional observers. This has been especially the case in America. The writer can speak to the enjoyment and pleasure obtained in such observations, for he has devoted his leisure hours to the variables for the past eleven years.

A photometer provides the means of bringing the images of two stars close together for study and comparison; but the naked eye can do this by a slight movement of the observer's head without the intervention of any lenses or prisms whatever. Again, the binocular commands a large field, and one or more comparison stars are generally included in it; but it also can, if necessary, be swiftly shifted a few degrees right or left, up or down, and a good estimate of relative brightness of two stars formed. In the telescope we are of necessity tied down to one field alone, and for the brighter stages of a variable star it is not always possible to include in it a suitable comparison star.

The meridian photometer of Pickering is of course, theoretically, a more accurate method of comparing the light of two stars; and so should photography be also. When, however, we come to practice, it is easy to see that the instrumental or photographic results are by no means in rigid agreement, *inter se*. Hence we are of opinion that, for some time yet, the ordinary method of direct eye estimates of brightness will hold its own against the other methods.

Photography, as a record, is more or less perfect, and we see how fruitful the study of plates has already become when we read of Mrs. Fleming announcing a batch of fourteen new long-period variables at once.[*]

In 1886, Mr. Gore published a very interesting paper on variable stars,[†] and with a slight modification we shall adopt his classification; one hundred and eighty-seven stars were then dealt with.

Taking now the second catalogue of variable stars by Dr. Chandler, together with the revised supplement to the same, which brings our information up to June, 1895, we find three hundred and forty-three variables contained therein. Those discovered since that publication are not here referred to.

The variables may be divided into the following classes:

Class I. Temporary or new stars (eleven).

Class II. Stars with large variations and periods of one hundred days and upwards in length (two hundred and thirty-eight).

Class III. Irregularly variable stars (thirty-two).

Class IV. Variable stars with periods of less than one hundred days (forty-seven).

Class V. Algol-type stars (sixteen).

This catalogue of Chandler's is quite a mine of information on the subject.

Going into a few statistics:—As to Class I., the text-books give two stars which are not included in the eleven, probably on account of insufficient data as to position, etc., viz., the star of B.C. 134 (Hipparchus), and that of A.D. 329, in Aquila. So that the number of temporary stars is just thirteen, which, however, has been augmented since by photographic discoveries.

Class II. comprises the great bulk of the variables. An analysis of the two hundred and thirty-eight stars is given in the following table:—[*]

Length of Period. Days.	No. of Stars.	Variation in Magnitudes.		
		Greatest.	Least.	Mean.
100 to 120	Nil.	—	—	
120 ,, 145	6	6·1	1·2	3·3
145 ,, 175	12	6·0	1·5	4·1
175 ,, 200	8	5·4	1·6	3·9
200 ,, 225	16	6·7	2·3	4·5
225 ,, 250	9	6·5	1·0	4·2
250 ,, 275	17	7·0	2·3	4·7
275 ,, 300	17	7·0	1·8	4·9
300 ,, 325	18	7·2	1·8	5·0
325 ,, 350	14	7·8	1·2	4·5
350 ,, 375	23	7·4	0·9	4·5
375 ,, 400	14	6·8	1·3	4·0
400 ,, 425	7	9·5	4·7	6·5
425 ,, 450	6	8·1	2·5	5·3
450 ,, 475	2	6·2	4·6	5·4
475 ,, 500	3	4·1	2·5	3·4
500 ,, 600	2	3·1	2·8	2·9
600 ,, 700	1	—	—	6·8
Over 700	1	—	—	3·8

It will be seen that up to three hundred and twenty-five days there is a marked tendency for the amount or amplitude of variation to increase with the period. This is not so marked from three hundred and twenty-five days to four hundred and seventy-five, although the variation is still considerable. Higher than this the stars are so few in number that the "mean" is not reliable.

Class III., the "irregulars," may be further subdivided into (*a*) those with small variation, (*b*) considerable variation. We thus get:—

	No. of Stars.	Variation.		
		Greatest.	Least.	Mean.
III. (*a*)	20	1·9	0·4	1·0
III. (*b*)	12	7·2	1·9	4·1

Class IV., or short-period variables of less than one hundred days' period, comprises forty-seven stars, analysed as under:—

Length of Period. Days.	No. of Stars.	Variation.		
		Greatest.	Least.	Mean.
0 to 5	11	1·4	0·5	1·0
5 ,, 10	16	2·0	0·7	1·1
10 ,, 15	2	1·1	0·8	1·0
15 ,, 20	3	1·7	0·8	1·3
20 ,, 25	1	—	—	1·1
25 ,, 30	1	—	—	2·4
30 ,, 35	1	—	—	3·4
35 ,, 40	2	1·8	1·5	1·7
40 ,, 50	2	2·1	0·7	1·4
50 ,, 75	4	4·3	1·6	2·5
75 ,, 100	1	—	—	1·2

Here again, as in Class II., can be seen a tendency for the amount of variation to increase with the period. One deduction, however, from the table is plain: the range or amplitude of variation in these short-period variables is much less than in the case of Class II., the stars of long period.

Class V. comprises the rare Algol stars—only sixteen in number up to the date of the catalogue. The star with the longest period and greatest amount of variation is S Cancri, viz., 9d. 11h. 37m. and 1·6 magnitude; that

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[*] *Harvard College Observatory Circular*, No. 6

[†] *Journal of Liverpool Astronomical Society*, Vol. V., p. 23.

[*] The author regrets that an error as to the total number of stars has crept into this table, and also the table of Class IV., which he is unable to correct in time for press owing to not having access to his original notes. The general conclusions are, however, in no way affected.

at the other extreme is S Antliæ, viz., 0d. 7h. 46m. and 0·6 magnitude.

As to the distribution of the variables in space, as we know them at present, one hundred and eighty-one are in the northern hemisphere, and one hundred and sixty-two in the southern. We have prepared maps of these on an equal surface projection, and on the same scale as the maps in Proctor's "Universe of Stars." The Milky Way is shown. In the northern hemisphere eighty-seven stars are either on or near the Milky Way, showing an evident connection with it. As the area of the Milky Way in the northern hemisphere is certainly not so much as one-fifth of the hemisphere, it is evident that far more variable stars are on it than should be, if they were evenly distributed over the sky. There seems a paucity of stars in the hours 9 to 14 of R.A.

In the southern hemisphere there is a "nest" of variables in about 16h. of R.A. and 20° declination, and another (evidently connected with the Milky Way) in 10h. R.A. and declination 60°. These aggregations might be due to the fact of a search of an investigator being confined to a limited part of the sky. On the whole the connection with the Milky Way does not seem so marked as in the northern hemisphere. In the hours 1 to 4 of R.A. there is a paucity of stars, and there is not a single star in hour 11.*

Now comes the plain question, what is the meaning of the variable stars? This is a hard nut to crack, and Class I., or the temporary stars, is perhaps the hardest of all to understand. Scientific men seem doubtful at present whether the outburst of light which we call a new star is due to an increase of heat and light in the star itself, or to a collision between the star and another body, whether solid or meteoric.

The various papers published in the scientific periodicals on the new star T Aurigæ, which appeared in 1892, show what different ideas prevail on the subject, and we quote some of them briefly. The Rev. W. Sidgreaves and Prof. Campbell think the phenomena of this star were produced in a single body. Dr. Huggins believes in Klinkerfue's and Wilsing's theory, viz.: two bodies travelling in opposite directions swing round, and tidal disturbances come in which bring about eruptions of the hotter layers of matter from the interior. Miss Clerke agrees with this. Mr. Maunder put forward the theory that a long and dense stream of meteors was travelling towards a star and rushed into or just grazed it. Mr. Ranyard explained the Nova as a small star moving away from us through a nebula which was moving towards us. Vogel thinks the Nova was produced by an encounter of a heavenly body with several others. Prof. Pickering suggests the phenomena as due to an outbreak of eruptive prominences on an enormous scale.

I do not mean to say that these are the views of the above-named at the present time, for our knowledge is evidently in a transitory stage, and views modify themselves rapidly as fresh discoveries are made. Enough has been said to show that it is a difficult matter to explain a new star.

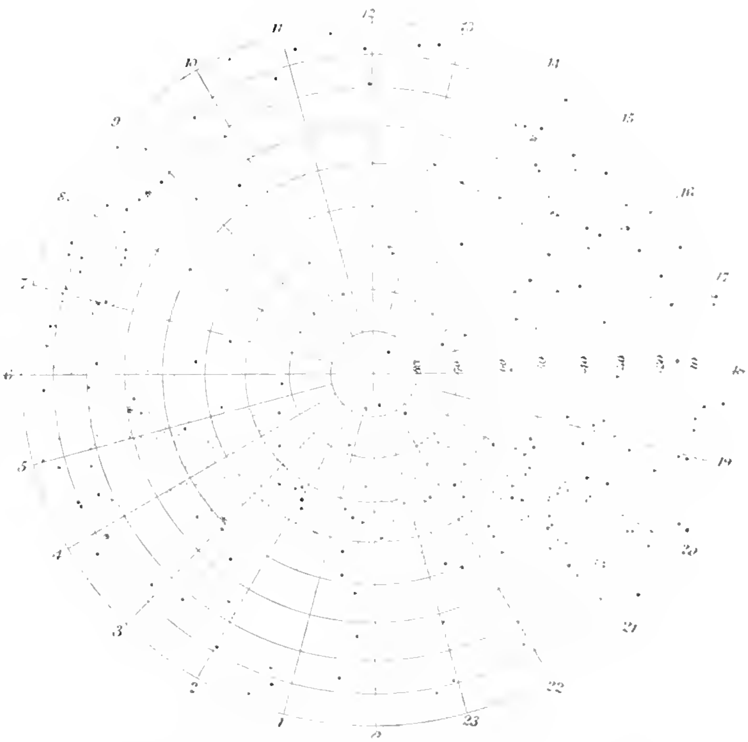
Then come the long-period variables. Here it is presumed the variation in light must take place in the sun itself, and Dr. Brester has recently enounced in this journal what appears to be a satisfactory theory to account for the increase and decrease in light.

The question of the interpretation of shift in the lines of a star's spectrum is discussed by Dr. Brester, and he does not think it can always be attributed to motion in the line of sight. Such shift may be produced by changes of pressure, temperature, chemical combinations, etc. In fact, the conditions under which gases, etc., exist in celestial bodies are so utterly different from what we can arrange in our laboratories, that it is necessary to be very cautious in interpreting a spectrum. It is, however, plain that motion in line of sight, when really existing, can be easily detected in the spectroscope, for Vogel observed Venus, and found that the observed (spectroscopic) velocity in line of sight only differed from the calculated velocity by 0·4 English miles per second.

The irregularly variable stars may, in many cases, be taken to be peculiar cases of Class II., but perhaps more difficult to explain.

It seems that the change in short-period variables like X or W Sagittarii or S Sagittæ is due to an orbital cause: a dark companion revolving round a bright central star, or *vice versâ*. But it is difficult to account for the *gradual* change in the light all through the period. The extreme regularity with which such stars go through hundreds and thousands of their phases is a well-marked feature. Other stars, like β Lyræ, are different. Vogel thinks the spectrum of β Lyræ is due to transiting of two bodies of unequal brilliancy in an elliptical orbit whose plane is in line of sight. When the less brilliant body occults the brighter, the principal minimum takes place. The equal maxima "occur when the bodies are side by side, at right angles to the line of sight. The second minimum occurs when the brighter body occults the darker." This theory might, perhaps, also cover a star like W Sagittarii, if the components are of nearly equal size and brilliancy.

Lastly come the Algol variables, about which much has been written. Vogel's theory of an opaque satellite revolving round the bright star in the plane of sight, and



The Variable Stars, Northern Hemisphere. Algol Stars thus : ⊙

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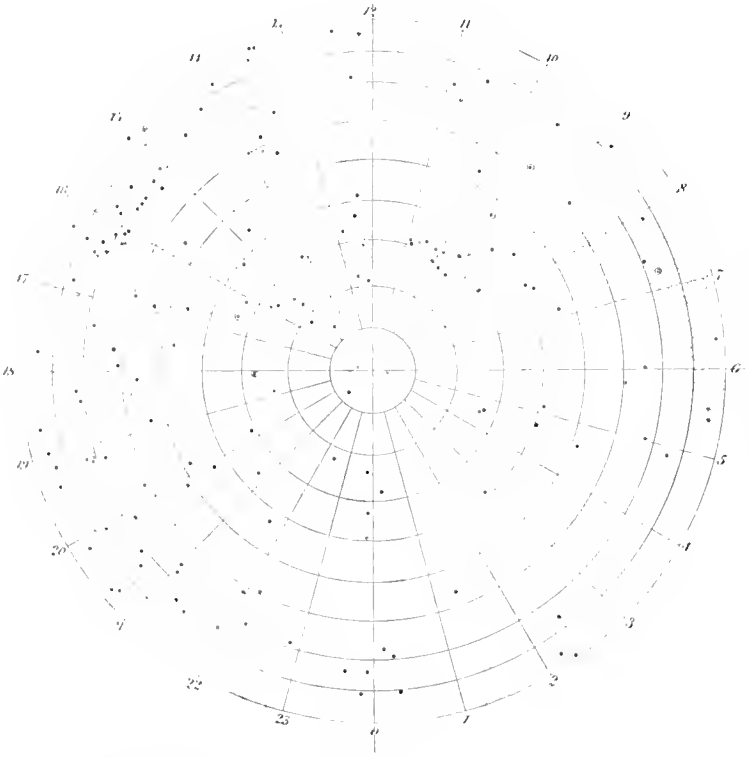
* In reproduction the maps have been reduced one-half linear.

periodically cutting off a part of the star's light, seems to account for the principal features of the phenomenon—viz., a sudden diminution of light followed by a rapid rise, more especially as the actual motion is revealed. But it does not explain all. Repeated observation has shown that the brightness of the star does not remain constant after the minimum has been passed; the old idea must be given up that the light curve can be represented by a straight horizontal line, with a sudden depression and then a recontinuation horizontally.

Dunér considers Y Cygni to consist of two equally large and bright companions and that the line of apsides revolves.

A remarkable announcement has been recently made that the spectrum of Altair (hitherto free from all suspicion of variation) shows peculiarities from which it is inferred that the star is a "spectroscopic triple," the two secondary bodies being dark as compared with the principal. Prof. Pickering foreshadowed this result some time before in a paper on the discovery of double stars by means of their spectra.



The Variable Stars, Southern Hemisphere. Algol Stars thus: ☉

Enough has been said to show how incomplete is our knowledge of the variable stars—yet that knowledge is advancing with such rapid strides that we may hope to obtain clearer views as time goes on; and when the problem of variable stars is solved a great step will be made towards that knowledge of the constitution of the heavens which Sir W. Herschel, Proctor, and others have so earnestly sought after.

Since the above was written the work of discovery of variable stars goes on apace, and Prof. Pickering announces ten new ones in *Harvard College Observatory Circular*, No. 7, of which one was previously noted by the writer. The Professor also finds that S Antliæ is not of the Algol type, but that its light is continually changing after the manner of δ Cephei and η Aquilæ.

OUR FUR PRODUCERS.—IV.

FUR-SEALS.

By R. Lydekker, B.A.Cantab., F.R.S.

PROBABLY there are still to be found persons who believe that "sealskin" is the product of our common British seals; and it is, therefore, well to state at once that this is not the case. It is true that the fur of an ordinary seal has much the same appearance as that of a fur-seal when in its natural state, but the former lacks the fine, soft, woolly under-fur which alone constitutes the sealskin of commerce. To remove the upper fur, the skin was formerly always, and still is frequently, shaved on the lower surface; and as the long hairs are more deeply emplanted than is the under-fur, their roots are cut away by this process, and the hairs themselves can then be brushed out. This process is technically known as "pulling"; and visitors to the Natural History Museum at South Kensington may see, in one of the bays on the left side of the entrance-hall, sealskin before and after it has been subjected to this process. After the removal of the long hairs the sealskin is dyed and curled, and is then ready for use. Seals that yield commercial sealskin differ from ordinary or true seals (*Phocidæ*) in many points—notably in the retention of small external ears, and in the circumstance that, when on land, the hind flippers are bent forwards beneath the body, instead of being stretched straight out behind. It must not, however, be supposed that all the eared seals (as the members of the family *Otariidæ* are best termed) yield commercial sealskin. On the contrary, many have only the long hairs without any of the woolly under-fur, and are consequently spoken of as hair-seals, in contradistinction to fur-seals. Not the least curious feature in connection with this difference is that hair-seals and fur-seals are found inhabiting the same districts, showing that the presence of under-fur does not depend by any means on the latitude of the habitat of the animals.

Although the price of the individual pelts is comparatively small, the enormous number brought into the market renders sealskin probably the most important item in the whole fur trade; and when it is stated that up to 1889 upwards of one hundred thousand fur-seals were killed annually on the Prybiloffs alone, while in 1874 about four and a half million individuals were computed to visit those islands, some faint idea may be obtained of the magnitude and importance of the trade. Human greed has, however, done its best to ruin this trade by indiscriminate and reckless slaughter; and from many parts of the world where fur-seals formerly swarmed they have now been more or less completely exterminated.

The habits of the fur-seals, and the numbers in which they formerly resorted to their "rookeries" during the breeding season, have been so frequently described that it will be quite unnecessary to allude to them further in the present article; and it will accordingly suffice to notice the species of most importance in the fur trade, with some remarks on the number and value of the pelts annually obtained.

Foremost among these is the northern sea-bear, or Alaska fur-seal (*Otaria ursina*), characterized externally by its short face, with a nearly straight profile, and the relatively weak dentition. The habitat of this seal is the North Pacific, where it ranges on the Asiatic coast as far south as the latitude of Tokio. The chief localities of the seals in Behring Sea are the Prybiloff and Commander Groups, the former constituting the head-quarters of the East Behring herd and the latter of the western herd. In the Commander Group, Copper and Behring Islands are the seal resorts; while in the Prybiloffs, St. George and St. Paul are the chief islands for seals. These latter were formerly leased to the Alaska Commercial Company. According to the terms of the lease, not more than 100,000 seals were to be killed annually on these islands; and this number was, as already stated, reached in 1889. Since that date the limit has, however, been very much reduced, the numbers killed in 1890 being 25,701; in 1891, 14,406; in 1892, 7509; and in 1894, 15,033. No females are allowed to be killed on the islands; and this prohibition has resulted in such a diminution in the number of males that probably five-sixths or more of the fur-seals now existing in the Northern Pacific are females. Indeed, to such an extent have the males been killed off that there are not sufficient full-grown individuals remaining to attend properly to the females landing on the islands. Large numbers of females are, however, slaughtered by the pelagic sealers cruising in Behring Sea during the months of August and September. In this pelagic sealing, eight out of every ten animals taken are shot whilst asleep on the surface of the water. Most seals when shot will float for some considerable time, and it is a curious fact that these sleeping seals hardly ever sink when struck. Those that are lost by sinking—from five to seven per cent. of the whole number killed—are, as a rule, awake, and when shot are struck in the throat. The reason for their sinking is supposed to be the escape of the air through the holes made by the buck-shot. Mr. Snow remarks with regard to those seals shot in the open sea, that they "all have pups on the 'rookeries,' which, being unable to shift for themselves, die of starvation. The fault lies with the regulations formulated by the Behring arbitrators, who have made the close season from the 1st of May till the 1st of August. May is too early, and is unfair to the pelagic sealers. Had the close season been from (say) the 30th of June to the 30th of September it would have been far better."

Cape Sea Lion (*Otaria pusilla*).

The skins are packed with salt in casks, each of which contains from forty to forty-five; such casks being forwarded to London in batches of from two to three hundred. On arrival the skins are sorted according to size, the largest being known to the trade as "middlings," while the smaller are classed as "pups" of various descriptions. A few years ago the average value per skin was seventy-eight shillings.

Regarding the process of preparation, after the remains of the blubber have been removed and the skins trimmed, Mr. Poland tells us that the pelts "are warmed on the fur side in the stove room and placed across the unhairer's beams, and the top hair is then removed with a blunt knife. The hair comes off in handfuls. The skins have to be kept warm during the whole process. . . . . The skins now have only the fur left, which is of a light drab colour. They are then tubbed—generally by machinery—in order to soften the leather, and shaved (old process), repaired, or sent as they are to the dyers." This dressing process occupies from one to three months, and the subsequent dyeing is still more complex. Although this part of the trade was formerly almost exclusively in English hands, it is now largely shared by the French. After dyeing, the skins are again scraped or shaved, and cleaned by being put in a revolving drum among a quantity of sawdust. Certain fine hairs, technically known as water-hairs, have still to be removed, this being effected by a special machine. Finally, the skins are trimmed, and sorted ready for the market.

The yearly catch of seals in the Commander Group is estimated at from forty to fifty thousand, the skins being packed in much the same manner as are those from the Prybiloffs, but they are not worth so much. Of recent years a variable number of skins of this species have been imported from Japan, the total varying from two to twelve thousand annually.

The northern sea-bear is the only fur-seal inhabiting the northern hemisphere; but there are at least three species found to the south of the Equator. The whole of these southern seals differ from their northern cousins externally in the greater length and narrowness of the muzzle—which is also more depressed—as they do by the smaller extent of skin projecting beyond the extremities of the toes of the hind flippers. In colour they are generally more distinctly grey than the northern species.

The finest skins from the southern seas appear to be the product of the South American or Falkland Island sea-bear (*Otaria australis*), which is found along the South American coast from Chili on the western side, and the mouth of the Rio de la Plata on the eastern side, to the extreme south, and reappears in the Antarctic lands, such as South Georgia and the South Shetlands. From the coasts of continental South America, northwards of Patagonia, these seals have to a great extent disappeared, but are more common on some of the adjacent islands, such as the Galipagos Islands. It will be found stated in some works that these seals occur on the coasts of Lobos (Seal) Island, near Monte Video; but the species found there, and also on some rocks close to the watering-place of Mar del Plata on the Argentine coast, is, we believe, the southern sea-lion (*O. jubata*), which is a hair seal. In the Falklands and South Shetlands, where they were formerly so free from fear of man as not to attempt an escape when their fellows were killed, they are more abundant. During the voyage of the *Challenger* these seals were found in

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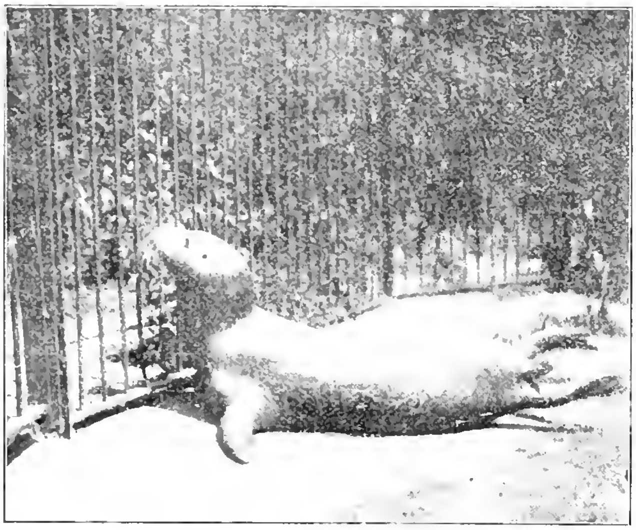
* For much of the information here given the author is indebted to two esteemed correspondents—Dr. C. H. Merriam, of Washington, and Mr. Snow, of Yokohama—who have pointed out certain erroneous statements unfortunately made in the "Royal Natural History."

some numbers on Kerguelen Land and Crozet Island, and they also inhabit, or inhabited, several other islands in the Indian Ocean, such as Marion, Prince Edward, St. Paul, and Amsterdam, although often described as a distinct species under the name of *O. gazella*.

The South American fur-seal affords one of the saddest examples on record of ruthless and short-sighted destruction. Soon after its discovery over a million pelts are stated to have been obtained from South Georgia, and nearly an equal number from Desolation Island; while in the year 1800 considerably more than a hundred thousand were shipped from the former locality. Again, in 1821-22, over three hundred thousand skins are stated to have been imported into London from the South Shetlands alone. At the present day the race has been more than decimated, both in South Georgia and the South Shetlands; and in 1887 the number of skins from those islands imported into London numbered, according to Mr. Poland, only a couple of hundred. There is some uncertainty with regard to the imports from the Falklands, as a confusion seems to have arisen between this seal and the southern sea-lion.



Common English Seal (*Phoca vitulina*).

Much the same story is told with regard to Crozet and Kerguelen Islands, which, as our readers are doubtless aware, are small barren rocks, rising in the middle of the Indian Ocean some distance southwards of the tropic. In his narrative of the *Challenger's* voyage Lieutenant Spry wrote that "the manner in which the seal fishery is carried on in the surrounding seas is both extravagant and destructive, for at the time of the discovery of this [Kerguelen] island it swarmed with sea-elephants, whales, and fur-seals. On this becoming known it soon became a favourite cruising ground for those engaged in the trade. This led, in an incredibly short space of time, to the reduction of all these species to a mere remnant, and in a few years their utter extinction is sure to follow." This prophecy has not, however, been strictly fulfilled, as it is stated of late years the seals, on account of the absence of molestation, have tended to increase somewhat in numbers. From St. Paul and Amsterdam Islands, lying to the north of Kerguelen, the seals appear to have been completely extirpated; and the cruisers despatched of late years from the Cape to Prince Edward and Marion Islands have been unsuccessful.

Nearly allied to the last is the Cape fur-seal (*Otaria pusilla*), which now seems to be restricted to the coasts of South Africa and the neighbouring islands, although it probably formerly inhabited Tristan d'Acunha. As a species it is characterized by the comparative straightness of the facial profile, the length of the ears, the sharp, overhanging muzzle, and the elongated bristles of the upper lip. Although this seal is still fairly abundant, the pelts are of small value owing to the shortness of the under-fur, those of young animals being superior in this respect to the adults. Indeed, the pelts of old males—the old "bulls" of the sealers—are often only usable for leather. Although formerly as many as seventy or eighty thousand skins were imported annually into London, the number now is much reduced. The skins of young animals—"pups"—are frequently used without the removal of the outer hair. The most productive sealing-grounds for this species are certain small islands in Algoa Bay.

All the southern fur-seals are very similar to one another, so that their specific determination is a matter of great difficulty. But it now appears that the Australasian seas are inhabited by a single species known as the New Zealand fur-seal, its scientific title being *Otaria forsteri*, although the name *cinerea* has been applied to the female. Although in greatly diminished numbers, this seal is still found in New Zealand and on the southern coasts of Australia and Tasmania. During the earlier years of Australian history it occurred in vast numbers, upwards of four hundred thousand skins being exported during the years 1814 and 1815. Flinders gives a graphic account of the hosts in which it frequented the shores of Passage Point, to the north-east of Tasmania, in his time. Reckless destruction has, however, done its usual work, and now the species appears to be comparatively scarce.

The above exhausts the list of well-defined species of fur-seals, which alone afford the best true sealskin. There is, however, no hard-and-fast line of division between fur-seals, or sea-bears, and hair-seals, or sea-lions, some of the latter having a small amount of under-fur mingled with the outer fur. The skins of some of these hair-seals are more or less used in the fur trade, but apparently in most cases without the removal of the outer fur. In regard to the small Californian sea-lion (*O. gillespiei*), which inhabits both sides of the North Pacific, and is specially preserved on the Farralone Islands off San Francisco, it seems, from Mr. Poland's account, that the fur of the back is capable of yielding a poor class of sealskin.

None of the true seals (*Phocidæ*) have under-fur, and their pelts are consequently used either for manufacture into leather or as fur which does not come under the designation of "sealskin." For rough purposes some use is made of the fur of the common English seal (*Phoca vitulina*), although the majority of skins, like those of most of the members of the family, are converted into leather. More use appears, however, to be made of the fur of the Greenland seal (*P. grœnlandica*), Mr. Poland remarking that, after the skins have gone through the preparatory processes, they are "dyed black or brown, the former being used for military purposes (Hussar or Fusilier busbies), and also a few for fur, such as edgings for robes, etc. The brown skins are used for fur purposes, and the inferior qualities find a ready sale in France." From five to ten shillings is the usual value of the skins of this species.

To give some idea of the immense extent of the trade in seal pelts, it may be mentioned, in conclusion, that, according to a recent estimate, upwards of one hundred and eighty-five thousand fur-seals and eight hundred and seventy-five thousand hair-seals are annually slaughtered to meet the requirements of the world. No wonder the whole tribe is in danger of extermination!

HOW TO OBSERVE AN EARTHQUAKE.

By Charles Davison, Sc.D., F.G.S.

The phenomena of earthquakes attain a very simple form in this country. To realize this we have only to compare the severest of recent British shocks with one of the great disturbances of other lands: say the Essex earthquake of 1884 with the Charleston earthquake of 1886 or the Japanese earthquake of 1891. In the former case, though many buildings were damaged and chimneys thrown down, the shock only lasted a few seconds; there were no great fissures in the ground, no crumpling of railway lines, no changes in the earth's surface features, such as the compression of river valleys or changes of level along lines of fault. There was some, though comparatively little, derangement of the underground water system. Two months after the earthquake a single slight shock was felt, that would hardly have attracted any notice had it not been for the interest already aroused in the subject. How different is this from the case in Japan! During the day following the disastrous earthquake of 1891 no less than three hundred and eighteen shocks occurred. The daily number, of course, rapidly declined; but before little more than two years had passed, as many as three thousand three hundred and sixty-five shocks were recorded at an observatory situated a few miles from the chief centre of disturbance.

The simple character, the short duration, and the isolation of British shocks are distinct aids to their observation; the attention is not distracted by a multiplicity of details. As the shocks are almost invariably slight, panic and the consequent exaggeration of description are to a great extent avoided. Their rarity is even, in one sense, a point in their favour. This is especially the case, as I have often found, when a seismologist endeavours to collect information from observers in different places, for those who have felt only one or two shocks in their lifetime retain for long the vivid impression they produce.

On the other hand, previous inexperience of earthquakes militates against their accurate observation. The shock begins so suddenly, and is often of such brief duration, that, almost before its true nature is recognized, it may be over and all opportunity for detailed study gone. In such cases, while some points stand out clearly enough and can be easily described, especially with the aid of guiding questions, others of perhaps equal importance escape notice, or the recollection of them is afterwards too indistinct or confused to be reproduced without uncertainty or error.

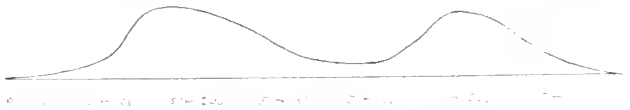
It is not difficult, however, to attend to the principal phenomena—those which will be of the greatest service in determining the surface position of the centre of disturbance and in throwing light on the nature and origin of the earthquake. To describe these phenomena and to point out others which are less deserving of notice may be of some assistance to those who live in the districts which are occasionally visited by earthquakes, and who are desirous, when one does occur, of making the best use of the brief time at their disposal.

It should be mentioned at the outset that the nature or order of the earthquake phenomena may vary much at different points of the disturbed area. At a place not far from the centre of the area, a low, rumbling sound is first heard; this gradually becomes louder, and after one or more seconds a slight tremor is felt, both sound and movement increase together in intensity, and then gradually die away, the sound lasting a few seconds after the movement ceases to be sensible. At its commencement the tremor resembles that produced in a building by a passing carriage or train, but, as it gets stronger, separate vibrations are perceptible. There is, indeed, no real distinction, except in magnitude and duration, between the tremulous motion and the perceptible vibrations. The movement sometimes, but not always, ends with tremors like those at starting.

At places near the boundary of the disturbed area the phenomena are of a simpler nature. If the shock be a strong one, and the disturbed area consequently large, it is possible that no sound at all may be heard, and the only thing observed is a more or less feeble movement. But in most earthquakes in Great Britain the sound is heard as far as the shock is felt. In such cases, at a place some distance from the centre, the sound may be heard first and may cease entirely before any motion is felt, or, at any rate, soon after it begins. The instant when the sound is loudest thus precedes the instant when the shock is strongest.

Very frequently, after a pause of a few seconds, the same phenomena are repeated with greater or less intensity, the movement and sound nearly or quite dying away in the interval.

In describing the nature of the shock it may be convenient to distinguish the tremulous motion from the principal vibrations, applying the latter term (principal vibration) to each distinct and complete to-and-fro movement. When the separate vibrations are so rapid and small as to be imperceptible from one another, the term "tremors" or "tremulous motion" should be used. However carefully written a description may be, it will always gain in value by the addition of a curve like that in the accompanying figure. This curve shows, for the great Charleston earthquake of August 31st, 1886, how the intensity varied during the course of the shock.



Very often a sense of direction is perceptible, and in many descriptions some importance seems to be attached to this. If, however, these directions as observed at different places are all plotted on a map (I am speaking here of British earthquakes), they are found to be governed by no definite law; they do not diverge from any particular point or area. One reason, no doubt, is that the direction itself at any place may change during a shock; but even if this were not the case, the apparent direction within a house is so largely governed by the direction in which the house itself vibrates—*i.e.*, by that of its longer axis—that observations on direction are generally of little, if any, value. It does not seem advisable, therefore, to pay much attention to this point, and the time often given to it may, as a rule, be more profitably bestowed.

Another point on which valuable time is often wasted is the determination of the time of occurrence. The first impulse of an observer, when he begins to feel a shock, seems to be to pull out his watch. Now, if the watch were very carefully regulated, or if its deviation from correct Greenwich time could be ascertained soon afterwards, it would be of the highest importance to determine the time of occurrence, especially if this could be done accurately to within a few seconds. But at the present day comparatively few watches can be depended on to this extent, and not many persons are able within a few hours to compare their watches with an accurately regulated clock. It is seldom, indeed, that observations of the time are of any use for determining the velocity with which the earth-wave travels. It should be remembered, too, that an appearance of accuracy, where none really exists, is easily given, and is most misleading; it would be better far if such an observation had never been made. As a general rule, therefore, when an observer is unprovided with a really good watch, he will spend his time more usefully in giving his whole attention to the nature of the shock and the accompanying sound. When the earthquake is over he should then record the time, and it is not difficult to estimate the brief interval which has elapsed. When, as is often the case in this country, successive earthquakes are separated by months or years, an error of a minute or two is not of much consequence. The time, however, should always be recorded as nearly as possible, if only for the purpose of identifying the shock with that observed by others. Sometimes also it is useful in tracing a doubtful or reported earthquake to its real origin, such as the firing of heavy guns at a distance, or the bursting of a meteor.

The preceding remarks apply in part to the duration of the shock. There is no difficulty, of course, in determining this with some accuracy; but here again the time can be more usefully employed. The duration is an element of little importance, unless it is determined by a seismograph, because the instants at which the movement begins and ceases to be perceptible depend entirely on the sensitiveness of the observer; and this varies in different persons, and even in the same person at different times. For all practical purposes, the direction can be estimated with sufficient accuracy when the earthquake is over. The observer should place himself in the same position as that in which he felt the shock and then imagine it repeated, marking the beginning and end, the aid of another person being obtained to time the interval.

One of the most important points to which an observer can direct his attention is the intensity of the shock. If nothing else but the mere occurrence of the sound and shock were noted, this element should not be omitted. Fortunately we are provided with a rough scale of seismic intensity, which has met with general adoption in nearly all countries where earthquakes are studied, and which is accurate enough for most purposes, besides being most easy to apply. This is known as the "Rossi-Forel" scale of seismic intensity.[*] The different parts of Question 6 in the list at the end of this paper refer to degrees iv. to viii. of this scale, the degree being added in brackets after each part of the question. One or two remarks should perhaps be made on this subject. In his own notes, at any rate, the observer should record a full answer (not merely "Yes") to each part of the question when it can be so answered. It should, for instance, be stated whether, in answer to the first part, doors, windows, etc., all rattled, or only one or the other; and whether the rattling was violent or slight. Answers, again, should be written to all parts of this question, especially if in the negative. The last affirmative answer of course determines the intensity of the shock. On this subject of intensity, however, the observer should not rest satisfied with his own impressions. He should make inquiries of his neighbours and others situated at a short distance in the same town or village, for the intensity often differs considerably at two points which are not very far apart.[†]

The last subject which need be referred to here is the observation of the sound phenomena. These, as a rule, are somewhat neglected, and yet they may prove to be of considerable importance, especially in concert with a large number of similar observations made elsewhere. The earthquake sound should of course be carefully distinguished from that produced by the rattling of loose objects, or, in rare cases in this country, by the fall of masonry. There is, indeed, little risk of confusion, for the earthquake sound does not resemble very closely any ordinary noise. On this account it is somewhat difficult to describe; but it is often compared to thunder (especially the low roll of distant thunder), the passage of a traction-engine or heavy vehicle along a rough road, the dragging of furniture across the floor of a room overhead, the roaring of a chimney on fire, or the rush of a gust of wind. Sometimes it is more or less short and abrupt, like the firing of distant cannon, the fall of a heavy body, or the slamming of a door; and occasionally it resembles a succession of these, such as would be produced by a hard and heavy ball rolling down a short flight of stairs. Particular attention should be paid to the time relations of the shock and sound—whether the beginning of the sound precedes, coincides with, or follows the beginning of the shock, and similarly with regard to the end. But on this sufficient is said in the questions given below. A rough curve might with advantage be drawn, showing the variation in intensity of the sound, and, if possible, this curve should be combined in the same figure with the curve of intensity of the shock—a dotted curve, say, for the sound, and a continuous curve for the shock. Such a figure would exhibit at a glance nearly every detail (except the absolute intensity and the time of occurrence) which it is desirable or necessary to observe.

The order in which the observations should be made and recorded is of great importance. The following is suggested as a convenient one, though the experience or inclination of each observer may lead him to adopt various modifications:—1. While the earthquake lasts the whole attention should be given to observing the nature of the shock and sound and their relations to one another; the variations in intensity and character of each. 2. Immediately the earthquake is over, take the time (in the following order: fraction of a minute or second, minute, hour), and estimate the interval between the instant when the shock was strongest and the instant of taking the time. 3. Write notes on the nature of the shock and sound, and their relations to one another. 4. Estimate the duration of the shock and sound, and the intervals between the beginning of each and the end of each. 5. Record the intensity. 6. Write notes about the position and occupation at the time of the earthquake.

List of Questions.

1. *Name of the Place* where the earthquake was observed?

2. *Situation of the Observer:* (*a*) Whether indoors (and on which floor of the house) or in the open air? (*b*) How occupied at the moment of the shock?

3. *Time* at which the shock was felt?

4. *Nature of the Shock:* (*a*) Was any tremulous motion felt before the principal vibrations, and for how many seconds? (*b*) How many principal vibrations were felt, and for how many seconds did they last? (*c*) Was any tremulous motion felt after the principal vibrations, and for how many seconds? (*d*) Did the shock gradually increase in intensity and then gradually die away, or were there two or more maxima or series of vibrations, and, if so, how many were there? what were the intervals between them? and what was the order of their intensity? (*e*) Were the principal vibrations strongest near the beginning, middle, or end? (*f*) Was any vertical motion perceptible, and, if so, was the movement first upward and then downward, or *vice versâ*?

5. *Duration of the Shock* in seconds, not including that of the accompanying sound.

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[*] For a full translation of the scale, *see Nature*, Vol. XLII., 1890, p. 349.

[†] See a paper by Prof. J. Milne, "On a Seismic Survey made in Tokio in 1884 and 1885." *Japan Seismol. Soc. Trans.*, Vol. X., 1887, pp. 1—36.

6. *Intensity of the Shock:* Was it strong enough (*a*) to make windows, doors, fireirons, etc., rattle (iv.)? (*b*) to cause the chair or bed on which the observer was resting to be perceptibly raised or moved (v.)? (*c*) to make chandeliers, pictures, etc., swing, or to stop clocks (vi.)? (*d*) to overthrow ornaments, vases, etc., or cause plaster to fall from the ceiling (vii.)? (*e*) to throw down chimneys, or make cracks in the walls of buildings (viii.)?

7. *Sound Phenomena:* (*a*) Was any unusual rumbling sound heard at the time of the shock, and, if so, what did it resemble? (*b*) Did the beginning of the sound precede, coincide with, or follow the beginning of the shock, and by how many seconds? (*c*) Did the end of the sound precede, coincide with, or follow the end of the shock, and by how many seconds? (*d*) Did the sound entirely precede the shock, and, if so, what was the length in seconds of the interval between the end of the sound and the beginning of the shock? (*e*) Did the sound become gradually louder and then die away, or were there several maxima of intensity? (*f*) Did the sound change in character at or about the time when the strongest vibrations were felt? (*g*) Was the sound loudest before, at, or after the instant when the shock was strongest?

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THE FACE OF THE SKY FOR AUGUST.

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

The decrease in solar spots is still noticeable. Conveniently observable minima of Algol occur at 3h. 19m. a.m. on the **14th**; at 0h. 8m. a.m. on the **17th**; and at 8h. 56m. p.m. on the **19th**.

Mercury, Venus, and Jupiter are all too near the Sun this month for the observer's purposes.

Mars is now becoming visible in the evening sky. On the **1st** he rises at 11h. p.m., with an apparent equatorial diameter of 8·2″, the defect of illumination on the *p* limb amounting to $1\frac{1}{4}''$. On the **7th** he rises at 10h. 46m. p.m., with a northern declination of 17° 41′, and an apparent equatorial diameter of $8\frac{1}{2}''$. On the **12th** he rises at 10h. 34m. p.m., with a northern declination of 18° 27′, and an apparent equatorial diameter of $8\frac{3}{4}''$. On the **19th** he rises at 10h. 17m. p.m., with a northern declination of 14° 10′, and an apparent equatorial diameter of nearly 9″. On the **26th** he rises at 10h. 2m. p.m., with a northern declination of 20° 15′, and an apparent equatorial diameter of 9·2″. On the **31st** he rises at 9h. 50m. p.m., with a northern declination of 20° 47′, and an apparent equatorial diameter of $9\frac{1}{2}''$, the *phasis* amounting to 1·4″. He describes a direct path through Leo during the month, passing through the Hyades towards the end of it.

Saturn is still an evening star, but should be looked for as soon as possible after sunset. On the **1st** he sets at 10h. 53m. p.m., or 3h. 8m. after the Sun, with a southern declination of 13° 30′, and an apparent equatorial diameter of $16\frac{1}{4}''$ (the major axis of the ring system being $39\frac{1}{2}''$ in diameter, and the minor $13\frac{3}{4}''$). On the **7th** he sets at 10h 30m. p.m., or 2h. 53m. after the Sun, with a southern declination of 13° 34′, and an apparent equatorial diameter of 16″. On the **17th** he sets at 9h. 52m. p.m., or 2h. 36m. after the Sun, with a southern declination of 13° 15′, and an apparent equatorial diameter of $15\frac{1}{2}''$. On the **31st** he sets at 8h. 59m. p.m., or 2h. 12m. after the Sun, with a southern declination of 14° 3′, and an apparent equatorial diameter of 15″ (the major axis of the ring system being $37\frac{1}{2}''$ in diameter, and the minor $13\frac{1}{2}''$). He describes a short direct path in Libra during the month, being about $2\frac{1}{4}$° north of α Libra (3rd magnitude) on the **12th**. Iapetus is in superior conjunction on the early morning of the **11th**.

Uranus is an evening star, but should be looked for as soon after sunset as possible, and his great southern declination militates against his successful observation. On the **1st** he sets at 11h. 2m. p.m., with a southern declination of 17° 37′, and an apparent diameter of 3·7″. On the **31st** he sets at 9h. 2m. p.m., with a southern declination of 17° 45′. He describes a short direct path in Libra during the month.

As Neptune does not rise till about 10h. p.m. at the end of the month, we defer an ephemeris of him till September.

This month is one of the most favourable ones in which to observe 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. + 11h. 52m. + 56°. Observations 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 places, and the direction of their shift, should be noted for the purpose of determining whether the radiant is a geometrical point or a circle, on an elliptic area, as suggested with regard to the November meteors (*Monthly Notices of the Royal Astronomical Society*, Vol. XLVII., pp. 66–73). The radiant point souths at 5h. 37m. a.m.

The Moon enters her last quarter at 6h. 31m. p.m. on the **1st**; is new at 5h. 2m. a.m. on the **9th**; enters her last quarter at 9h. 2m. p.m. on the **15th**; is full at 7h. 4m. a.m. on the **23rd**; and enters her last quarter at 10h. 55m. a.m. on the **31st**. She is in perigee at 6h. p.m. on the **11th** (distance from the Earth, 226,310 miles), and in apogee at 3h. p.m. on the **27th** (distance from the Earth, 251,880 miles). There will be a total eclipse of the Sun on the morning of the **9th**, invisible at Greenwich, and a partial eclipse of the Moon on the morning of the **23rd**; but only the penumbra of the Earth's shadow will be projected on the Moon at Greenwich, the Moon setting before the contact with the umbra occurs.

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Chess Column.

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

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of July Problem.

(A. C. Challenger.)

Author's intention:—1. P to Kt3, etc.

Unfortunately, there is a second and similar solution beginning with 1. R to Rt.

Correct Solutions received from H. H. Quilter (both solutions), H. F. Biggs, W. Willby, G. A. F. (Brentwood), C. H. G., H. Le Jeune, and Ubique.

A. S. Coulter.—In self-mate problems, Black is not compelled to defend himself from being mated. His sole object is to avoid mating White.

H. Price.—There is a second solution to your problem, commencing with 1. R to KKtsq. 2. B to B3ch, etc. If you correct it please send a diagram. We insert the challenge below.

C. H. Gaskin.—Thanks; but the want of economy in the construction is fatal.

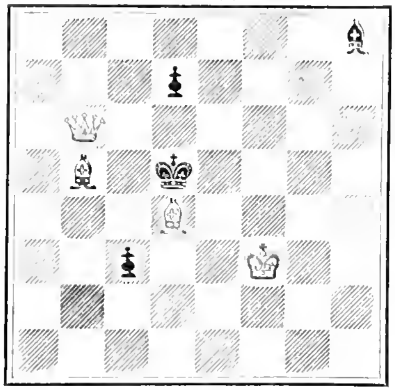
J. F. Welsh.—The tournament is noticed below.

PROBLEMS.

By A. C. Challenger.

No. 1.

Black (4).

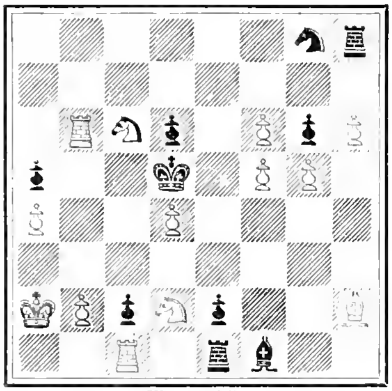


White (4).

White mates in two moves.

No. 2.

Black (10).



White (13).

White mates in three moves.

Correspondence Chess.—Mr. Hubert Price, 89, Clarke Street, Ladywood, Birmingham, would be glad to play one or two games, by correspondence, with a strong player.

CHESS INTELLIGENCE.

After a protracted contest, the tournament at Simpson's Divan resulted in the following score:—R. Teichmann, 9; F. J. Lee and L. Van Vliet, 8½; R. Loman, 7; O. C. Müller, 6; E. Cresswell, 5½; and six other scores smaller than 5. Mr. Teichmann was naturally expected to be the winner, and by a larger majority than that of half a game over Messrs. Lee and Van Vliet. However, 9 out of a possible 11 is a good winning score, and the two scorers of 8½ must either have been in exceptional form or have encountered in some cases a weak resistance. Mr. Bird's score of 4 is very disappointing.

Mr. J. W. Showalter has had all the best of a match with Mr. Barry, of Boston. The former is the leading native-born American player, and is expected to take part in the Nuremburg Tournament.

The Amateur Championship of the Southern Counties Chess Union will take place at the Imperial Hotel, Clifton, from September 7th to September 16th. Entrance fees, 10s. each, must reach Mr. T. Letchford, 6, Eastfield Road, Cotham, Bristol, on or before August 15th.

The present score in the Quadrangular Tournament of the Vienna Chess Club is:—C. Schlechter 6, B. Englisch 5½, M. Weiss 5, G. Marco 4.

The *Standard* gives the following list of competitors in the International Tournament which begins this week at Nuremburg:—Blackburne, Burn, Lasker, and Teichmann (England), Janowski (France), Schiffers, Tschigorin, and Winawer (Russia), Schallopp, Tarrasch, and Walbrodt (Germany), Porges (Prague), Maroczy (Buda-Pesth), Pillsbury, Showalter, and Steinitz (U.S.A.), Albin, Marco, and Schlechter (Austria).

Mr. Lasker is a doubtful competitor, and the same, we have always understood, applies to Dr. Tarrasch. Should both these play, it will be the strongest tournament on record, superior even to that of Hastings last summer. Even such a strong player as Mr. Albin will have to fight hard not to occupy the last place. Mr. Maroczy will be remembered as the winner of the Minor Tournament at Hastings last year.

The subjoined game was played in the recent Divan Tournament:—

"Giuoco Piano."

White. (Mr. J. Mortimer.)	Black. (Mr. Van Vliet.)
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	3. B to B4
4. Castles	4. Kt to B3
5. P to Q3	5. P to Q3
6. P to B3	6. Castles
7. B to KKt5	7. B to K3
8. QKt to Q2	8. Kt to K2
9. B × Kt	9. P × B
10. Kt to R4	10. P to B4
11. Q to R5	11. P to B5
12. QKt to B3	12. K to Kt2
13. Kt to Kt5	13. P to KR3
14. B × B	14. P × Kt
15. Q × KtPch	15. K to R2
16. Kt to B5	16. Kt × Kt
17. B × Ktch	17. Resigns.

Contents of No. 129.

NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

Bound volumes of Knowledge, New Series, can be supplied as follows:—Vols. I., II., III., and VIII., 10s. 6d. each; Vols. VI., VII., IX., and X. (1895), 8s. 6d. each.

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KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: SEPTEMBER 1, 1896.

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WAVES.—IX.

NOTES ON SOUND WAVES.

By Vaughan Cornish, M.Sc.

We leave for the present the waves of water in order to apply our study of the wave patterns given by moving bodies to the study of the physical properties of sound waves in air.

By means of the electric spark it is possible to see a noise. The arrow-headed wave front in Fig. 1 is the photograph of the hum of a bullet. The bullet completes an electric circuit when it brushes by the two wires shown in the figure, a spark illuminates the chamber through which the bullet is passing, and the phenomena may either be photographed by the light of the spark, or the whole thing can be seen if the eye be placed in the position of the photographic plate. The wave pattern is simpler than that formed in front of a small floating body; it is as if all the ridges and hollows of the water pattern had been omitted except the ridge of the wave of minimum velocity—that nearest the body. The single wave formed in front of a flying bullet is a wave of compressed air, as is shown by the fact that it appears dark. The light comes from the further side of the bullet, and where it meets this denser air at a grazing angle is deflected from its path, leaving a dark line. The bright line behind it is believed to be due simply to the fact that this part of the photographic plate is illuminated both by the light which passes straight through the place and by the light deflected from the condensed air. The velocity of the free wave of compressed air can be determined from the angle of the cone, the velocity of the bullet being known. With a Martini bullet (Fig. 1) the apex of the cone advances one thousand three hundred feet, while the wave has spread laterally one thousand one hundred feet on each side. The velocity of the free wave is therefore not one thousand three hundred feet per second, the velocity of the bullet, but one thousand one hundred feet per second, which is the velocity of sound. The bullet from a Lee-Metford rifle travels at two thousand feet per second, and consequently the wave front makes a sharper arrow-head (Fig. 2). On the other hand, when a bullet is moving at less than one thousand one hundred feet per second there can be no arrow-headed wave track, for the sound wave would run beyond the bullet. The figures show clearly that when the hum of a rifle bullet is heard overhead the bullet has already gone by, though everyone sympathises with the impulse to "duck." Meteors, which move much faster than bullets, are accompanied by a sound wave of extremely acute angle. The wave front does not reach the observer until the meteor has passed far beyond his station, or it may be not until some time after the meteor has burst. Therefore, as Prof. Boys has pointed out, the noise often heard after the bursting of a meteor may not even be due to the shock of its disruption, but must frequently, if not always, be caused by the wave track crossing the observer's position, a consideration which may avert erroneous calculations of the altitude and position of the bursting points of meteors.

Fig. 1.—Photograph of Martini Bullet in Flight.
(By permission of Messrs. Newton & Co.)

Enlarged Drawing of above, showing Form of Air Waves.

A projectile being bodily immersed in air, the wave of compressed air travels out in all directions from the projectile, and in this the phenomenon differs from that of the surface waves given by a floating body. The wave front is really a cone-shaped shell. The photographs, however, do not show this, for it is only where the light meets the layer of compressed air at a grazing angle that the refraction is sufficient to give a dark line; through all other parts of the cone the light passes practically undiminished. The fact that the wave front has three dimensions instead of being a surface phenomenon, shows that the displacement of the air is not a hillock or billow, as in the case of water waves. The work both of a ship and a projectile is so far alike that they both drive the fluid forward from the stem, but in the case of a ship the level of the water is at the same time raised, whereas in the case of a projectile the displaced particles of air penetrate among those in front of them, thus producing a greater density. This action goes on continuously in front of the bullet where the wave is created, and on either side where the wave is travelling freely the compressed air acts similarly, transmitting its energy to the neighbouring layer of air, which, being thus compressed, becomes in its turn the wave front. The particles of air in the first layer then recoil promptly to their original places, the layer returning at once to the ordinary pressure of the air. Thus behind the sound pulse there is no noisy turbulence of the air similar to the persistent heaving of the sea. The motion of the air particles is wholly forwards and back to rest along the same path, the whole of the energy of motion being transmitted during this single oscillation, as in a "long wave." Were it otherwise, the air would be filled always and everywhere with a jangle of sounds.

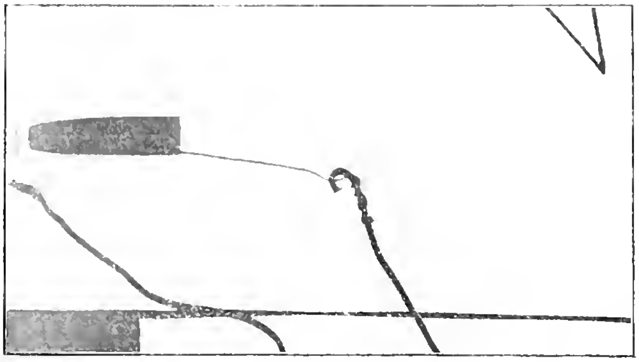

Fig. 2.—Photograph of Lee-Metford Bullet in Flight.

Enlarged Drawing of above, showing Form of Air Waves.

The velocity with which a free sound wave propagates itself through any gas depends upon the elasticity with which the gas recovers its state when pressure is released. This force of elastic recovery depends *directly* upon the pressure.[*] The velocity also depends *inversely* upon the density of the gas, which is itself proportional to the pressure, so that, taking both factors into account, the velocity of propagation of a sound does not depend upon the violence of the compression—that is to say, upon the loudness of the sound. Were it otherwise an orchestra could not keep time for an audience.

This law only holds, however, for reasonable pressures. With excessively violent compression the speed is somewhat greater. Thus, in Fig. 2, close to the V-shaped reflector on either side, the wave front is in advance of its proper position, where the darkness of shadow (at least in the original photograph) shows that the intensity of the sound is great. The V-shaped reflector was arranged so that the sound met it at a grazing incidence. In this case the wave is not reflected, as it is from the plate near the bottom of the figure, but, instead, it gathers force by what Scott Russell called "lateral accumulation." Something of the same kind happens with the "solitary" canal wave when it meets a wall at a grazing angle. The increased velocity is in this case connected with the increased height resulting from lateral accumulation, which causes the wave to travel faster by increasing the effective depth of the canal. The wave ultimately forms a breaker. Perhaps the extra swiftness of very loud sounds may be due to breaking, or rather spraying, jets of air shooting forward from the wave front and accelerating the compression of the next layer. Lateral accumulation is, Prof. Boys thinks, the secret of whispering galleries, the sound running round the wall without any true reflection. Perhaps it may also be a reason why sound often carries so wonderfully over water.

The movement required to make an audible wave must be sharp and quick, but may be very small. Lord Rayleigh has shown experimentally that a displacement of air particles of less than one ten-millionth of a centimètre in amount is distinctly audible. On the other hand, the motion of a large mass does not give rise to an audible wave if the motion be so slow that the air can escape compression by sliding round its sides and in behind.

Solid bodies, when struck, tremble with a rapid movement, and this is the usual source of sounds. A solid in regular vibration sends out a succession of pulses, each of which is an elastic air wave independent of those which precede and follow it. As, however, many bodies, especially those which are uniform in material and regular in shape, vibrate persistently at a constant rate, the sound pulses thus produced succeed one another in a perfectly regular manner—a definite, short, lapse of time and a definite distance separating each pulse from that which precedes it and from that which follows. Such a regular succession of pulses has a *note* depending upon the interval of time between them, or, which comes to the same thing, upon the distance from crest to crest. This distance is called the wave-

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[*] Allowance must be made for the fact that in the sharp and sudden compression of the air which takes place when sound is made the air becomes heated. Conversely, sudden heating, as in the explosive combination of gases, develops pressure, which heats and assists in firing the next layer, detonation proceeding as a wave which is very much like a violent sound wave. It seems as if jets of heated gas are projected from the front of the "explosion wave," helping to fire the mixture in front. Such jets correspond to the spray shot forward from a breaking wave.—(*Vide* Dixon on "The Rate of Explosion in Gases": *Phil. Trans.*, 1893.)

length of a musical sound or note, but there is no such physical connection between the waves as there is in a group of ship waves or of wind-raised waves; they are independent of one another, like the successive ridges of water which roll in upon a flat shore after the bursting of the breakers. Each vibration of a solid consists of a forward and a backward swing. During the former the air is compressed; during the latter it is rarefied; each pulse of compressed air being followed by one of rarefied air. The whole air-space round the sounding body thus becomes a series of concentric shells of compressed and rarefied air. The compressed parts may be called crests, the rarefied parts troughs. The middle C string of a piano sends out waves of which the crests are separated by distances of about four and a-half feet.

The quality or timbre of a note depends upon the physical character of the individual air pulses, which in its turn depends upon the manner in which the vibrating body executes its swing-swang motion. Each vibration of a tuning-fork compresses the air gently at first, the pressure rising gradually to a maximum, and then decreasing as gradually. This gives a smooth soft sound. The vibration of a violin string, on the other hand, after compressing the air to a maximum, releases the pressure very suddenly; hence its sharper sound. The curves often used to represent sound waves are no more like them, in the ordinary sense of likeness, than an equation is like the curve it expresses; and the similarity of these curves to the forms of water waves sometimes misleads people into a mistaken notion of the kind of similarity between sound waves and water waves. A shaded band is the most natural mode of representation.

Although different sound waves travel at the same speed, yet, owing to the difference of interval between the pulses sent out by bodies not accurately tuned to the same note, reinforcement and enfeeblement can take place between sounds, much as in the case of water waves. "Beats" are thus similar to the occasional arrival of unusually large breakers.

We have considered the forms of wave front given by a projectile and by a vibrating body, each immersed in a deep ocean of air. A disturbance on a sufficient scale to affect the atmosphere through its whole height sends out a wave which has a very different form of wave front. Such were the explosions which accompanied the final paroxysms of the Krakatoa eruption. These sent out elastic waves which must have moved the air to the highest limits. Viewed as a whole, the atmosphere is a thin spherical shell or envelope surrounding the solid earth. The front of the great Krakatoa air wave was, therefore, a ring or annulus with a nearly vertical face equal in height to the height of the atmosphere. From Krakatoa the pulse radiated out to all points of the compass, the ring-shaped wave front attaining its greatest dimensions when the wave had gone halfway round the earth from its starting point. Then of necessity a contraction of the ring began, and this continued until, at the antipodes of Krakatoa, the disturbance was approximately focussed round a vertical line. From this focus of concentrated energy the wave front again expanded to the full circuit of the earth, and then, contracting, focussed once more around Krakatoa. Thence once more the wave spread out, and thus continued, with diminishing intensity at each journey, for several complete circuits of the globe. The record of its marvellous journey was registered by barometers in all parts of the world, the mercury column responding to the variation of pressure as the air pulse passed each recording station. This was a sound wave, as its rate of travel showed, though it affected the barometer far beyond the range at which the noise of the eruption was recognized.

The audibility of a sound depends upon the amount of compression of the air at the point where the wave encounters the auditor. In the above case the effect upon the barometer was greater than that of sounds more locally intense, owing presumably to a nearly simultaneous increase in density in the whole atmospheric column above the barometric station.

The effect of wind upon the velocity of sound is easily understood; the disturbance advances more slowly, relatively, to an auditor on the earth's surface, when the air is bodily moving in the opposite direction to the wave of sound. This does not explain why sound becomes so much feebler when travelling against wind, for the existence of a current ought not to affect the amount of condensation and rarefaction. Experiments made by Prof. Osborne Reynolds show that sound going against wind is thrown upwards, and passes over the head of the listener. By ascending to a height from the ground, the sound can be caught again. This is probably due to the circumstance that the wind is stronger above than below, where it is retarded by the ground; the front of a sound wave travelling against the wind being consequently tilted upwards. Down wind the tilt would be downwards, and the sound should therefore be kept close to the ground.

The sound wave travels quicker in hot air than in cold, the density being less for the same pressure; consequently on passing obliquely from a stratum of hot air into a stratum of cold air, the front of the sound wave swings round, as the rollers from the sea wheel round upon the end which first reaches shallow water. The continual refractions and reflections which sound undergoes when the air is irregularly heated interfere greatly with the carrying power of sound. Thus a hot bright day, even when there is no wind, is often bad for sound; whilst a fog, which screens off the rays of the sun, often makes the air more transparent to sound, for the little fog particles are too small to interfere much with sound waves. Only obstacles of large size cast a sound shadow, the wave-length of ordinary sounds being considerable; a man's head, for instance, scarcely screens off sound at all. Were it otherwise, the ears would have to work independently. Similarly, to concentrate sound to a focus would need a very large lens, so that the ear has no focussing arrangement corresponding to the crystalline lens of the eye, and our perception of the direction of sound waves remains less perfect than of light waves.

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LINOLEUM.

By Dr. George McGowan.

Many a one has doubtless put to him- or herself the question—What is linoleum, and how is it made? As this material is now so widely and universally used for household purposes, a few notes from an exhaustive article upon its history and manufacture, contributed by Mr. Walter F. Reid to the February Number of the *Journal of the Society of Chemical Industry*, may not be without interest to many readers of Knowledge.

Although linoleum itself is quite a modern product (the first factory for it was started only thirty years ago), it has had numerous precursors, the earliest of which was waxed cloth or canvas. A varnish called "linoleon," containing linseed oil, was used in the eighth century; and in 1239—*i.e.*, during the reign of Henry III.—we find oil being employed for painting in this country. In 1636 a patent was granted for "painting with oyle cullors upon wollen cloath, kerseys, and stuffes, being pper [illegible] (?) " for hanging, and alsoe with the said cullors upon silk for windowes." Numerous mixtures of oils with resins were used until 1751, at which date mention is first made of india-rubber or gum lastic as an ingredient in the coating material. In 1811 Mr. E. Galloway proposed the addition of powdered cork to plastic india-rubber, in order to give a "certain elasticity" to the combination, and cloth coated upon one side with this mixture was brought into the market as a substitute for floorcloth, under the name of "kamptulicon." This latter was the immediate forerunner of our present linoleum, for which we are indebted to Mr. F. Walton. And now, at the present moment, there are twenty-five factories in operation, the greater number of them being in this country, at which 12,000,000 yards of linoleum are annually produced.

The two main ingredients in the manufacture of linoleum are cork and linseed oil, to which are added smaller quantities of kauri gum, resin, and pigments of various kinds. In the manufacture of bottle corks about one-half of the cork is wasted, and this waste is the chief source of the cork for linoleum. Mr. Reid, however, adds that in the cork forests of Algeria, etc., there is plenty of material available which, while not suitable for bottle corks, would answer admirably for linoleum. The cork waste, after being freed from dust and other admixed substances by means of a sieve with a rapid reciprocating motion, is crushed. This sounds very simple, but, as a matter of fact, the machinery required for the actual operation has to be of a very special character, both on account of the elasticity of cork and also because of the almost incredible rapidity with which it blunts the hardest steel knife-edge. The breaker reduces the cork to pieces of about the size of a pea, in which state it is passed on to the grinding mill, the latter being like an ordinary flour mill, but with stones of lava, sandstone, or some other rough material. Cork dust being excessively light, it quickly disseminates itself through the air of the mill; hence the utmost precautions have to be taken to ensure the protection of all artificial lights, and thus to prevent the explosive mixture of air and cork dust being set on fire. Even with every precaution, small explosions are sometimes caused by sparks from the machinery. The author says, in fact, that "speaking after considerable experience of both materials, I would rather handle dynamite in bulk than cork in a loose state." The dust has not yet been bleached successfully, *i.e.*, the colouring matter adheres to it with such tenacity that it can only be got rid of at the cost of lessening the strength and elasticity of the cork itself. Further, although many experiments have been made with the view of replacing cork by other substances—sawdust, spent tan, peat, etc.—the resulting product possesses less elasticity than when cork is used, and so wears out more rapidly.

The next stage in the manufacture is the preparation of what is technically known as "cement," the chief ingredient of which is oxidized linseed oil. As everyone knows, oils are divisible into two classes, drying and non-drying oils, the "drying" being brought about in the case of the first-named by the absorption of oxygen from the air, and the consequent transformation of the oil into a solid resinous mass. For linoleum manufacture the linseed oil used must be of good quality, and great care must be taken in its treatment. The oil is first boiled, much as in the manufacture of paints and varnishes. It has been found that the process of drying is much facilitated by the addition of a small quantity of the oxides of lead. The boiled oil, after being allowed to deposit any sediment in a settling tank, is pumped to the top of a high building, and from thence allowed to flow over a number of pieces of light cotton fabric known as "scrim," which hang vertically from iron bars. The air in the building being heated to a temperature of about 100° Fahrenheit, the layer of oil which adheres to the surface of the scrim becomes rapidly oxidized, or, in other words, it solidifies in the course of twenty-four hours. This operation is repeated daily for six to eight weeks, until a sufficient number of solidified layers of oil are deposited on the cloth, the mass of oxidized oil having now a thickness of half an inch, and being termed a "skin." The skins are then cut down and ground between rollers. This plan of drying the oil is a slow one, but more rapid methods have apparently not been found to answer very well as yet, because there is a danger of pushing the oxidation too far, in which case the dried oil again changes into a liquid.

To prepare the linoleum "cement" itself, the ground oil is mixed with resin and kauri gum in different proportions until the whole mass is homogeneous. And here again fire has to be guarded against, as the cement has a great tendency to heat and even to inflame if left in bulk exposed to the air. The cement and cork dust are now intimately mixed together by machinery in a series of operations, various colouring matters being added at the same time, according to the colour required for the finished linoleum. This linoleum mixture is then rolled on to jute canvas, to which it is made to adhere thoroughly. It should be added that, instead of jute, wire gauze imbedded in india-rubber is now being much used, especially for linoleum intended for staircases.

Linoleum, as prepared above, is of the same colour throughout, and when an ornamented surface is required the designs are printed upon it in oil paint. This, of course, merely gives a surface colouring, which is liable to wear out, and hence various plans have been and are being tried with more or less success, whose object is to produce a mosaic linoleum coloured throughout its entire thickness. But although such linoleums with inlaid colour patterns have some advantages over the older kind, they have also—up to the present time of writing—certain disadvantages.

Plain linoleum is usually made in two colours, brown and red, of which the brown is the more elastic. The fact that wet linoleum is stained when any article of iron is placed upon it must often have been noticed, this being due to the tannin contained in the cork. In course of time linoleum loses its elasticity and becomes brittle, this being caused in the first instance by a change in the cement induced by further oxidation, the cork remaining unaltered. With regard to this the author of the paper remarks that a more stable cement will probably be worked out in time—possibly one derived from mineral oils, which have little or no tendency to undergo oxidation in the air. The linoleum industry, already a large one, will doubtless continue to grow, and the manufactured product itself to improve. Space will not permit of our entering into further details regarding it here, and any reader who wishes to know more about the subject is therefore referred to Mr. Reid's able and interesting paper.

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THE SOOTY OR BROWN ALBATROSS.

THE accompanying reproduction is from a photograph very kindly supplied by the Hon. Walter Rothschild. It was taken, as was the photograph of the white-breasted albatrosses reproduced in Knowledge for April, 1895, by Mr. Rothschild's collector some years ago, in Laysan Island, on a sandbank in the Pacific off the Sandwich Islands.

The sooty or brown albatross, sometimes called the

PHOTOGRAPH OF THE COLONY OF SOOTY ALBATROSSES ON THE SOUTH SIDE OF LAYSAN ISLAND, A SANDBANK NEAR THE SANDWICH ISLANDS.

Kindly supplied by the Hon. WALTER ROTHSCHILD, and reproduced by his permission.

brown gooney, and scientifically known as *Diomedea chinensis*, is one of the commonest species of the genus. Gould says of the birds of this species, in his "Birds of Australia," that their actions and mode of flight differ considerably from those of all other species of albatrosses, their aërial evolutions being far more easy, their flight much higher, and their stoops more rapid. The cuneated form of the tail, which is peculiar to the species, together with the slight and small legs and more delicate structure, clearly indicate the most aërial species of its genus.

On French Frigate Island, Laysan, and all other islands visited by Palmer (Mr. Rothschild's collector), the dark albatross was fairly numerous. On Laysan Island the breeding-place was to the south side of the island, where the birds sat on the beach with their young, as is shown in the photograph.

The young feed by putting their beaks crosswise into the old bird's mouth, and thus they catch the cast-up fish.

Herr von Kittlitz, who visited these islands in 1828, remarks that the sooty albatrosses are extremely foolish and fearless. They can be caught with the hands, as they must run a good distance before being able to get up on the wing. If two birds meet, they bow to each other, uttering a low cackling. When Herr Izenbeck, a friend of Herr von Kittlitz, met one he used to bow to it, and the albatross was polite enough to answer, bowing and cackling. This could easily be regarded as a fairy tale; but considering that these birds, which did not even fly away when approached, had no reason to change their customs, it seems quite natural.

The brown gooney in colouring is sooty brown above, with the forehead a dirty white; underneath the colours are much paler and more grey. The quills and tail-feathers are blackish brown, and the bill dark brown with a blackish tip. The total length of the bird is thirty-three inches, the wing being nineteen inches in length.

The French Frigate Islands, Laysan, and other islands in this group, are simply low sandbanks with little or no vegetation on them, but they are covered with birds. One would expect that these immense colonies would not be altogether peaceable, and that such is the case may be gathered from the following anecdote told by Palmer of the frigate-bird, found there in large numbers. He says: "Scarcely had I pushed one off, when another frigate-bird would rush up, seize the young one, fly off, and eat it. Sometimes the parent bird would give chase, but it always ended in one or the other eating the young bird. I could scarcely believe my own eyes, so I tried several; but they would even take young birds out of the nest which were almost fully feathered."

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THE CAUSES OF COLOUR.

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

The beauty of the objects of nature around us depends so much on the varieties of colour which they exhibit that it becomes an interesting question, what is the cause of these differences? We have only to think of the blue sky, the green foliage, and the various splendours of flowers and fruits to realize to how great a degree the pleasure we experience in viewing a country scene is due to the many-hued surfaces of natural objects. The pleasurable feelings aroused by the sight of the deep blue of the sea contrasting with the bright red colour of the sandstone cliffs, or the effect of the sunshine when it lights up the splendid purple of the heather on the slopes of the hills, can be forgotten by none who have experienced them; and the striking effect of Eastern scenes is owing largely to the brilliance of the tints which meet the eye. It is needless to enlarge on the part played by colour in this world of ours; the difference between a world of colour and one in which surrounding objects were only distinguished by different shades of grey can be realized by all.

When we come to enquire how the red colour of a rose is produced, and why it differs in appearance from a blue flower, we must consider what happens to the light which falls upon the petals of the rose. We see the flower because the light from the sun is reflected from it, but something has happened to the light before it reaches our eyes; the light we receive differs from that which fell upon the flower. The rays from the sun penetrate to a certain extent into the substance of the flower, and most of them are reflected from particles beneath the surface. Now the cells making up the petals of a rose contain a fluid which has the power of absorbing certain of the rays of light, and the light entering the eye after penetrating a short distance below the surface of the petals and coming back has passed through this fluid, and in its course some of the rays of the sunlight have been abstracted from it. Thus the light reaching us is lacking in certain of the constituents of white light—that is, it is coloured. White light may be considered as made up of the three fundamental colours, red, green, and violet, blended together. The light which has passed through a certain extent of the substance of the rose petals has been deprived of its green and violet portions, and thus the red rays alone reach our eyes. All substances which possess colour exercise this power of sifting the rays of light. Light falling on the leaves of the rose-bush passes through their superficial layers and is reflected from below the surface; thus it has to traverse certain particles which take from it the red and violet rays and allow the green to pass. The green rays which escape absorption are the only ones which reach our eyes, and we therefore call the leaves green.

When white light passes through a prism it is found that in the band of colour or spectrum produced, the blue and violet rays are the most bent out of their original course: they are the most refrangible. The red rays are the least bent. It is found also that the vibrations of the ether filling space which produce waves of light are quickest in violet light and slowest in red light. Some substances absorb the quick vibrations more readily and thus appear reddish in colour. Others absorb the slower vibrations, allowing the others to pass through, and therefore have a green or blue colour.

When a substance is heated its particles are thrown into a state of rapid motion, and soon set up a motion in the ether which, when the vibrations are of a certain rapidity, produces light. If a ball of iron is heated it first of all gives out radiation consisting of dark rays which have the effect of producing heat. As its particles become hotter and hotter, and thus vibrate more rapidly, the radiation begins to affect our eyes and the ball glows with a dull red heat. As vibrations of greater and greater rapidity take place owing to the further heating, the ball appears bright yellow, and finally white, when vibrations of all the different rapidities which affect our eyes are given out. In this case it is the motion of the particles or molecules of the heated body which is imparted to the ether, and so produces the effect we call light. Now those molecules which are able to execute certain vibrations and give them to the ether, absorb these same vibrations from the ether—that is, absorb certain rays of light. This effect is best seen in the case of gases, and the phenomenon is analogous to that which occurs with sound. A tuning-fork or stretched wire which can give a certain note when it is struck, is able to take up and absorb the note from the vibrating air around it when that note is sounded in its neighbourhood.

It may be noticed that the light from the electric arc when seen near at hand has a distinctly bluish colour; but this same light when viewed from a distance appears yellowish, as certain of its rays have been absorbed by the water vapour in the air on its passage to the eye. For a similar reason the sun is now considered to be a blue star; his light, which would appear intensely white, and rich in blue rays especially, if it could be seen from beyond our atmosphere, appears yellowish after it has passed through that atmosphere and has lost some of its most refrangible constituent rays.

The effect of absorption in producing colour is seen from the fact that powdered bodies generally appear white. This is accounted for when we consider that a powder consists of particles arranged at all angles, so that the light falling upon it meets various surfaces and is mostly reflected before it has passed below the surface. Thus the white light reaching it, is not deprived of some of its constituents by selective absorption, as it would be if it penetrated the substance and was then reflected. In this way powdered red glass appears white. For a similar reason the froth of coloured liquids, such as brown ale, appears pure white. The light is reflected from the surface of numerous small bubbles, and does not pass much through the liquid itself. Thus also a cloud is very opaque to light, the light falling on it being reflected at the surface of the numerous globules of water. To this is due the brilliantly white appearance of large fleecy clouds in bright sunshine.

Some substances absorb equally all the rays of light. Such substances, of which soot is an example, appear black. The reason why a flower like a white lily appears white is that the fluid contained in its cells does not absorb one sort of rays more than another, but allows all to pass with comparative freedom. White light then reflected from its surface, or from a little below, is not deprived of any of its constituents, but remains white.

The effect of reflection from internal surfaces accompanied by absorption in producing colour, can be seen by pouring a coloured liquid, carefully freed from floating particles, into a white porcelain basin. Light is reflected from the sides of the basin, passes through the liquid, and its colour is seen. If now the sides of the basin be covered with some black substance, no light will be reflected from them and the liquid will appear black; no light comes to the eye from the interior, and the surface of the liquid reflects all the rays equally. If next we place in the black-looking liquid a white powder like chalk, its colour is at once restored, light being now reflected from the interior at the surfaces of the chalk particles.

From the above considerations we can understand to what causes the colour produced on mixing pigments is due. A mixture of blue and yellow paints has a green colour because that is the only colour transmitted by both pigments. The blue paint absorbs the red, orange, and yellow rays, allowing the others to pass through it; the yellow paint absorbs the blue, indigo, and violet. Thus green rays alone are permitted to pass through both, and the result is that the mixture appears of that colour.

Some substances appear of one colour when viewed by reflected light, and another when seen by transmitted light. Thus the light reflected by gold is yellow; but a leaf of gold made so thin that light can pass through it appears of a green colour. This appearance of different colours on reflection and transmission is also seen with many of the aniline dyes. The colour of the light due to reflection is then made up of those rays which are not admitted at all, but sent back at the surface, together with that light which has been reflected from a certain depth below the surface, and has thus lost some of its constituent rays by internal absorption. The light to which the colour is due when the substance is viewed by light which has passed through it, is that which has been deprived of some rays by reflection at the first surface, and again of others by absorption in passing through. Hence the difference of colour when viewed in the two different ways.

Variations in colour perception no doubt depend on varying sensations in our own eyes as well as on changes in the light itself. Some curious experiments have been made with a view to testing our different sensations as to colour. It has often been noticed that a bright scarlet uniform will appear perfectly white in a good photographic dark room with ruby glass windows. With regard to such effects, Herr H. W. Vogel described recently in Berlin some experiments he had made. He used oil lamps and fitted on to them pure red, green, and blue colour screens. It was found that when the white light was entirely shut out, no sense of colour was perceptible to the observers, and objects in the room appeared of various shades of black and white. He found that when a set of colours was lit up by red light, the red pigments appeared white or grey, and this changed at once into yellow, not into red, when blue was added to the light under which they were viewed. Thus a colour was perceived which did not exist in either of the sources of light used. The colour sensation produced by a source of light also depends partly on the intensity of the illumination. From these and similar experiments, Herr Vogel comes to the conclusion that our opinion as to the colour of a pigment depends upon our perception of the absence of certain constituents from the light reflected from it. Thus a surface which has a red colour is only perceived as red by us when light of other colours shines upon it, and we observe its incapacity for reflecting these colours.

When a solution of quinine is viewed in sunlight, a remarkable blue shimmer is noticed extending for a short distance beyond the surface at which the light enters. A similar effect is noticed with many other substances, the colour being different in different cases. The phenomenon is known as fluorescence, as it is well observed in the mineral fluor-spar, and is due to the fact that light is absorbed by the substance and is again given out as light of a different colour. For instance, rays of high refrangibility towards the blue end of the spectrum may be taken in and given out as yellow rays of lower refrangibility. In the case of quinine, invisible rays beyond the violet are absorbed and blue or violet rays are emitted by the solution. In all cases of fluorescence a degradation of the rays takes place; those given out are of lower refrangibility than those which disappear on absorption. By painting a screen with a solution of sulphate of quinine, the spectrum beyond the violet can be made visible, as those vibrations which are too rapid to affect our eyes are changed into others of lower refrangibility, which can be perceived when they fall on the retina. The curious blue colour of the solution of quinine extends only a short distance into the liquid, because those rays which are capable of producing it are soon absorbed, and the light which passes onward through the fluid is destitute of such rays. The colour produced in cases of fluorescence has a different origin from that of the ordinary surface colour of substances, for the rays absorbed do not disappear as light, but their place is taken by other rays of a different sort.

The nature of the vibrations which constitute light still remains mysterious, but great advances have been made in recent years in our acquaintance with these and allied phenomena, and we may hope for still greater accessions to our knowledge in the not distant future.

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MICROSCOPY.

By A. B. Steele.

It is stated on some authority that magnifying lenses were not in use till about the end of the sixteenth century. It was known long before then, however, that letters were enlarged when seen through a globe filled with water, but it was thought that magnification depended upon the nature of the water or of transparent bodies, and not upon the lenticular form of the glass. From the gradual deepening of curves, no doubt, the idea originated of producing lenses of shorter and shorter focus, until the combination of a convex lens as an objective with a concave lens as an eyepiece, distanced apart by the hands, led to the discovery of the telescope. Its conversion into a microscope would immediately follow, for, as Herschel says, a telescope used for viewing very near objects becomes a microscope.

The first microscope would most likely be in the shape of a hand lens, and this would soon be improved upon by mounting the lens at one end of a tube with the object held at the focus or attached to a piece of glass. For higher powers some system of focussing would be applied, either by sliding the object cover or the lens, and for still higher powers globules of blown glass would be used. It is said that Huyghens brought microscopes from Holland of minute spheres of glass about the size of a grain of sand, and one of the earliest experts in microscopical observations is said to have constructed an instrument of blown glass and used it in the discovery of minute forms of life. The honour of having produced the first microscope consisting of a combination of lenses is generally ascribed to a spectacle maker named Jansen, in the small town of Middelburg, in Holland. The date can only be approximately given as shortly before or after the beginning of the seventeenth century. One of Jansen's microscopes was found at Middelburg in 1850, and was exhibited at the Loan Collection in London in 1876. It resembles one of the present-day compound microscopes without the field lens. At the time of its manufacture clear glass was scarcely to be had in Holland, and microscopes were constructed with lenses of rock crystal and designed to view opaque objects by reflected light.

In 1637 Descartes published a description of a simple microscope which was a decided improvement upon the form commonly used before his time. It consisted of a simple lens mounted in a central aperture in a polished concave metal reflector, and was practically the same as the lens constructed a century later. He also designed a machine for grinding and polishing lenses, nearly a quarter of a century before practical men had their attention drawn to this important subject. But about this time the man whose fame as a microscopist is best known, and who gave the first real impetus to microscopy, was Hooke. He was the first to employ diffused light instead of direct sunlight. He introduced the field lens, and invented the ball and socket movement in the construction of the microscope. He was also the first to discover that a drop of water placed on the front lens of the objective would allow more light to pass than a dry lens could in the proportion of unity to the refractive index of water. Such lenses were subsequently known as immersion lenses. So distinguished a person was Hooke that Herschel speaks of him "as the great contemporary and almost the rival of Newton." It was not till nearly fifty years after his time that microscopes were provided with mirrors. The early system of focussing seems to have been effected by a "screw-barrel" arrangement acting on the object, which was clipped between two plates and depressed from the objective by a spiral spring; and "screw-barrel microscopes"—so named from the objective being mounted in a little barrel—became common in the eighteenth century. Many improvements in the screw-barrel system of focussing were introduced, but all were more or less defective, until a plan was discovered by which the image would remain steadily in the field, and allow the object to be viewed during the actual process of focussing.

The invention of means to determine the exact magnifying power of any objective is due to Benjamin Martin, who applied a screw micrometer to the eyepiece with fifty threads to the inch, so that the precise number of diameters could be stated. A ruler, divided into tenths of an inch, was placed under the microscope so as to have a tenth in full view on the image; then by measuring it with the microscope, and counting how many turns were made in so doing, the number of turns divided by five showed how much larger the image was than the object. Martin made a large compound microscope for His Majesty George III., which is now in the possession of the Royal Microscopical Society. The instrument stood on the floor, and was so large that the King could conveniently use the eyepiece while sitting in his arm-chair. The compound microscope of to-day, known as the "Continental model," by which most of the scientific work of our time has been performed, was evolved out of Martin's reflecting microscope. In designing and executing microscopes Martin excelled all others of his day. But his fame rests chiefly on his being the first to construct an achromatic objective.

The possibility of applying achromatism to the microscope attracted the attention of men like Wollaston, Herschel, and Brewster, but, notwithstanding the researches of these, its adoption made slow progress. In fact, there is very little difference in the definition of the image between a microscope made last century and one made during the first quarter of this. It was achromatism that gave the stimulus to the discovery of a more precise means of focussing, and since its application in 1824 by the French optician, Chevalier, the development of the microscope has made greater progress than during the whole former period of its existence. The neglect given to fine adjustment can only be accounted for by there being little or no original investigation done with the microscope, and consequently there was no impetus given to its development. The best designs of fine adjustment were first devised by Englishmen. To Powell we are indebted for a system of focussing applied to the nosepiece. In Andrew Ross' instruments the fine adjustment tube was raised and depressed by means of a screw acting upon the end of a lever of the second order, while in those of Powell and Lealand the screw acted upon a lever of the first order. The rival to these was the "Jackson system," the fine adjustment of which was deficient in delicacy and precision, chiefly owing to the extreme shortness of the acting lever. Lister's discovery of aplanatic foci led to still greater improvements in objectives, for his investigations were taken advantage of by three of the then leading firms of opticians in London, and very fine objectives were produced after long and persistent experiment.

The first really practical immersion lenses were made by Prof. Amici, of Modena, and were improved upon by Hartnack and others, who succeeded in producing such excellent objectives as to make it possible to resolve the most difficult tests known to microscopists. Water immersion lenses were constructed by Englishmen about 1860, who made both new lenses and also new front combinations to screw on to old glasses. About twenty years ago a farther great advance was made by Mr. J. W. Stephenson, of the Bank of England, who induced the firm of Zeiss, of Jena, to construct lenses in which a drop of cedarwood oil was substituted for water. These were termed homogeneous immersion lenses, because the oil being of the same refractive index as the glass of which the objective was made, the light from the object passes into the optical system without refraction. But for greater improvements still we are indebted to the optical knowledge of Prof. Abbé, of Jena University, in combination with the mechanical skill of the late Carl Zeiss. In every achromatic object-glass it is impossible to unite more than two rays of the dispersed light in the spectrum, viz., red and green, the others being left out and forming what is called the secondary spectrum. It occurred to the Professor to construct an objective with the mineral fluorite —which has a very low refractive index—as a component, and so to obtain a greater command over the removal of the chromatic dispersion. He thus devised what are now known as apochromatic objectives, which are slightly over-corrected for colour, while the eyepieces used with them are under-corrected, the result being that three rays of the spectrum are united and an almost colourless image is produced. The magnification by means of these eyepieces may be carried to a large extent, eyepieces having a magnification of twenty-five times being used with these objectives without any apparent degradation as regards colour, especially with the lower powers. This discovery has been followed by every optician of note, both here and on the Continent, and it may be truly said that no scientific work of any importance with the microscope can be done without an apochromatic objective. The microscope has by this means been firmly established on a footing which the telescope can never, we fear, hope to possess. It "holds the head" in optics, as our French neighbours say. It is much to be regretted, however, that we are so very dependent upon foreign workmanship for the optical tools with which important scientific work is done. Our British manufacturers are no longer leading but following, for most of the firms are making microscopes upon what is called the "Continental model," the instruments with which nearly all real scientific work is done at the present day.

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A QUARTER OF A CENTURY'S WORK ON RESPIRATION.

By C. F. Townsend, F.C.S.

Among the achievements of this century, the advance that has been made in our knowledge of physiology will not be the least. The brain and the various glands, however, have absorbed the lion's share of attention, and, until the work of Drs. Haldane and Lorraine Smith awoke renewed interest in the subject, the study of the lungs had been largely neglected. Of the few who have devoted themselves to this branch of research, Dr. W. Marcet, F.R.S., has been the most constant, and has given a large part of his life to the solution of the problems connected with respiration. His investigations have not been confined to the laboratory, but have been conducted frequently in the open air at varying elevations, extending from sea-level to the summit of the Breithorn. Most of the results are scattered through the *Transactions and Proceedings of the Royal Society*: but recently Dr. Marcet, as Croonian Lecturer to the Royal College of Physicians, had an opportunity of summing up the whole of his work.

The early experiments during three summers in Switzerland gave decidedly interesting results. The following stations were chosen :—

1.	Yvoire on the Lake of Geneva	1,230 feet.
2.	The Hospice of the Great St. Bernard	8,115 ,,
3.	The Riffel Hotel, Zermatt	8,428 ,,
4.	The Hut in the St. Theodule Pass ...	10,899 ,,
5.	The Summit of the Breithorn ...	13,685 ,,

The person under experiment breathed through a face-piece made to cover both mouth and nose, and fitted with ebonite valves, so that the air coming from the lungs (expired air) should pass without loss to the receiver—a large india-rubber bag, communicating with the face-piece by a flexible tube. Breathing was commenced at a given signal and continued until a definite volume of expired air had entered the bag. The time required for the lungs to expire this volume of air was determined accurately by means of a stop-watch. The results showed an increase of carbonic acid given off, equivalent to increased combustion at high altitudes in the Alps. The actual weight of air breathed in a given time was less, however, at high altitudes than at the seaside. It follows that breathing is easier in the Alps than in the plains.

In order to ascertain whether the increase in the carbonic acid given off from the lungs, and consequent greater chemical action, was due to cold or to altitude, Dr. Marcet, in 1878, determined to proceed to Teneriffe, with the necessary apparatus for continuing the research. The baggage included a shed of wood and canvas made to take to pieces, a chemical balance, a number of sealed bottles full of standard baryta solution for the determination of carbonic acid, tubes filled with calcium chloride for the determination of the moisture in the air exhaled from the lungs, provisions, and everything necessary for camping out on the Peak for three weeks. An Alpine guide from Chamounix, who had assisted the investigator in his previous expeditions, again accompanied Dr. Marcet. The great advantages of Teneriffe for this work were, first, its accessibility; secondly, its dry climate and its Peak, which rises sheer out of the sea to a height of over twelve thousand feet; but mainly the fact that stations could be selected at various heights on the Peak, varying but little in their respective temperatures.

In his book on "Southern and Swiss Health Resorts" Dr. Marcet gives a very interesting account of his expedition up the Peak. The first station was at the foot of Mount Guajara (seven thousand and ninety feet), and the camp was made on a patch of white baked clay in the old crater, which is now mostly a chaotic field of lava. The landscape is the most desolate and dreary that could be imagined, nothing but lava and volcanic rocks with an occasional patch of sand or clay baked by the sun, and a few straggling bushes of *Rhetama*—a kind of broom. The heat everywhere on the Peak seems to be very great whilst the sun is shining. Mr. Piazzi Smith, who was engaged in astronomical work on the Peak, found the temperature in the sun on the summit of Mount Guajara to be 212·4° Fah. It must have been but slightly less than this at Dr. Marcet's camp in July and August, although the cold was great at night. The radiation was intense, water left out in the open all night becoming a solid block of ice by the morning. The dryness of the atmosphere on the Peak was quite as remarkable as the heat. The skin became dry and scaly, so that it was almost painful to touch anything. Fresh meat brought up from Puerto Orotava kept good for any length of time. Deal boxes split with the heat and dryness, as did the boots of the two members of the expedition, the soles coming away from the uppers, so that the party returned to the seaside in a somewhat dilapidated condition. From the highest station at Alta Vista (ten thousand seven hundred feet) two expeditions were made to the cone and summit itself, but the sulphurous vapours given off prevented any determination of carbonic acid being made on the summit.

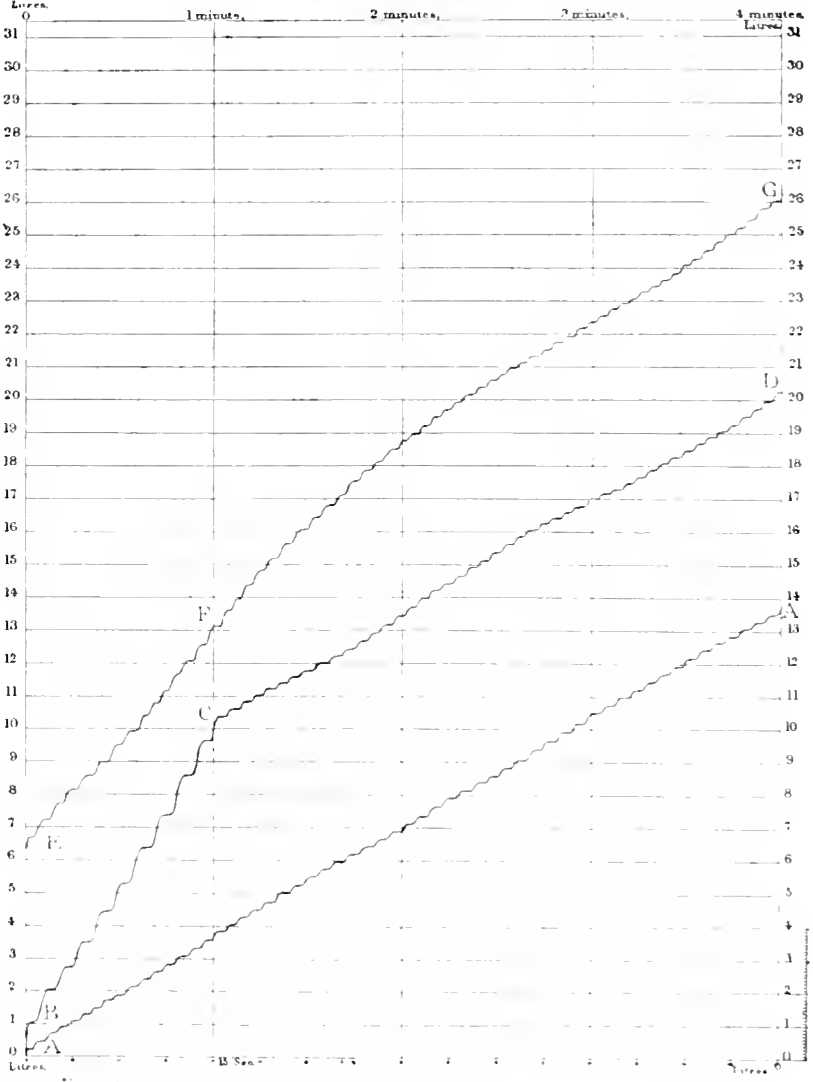
The results of the experiments at Teneriffe showed, as had been anticipated, that there was no increase in the carbonic acid given off from the lungs between the seaside and the summit of the Peak; so that the increase found in Switzerland on the Col St. Theodule, the Breithorn, etc., must have been due to cold and not to altitude. In addition it was noticed, as had been the case in the Alps, that the actual volume of air breathed, reduced to normal temperature and pressure, was less than at the seaside.

Experiments were made on the amount of water exhaled from the lungs at the seaside and at the three stations on the Peak. The results showed most distinctly that the less the atmospheric pressure the greater the amount of water given off. This might have been expected, as a decrease in pressure is known to facilitate evaporation. In the winter of 1888-9, Dr. Marcet continued his inquiry into the subject of respiration. Instead of collecting the air expired from the lungs in bags, as had been done in the mountains, bell-jars were used in this latter work, which was carried out in the Physiological Laboratory at University College, London. These bell-jars held forty litres, and were so beautifully balanced that it was impossible for the person under experiment to tell whether he was breathing into them or into the open air. With the use of these bell-jars Dr. Marcet undertook an inquiry into the subject of re-breathed air. One of the bell-jars was filled with thirty-five litres of air, and the person under experiment breathed both into and out of this vessel for five minutes. At the end of this period, by merely altering the connections he was enabled to breathe with fresh air. The air coming from his lungs was conveyed to a second bell-jar, previously emptied. The conclusions derived from this work are interesting. A large proportion of the carbonic acid produced remains stored up in the blood, so that when fresh air is taken into the lungs large volumes of air are breathed, because of the desire to get rid of the excess of carbonic acid. All effects of re-breathing pass away in about six minutes when fresh air is turned on.

Regnault and Reiset were the first to observe that all the oxygen absorbed in the lungs was not returned as carbonic acid, a fact that has been confirmed by all later observers. Dr. Marcet found that this "occluded oxygen" was greatest in the hour that follows a meal, falling off, apparently, after that period; but the changes in this absorption of oxygen are so great that it is difficult to follow them at all closely. This oxygen is used obviously in tissue changes apart from mere combustion. We do not know by what process carbonic acid is generated in the body, but, according to Hermann, there is no single instance of direct oxidation in the chemical phenomena of life.

After completing this chemical work by the aid of an ingenious burette he had constructed for the purpose, Dr. Marcet undertook an investigation into the different forms of human respiration. Beginning with normal breathing in a state of repose, experiments were made on forced or laboured breathing, respiration under exercise, and respiration as controlled by the mental exercise of the will. In order to obtain records of these different conditions of breathing, an apparatus was employed to trace the actual movements of the lungs. For this purpose a glass pen, charged with ink, was fixed to the end of a rod attached to the bell-jar. The point of the pen pressed against a ruled chart stretched on a drum, made to revolve horizontally at a given rate by clockwork. The horizontal lines on the charts showed the number of litres of air expired, and the vertical lines the time in minutes. When breathing commenced the

BREATHING CHART.



A Normal
[illegible] After stop
E [illegible] stepping [illegible] times per minute. FG After stage

clockwork was started; the combined movements of the drum and the rising bell-jar giving a diagonal tracing or curve on the paper, showing exactly the rate at which the air was expelled from the lungs. The kindness of Dr. Marcet enables us to reproduce one of the charts, and a reference to it will enable the reader to understand the nature of the experiment better than any amount of explanation. The bottom curve A A shows normal breathing with the body in repose; the next curve shows the working of the lungs under forced breathing—*i.e.*, when taking series of deep breaths intentionally—and the after-effect when the person returns to natural breathing; the top curve shows the effect of exercise on the breathing. In the bottom tracing it will be noticed that the curve is practically a straight line, showing that about three and a half litres per minute were taken into the lungs regularly. In the middle curve two and a half times as much air was taken into the lungs as in natural breathing; after this follows a short "pause," which is more marked in some of the other charts, then an increase above the normal, followed by a return to natural breathing. Sneezing, sighing, and yawning may all be considered as different forms of forced breathing.

The experiments on breathing whilst under exercise were carried out by "marking time" in military fashion—raising the feet a given distance off the ground, keeping time to a metronome, so that the work done could be measured approximately. The tracings obtained whilst breathing under exercise differ considerably from those illustrating forced respiration, especially on the return to natural breathing. During exercise the respirations, though deeper than the normal, are less deep than in forced breathing, and immediately on sitting down the line continues its upward tendency, showing no pause as in forced breathing; then returning parallel to the normal. In talking, singing, reading, and coughing, the respiration assumes the form of breathing under exercise; but in talking and reading, where the strain on the lungs is very feeble, the tracing returns parallel to the normal almost immediately after the exercise has come to an end. A similar remark applies to singing: a practised singer will never become breathless after singing, hence the curve in such cases will return immediately parallel with the normal. In singing, however, a marked difference was observed in the breathing when standing and when sitting. The tracing obtained in the latter position resembles the "forced breathing" curve almost exactly, which is not the case when standing, so that the erect position is the correct one for singing.

Another fact of interest to athletes and people who run for their trains was demonstrated. It was found that if on sitting down after "stepping exercise" one or two deep breaths were taken immediately, the breathlessness passed away at once, because the carbonic acid accumulated in the blood was thus got rid of. It follows from this observation that in case of extreme breathlessness, as would occur after running for a train, great relief would be experienced from taking a few deep breaths.

Some novel experiments were made by Dr. Marcet on the effect of the exercise of the will on respiration. The person under experiment sat down in a chair, and imagined himself to be engaged in some form of physical exercise, such as running after somebody up a hill or rowing against the tide. Whilst his imagination was at work the air from his lungs was collected and the recording instrument set going. The tracing obtained was not that of natural breathing, but resembled the "forced breathing" curve, followed by the same pause that is always observed after forced breathing. It must be remembered that the breathing was not forced intentionally, and after a long series of experiments Dr. Marcet has come to the conclusion that an increased supply of oxygen is actually needed by the brain centres that are at work. This would take too long and is too technical a matter for us to go into here, but full particulars will be found in the third of the Croonian lectures, published in the *Lancet* and *British Medical Journal* for 1895. The question will be considered also *in extenso* in a book by Dr. Marcet now in the press.

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THE REV. FRANCIS WOLLASTON, AMATEUR ASTRONOMER.

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

The Rev. Francis Wollaston was for nearly half a century rector of Chislehurst, in Kent, where he made a considerable number of useful astronomical observations. It is an interesting circumstance that the list of Fellows of the Royal Society in 1815 and a few previous years includes the names of this astronomical amateur and of three of his sons; one of the latter the celebrated chemist, and another the Rev. F. J. H. Wollaston, for some years Professor of Natural Philosophy at Cambridge, and afterwards Archdeacon of Essex, and vicar of South Weald, in that county. Francis Wollaston was born on the 23rd of November, 1731. He was the eldest son of Francis Wollaston, of Charterhouse Square, and grandson of William Wollaston, the author of that well-known work, "The Religion of Nature Delineated." Young Francis was sent to Sidney Sussex College, Cambridge, in the month of June, 1748, and two years afterwards was admitted to Lincoln's Inn with a view to entering on a legal career; but conceiving a distaste for it, because he saw that barristers took any side for their clients, whether right or wrong, he returned to Cambridge, graduated LL.B. (since it was too late to take a degree in arts in the regular course), and entered into orders, being ordained deacon in 1755 and priest in 1756. In the latter year he returned to his father's house, and undertook the Sunday morning preaching at St. Ann's, Soho, for Dr. Squire, afterwards Bishop of St. David's. In the summer he married Miss Althea Hyde, fifth daughter of Mr. John Hyde, of Charterhouse Square, soon after which he was instituted to the rectory of Dengey, in Essex. In 1763 he obtained the living of East Dereham, in Norfolk (where William Hyde, his second son, was born in 1766), which he held until 1769, when he was collated to the rectory of Chislehurst, in Kent, where he remained until his death forty-six years afterwards, zealously discharging all the duties of a parish clergyman amongst a small country population. The liberality of his mind towards those who differed in doctrinal views led him to take rather a prominent part in an agitation respecting relief in the matter of subscription to the Articles, which caused him to be unjustly suspected of a tendency to Socinianism. In consequence of this, and the abortiveness of the attempt about subscription, he determined to enter no more into controversial matters, but devote his leisure to the study of astronomy. His earliest recorded astronomical observations were, I believe, those of occultations and other phenomena made in 1775, and published with later ones in the *Philosophical Transactions for 1784*. In the following year he contributed a paper (read April 7th, 1785) to the Royal Society on "A

Description of a New System of Wires in the Focus of a Telescope for observing the comparative Right Ascensions and Declinations of Celestial Objects." Next year (1786) he was elected a Fellow of the Society, and communicated a paper containing observations of a comet which had been discovered by Miss Herschel on the 1st of August in that year, and which he observed during August and September. We do not meet with any other papers of his until 1793, when he communicated on May 9th a "Description of a Transit Circle for determining the Places of Celestial Objects as they Pass the Meridian;" and after this the results of his astronomical observations appear in separate works. The *Fasciculus Astronomicus* was published in 1800, and contains an extensive catalogue of northern circumpolar stars, with some account of the transit circle (described in the paper just mentioned) with which the observations were made; also of a portable altitude and azimuth instrument made for the author by Templeton, and various tables used in astronomical calculations. The observations were made in the years 1794–7, and reduced to the beginning of 1800. The author also took the trouble of comparing them with places deduced from observations made by Flamsteed, Hevelius, and earlier astronomers, and points out a mistake fallen into by Flamsteed in giving the date 1463 to the catalogue of Ulugh Beigh. The date assigned is 841 of the Hegira, which took place in A.D. 622; but as the mean Mohammedan year (allowing for the intercalary years) consists of 354·366 days only, eight hundred and forty-one of their years amounts to only about eight hundred and sixteen of our calendar years, so that 841 of the Hegira corresponds most nearly to A.D. 1438. Wollaston had published some years before a "Specimen of a General Catalogue of Stars, arranged in Zones of North Polar Distance." In that he had inserted some notes on double stars by Herschel, who, it appears, objected to the abbreviation (from want of space) of these; therefore, in the *Fasciculus* all such particulars are omitted, references only being given, as before, to Herschel. In closing this account of Wollaston's astronomical work, we need only further mention his star-maps, published in 1811 (when the author was eighty years of age), from observations extending over several years, under the title, "A Portraiture of the Heavens." It is remarked that some of them were found useful in observing the comet of 1807. Wollaston died at Chislehurst on the 31st of October, 1815, in the eighty-fourth year of his age. The *Gentleman's Magazine* for February, 1816, contains a short appreciative obituary notice of him.

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THE TOTAL ECLIPSE OF AUGUST 9, 1896.

By E. Walter Maunder, F.R.A.S.

It is difficult to write a satisfactory account of an eclipse expedition to which a sight of the eclipse has not been vouchsafed, and, as all the world now knows, that has been our fate at Vadsö.

Nevertheless, there is a story to tell, though but a meagre one compared with that for which we had hoped. The various preparations for drawing and photographing the corona and for photographing the spectrum were necessarily of no avail, and it would appear useless to recount again the details of programmes which the weather defeated. Something, however, was done. The general spectacle of the eclipse was watched with sedulous care by scores of observers, most of whom, under more fortunate circumstances, would have had their whole attention fixed upon their instruments; so, though thick clouds concealed the sun almost without a break for the whole period of the eclipse, yet the weird effects of the gradual darkening were watched with great minuteness. The edge of the shadow was distinctly seen by several observers as it swept upwards from the south, some observing it on the clouds, others on the hills and fjord. The shadow appeared to travel from the south, not from the west—the direction in which the track of totality really lay—this effect being due to the oval shape of the shadow itself, and the fact that the central line was south of Vadsö, where the observers were stationed. With the sweep of the shadow across the country there came a distinct increase in the darkness, an increase so distinct that it was possible to assert with great confidence that the predicted time of the commencement of totality, as given by the *Nautical Almanack*, is quite four seconds too late; the duration would appear to be practically correct, as the return of light—more sudden and more easily marked, in the opinion of nearly every observer, than the accession of darkness—took place about three seconds before the tabular time.

Regarded from the point of view of actual amount of illumination the darkness was not excessive: it was probably less than in any recent eclipse—less even than it would have been had the sky been clear. It was perfectly easy to read the seconds hand of a watch even at mid-eclipse, distant objects were still retained in sight, and the surrounding features of the country did not entirely lose their colour. The total light did not probably differ very much from that of a bright night at the full of the moon, but the impression produced was of a totally different character. Instead of the cold but cheerful light of the moon—a light felt to be beautiful and helpful—the light of the eclipse could only be regarded as darkness, a terrible darkness, darkness made visible, darkness that might be felt.

It is not possible to explain exactly the cause of this feeling, one which the most stolid and the most cynical were alike obliged to confess to. Possibly the speed with which it came on, continually and inexorably increasing without any obvious cause, had something to do with it. Possibly it may have been rather due to the strange colouring of earth and sky, for, above, the heavy clouds which almost entirely covered the heavens were dyed a deep purplish black: below, the dark rocks took a hue as sombre and deep, though perhaps of a more bluish tone: whilst in the few narrow rifts, especially immediately below the sun, in the east and away between dips in the hills to the north-west and south a bright amber light appeared. It was as if a funeral pall with a golden fringe had been laid upon the face of nature.

The effect of the darkness upon men and animals was the same, as has been so frequently noticed in other eclipses wherein the sky has actually been clear. The birds flew home straight and low and with shrill cries of terror as the gloom deepened. The goats on the island of Vadsö, where the British Astronomical Association were encamped, whose restless curiosity had made them a sad plague to the party during the previous week, hid themselves in the hollows of the rocks and lay down to rest, and all conversation amongst the large crowd of onlookers entirely ceased. Even a little band of obstreperous Germans from the *Erling Jarl*, who had made themselves offensive by their disorderly conduct before the eclipse began, were awed into silence, and the most profound stillness prevailed until the return of light.

No stars were seen in any of the small breaks which the clouds afforded. Indeed, these looked far too bright for any such to have been seen.

Nothing is more difficult than to give such a description of the appearance of the light during totality as to enable those who have not seen an eclipse to realize it. One observer speaks of "sea, sky, and hills all becoming an intense livid blue"; others preferred to call it the "deepest indigo purple" they had ever witnessed; others again differentiated between the tone of cloud and land, and spoke of the former as being of a "cold dark-grey black," whilst the hills retained in their blackness some tinge of blue or purple. But there was a general opinion that the colour of the amber and ruddy rifts were not only like "sunset colours," but had identically the same origin. Mr. Green urges that the golden light so conspicuous at sunset is always present at its proper low altitude in the sky; it is only that it becomes more conspicuous when the daylight fades as the sun sinks below the horizon. On this hypothesis there is no need for wonder that the amber and ruddy tints seen in the low-lying rifts appeared so vivid. This would naturally follow as an effect of contrast with the dark masses of cloud and rock above and below them.

And now for the lessons of the eclipse, for though we were not fortunate enough to see it, our experiences have their lessons.

First of all, the fact that a magnificent view was afforded at Bodo, where the small altitude of the sun rendered success so unlikely, whilst at Vadsö, and at Bugonæs, where the chances seemed reasonably good, the eclipse was hidden by clouds, reinforces and drives home the lesson taught by a dozen previous eclipses, that no accessible station whatsoever must be left unoccupied; and that those who are sufficiently self-denying as to adopt a location apparently hopeless, may, in spite of meteorological reports, carry off the prize even before those who have stationed themselves where all seemed promising.

Another lesson, not less important, is that of the value and necessity of drill. The work accomplished by Prof. Lockyer and his assistants at Syd Varanger was most remarkable, and calls for very full recognition. The organization of practically an entire ship's company as an observing staff, and their training into a state of thorough preparedness, was a most remarkable achievement.

If Mr. Lockyer's achievement was surpassed, then I think the British Astronomical Association may lay claim to that merit. In many ways the task before the officers of the Association was a far heavier one than that before Prof. Lockyer. The number of observers to be brought into line was considerably larger, and these were not naval officers well accustomed to strict discipline and exact obedience, but independent ladies and gentlemen out on a holiday excursion. Nevertheless the task was accomplished. The observers were organized, trained, and exercised, and on the morning of the eclipse each was in his or her appointed place, knowing what to do, and confident, from the rehearsals that had taken place, as to their ability to accomplish it. That this was possible was due, first, to the unsparing earnestness of those undertaking the work of organization—Dr. Downing, Messrs. Crommelin, Evershed, Green, and Lunt Wesley, and the Rev. J. Cairns Mitchell —and, next, and not less, to the most cheerful and ready co-operation and help, not only of those who had come out expressly as observers in connection with the British Astronomical Association, but also those who had come merely to make a holiday, and to see an unwonted spectacle.

Lastly, I think that it is clear that the equatorial in its ordinary form will be less and less the eclipse instrument of the future. In some cases the most convenient device will be that adopted by Prof. Schaeberle, in 1893, and by Dr. Copeland on the present occasion, of a fixed telescope and a travelling plate, the motion of the plate being regulated to compensate for the motion of the sun. In many respects, a better way of getting over the difficulties of a fixed telescope is by the use of an auxiliary mirror, mounted in one of several ways. The ordinary heliostat has the drawback that it is not suitable for any but very short exposures, on account of the apparent revolution of the image. The double heliostat overcomes this difficulty, but at the cost of a second deflection. The polar heliostat requires the telescope to be parallel to the polar axis, often a very inconvenient arrangement. On the whole, the cœlostatic method, employed for the first time in this eclipse, appears to offer great possibilities, and will probably obtain greater favour as time goes on.

For those, however, who have only small instruments at their disposal, and especially cameras in which the focal length is small and the aperture relatively large, there can be no doubt that the best plan, in default of the assistance of a cœlostat or its equivalent, will be to fix the instrument rigidly pointing to the sun, to dismiss all idea of following, and to limit the exposures, so that the blurring due to the apparent motion of the sun would not be appreciable in the time.

The above remarks apply, of course, only to photographs of the corona itself. The inner portions of the corona are so bright, and the best modern plates so sensitive, that an exposure practically instantaneous is sufficient to obtain a good record. The experience of former eclipses shows that the tendency has been distinctly to over-expose—even with the less rapid plates formerly available—and, indeed, save under the most exceptional conditions of sky, a limit is soon reached in which further exposure, instead of bringing up more coronal features, only brings up the general sky illumination. It has become, therefore, clear that short exposures must be the rule, and, if short, there is the natural desire to obtain as large a number of these as possible. The crucial question then becomes, how to obtain the greatest possible number of exposures, without, in the process of changing plates, setting up such tremors as will destroy all definition? To effect this it is of first necessity that the telescope itself be as stable as possible, and this can be far better secured where it is immovably fixed than where it is equatorially mounted and driven by clockwork.

As to the methods of changing plates, there seems little advantage in one over another. Perhaps the method which promises best is that of a separate dark slide for each plate, the dark slide being made to rest on the end of the camera, not to fit into a tight groove—to be held in its place by an easily moved spring, and the shutter of the slide to open door fashion. The changes in this case will probably be made as quickly, if not more so, than by any arrangement of changing boxes, revolving drums, or long continuous slides; it will be much less weighty, less liable to jar, and free from all possibility of sticking at a critical moment.

For spectroscopic work, the conditions are quite different, and vary with the different departments of work to be attempted. Here the equatorial may still hold its ground, though the balance of convenience will be greatly on the side of the cœlostat.

Lastly, the one great lesson which the disappointment of Vadsö seemed to enforce upon all those who suffered from it, was to leave no stone unturned to secure that they should take part in the observation of the next solar eclipse, that visible in India in January, 1898, whence, so far as mortal can foresee, there will be little or no fear of the untoward weather that baffled our efforts in Finmark.

PHOTOGRAPH OF NEBULOSITIES NEAR ANTARES AND NU SCORPII

Taken by Professor E. E. Barnard, at the Lick Observatory, Mount Hamilton, California, on June 21—22, 1895. Exposure, 7h. 30m.

EXTENDED NEBULOSITY ROUND ANTARES.

By Prof. E. E. Barnard, F.R.A.S.

In the *Astronomiche Nachrichten*, Band 138, Nr. 3301, I have given an account of a great nebula near Antares, which is shown on my photographic plates of that region, made with the Willard lens of the Lick Observatory in the spring of 1895.

Several photographs of this nebula were secured during the season of its visibility in that year. These pictures show that the sky at that point is quite as extraordinary as the nebula itself. Indeed, the stratum of stars, the long vacant lanes, and the nebula are all so apparently connected that one can hardly doubt that there is an actual connection existing here, and that these objects are but different features of the same phenomenon: that is, the nebula, the vacant lanes, and the sheeting of stars appear all to be at the same distance and intimately connected.

From the accompanying photographs it will be seen that the condensations in this nebula occur at certain bright stars—Rho Ophiuchi, 22 Scorpii, and others. From this it is certain that these stars are at the same distance as the nebula, for they form part of it. By inference it would therefore appear that these bright stars are at the same distance as the stratum of small stars through which these vacant lanes run.

If this is so—and it seems reasonable—these photographs prove what I have held to be the case for many years: that the stars which make up the general structure of the Milky Way are comparatively very small bodies, and that they consequently differ vastly, in point of size at least, from the ordinary stars of the sky.

The original negatives show that Sigma Scorpii and Antares are also connected with this great nebula by fainter nebulous extensions, though they are not centres of condensation. It would seem, therefore, that not only are the Milky Way and the nebula here at the same distance, but that many, if not all, of the bright stars in this region are also at about the same distance from us.

The late lamented A. C. Ranyard, formerly editor of Knowledge, and one of the brightest minds that have adorned the astronomy of to-day, long held that the general stars of the Milky Way were smaller than the average stars of the sky elsewhere. The photographs which I have obtained of the various parts of the Milky Way, I think, prove this in many cases, but in none so emphatically as in these pictures of the Antares region.

One feature about this nebula that seems to distinguish it from the other great nebulosities of the Milky Way is the fact that it strongly condenses about these several bright stars (Rho Ophiuchi, 22 Scorpii, and the two small stars Cord. Dur. −24° Nos. 12683-4), and thus shows unmistakably its connection with them. The other great nebulosities of the Milky Way seem to be mixed freely with the stars, and not to condense about any individual star. Even in the case of the condensation of the great nebulosity of 15 Monocerotis, though it is denser at the several bright stars it does not actually condense *at* any one of these stars. In its manner of condensation at the several bright stars, the great nebula of Rho Ophiuchi resembles the nebula of the Pleiades, for there is an actual condensation at bright stars, and not alone a simple involving of the stars within the limits of the nebula. I have previously called attention to this peculiarity of mixtures of stars and nebulæ in *Astronomy and Astrophysics*.

"There is one point, however—and it may be an important one—where the Pleiades differ from the rest of these nebulous clusters. In its case the nebulosity is condensed about the individual stars; in nearly all the other clusters referred to the nebulosity does not seem to attach itself to any individual star, but simply to involve the group, the stars themselves not showing any special tendency to condensation individually."

I think this peculiarity of condensation or non-condensation is an extremely important one, and well worthy of special attention from those who are interested in such subjects.

In the original photographs of the Antares region there are different degrees of darkness in the vacant lanes that run easterly from the nebula.

There are dark holes in these vacancies.

This would seem to show that all this region—lanes and star areas—is covered with a vast diffusion of nebulosity, and these darker places in the vacant lanes are thin places or holes in this nebulous veiling. However unexplainable these features may be, they are real, and are verified by the different negatives. Indeed, I believe that all this region, as far east as Theta Ophiuchi, is covered by a vast sheeting or substratum of nebulosity. Still east of this is another region where the Milky Way is of a nature wholly different from any other part—that is, it looks like neither stars nor nebulosity, and I believe that, in the ordinary sense of the words, it is neither.

On the upper part of the unenlarged picture of this region, the star ν^2 Scorpii is shown to be in a great wing-like nebula—a very remarkable object and unknown previous to the making of these photographs. This nebula does not condense about ν^2, but extends from it great wings of light. I think I can trace diffusions of this nebula to a connection with the great nebula of Rho Ophiuchi. It is certainly connected with the nebulous mass that is seen to surround the two stars B.D. −19° No. 4358 and −19° No. 4361 (this last star is 1855·0, 16h. 12m. 1s. −19° 46′).

With a one-and-a-half-inch lantern lens the great nebula of Rho Ophiuchi is shown to extend in a feeble diffusion to several degrees south and west of Antares and Sigma Scorpii.

The position of Rho Ophiuchi, Yarnall$_3$ 6970 for 1860·0, is in $\alpha = 16h. 17m. 12s., \delta = -23° 7'$. ν^2 Scorpii, Yarnall$_3$ 6810 for 1860·0, is $\alpha = 16h\ 3m. 52s., \delta = -19° 6'$.

It would seem that these stars, which are shown to form a part of this great nebula, should be productive of extremely interesting results if investigated with the proper spectroscopic apparatus.

It will be seen that the great nebula occupies a vacancy here among the thickly strewn stars. From this vacancy dark lanes, with singularly abrupt and well-defined edges, run easterly for many degrees. One of these lanes runs in a broken manner as far east as Theta Ophiuchi, and, sweeping around that star, turns under it westward again, as shown in the photograph published in Knowledge for November, 1894. (*See also* the *Astrophysical Journal* for December, 1895.)

I have before called attention to the fact that these great nebulæ of the Milky Way either occupy a vacancy among the stars or are on the edges of such a vacancy—such nebulæ, for instance, as the great nebula near α Cygni, that of 15 Monocerotis, the one near ξ Persei, and the present one near Antares. This is a very significant fact, that deserves careful attention.

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Notices of Books.

The Elements of Physics. By Edward L. Nichols and William S. Franklin. Vol. I., Mechanics and Heat. Pp. 228. Illustrated. (New York: Macmillan & Co.)

The necessity of a good knowledge of mathematics in the proper study of physics is illustrated by the fact that the present volume, called with somewhat doubtful policy "The Elements of Physics," requires a knowledge of the calculus, and does not shirk the difficulties of the subject in the way that ordinary text-books usually do. In Part I. the subjects treated are physical measurements; physical quantity; laws of motion, falling bodies, projectiles; harmonic motion, statics, energy; moment of inertia, the pendulum; elasticity, friction of solids; hydromechanics; and chemical physics: while Part II. includes chapters on thermometry; calorimetry; the properties of gases, and thermo-dynamics. The regions of electricity and magnetism and of sound and light have been allocated to two other volumes. The distinctive features of this book are the systematic way in which the principles of physical science are developed, the conciseness of the statements made, and the fundamental accuracy of the various proofs and demonstrations described. Advanced students of physics will have little difficulty in working through the volume, and they will find that by so doing they will not only bind their ideas more firmly together but will also extend their knowledge. The authors seem to hold that students of physics should first read text-books and attend lectures and demonstrations, and finally make physical measurements in the laboratory. This may be the proper plan for students in colleges of University rank, though we doubt whether it is an ideal one. Lectures and demonstrations may make mathematical physicists, but the best way to foster investigation is to begin with laboratory work instead of ending with it.

A Compendium of General Botany. By Dr. Max Westermaier. Translated by Dr. Albert Schneider. Pp. 299. Illustrated. (New York: John Wiley & Sons. London: Chapman & Hall, Limited.) So many good scientific handbooks are translations from the German that it is a wonder the cry "Made in Germany" has not been applied to them. Especially is this the case with biological and psychological works, and scarcely a month passes without the appearance of two or three of them. The reason is not far to seek: German scientific men have an infinite capacity for collecting facts, and for piling up information into *Lehrbücher*. Prof. Westermaier's work is not perhaps so diffuse as others from the Fatherland, and students of botany will certainly be grateful for Dr. Schneider's translation of it. It is truly a compendium of general botany, and its value as a text-book lies in the logical and scientific treatment of the subject-matter. The arrangement adopted testifies to this; it is as follows:—(I.) The cell. (II.) Tissues: (*a*) structure of tissues and simple organs; (*b*) differentiation of tissue. (III.) Systems of organs. (IV.) Reproduction. (V.) General chemistry and physics of plant life. (VI.) System of plant classification. To the necessarily limited text on these matters numerous references to standard authors are added, as an inducement to the student to extend his reading. The work was written for use as a text-book of elementary instruction for German *Hochschulen*, which are, as is well known, far in advance of our own high schools. Dr. Schneider's translation is a readable rendering of the original, and we have no doubt it will do good service to botanical science.

Text-Book of Comparative Anatomy. By Dr. Arnold Lang. Part II. Translated into English by H. M. Bernard, M.A., and Matilda Bernard. Pp. 618. Illustrated. (Macmillan.) The first part of this translation of Prof. Lang's work appeared in 1891, and it is to be regretted that there should have been so much delay in the completion of the work. The delay is partly due to the tardy issue of the concluding parts of the German edition, and partly to the great difficulty in giving a faithful and fluent rendering of the original. The present volume deals with the Mollusca, Echinodermata, and Enteropneusta, and the entire work forms a text-book of the comparative anatomy of the invertebrata. But the phyla described in the volume under notice are treated much more comprehensively than is usual in text-books—so elaborate, indeed, are the chapters on the Mollusca and Echinodermata, that they constitute valuable treatises on these groups of the animal kingdom. The text is lavishly illustrated, and the majority of the cuts are new. Prof. Lang has adhered to his method of excluding from the descriptive text the names of the authors whose observations and statements he has used in the construction of his work. In place of this a list of works consulted, and bearing upon the subject, is given at the end of each chapter. Some dissatisfaction was expressed at this departure from the historical method when the first part of the translation appeared, and the adverse criticism then aroused applies equally well to the volume before us. In a work of this character, references to papers and authors should be given in footnotes, so that students may know exactly where to seek further information upon any particular point described. No bibliography can entirely compensate for the omission of such finger-posts to fuller knowledge. This point aside, it is almost unnecessary to tell zoologists that Prof. Lang's book is of a high order of excellence, and that the translators have very successfully put it in English dress.

A Dictionary of the Names of Minerals, including their History and Etymology. By Prof. Albert H. Chester. 8vo, cloth, 15s. net. (Chapman & Hall.) In this work the author has endeavoured to give the history and etymology of every mineral name, including the following points:—1st, the name correctly spelled; 2nd, its author; 3rd, a reference to its first publication; 4th, its original spelling; 5th, its derivation; 6th, the reason for choosing this particular name; 7th, a short description. These particulars are fully given in most cases, but a number remain incomplete, and a list of such is given in the hope that information may be elicited, to be used in a subsequent edition.

Chemistry in Daily Life. By Dr. Lassar-Cohn. Translated by M. M. Pattison Muir. (H. Grevel & Co.) Illustrated. 6s. Mr. Pattison Muir, in his preface to the translation, says that when Dr. Lassar-Cohn published these lectures in book form they caused quite a stir in German circles; and we are pleased that he has undertaken the work of putting the book into English. Although the subject matter is very disjointed, the author has certainly managed to give an account of the chemistry of manufactures of substances used in daily life in a way which would be intelligible to a reader who had no knowledge of chemistry. It is surprising, when one thinks of it, how much the chemical arts at the present day are interwoven into our daily life, and a book of the character of the one before us cannot therefore fail to be of interest to the general reader. When we mention that argon, X rays, bimetallism, cordite, colour photography, incandescent gaslights, all receive appropriate treatment, sufficient proof is surely advanced to show that the book is popular and up to date.

Outdoor Life in England. By Arthur T. Fisher. (Bentley & Son.) This book is a series of chatty sketches of natural history and sport—chiefly the former. The author conveys his information in a very pleasant way; and although he tells us that he does not pose as a naturalist, yet his knowledge of nature is both extensive and sound. He writes of many things—animals, birds, fish, plants, shooting, hunting, fishing, and poaching. We may mention that the black rat (*Mus rattus*) is not so rare as laid down by Mr. Fisher, who says, "I very much doubt if it would be possible to procure a single specimen of this rat at the present time." The book, as a whole, is excellent, and deserves every praise as a popular work on our outdoor life.

Introduction to the Study of Fungi, for the Use of Collectors. By M. C. Cooke, M.A., LL.D., A.L.S. Pp. 360. Illustrated. (A. & C. Black.) Students of mycology know that a work by Dr. Cooke is always a desirable possession, and the confidence they have in his productions will induce them to add this volume to their libraries without considering the evidence of reviewers as to its value. And their action would certainly not give them cause for regret in the present instance. No work that we know of gives a better account of the distribution and classification of fungi, and in none is the organography described with greater regard for the interests of students. The illustrations are instructive and sufficient, and though many of them are old friends they are none the less truly helpful adjuncts to the text. A serviceable bibliography is given at the end of each chapter, and these, with the footnotes, will be appreciated by inquiring minds. The work, as a whole, is a valuable introduction to the systematic study of fungi, and it supplies an acknowledged want. We regret to note that Dr. Cooke says of it: "It is probably my last contribution of any importance to British mycology."

Branched Carpophore of *Peronospora*. From Dr. Cooke's *Study of Fungi* (A. & C. Black).

The Astronomy of Milton's "Paradise Lost." By Dr. Thomas N. Orchard. Pp. 338. Illustrated. (Longmans, Green, & Co.) Of all the sciences, astronomy best lends itself to poetical description. A glance at the heavens when stars are sparkling on the black infinitude of space is sufficient to inspire anyone, while knowledge of the simple laws obeyed by celestial bodies in their motions gives the poetic fancy still wider scope. Dr. Orchard, by bringing together the astronomical allusions in Milton's "Paradise Lost," has added a choice work to the literature in which cultured men find pleasure. Milton possessed a comprehensive knowledge of astronomy, and this enabled him to rise to lofty flights in his sublime poem. Though he was conversant with the Copernican system, and appeared to be convinced of its truthfulness, he selected the Ptolemaic cosmology as the scientific basis upon which to construct his poem, thinking, perhaps, it was better adapted for poetic description. How very proficient he was in the astronomical knowledge of his day is clearly shown by the extracts from "Paradise Lost" given by Dr. Orchard. The title of the book hardly expresses the scope of the contents. At least one-half of the text is made up of descriptions of astronomical objects and phenomena—instructive in every sense, but not directly connected with the subject. We suggest to Dr. Orchard that his volume should have borne some such title as "Celestial Systems and Objects, with Astronomical Allusions in 'Paradise Lost'"; at any rate, the Miltonic description of the book should only form a sub-title.

British Moths. By J. W. Tutt, F.E.S. (Routledge.) Illustrated. Written for young entomologists, this forms an excellent book for the beginner. Besides giving a good description of the moths and larvæ, the author tells when and where and how to find them, and also explains very lucidly the phraseology in use in connection with the study of entomology. Some sound advice is given to the would-be student of the Lepidoptera, and the book forms quite the best guide and companion that we know to the youthful collector, and as such we would heartily recommend it. The illustrations are not of course so good or extensive as those in more elaborate books, but the coloured plates, together with the cuts in the text, are all that is needful in a first book.

BOOKS RECEIVED.

New Ground in Norway. By E. J. Goodman. With Illustrations from Photographs by Paul Lange. (Newnes.) 10s. 6d.

Other Suns than Ours. By Richard A. Proctor. (Longmans.)

Results of Rain, River, and Evaporation Observations made in N. S. W. By H. C. Russell, B.A., C.M.G., F.R.S. (Sydney: Charles Potter.) 3s. 6d.

Skertchly's Physical Geography. (Murby's Text Books.) 1s.

The Reign of Perfection. By Walter Sweetman B.A. (Digby, Long, & Co.) 3s. 6d.

The Site of Camulodunum. By I. Chalkley Gould. (Marlborough & Co.)

British Mosses, Students' Handbook of. By H. N. Dixon, M.A., F.L.S., and H. G. Jameson, M.A. (John Wheldon & Co.) 18s. 6d.

Artistic Landscape Photography. By A. H. Wall. (Bradford: Percy Lund & Co., Ld.)

Navigation and Nautical Astronomy. By F. C. Stebbing, M.A. (Macmillan.) 8s. 6d.

Astronomical Observations and Researches made at Dunsink. (Dublin: Hodges, Figgis, & Co.)

Modern Astrology for August. (Bouverie St.) 1s.

Ocean Rainfall, with Chart and Tables. By W. G. Black, F.R.M.S. (2, George Square, Edinburgh.)

The Junior Salon. (Percy Lund & Co., Ld.) 6d.

Science Progress for August. (Scientific Press, Ld.) 2s. 6d.

Photo-Trichromatic Printing. By C. G. Zander. (Raithby, Lawrence, & Co., Ld.)

We have received a very useful illustrated catalogue of surveying and drawing instruments from Messrs. T. Cooke & Sons. It contains, among other things, details of a new Tacheograph, which consists of a combination of a tacheometer and a plane table, the joint invention of Messrs. Victor de Ziegler and Charles Hager. One of these instruments has been recently supplied to the Indian Government for the purpose of experiment and trial. Messrs. Cooke's patent reversible level still holds its own, we believe, as one of the most reliable instruments. The catalogue contains details of many other instruments, besides a very useful appendix, consisting of two descriptive chapters on the adjustment of their levels and theodolites.

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Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE THEORY OF THE TIDES.

To the Editors of Knowledge.

Sirs,—I have read with interest the letters of your correspondents on the subject of tides, and I cannot help thinking that, although the details of tidal phenomena are doubtless very complex owing to the numerous causes at work, the difficulties of explanation of the outlines of the main phenomena have been somewhat exaggerated.

Sir John Herschel, in his "Outlines of Astronomy," says, when speaking of the tides, that "many persons find a strange difficulty in conceiving the manner in which they are produced. That the sun, or moon, should by its attraction heap up the waters of the ocean under it, seems to them very natural. That it should at the same time heap them up on the opposite side seems, on the contrary, palpably absurd. The error of this class of objectors . . . . consists in disregarding the attraction of the disturbing body on the mass of the earth, and looking on it as wholly effective on the superficial water. Were the earth indeed absolutely fixed, held in its place by an external force, and the water left free to move, no doubt the effect of the disturbing power would be to produce a single accumulation vertically under the disturbing body. But it is not by its whole attraction, but by the difference of its attractions on the superficial waters at both sides, and on the central mass, that the waters are raised."

He then goes on to say that it has been found by calculation that the moon's maximum power to disturb the waters on the earth is about one 12,560,000th of gravity, which would be sufficient to make a difference of about fifty-eight inches between high and low water; the power of the sun being about two and a half times less, or about twenty-three inches.

Your correspondent, Mr. J. Creagh, seems to be under the impression that if two forces are acting in opposite directions on a body, that body would act as though it were affected solely by the more powerful of the two forces, instead of acting as though it were affected by a force equal to the excess of one of the forces over the other. Otherwise he would scarcely say that "the authors" (to whom he frequently refers, but never by name) "fail to see that the tidal power of the moon, being almost infinitesimal compared to the earth's gravity force, could raise towards herself in direct opposition to gravity neither a particle of water, nor a grain of sand, nor any portion of matter, small or large."

This is with reference to the "suction theory." That which he calls the slip theory" he dismisses on the same grounds.

In his "weight theory" I do not perceive how, by "descending to the application of the idea," he arrives at the conclusion that "in order to account for a rise of only three feet in their height, a depth of water of between three thousand and four thousand miles would be required."

G. H. Hill.

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To the Editors of Knowledge.

Sirs,—Will you kindly allow me to add a few remarks to what I have already said upon the interesting problem of the tides?

A satisfactory solution might be arrived at, or at any rate greatly facilitated, if philosophical writers were to definitely state from what source the tides derive their dynamical energy. From the text-books it is difficult to say whether they derive their energy from the moon, or the moon and the sun combined, or from the earth's rotation; such is the ambiguity of the language used and the obscurity of the ideas entertained by different authors. I may be thought pedantic for not accepting without demur the dictum of men much more learned than myself, and for having an opinion of my own; but I firmly believe that the tides cannot derive any dynamical energy from an inert body like our satellite, neither can I believe that two such dissimilar bodies as the sun and moon have a similar physical and mechanical effect upon the ocean. No doubt the sun—unlike the moon—does have a dynamical effect upon the ocean by means of its heat, but this manifests itself in the form of currents flowing from the tropical to the polar seas, and are movements totally distinct from and different to the tides.

Although the moon is a source of no dynamical energy to the earth, the latter body may be a source of energy to the moon, and by its diurnal rotation may also cause the tides, the centrifugal force acting more powerfully upon the liquid and mobile ocean than upon the earth's solid crust.

"We cannot account," as Mr. Proctor says, "for the moon's peculiarity of rotation, without regarding it as due to the earth's controlling influence"; and this belief is confirmed by the singular coincidence that the energy of the tides and the velocity of the moon's motion vary concurrently and in a precisely similar manner, proving that the tides and the moon's motion in her orbit must have a common cause. What else can this cause be than the earth's centrifugal force?

In conclusion I would draw especial attention to the remarkable correlation that exists between the height of the tides and the lunar variation. This synchronism—that the highest tides (the spring tides) should occur when our satellite is in syzygy, and moving at her greatest speed, and that the lowest tides (the neap tides) should occur when the moon is in quadrature, and moving at her slowest speed—is most significant, and must have an important bearing upon the causation of the tides, although it is overlooked or ignored by every author that I have come across who deals with the theory of the tides.

H. A. Cookson.

A LUNAR RAINBOW.

To the Editors of Knowledge.

Sirs,—On the night of June 27th last—a cloudy, dark night—I was sitting in the verandah of my quarters, when, just as rain, which had been imminent for some time, began falling, I was astonished by seeing a distinct band, which emanated from a patch of light cloud and fell in the shape of a rainbow into a tank of water in front of my house. The moon was shining brightly at the time, and on watching the band I distinctly noticed that it had a dark reddish appearance on the outside edge and was of a bluish-green tinge elsewhere. There was also a reflection appearing of a uniform whitish hue.

I first noticed the lunar rainbow, as I believe it to be, at 9.48 p.m., and watched it carefully till its disappearance at 10.1 p.m.

The outer arc or reflection disappeared almost immediately, and the rainbow, as it receded, appeared for a short space as of a uniform bluish-green hue, and finally, before its disappearance, seemed to me of a whitish hue like the outer arc at the commencement.

R. J. D. Sair, Lieut.,
Bhamo, Upper Burma. 30th (5th Burma Bn.) M.I.

SOME CURIOUS FACTS IN PLANT DISTRIBUTION.—IV.

By W. Botting Hemsley, F.R.S.

With the exception of a brief account of the new vegetation of Krakatoa, I have so far only given some particulars of the plants inhabiting a few of the remote islands of the temperate and frigid zones of the southern hemisphere. The countless islands of the Pacific Ocean within the tropics, as well as the comparatively few remote isolated islands in the Atlantic and Indian Oceans, are no less interesting from a botanical standpoint—to say nothing of their animal inhabitants. The Seychelles group in the Indian Ocean is specially so. These islands, upwards of thirty in number, are situated about six hundred miles to the north-east of Madagascar; the largest being seventeen miles long and five in average breadth, with an altitude of nearly three thousand feet. Formerly most of the islands were covered with forest, the greater part of which has disappeared before cultivation and fires. Still, sufficient is left in the less accessible places to give an idea of the composition of the aboriginal vegetation. Some three hundred and fifty species of flowering plants and ferns are recorded from the islands, one-sixth of which have not been found elsewhere. Palms and screw pines constitute the most striking features in the vegetation; the former, indeed, exhibiting a more numerous and varied development than in any similar situation in the world. The only approach to it is in Lord Howe Island, a speck of land less than a quarter of the size of the Isle of Wight, situated in mid-ocean, about three hundred miles from the coast of New South Wales. This island, however, is some ten degrees out of the tropics, yet it produces four species of palms peculiar to itself. It is probable that Eastern Polynesia formerly possessed a more varied palm vegetation than at present, because, apart from the universal coconut, individuals of several other kinds are now of rare occurrence, whilst others may have disappeared altogether.

But to return to the palms of the Seychelles, which, I may mention in passing, are admirably depicted in the Marianne North gallery of paintings at Kew, and most of them may also be seen growing in the large palm house. Including the coconut, nine distinct kinds of palm inhabit these islands, and seven out of the nine have not been found elsewhere. Specially noteworthy among these palms is the double coconut, or coco de mer, *Lodoicea sechellarum*, whose huge, curiously formed fruits were known long before the tree that bears them was discovered. Like the coconut, it has an outer fibrous covering and an excessively hard inner shell. Usually, when divested of its outer covering, it is a two-lobed body, consisting of two oblong lobes side by side. Sometimes it is three, four, or five-lobed, and very rarely six; and then about eighteen inches in diameter. There is a fine series of this singular production in Museum No. 2, at Kew, and young living plants of the palm in the Victoria and palm houses.

It was not until very nearly the middle of the last century that the home of the double coconut was discovered. Previously the nuts had been discovered floating in various parts of the Indian Ocean, and most fabulous accounts of their origin and virtues were given, even by writers of some repute. Among other things the tree was supposed to grow at the bottom of the sea, and enormous prices were paid for the nuts by Asiatic and even some European potentates.

Though not so graceful and elegant as many other palms, the double coconut is a handsome and striking object, having a very slender unbranched trunk, from fifty to a hundred feet high, crowned with a tuft of broad, plaited leaves. The male and female flowers are borne on different individuals, and the nuts hang in clusters at the base of the leaf stalks. It is, or was, common only in Praslin Island, growing singly and in groups on the rocky hills, often almost overhanging the sea.

I will now take the reader to the historically interesting Island of St. Helena, in the Atlantic; a rugged, rocky island, rising nearly three thousand feet above the sea, and having an area of twenty-eight thousand acres. Its isolation is extreme, being upwards of a thousand miles from the coast of Africa, and nearly two thousand miles from the nearest point of the American continent. When first discovered it was entirely clothed with forests, but no mammals of any kind inhabited the island. As was customary in those days, hogs and goats were introduced, in order to provide food for chance visitors in the future. The goats especially multiplied to such an extent that they destroyed the vegetation, or at least prevented seedlings to grow up and replace that removed by decay or felling. The aboriginal vegetation consisted almost entirely of woody plants and ferns, the bulk of the former belonging to the great family *Compositæ*, of which the daisies and asters are familiar examples.

It was not until the beginning of the present century that the island was thoroughly botanized, and it is possible that some of the native plants had already disappeared; at all events, many were already very rare. In 1875 an exhaustive account was published of the condition of the then almost entirely displaced native plants, as well as of the plants that had replaced them. At that date less than half a dozen of the sixty-five certainly indigenous species of flowering plants and ferns collected in the island at the beginning of the century were actually extinct; yet, with the exception of a few scattered individuals, the only remnant of the former flora was high up in the central ridge of mountains and in inaccessible parts of the island. Trees that once covered hundreds of acres were reduced to a few individuals; some to a single example. Large areas once covered with vegetation are now bare, in consequence of the rains having washed the soil from the rocks. In other parts the ground has been completely taken possession of by introduced plants from various parts of the world, prominent amongst which are many British species. Our common furze is now the most abundant shrub in the island, affording employment to many natives, who cut it and take it into the town to be used as fuel. Among trees the British oak is one of the most thoroughly naturalized, growing to a great size and producing acorns in profusion; and the Scotch fir and allied species had been planted to the extent of two hundred acres in 1875. Thus has nearly the whole surface of the island been completely altered; and soon, doubtless, most of the original plants of the island will be extinct, for they exist nowhere else in a wild state, and those in cultivation are difficult to preserve.

Although St. Helena is rather less than fifteen degrees south of the Equator, the general character of the aboriginal flora is not even subtropical. It is like the remains of an intertropical mountain flora, and turning again to Lord Howe Island for comparison, no greater contrast could be found. This island is situated in 31° 30′ S. latitude, yet its vegetation consists largely of tropical types, such as palms, screw pines, banyans, and epiphytal orchids. These differences suggest many interesting deductions, among others a much greater antiquity for the flora of St. Helena.

As already pointed out, a very large proportion of the native plants of such tropical islands as the Seychelles and St. Helena are peculiar to the respective islands, and this holds good for many other islands and groups of islands: the Galapagos and Sandwich groups, for example.

The opposite extreme is found in the numerous coral islands of the Indian and Pacific Oceans, where there are absolutely no endemic or peculiar plants, and the species are nearly all the same, whether we go to the Keeling Islands, six hundred miles off the coast of Sumatra (rendered famous by Darwin's visit some sixty years ago), to the Chagos Archipelago in the centre of the Indian Ocean, or to Caroline Island, upwards of eight thousand miles eastward in the middle of the Pacific. Many of the same plants are also found on continental seashores throughout the tropics, where the conditions are favourable; but to a less degree in the Atlantic than elsewhere. Many of these so-called islands are really atolls, or rings of islets, rising only a few feet above high-water level, and enclosing a central lagoon of varying extent, ranging from a mile to fifty miles or more in diameter. A bird's-eye view of one of these atolls from the masthead of a ship is very singular, giving the impression of a circular or oval fringe of vegetation almost on the surface of the ocean. The number of species of plants inhabiting these islands varies from half a dozen to five and twenty, usually representing nearly as many different genera and natural orders as there are species. In some instances the vegetation consists of scattered individuals of herbaceous plants and low bushes; in others of dense thickets, and even forests of trees of considerable size. The coconut palm is usually the most abundant and most conspicuous feature; but how far it owes its presence to human agency is uncertain. There is no doubt that the fruit, like that of almost all the plants associated with it, will bear long immersion in sea-water without injury to the seeds, and seeds that are cast ashore by unusually high seas germinate and grow. It is also known that the Polynesians when visiting uninhabited islands sometimes plant coconut and other seeds. Probably more has been done in this way to spread this useful palm than is generally supposed. Common among the herbaceous plants are a convolvulus, one or two kinds of purslane, and in Polynesia a kind of cress. Screw pines abound in some of the islands; and other trees occasionally occur up to fifty feet in height, with a trunk as much as four feet in diameter.

The natives of these islands subsist almost entirely on coconuts and fish, the latter being extremely abundant in the lagoons.

EMERY.

By Richard Beynon.

WITH the ordinary uses of emery everyone is familiar. From time immemorial this valuable mineral product has been used in burnishing metals and polishing stones, while during more recent times it has become an essential factor in the machinery of the steel worker or user. Few, however, of those who are thoroughly familiar with the emery paper or the emery hone of everyday life are aware of the interesting story embodied in this useful substance.

The emery of commerce is neither more nor less than an impure form of the mineral corundum. This latter product contains, or should contain, little else than alumina—aluminium and oxygen—and the value of emery depends upon the nearness of its approach to pure alumina. Ordinarily emery contains about seventy or seventy-five per cent. of alumina, the chief remaining constituent, so largely accountable for the dark or reddish-brown colour of emery, being iron oxide.

Emery does not appear to be what may be termed a common mineral, though its geographical range is very extensive. But whether occurrent in ice-bound Greenland, the United States, the Spanish or Scandinavian peninsulas, or the more classic regions of the Eastern Mediterranean or Asia Minor, it is always found in amorphous masses, usually detached blocks associated with gneiss, granular limestone, or other crystalline rocks.

So hard a mineral as is emery can only be quarried with considerable difficulty, and though this is the case the methods employed in the principal European source of emery—Naxos, in the kingdom of Greece—are of the most primitive character imaginable. The mineral is there found in conjunction with hard limestones, and has in great part been forced to or near the surface by igneous upheavals, while aerial and other denuding forces have further assisted in placing large quantities of emery within easy reach of the miners or quarrymen. It is, perhaps, only by a stretch of courtesy that these emery operators can be designated miners or quarrymen, so little is the skill which they show in working the mineral. When a block of emery is discovered, it has to be broken into small portions so as to admit of easier transit to the coast. The means employed to effect this breakage are exceedingly crude and simple, but at the same time not lacking in ingenuity. Fires are lighted round the block so as to materially increase any natural fractures or cracks which the stone may show. Steel levers and wedges are then employed, and in this way the most refractory blocks are reduced to sizeable fragments, which admit of being carried on the backs of mules to the port of debarkation. Inferior, however, as the appliances and plant of these Greek quarrymen may be, the labourers themselves are not without a certain measure of skill in dealing with the emery. The quarries are nominally worked by lessees, who indemnify the Government for the right of exploiting the mines. The quarrymen do not brook importations of non-local labour, their sons succeeding them as labourers at the mines when sufficiently old for the work. There is thus a certain traditional lore extant at the mines, which is looked upon by its possessors as a sort of professional secret and jealously guarded as such. The miners are paid by the lessees according to the output—in fact, they sell the emery to the nominal owners of the mines.

While such primitive methods are employed, it goes without saying that the mines of Naxos are capable of much more effective exploitation. As the surface supply is practically exhausted, it is necessary, of course, to sink shafts in order to reach the mineral, and the *débris* thus excavated is simply dumped on the adjacent bank. Thus it frequently happens that to reach further supplies these heaps have to be subsequently removed, a proceeding necessitating much labour and cost.

In days gone by, when Naxos emery enjoyed a monopoly, such unscientific methods of working did not matter much. Now, however, the inferior emery found in the vicinity of Smyrna is rapidly pushing it from the market. In fact, were not the quality of the emery of Naxos guaranteed by the Greek Government, and none but the best quality allowed to be exported, the emery of Naxos would ere this have disappeared from the markets of the world. In 1818 it commanded over £30 per ton, a price which has now sunk to about one-twelfth of that amount. These prices are those for the port of shipment only, the London merchant charging £4 per ton or thereabouts, according to quality. At present Naxos exports something like four thousand tons per annum. It is shipped like coals, and on arrival at the English or other manufactory is broken, pulverized with stamps, sifted, and then by special processes made into the hones, emery wheels, emery paper, and such things, so necessary to the cutter and glass polisher. Such in brief are some of the more interesting facts relative to emery.

A CROCODILE MUMMY IN THE BRITISH MUSEUM.

By H. Spencer.

UNDERGROUND Egypt is continually furnishing us with new light on the religion, manners, and customs of the people who lived in the land of the Pharaohs long before the time of Moses.

The discovery of the Rosetta Stone in 1801 gave fresh impetus to the study of the language known as hieroglyphic and hieratic; thus, with the facilities for visiting Egypt now available, and the fact that the country is to some extent the foster-child of Great Britain, its history and antiquities are more generally studied. The majestic monuments, gorgeous temples, inscribed obelisks, rolls of papyri, and embalmed bodies in animal and human form, which for centuries baffled the learned and astonished the tourist, have been made to tell their story of battles and victories, arts and sciences, domestic scenes and funeral ritual, which flourished five thousand years ago.

The monumental records and inscriptions in palaces and temples were the principal means by which kings of Egypt perpetuated the record of their deeds of adventure and heroic achievement.

It is the tombs, however, which have preserved to us relics of the life, language, literature, and religion of the people. It is the mode of embalming, the rolls of papyri, the provision of all kinds of domestic furniture which were deposited in the tomb for the use of the soul of the deceased in the future life, which have given us a means of reading anew the story of the life and religion and the part animal worship played in the polytheistic notions of this pious race.

The varied and interesting collection of mummies, mummy cases, and funereal furniture contained in the British Museum has recently been enriched by the acquisition of an enormous crocodile mummy. This creature measures thirteen feet in length, and is well preserved, having a swarm of young crocodiles on its back. Dr. Pritchard, in his "Analysis of Egyptian Mythology," says: "The ancient Egyptians believed that the souls which emanated from the primitive source transmigrated through various bodies; nor was this change confined to emanations of a lower and secondary order. As the souls of men transmigrated through different shapes, so the higher order or spiritual agents could, as occasion required, assume any form they chose; and sometimes the gods appeared in the world under the disguise of bulls, lions, eagles, or other creatures."

This accounts for the vast army of gods, representing so many species in the natural world, which abound in European museums. These were maintained in their day at great expense in sacred parks and lakes, and persons were appointed to nourish them with the greatest care; and, when they died, the same sacred rites were performed over their bodies and the same preparation was made for their interment as if they had been one of the highest functionaries of the state.

The famous fellow that has just been added to our national collection was discovered at Kom-Ombos, in Upper Egypt, a city where this creature was venerated as early as 2500 B.C., and where ruins still remain having paintings relating to the adoration of Sebek. At the south side of one temple the remains of a large pond have been found, which probably served to satisfy the amphibious instinct of this adorable monster. During the reign of Ptolemy Philadelphus, B.C. 330, the worship of the crocodile reached its highest point.

The method employed in making crocodile mummies seems to have varied with taste and means. While some are exquisitely bandaged, others (as in the case of our latest addition) were simply dipped in a solution of wax and pitch, which renders them perfectly hard, and by which the young progeny are securely fixed in the hollow parts of the back.

This is one of the finest specimens of a mummied crocodile that we have seen. It was presented to the British Museum by the Egyptian Government.

SOME NOTES ON SPIDERS.

By Rev. Samuel Barber.

In a recent article in Knowledge (April, 1895) a graphic illustration was given of spiders' pugnacity. This quality is amusingly shown in their conjugal habits; the female so often devouring the male that a species which live together in peace have acquired the special epithet of "benigna" (*Ergatis benigna*).

The instinct of spiders in at once attacking a vital part of their antagonist—as in the case of a theridion butchering a cockroach by first binding its legs and then biting the neck—is most remarkable; but they do not always have it their own way. A certain species of mason-wasp selects a certain spider as food for its larvæ, and, entombing fifteen or sixteen in a tunnel of mud, fastens them down in a paralyzed state as food for the prospective grubs.

Perhaps the most entertaining points in connection with spiders are their concentration of energy, their amazing rapidity of action, and their inscrutable methods of transition and flotation.

During the past autumn large numbers of these creatures appeared at intervals. Thus I observed a vast network of lines that seemed to have descended over the town of Whitstable, in Kent, and which were not visible the day before or the day after. Many were fifteen to twenty feet long; they stretched from house to lamp-post, from tree to tree, from bush to bush; and within six or seven feet of the ground I counted, in a garden, twenty-four or more parallel strands. The rapidity with which spiders work may be gathered from the fact that, while moving about in my room, I found their lines strung from the very books I had, a moment before, been using.

Insect life, as might have been expected after so mild a winter and so dry a spring and summer, is (1896) intensely exuberant. The balance is preserved by a corresponding number of Arachnida. On May 25th and 26th the east wall of the vicarage of Burgh-by-Sands was coated with a tissue of web so delicate that it required a very close scrutiny to detect it. I could find none of the spinners. Every square inch of the building appeared coated with filmy lines, crossing in places, but mostly horizontal, from north to south.

Walking by the edge of a wheatfield in Suffolk on May 14th, I observed all over the path, which was cracked with the drought, dark objects flitting to and fro. They were spiders—mostly of the hunting order. Tens of thousands must have occupied a moderate space of the field, and the cracks in the parched soil afforded them a handy retreat. In reference to the visitation of spiders at Whitstable during the autumn and winter of 1895-6, it is right to note that the people of that place regard them as a sign of an east wind. In this connection we can note the fact of phenomenal clouds of flies occurring at times on the east coast of England; and it would be interesting if observers could ascertain whether spiders ever cross the Channel and accompany such visitations of insects.

The production of the flotation line, and its method of attachment, are the two points to which I ask the attention of observers.

Is it not evident that air (and probably at a high temperature) must be enclosed within the meshes of the substance forming the line when it passes from the spinnerets into the atmosphere? The creature with this substance within its body drops to the ground at once by force of gravitation; yet, when emitted, the very same substance lifts it into the air. It has been usual to explain the ascent by the kite principle, *i.e.*, the mechanical force of the contiguous atmosphere. But air movements, especially on a small scale, are so capricious and uncontrollable that, without a directive force, the phenomena seem quite inexplicable.

Moreover, all my own observations lead me to accept the theory of a direct propelling force, and I can hardly accept the conclusions on this point of Mr. Blackwall, though he is an authority on the subject. The intense rapidity with which the initial movements are made cannot be reconciled with any theory of simple atmospheric convection; and illustrations such as the following go to prove that spiders possess the faculty of weighting or condensing the ends of their threads, and throwing them, within limited distances, to a point fixed upon.

I was writing, and had two sheets of quarto before me. Perceiving a small spider on the paper I rose and went to the window to observe it. To test its power of passing through air, I held another sheet about a foot from that on which the creature was running. It ascended to the edge, and vanished; but in a moment I saw it landing upon the other sheet through mid-air in a horizontal direction, and picking up the thread as it advanced.

In this case there was no air-movement to facilitate, nor any time to throw a line upward, which, indeed, would not have solved the difficulty. Propulsion appears the only explanation.

The next illustration is more marvellous, and seems to indicate that some species, at any rate, have the power of movement through the air in any direction at will.

Some years ago, at a dinner party in Kent, four candles being lighted on the table, I noticed a thread strung from the tip of one of the *lighted* candles close to the flame, and attached to another candle about a yard off; and all the four lights were connected in this way, and that by a web drawn quite tight. No little surprise was caused among the guests on finding that the diamond form of the web was complete.

No satisfactory explanation of this has been offered, and I can only suggest that the spinner was suspended at first by a vertical line from above, and thus swayed itself to and fro, from tip to tip of the candles. It was certain that the spider could not have ascended from the table; and it was equally certain that aërial flotation of the line from a fixed point was impossible, as it involved floating in four opposite directions. I have seen a creature of this or a nearly allied species moving laterally through the air of a room in this way.

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THE AFFINITIES OF FLOWERS.—THE HAREBELL AND THE DAISY.

By Felix Oswald, B.A.Lond.

Few subjects are more fascinating to the botanist than the investigation of the natural relationships existing between the various orders of flowering plants. Very often these affinities have become so much obscured by later adaptations which have rendered the flower better suited to different surroundings that it is not easy to detect, by mere inspection, its more deeply-seated relations.

For instance, there does not seem, at first sight, to be any resemblance between a harebell and a daisy; but in this paper the attempt will be made to show, by the study of characteristic intermediate types, that the two flowers, externally so dissimilar, may yet be considered to mark the opposite extremes of one and the same series. Of course it is not intended for one moment to infer that the one is directly derived from the other; on the contrary, they stand to each other in the relation of distant cousins, very many times removed, the one having retained to a greater extent the features of the common ancestor, while the other has become more highly specialized in quite a different direction. Keeping this principle in view, we may regard the flowers which are chosen here to bridge over the gap as indicating roughly the various stages from a lower to a higher type of structure. It must, however, be remembered that these transition forms—harebell, rampion, sheep's bit, hemp-agrimony, and daisy—have deviated each more or less from the direct line by reason of adaptation to climate and surroundings as well as to the severe competition to secure a place in nature, but most of all to the requirements of those insects which have (by parallel development) become best fitted to cross-fertilize the particular species.

Everyone is familiar with the delicate drooping blue flower of the harebell, or witch's thimble—a pale blue so perfect as to seem to be the reflection of the sky. Let us now pluck a flower and examine it more closely. The five teeth on the margin of the bell indicate that it is made up of five petals. The bell, however, is not formed by the mere coalescence of the petals by their edges, but by the intercalary growth of the tissue at their bases raising them up. Thus the teeth or lappets alone represent the petals. The body of the bell, as in most tubular flowers, is a new and superadded structure; indeed, in some members of the Campanulaceæ or harebell family—*e.g.*, the sheep's bit—the corolla-tube is so short that at first sight the petals appear to be quite separate from each other (Fig. A).

Fig. A.—Single floret of Sheep's Bit.

When we come to examine the really essential parts of the flower, viz., the stamens and pistil, we find that they present a different appearance according to the age of each flower. Thus, just before the flower bud has opened, the ripe anthers are closely pressed against the immature cylindrical style. The latter is provided with longitudinal rows of small stiff hairs projecting into the anther-cells, which have opened inwardly, facing the style (*i.e.*, are "introrse"). Consequently, as the style grows in length, the pollen is swept out of the anthers by these hairs, and is left adhering to the surface of the style in a broad zone. The stamens, having now fulfilled their purpose, shrivel up and wither. This is the state of things which a newly opened flower presents to view. The style continues to grow longer, and finally expands at its apex into three branches, exposing the stigmatic surfaces, which are sticky, in order to catch and retain the pollen-grains brought from another flower.* (Fig. B, I., II., III.)

Fig. B.—Section of Harebell at successive stages. I. Stamens depositing pollen on style. II. Stamens shrivelled; stigmas still immature. III. Pollen removed by a bee; stigmas expanded.

A bee visiting a young flower of the harebell will

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* The harebell thus furnishes us with a very clear and instructive example of the phenomenon termed "protandry"—that is to say, the anthers reach maturity and shed their pollen before the stigmatic surfaces of the same flower are ready to receive the fertilizing grains. By this means self-fertilization is avoided, and the flower secures, by the agency of winged insects, the advantages arising from being crossed with other flowers of the same species.

inevitably receive on its legs and abdomen some of the pollen adhering to the style, since it uses the style as a support during its search for the honey beneath the spreading bases of the stamens. Subsequently, the bee will visit a rather older flower in which the stigmas are expanded on a level with the entrance to the bell, so that the pollen adhering to the bee's body must necessarily be transferred to the sticky stigmatic surface. But if, after all, the flower should fail to be cross-fertilized by insects, then it takes to self-fertilization as a last resource, and the stigmas curl right back so as to expose their receptive part to the zone of pollen round the style.

In the rampion (*Phyteuma*), another member of the Campanulaceæ, we find indications of an advance on the simpler harebell type. The flowers are no longer on separate stalks, but are collected in heads; we may regard this habit as a step in the direction of economy, for an insect can evidently visit and cross-fertilize a greater number of flowers thus arranged without wasting so much time as if they were each isolated and needing separate visits. The corolla in the rampion is no longer an open bell but a narrow cylindrical tube; the lower part ultimately splits into five ribbons, while the upper part, with a toothed margin, remains a tube for a longer time. The pollen is shed (as in the harebell) by the anthers upon the style within the corolla-tube, and adheres in a broad zone to the lateral collecting hairs. The gradual lengthening of the style, as well as the contraction of the corolla caused by the splitting of the lower part, exposes the zone of pollen for the visits of bees, while the stigma itself remains immature for a day or so longer before unfolding its branches (Fig. C, I.). In the absence of visits from insects, self-fertilization may, however, occur in the rampion precisely as in the harebell, by the excessive curling back of the stigmatic branches on to the pollen adhering to the style beneath (Fig. C, II.). The presence of an involucre—*i.e.*, a group of floral bracts round the compound flower—as well as the reduction of the stylar branches from three to two, enhances the resemblance to the Compositæ, which has already become foreshadowed by the grouping of the flowers in heads.

FIG. C.—Single floret of Rampion. I. Stigmas immature. II. Stigmas expanded above the zone of pollen.

In the spherical flower-head of the sheep's bit (*Jasione montana*)—a pretty little blue flower, frequent in mountain districts—the kinship of the flower to the Composite type becomes still more manifest. Here the anthers, instead of being separate from each other, are now "syngenesious"*—that is to say, they are united by their edges, forming a closed ring round the style—but the union is not yet perfect, for only the bases of the anthers have become coherent. The inflorescence, however, is almost identical with that of the Compositæ, for the flowers are crowded together in capitate umbels with involucres, and the stylar branches (as well as the cells of the capsule) have become reduced in number from three to two. Indeed, the similarity is so close that Linnæus himself classed it with the Compositæ.

The flowers of these three members of the Campanulaceæ naturally show more affinity between themselves than with the flowers of the usual Composite type. But the gap seems less wide if we consider the structure of one of the more primitive Compositæ, such as the lilac hemp-agrimony (*Eupatorium cannabinum*). Only a few flowers occur in each head, but many of these small heads are grouped together to form a large inflorescence. Moreover, the florets in each little head are not so tightly packed together as in most Compositæ. Each floret presents in the main a similar structure to the more advanced bellflower type, being tubular with five well-marked teeth; but the green calyx becomes reduced here to a number of bristly hairs, and the anthers are now completely united to each other, side to side. However, there is no differentiation as yet into ray and disk-florets; all are alike and all have the same lilac colour. The branches of the style are long and hairy, and as they grow in length they sweep out the pollen from the anthers. Subsequently, when mature, the branches separate widely, exposing the stigmatic surfaces (Fig. D). If the flower fails to be fertilized by insects, then the long curling styles come into contact with the pollen still adhering to the collecting hairs of younger and immature styles of neighbouring florets; thus the florets of the same head become fertilized with each other's pollen.

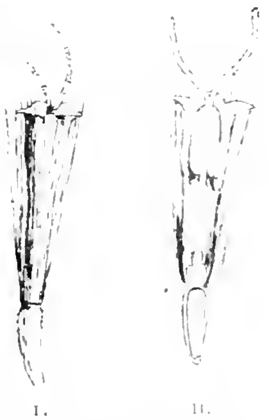

FIG. D.—Single floret of Hemp Agrimony. I. Side view. II. Section.

Finally, the "wee crimson-tipped" daisy (*Bellis perennis*) has carried the differentiation of its flowers to a still greater extreme. Here the florets are of two kinds: white ligulate ray-florets and yellow tubular disk-florets (Fig. E, I.). Moreover, all trace of a calyx, even in the form of hairs or scales, is entirely absent. The ray-florets have become considerably modified from the simple tubular type, which continues to be exemplified in the disk-florets; the lower part of the tube still exists, but the upper part has split open, spreading out into a flat, ligulate (strap-shaped) corolla. But the five minute teeth on the end of the strap betray the parent character. The corolla has been modified in this way chiefly for the sake of making the flower more conspicuous, but also in order to protect the pollen from rain and dew. At night, or when a shower is impending, these flat straps bend over and inwards and effectually cover over the exposed pollen.

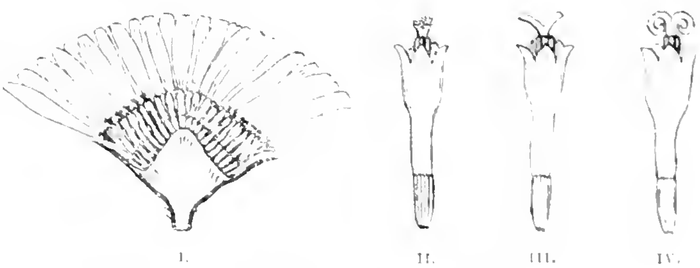

FIG. E.—I. Section of Daisy. II., III., IV., Successive stages in the growth of a disk-floret

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* *Symphyandra*, another member of the Campanulaceæ, has likewise syngenesious stamens.

In this flower, and in most other Compositæ, the pollen is not deposited on a zone round the style, as in the Campanulaceæ, but is set free above its immature tip, which is provided with small stiff hairs. As the style develops and lengthens, this circular array of bristles acts like a chimney-sweep's brush, and pushes in front of it the pollen filling the upper part of the corolla-tube, leaving it on the surface of the flower-head: thus the pollen grains cannot fail, in this exposed position, to come into contact with the abdomen or legs of an insect settling on the flower in search of honey or pollen.

Subsequently, the apex of the style divides into two branches, just like the previous cases, laying bare the receptive surfaces, which up to that moment had been protected by their mutual pressure from contact with pollen from the same floret (Fig. E, i., ii., iii., iv.).

The differentiation in the daisy of some of the marginal florets into ray-florets, with their characteristic ligulate corolla, has reached a yet higher stage in the large Ligulate section of the Compositæ, some of which possess characteristics of the Campanulaceæ which are wanting in the daisy. Thus, in the pale blue flower-heads of the chicory (*Cichorium intybus*) all the florets are ligulate, but the calyx seems to be a little less degenerate than in most other Compositæ, for it consists of little scales which certainly approach the nature of sepals more closely than the hairs and bristles which usually take the place of the calyx in this order. A striking quality which the chicory tribe possesses, in common with the Campanulaceæ, is the presence of *latex*, or milky juice, in their tissues. Everyone who has plucked a dandelion will be familiar with the appearance of the dense white juice welling up from the wound; and it is highly probable that this forms another of the characteristics which the two groups of plants derive from a remote common ancestor.

To sum up: the points in which the Compositæ resemble the Campanulaceæ are the following:—

1. The valvate æstivation of the corolla—*i.e.*, the petals in the flower-bud are placed edge to edge, and do not overlap in any way.
2. The occurrence of inulin (Dahlia, Jerusalem artichoke) and of latex (chicory, dandelion).
3. The ovary is inferior to the corolla. This condition always points to the flower having reached a high state of development.
4. The tendency in some of the Campanulaceæ for the anthers to adhere by their sides to form a tube, becomes a general rule in the Compositæ. In *Eupatorium* the pollen is shed on to the lateral surface of the style as in Campanulaceæ, although in most Compositæ it is discharged above the tip of the style.
5. The phenomenon of protandry as explained above.
6. The ovule is anatropous—*i.e.*, the ovule, though straight itself, is bent on its own stalk so that the micropyle (the pore through which the pollen-tube penetrates) is close to the place where the ovule is attached to the placenta.

It still remains necessary to give some explanation of the differences between the two orders. These, although of importance, do not, I think, present any insuperable difficulties.

The Campanulaceæ differ from the Compositæ in the following particulars:—

1. The arrangement of the veins in the corolla.
2. The plurality and horizontal direction of the ovules. (In the Compositæ there is only one ovule in the ovary, and it is erect.)
3. The fruit in Campanulaceæ is a capsule with two or three divisions, and not an achene.
4. The collecting hairs on the style are arranged in lines and not in a ring.
5. The seed contains endosperm.
6. The prevailing colour of the flowers is blue, while that of the Compositæ is yellow.

Most of these differences (2, 3, and 5) result from the crowding together of great numbers of flowers into compact heads. In all such cases the number of ovules tends to become reduced. Moreover, the fact that there are two stigmatic branches to the style in Compositæ seems to indicate that their ancestor possessed an ovary with two loculi or compartments, just as in the rampion and sheep's bit. And, furthermore, the suppression of endosperm in the seeds of the Compositæ is not, after all, a hard-and-fast distinction between the two orders, for the seed of *Tagetes*, a Composite plant, still contains some endosperm, and can therefore be termed albuminous.

The other points hardly seem to constitute deep-seated differences in the essential structure of flowers, but may be regarded rather as superficial and responsive adaptations to secure fertilization by different insects or to differences in the climatic surroundings.

But the question will very naturally arise, "If the Compositæ are descended from an ancestral type somewhat like the harebell, how is it that the prevailing colour of Composite flowers is yellow, while nearly all the Campanulaceæ have blue flowers?"

To this question, Grant Allen, in his "Colours of Flowers" (pp. 81-85), has suggested a very plausible and ingenious answer, the gist of which I venture to reproduce as an extremely probable solution of the difficulty. Observation of analogous cases (Rubiaceæ, etc.) tends to show that when flowers with highly specialized colours, such as blue, become dwarfed and crowded together, they show a tendency to revert through lilac, pink, and white back again to the more primitive yellow. This retrogression in colour is probably due to the fact that the crowded florets are no longer dependent on the visits of only one species of insects to secure cross-fertilization, and hence the reversion in many flower-heads to the yellow of their distant ancestors, since it is the colour which appeals to a great number of miscellaneous insects. In accordance with this principle, Grant Allen considers that "the primitive ancestral Composite had reached the stage of blue or purple flowers while it was still at a level of development corresponding to that of the sheep's bit (*Jasione*)." Thus the Cynaroid or thistle group of the Compositæ are all purple or blue, and the florets are fairly large. In the group of the Corymbifers yellow becomes general; but the least evolved type, the hemp-agrimony, is still purple. Yet, while in many members of the group both ray-florets and disk-florets are a uniform yellow, the daisy shows evidence of a progressive step in its development of colour, for not only are the ray-florets white, but their edges have begun to show signs of pink. Lastly, the delicate blue colour of the chicory may perhaps indicate a similar forward development, which in this plant has reached the higher notes of the scale of colour.

The Compositæ have often been bracketted together with the Teasel tribe, the Dipsacaceæ, and even a genetic connection between them has sometimes been assumed. But when we come to balance all the facts of the case, this alliance is more apparent than real. It would take too long in this article to dwell upon the technical but essential differences which distinguish the Dipsacaceæ from the Compositæ, such as the presence of an epicalyx, a simple style and a terminal undivided stigma, the imbricate æstivation of the corolla, the stamens being only four in number, the pendulous ovule, etc.; but it is perhaps sufficient to state that there is satisfactory evidence to show that they form the final stage in the series Rubiales-Dipsacales, and hence are not really related to the Compositæ, but have arrived by a different path at somewhat analogous structures. Similar capitate inflorescences are likewise to be found in the final stages of other lines of descent, as in the sea-holly (*Eryngium*) among the Umbelliferæ.

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THE FACE OF THE SKY FOR SEPTEMBER.

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

The number of spots diversifying the solar disc is still very small.

A conveniently observable minimum of Algol will occur at 10h. 50m. p.m. on the **8th**.

Both Mercury and Venus are too near the Sun this month for the observer's purposes, and Jupiter does not rise till after midnight at the end of the month.

Mars is an evening star, and is now a fine object in the evening. On the **1st** he rises at 9h. 46m. p.m., or 3h. 2m. after sunset, with a northern declination of 20° 53′, and an apparent equatorial diameter of 9⅓″, the defect of illumination on the preceding limb amounting to 1·4″. On the **9th** he rises at 9h. 28m. p.m., with a northern declination of 21° 35′, and an apparent equatorial diameter of 10·0″. On the **16th** he rises at 9h. 12m. p.m., or about 3h. 2m. after sunset, with a northern declination of 22° 6′, and an apparent equatorial diameter of 10½″, the defect of illumination on the preceding limb amounting to 1½″. On the **23rd** he rises at 8h. 54m. p.m., or 3h. after the Sun, with a northern declination of 22° 27′, and an apparent equatorial diameter of 11·0″. On the **30th** he rises at 8h. 35m. p.m., or 2h. 57m. after the Sun, with a northern declination of 22° 52′, and an apparent diameter of 11½″, the phasis on the preceding limb amounting to 1½″. He is in conjunction with Neptune at 6h. a.m. on the **24th**, Mars being 50′ to the north. During the month he describes a direct path in Taurus, almost to the confines of Gemini.

Saturn is an evening star, and is still visible shortly after sunset during the first half of the month. On the **1st** he sets at 8h. 55m. p.m., or 2h. 11m. after the Sun, with a southern declination of 14° 4′, and an apparent equatorial diameter of 30″ (the major axis of the ring system being 37½″ in diameter, and the minor 13½). On the **7th** he sets at 8h. 34m. p.m., or about two hours after the Sun, with a southern declination of 14° 13′, and an apparent equatorial diameter of 30″ (the major axis of the ring system being 37⅓″ in diameter, and the minor 13½″). On the **16th** he sets at 7h. 58m. p.m., or 1h. 45m. after the Sun, with a southern declination of 14° 28′, and an apparent equatorial diameter of 29¾″ (the major axis of the ring system being 37″ in diameter, and the minor 13″). He describes while visible a short direct path in Libra.

Uranus is too near the Sun to be conveniently observed.

Neptune is an evening star, rising on the **1st** at 9h. 50m. p.m., with a northern declination of 21° 12′, and an apparent diameter of 2·6″. On the **30th** he rises at 8h. 30m. p.m., with a northern declination of 21° 41′. He is almost stationary in Taurus during the month.

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

The Moon is new at 1h. 43m. p.m. on the **7th**; enters her first quarter at 4h. 10m. p.m. on the **14th**; is full (Harvest Moon) at 10h. 49m. p.m. on the **21st**; and enters her last quarter at 1h. 58m. a.m. on the **30th**. She is in perigee at 8h. p.m. on the **8th** (distance from the Earth, 223,420 miles), and in apogee at 3h. a.m. on the **24th** (distance from the Earth, 252,400 miles). The Moon will pass through the Pleiades on the evening of the **26th**, occulting several of the bright stars in that asterism.

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Chess Column.

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

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of August Problems.

(A. C. Challenger.)

No. 1.

1. Q to B7, and mates next move.

No. 2.

Key move.—1. Kt to K5.

If 1. . . . K × P,	2. R × Pch, etc.
1. . . . P × Kt,	2. B × P, etc.
1. . . . R or Kt moves,	2. R to QKt5ch, etc.
1. . . . P × P,	2. R to Kt5ch, etc.
1. . . . B to Kt7,	2. Kt(K5) to KB3, etc.

[It will be noticed that though there is a double threat, Black is cleverly compelled to defend himself against at least one of the threats.]

Correct Solutions of both problems received from Alpha, Arthur S. Coulter, A. G. Fellows, H. S. Brandreth (Dresden), H. Le Jeune, G. A. F. (Brentwood), and W. Willby. Of No. 1 only from G. G. Beazley and A. E. Whitehouse.

Hubert Price.—In the amended position the key is doubly weak, because (i.) it shuts out the Black King from his only available square; and (ii.) the piece moved is *en prise*. A remedy would be to omit the first move, and publish the position as a simple three-mover; but the idea, we fear, is one that has been often represented before.

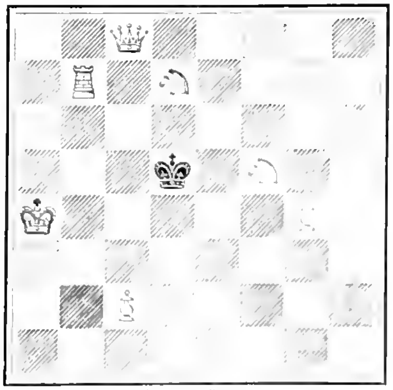
S. J. Charleston.—In the position you send you appear to have overlooked the defences Kt to B7 or Ksq or Q4, preventing mate. In any case, we should say the idea is not suitable for a problem.

PROBLEMS.

By C. D. Locock.

No. 1.

Black (1).

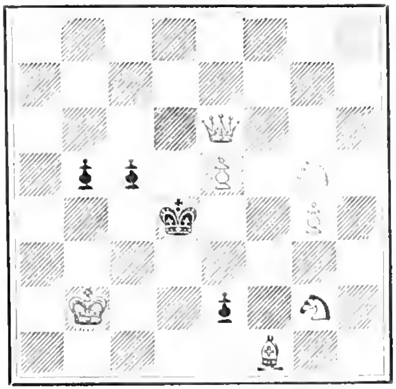


White (7).

White mates in two moves.

No. 2.

Black (4).



White (7).

White mates in two moves.

CHESS INTELLIGENCE.

The event of last month was the International Tournament at Nuremburg. There were nineteen competitors, each playing one game a day as far as possible, though, owing to the odd number of players, there was necessarily a bye every day. The list of players differed only in one instance from that given last month, M. Charousek taking the place of Mr. Burn. Other notable absentees were Lipke, Makovez, Englisch, Weiss, Bird, Mason, Gunsberg, Mieses, Lipschütz, and Bardeleben.

The players came out in the following order :—

		Won.	Drawn.	Lost.	Total.
First Prize ...	E. Lasker ...	12	3	3	13½
Second Prize	G. Maroczy ...	8	9	1	12½
Third Prizes	H. N. Pillsbury	10	4	4	12
Fourth Prizes	Dr. Tarrasch	9	6	3	12
Fifth Prize ...	M. Janowski...	10	3	5	11½
Sixth Prize ...	W. Steinitz ...	10	2	6	11
Seventh Prize	C. Schlechter	5	11	2	10½
	C. A. Walbrodt	7	7	4	10½

The other scores in order being : Schiffers and Tchigorin, 9½; Blackburne, 9 : Charousek, 8½ ; Marco, 8 ; Albin, 7 ; Winawer, 6½ ; Showalter, 5½ ; Porges, 5½ ; Schallopp, 4½ ; and Teichmann, 4. Mr. Blackburne obtained the Special Prize for the best score against the prize-winners.

Mr. Lasker won rather more easily than his score indicates. Nothing depended on his last game with Charousek, otherwise he would probably have contrived at least not to lose it. His position and that of Tchigorin confirms the result of the St. Petersburg quadrangular tournament. Pillsbury and Steinitz reversed their respective positions, but the result depended on the last game played. Pillsbury started badly; but among his later victims were Lasker, Tarrasch, Tchigorin, and Steinitz, the four of greatest repute among his opponents.

Maroczy's was a very fine and rather unexpected performance. He is twenty-six years of age, and has only played chess two or three years, we believe, so that he is not unlikely to succeed in his turn to the championship. It will be seen that he lost only one game out of the eighteen. Dr. Tarrasch, who may have been handicapped somewhat by the cares of management, recovered from an indifferent start, and was as steady as usual. Janowski at one time looked like being second, but he went to pieces at the finish—the fate also of Walbrodt. Steinitz succeeded in avoiding the draw with his usual skill, but too often at the expense of a loss. One does not expect the veteran champion to lose so large a proportion of his games as one-third. Schlechter, as usual, drew most of his games. His score is quite a curiosity ; he and Walbrodt will always come out halfway down the list in any tournament, with Marco, the other drawing master, a little below them. Schiffers came out in his right place, but Tchigorin should have been equal to the seventh prize. Blackburne started badly, but afterwards did well, especially against the prize-winners. Charousek is an unknown player who made a brilliant *début* : and Albin, another brilliant but uncertain player, made a creditable score. Showalter, the American, came out in his right place ; but the veterans Winawer, Schallopp, and Porges are clearly past their prime. The action of the Hastings committee in reluctantly giving younger men the preference over them last summer seems to be vindicated by their present performances. Teichmann's position is a great surprise, especially after his victory in the Divan Tourney had shown him to be in good form. No doubt ill-health or some similar cause may account for his poor score. It is rather remarkable that the three representatives of "English" chess came out one first, another last, and the third as nearly as possible halfway down the list. Also noteworthy is the fact that Steinitz, as at Hastings, lost to Janowski, Lasker, Pillsbury, and Tarrasch. He was also the only player who beat Maroczy, and one of the two who beat Schlechter, the other being Janowski.

Contents of No. 130.

NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

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KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: OCTOBER 1, 1896.

CONTENTS.

ENGLISH COINS.—III.*

By G. F. Hill, M.A.

The union of the English and Scottish Crowns in 1603 did not lead to any unification of the currency. James I. continued to strike separate series for both parts of his kingdom, but there are frequent allusions in his coinage to the union of the two countries. The most important is found in the shield, which now bore, in the first and fourth quarters, France and England quarterly; in the second, Scotland; in the third, Ireland. James's first gold coinage consisted of sovereigns, half-sovereigns, crowns, and half-crowns, all of which have the Scottish thistle for mint-mark. But this was replaced in the same or the next year by a gold coinage, the largest piece in which, though of the same value as the old sovereign, was known as the "unite" (Fig. 1). On this coinage the king is called "King of Great Britain, France, and Ireland," and the legend of the reverse (FACIAM EOS IN GENTEM VNAM) gave rise to the name of the coin. In 1611 these pieces were given a value of twenty-two shillings, the weight remaining the same (about one hundred and fifty-four grains troy); but in 1619 the old value was restored, the weight being reduced proportionally. At the same time for the old crowned bust was substituted a laureated one (Fig. 2), which gave the name of "laurel" to the coin. Yet a third name was the "broad." Besides the unite, we may mention among the gold coins of James I., the "Britain crown," with the motto HENRICVS ROSAS (conjunxit) REGNA IACOBVS ("Henry united the Roses, James the Realms"), and the "thistle crown," bearing a rose on one side, a thistle on the other, with TVEATVR VNITA DEVS ("God protect the United Kingdoms"). This was worth at first four shillings, but was raised in 1611 in proportion to the unite. The denomination was not issued again in gold. An exceptional place in the coinage of this reign is occupied by the rose ryal* of thirty shillings (afterwards raised to thirty-three), the spur ryal of fifteen shillings (16s. 6d.), the angel of ten shillings (11s.), and its half. "Spur ryal" is a misnomer, occasioned by the rose on a sun, which appears on the reverse, and has been taken for a spur. These coins belong rather to the series of James's predecessors than to the new type of coins which he introduced. From this time onwards there is a tendency towards reducing the number of denominations; Charles I. coined no ryals, and was the last to coin angels.

In silver, James made an alteration in the type of the crowns and half-crowns, which now represented the king riding on horseback to the right (Fig. 3), a rose (crowned) on the housings, and the motto EXVRGAT DEVS DISSIPENTVR INIMICI (Psalm lxviii. 1), or QVÆ DEVS CONIVNXIT NEMO SEPARET (Matt. xix. 6, again an allusion to the union of the kingdoms). On the shillings the king's bust to the right is the type. From this time we may note in the English coinage the principle that each sovereign reverses the direction of the obverse type adopted by his predecessor. Thus the types on the coins of Elizabeth and Charles I., when profiles, look to the left, those of James I. to the right. The rule was broken by Charles II. and James II., but thenceforward has been rigidly observed.

In 1613 a patent was granted to Lord Harrington of Exton to coin copper farthings (Fig. 4). They are very common, and equally common were the forgeries which were made of them at the time. The obverse type is a crown over two sceptres in saltire, the reverse a crowned harp, which gives them an Irish appearance. Owing to the number of counterfeits which were made, these coins were exceedingly unpopular, but they were forced upon the public throughout the reign of James and the first ten years of that of Charles.

The reign of Charles I. did not see any important alteration in the coinage, but at the same time the troubles of the reign could not but be reflected in the coins, and lend them an unusual interest. The legends employed by James were replaced by others, as on the angel here figured (Fig. 6), which reads AMOR POPVLI PRÆSIDIVM REGIS. The facts of the reign lend a peculiar irony to this as to many others of the legends of Charles I.'s coinage. Another legend of interest is that relating to the declaration made by the king, in 1642, that he would preserve the Protestant religion, the laws of England, and the freedom of Parliament. This is recorded, for instance, on the fine three-pound pieces, which read RELIGio PROTestans, LEGes ANGLiæ LIBERtas PARliamenti, with a motto revived

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* The first of these articles appeared in the May and the second in the August numbers of Knowledge.

* The ryal, or rial (from *regne*) was a gold coin which fluctuated in value from ten shillings sterling in the reign of Henry VI., and fifteen shillings in that of Elizabeth, to the amounts mentioned in the text.

from the coinage of James I. These pieces were struck at Oxford, the only mint besides that at Bristol from which gold is certainly known to have been issued.

The number of mints for silver was, however, considerable, the most important being the Tower. Among the silver coins, particular notice is due to the crown, which was designed at Oxford by the engraver Rawlins, but which probably never came into circulation (Fig. 5). The work, though somewhat finicking, is above the average, and the piece gains a special interest from the view of Oxford, in which the tower of Magdalen and the spires of St. Mary's and another church, as well as the fortifications, are clearly discernible. The signature R is in the left-hand corner. The reverse bears the Declaration. Another famous engraver of the time was Nicholas Briot, a Frenchman, who was employed in England from 1628, and whose work is exceedingly neat, though wanting in spirit. The angel here figured (Fig. 6) is from his hand.

Several of the fortresses which were besieged in the Civil Wars produced an irregular currency—known as siege-pieces, or money of necessity—to supply the want of ordinary money. These were supposed to be redeemable at the close of the siege. The rudeness with which some of them were executed is well shown by the piece of Scarborough (Fig. 8), which is merely a piece of silver plate doubled up and stamped on one side with a representation of the keep, and the value (II. S. VI. D.), on the other with OBS *Scarborough* 1645. The castle of Pontefract held out after the death of Charles I., and we find siege-pieces struck there in the name of Charles II. with the motto POST MORTEM PATRIS PRO FILIO.

The abuse of the farthing coinage instituted by James I. led Charles, in 1635, to issue, no longer by contract but under his own direct authority, a series of farthings, differing from the old issue mainly in having the harp replaced by a rose. These were known as "rose" or "royal farthings," as opposed to the old "Harringtons."

The Commonwealth coinage is somewhat uninteresting, owing to the fact that the device on all denominations except the halfpenny is the same, viz.: on the obverse, in a wreath composed of branches of palm and laurel, a shield bearing St. George's cross; on the reverse, two shields bearing St. George's cross and the Irish harp. The appearance of the reverse gave rise to the nickname "breeches-money." The legends are in English: THE COMMONWEALTH OF ENGLAND and GOD WITH VS. The illustration (Fig. 7) is of a gold crown of 1650. The halfpenny has simply shields with the cross of St. George on one side and with the harp on the other, without legend, date, or value.

In 1656 and 1658 the mint produced several pieces in gold and silver bearing a fine portrait of Oliver Cromwell. These were executed by Thomas Simon with the mill and screw, instead of with the hammer, which had been commonly used under the Stuarts. But these pieces were never put into circulation, Cromwell probably fearing to assert his personal power in this way. For the sake of the portrait a pattern for the "broad" may be illustrated (Fig. 9).

Some of the gold and silver patterns made at this time furnish the first instance of an inscription on the edge of a coin. The motto, DECVS ET TVTAMEN, which now protects, though hardly ornaments, the edge of our crown pieces, first occurs on the five-guinea pieces of Charles II.

A large number of patterns for copper coins were made during the Commonwealth, but none appear to have been put in circulation. Many of the patterns from this time are made of two metals, as of brass with a copper centre, or a copper centre enclosed in a ring of bell-metal, or with a brass obverse and a copper reverse. The Commonwealth copper patterns have all English legends, as: ENGLAND'S FARDIN; reverse, FOR NECESSARY CHANGE.

The Restoration brought about a return to the old types and the old method of hammering. Before long, however (1662), the mill was re-introduced, and this time for good.

In order to establish the new process, Blondeau, who had perfected it, was brought over from Paris. A previous attempt to bring him over, as early as 1649, had failed, owing to the jealousy of the English officials. He was now appointed to strike coins from dies provided by Thomas Simon, and by John Roettier, a native of Antwerp. Simon is undoubtedly the greatest of the engravers of English coins, but Roettier's patterns were preferred, and this caused Simon to produce the splendid piece known as the "Petition Crown" (Fig. 11). Round the edge runs the petition: *THOMAS SIMON* MOST HVMBLY PRAYS YOVR *MAJESTY* TO COMPARE THIS HIS TRYALL PIECE WITH THE DVTCH AND IF MORE TRVLY DRAWN & EMBOSS'D MORE GRACEFVLLY ORDER'D AND MORE ACCVRATELY ENGRAVEN TO RELEIVE HIM. For delicacy and finish, both of design and of execution, this piece has never been surpassed.

The value of the gold coins struck with the hammer was slightly raised in 1661, and the new gold pieces struck from Roettier's dies with Blondeau's mill were made somewhat lighter in proportion. The twenty-shilling pieces were struck at $131\frac{29}{41}$ grains, and were known as Guineas, to distinguish them from the older broads. The name is due to the fact that most of the gold used for these coins was brought from Guinea by the African Company. In 1670 the weight of the guinea was reduced to $129\frac{39}{89}$ grains, at which it subsequently remained. The specimen illustrated (Fig. 10) is one of the first struck. There were also five-guinea, two-guinea, and half-guinea pieces. In this reign Maundy money of groats, threepences, half-groats, and pennies was first issued.

In copper, in the reign of Charles II. we have issues of halfpence and farthings; there are also farthings in tin, with a square stud of copper in the centre. The copper coins were not issued for currency till 1672, of which date is the halfpenny here illustrated (Fig. 12). On these coins for the first time appears the figure of Britannia. It was doubtless suggested by the design of some Roman pieces, but it is at the same time a portrait of the famous Duchess of Richmond.

We may pass over the next two reigns, only mentioning that by the time of the sole reign of William III. the silver coins had deteriorated so much in quality that the guinea passed current for thirty shillings, *i.e.*, fifty per cent. above its nominal value. The guinea, however, fell to its old value during William's reign, owing to the increased coinage of silver.

Copper (in both halfpence and farthings) was also coined to such a great extent in this reign that no fresh issue was necessary on the accession of Anne. Towards the end of her reign several patterns for copper coins were made. Among these is the Queen Anne's farthing (Fig. 14), with regard to the rarity of which the most absurd errors are prevalent. Of this coin, which, perhaps, was never actually in circulation, there is no lack of specimens. Another common error is to mistake copper or brass counters for the farthing; these were made in imitation of the silver sixpence, and therefore bear on the reverse the four shields instead of the figure of Britannia. The engraver of the farthing, as of many other coins of this time, was Croker, or Crocker, a German. The bust of Anne on her coinage is draped; her modesty, it is said, having induced her to alter the fashion of her predecessors.

ENGLISH AND IRISH COINS

Some of the gold coins of Anne have an elephant and castle placed under the bust, in token of the fact that they are made of gold brought to England by the African Company. Other pieces, both of gold and silver, struck in 1702 and 1703 out of metal captured at Vigo, in 1702, bear the name of that town. After the union with Scotland in 1707 an alteration was effected in the arms. These had been represented on four shields placed crosswise: the arms of England at the top, of France at the bottom, of Scotland to the right, and of Ireland to the left. The arms of England and Scotland impaled were now placed in the top and bottom shields, and France transferred to the right.

The accession of George I. brought about some slight alterations in the coinage. The letters F D (Fidei Defensor) were now for the first time added to the king's title. Besides this, a string of letters denote George's title as Duke of Brunswick and Luneburg, Chief Treasurer and Elector of the Holy Roman Empire. The arms of Hanover are now placed in the left-hand shield and the Irish harp in the bottom one, the others remaining as before.

In 1717 the value of the guinea was fixed at twenty-one shillings, which it retained until the re-introduction of the sovereign. In the next year quarter-guineas were also struck for the first time.

George II.'s coinage hardly calls for remark. After Crocker's death in 1740, John Sigismund Tanner was made Chief Engraver to the Mint; and it is possible that the slang term for a sixpenny piece is derived from his name. Some of the gold coins of this reign, either because they were issued for the East India Company or because they were made of gold from India, bear the letters E I.C. under the bust. Others, both gold and silver, of the years 1745 and 1746, read LIMA. The metal for these pieces came from Peru, whence Lord Anson had brought a quantity of bullion in 1744.

The reign of George III. is perhaps the most disgraceful period in the history of the later English coinage. In 1762 the issue of quarter-guineas was temporarily revived; in 1797 a new denomination of seven shillings, or one-third of a guinea, was issued. But the coinage of five and two guinea pieces was dropped, and even the ordinary gold currency was allowed to deteriorate to a very serious extent. As to the silver, it was excessively scanty and in a worn condition. With one small exception (one hundred pounds worth of shillings struck in 1763 for a special purpose) no silver beyond the usual Maundy money was issued until 1787.

The issue of 1763 was made on the occasion of the Earl of Northumberland's first public appearance as Lord Lieutenant of Ireland, when the shillings were distributed among the Dublin populace. By 1787 the silver coinage had become so worn that pieces on which nothing could be made out passed current. The shillings and sixpences now issued were quickly melted down, and now the Government resorted to the device of countermarking Spanish dollars to make them legal tender in England (Fig. 13, with the king's head), or even of completely re-striking the Spanish coins. It was not till 1817 that an entirely new coinage was issued. Guineas, half-guineas, and seven-shilling pieces were last coined in 1813; the sovereign, of 123·27447 grains (Fig. 15), and the half-sovereign, were now introduced. The dies for the early coinage of George III. had been engraved by Lewis Pingo. He was now replaced by Thomas Wyon, but the designs of a number of the coins were made by Pistrucci. To this somewhat over-rated artist the design of St. George and the Dragon, which now appeared on the reverse of the sovereign and crown, was due. It is not wanting in spirit, but has many faults. The admiration it excited at the time was partly due to the excellent way in which it was produced by the Mint. The reverse of the half-sovereign bore the royal arms.

No copper coinage was issued until the year 1770. From 1775 to 1797 there was again a cessation of copper coinage. The last year saw the first and last coinage of the "cart-wheel" type, including the only two-penny piece ever officially issued in copper. These pieces have a broad rim raised above the level of the *flan* and bearing the inscription. The coins were designed by Küchler. Another extensive copper coinage was issued in 1806 and 1807.

The new gold coinage of 1816 differs from the earlier issues in that the coins are smaller and thicker, and that the rim assumes a greater importance. The sovereigns will pack together more firmly than the old guineas, in which the rim was not raised to any appreciable height. The change is an improvement only from a commercial point of view, for it detracts from the value of the relief, such as it is. At the same time, the execution of the coinage of this period is an improvement on the last century, and infinitely superior to that of the present day.

The union of the kingdoms of Great Britain and Ireland in 1800 caused a further change in the arms. They were now quarterly—first and fourth England, second Scotland, third Ireland; the Hanoverian arms were borne on an escutcheon of pretence, and the arms of France abandoned with the title.

The coinage of George IV. is lacking in interest. It is only necessary to mention that in this reign a double sovereign was struck. Pistrucci engraved the dies. In 1824 he was ordered to engrave a portrait from a bust by Chantrey, but refused to work from any but his own models. The task was therefore given partly to William Wyon, partly to the Frenchman, J. B. Merlin.

Under William IV. some experiments were made with the coinage. The Masters of the Mint have been abused for abolishing the armorial device on the shillings and sixpences, and substituting the name of the denomination. The value had long been indicated on the smaller coins, and the art of the period was so bad that we can hardly find fault with the authorities for introducing what was at any rate a practical improvement.

In 1836 groats were once more issued for general circulation. They were continued into the next reign, but since 1856 have only been issued for Maundy purposes. The copper coins of this reign are somewhat rare, only a comparatively small number having been struck.

Pistrucci's St. George and the Dragon disappeared from the coins at the beginning of the present reign, and was replaced by a shield of arms, from which, of course, the arms of Hanover were removed. The portrait is by William Wyon, and is not unpleasing. Pistrucci's design was revived in 1871 for the reverse of the sovereign, in 1887 for the crown, in 1893 for the half-sovereign. In 1849 the florin was first coined. The bust was represented crowned, a revival from the times of Charles II. For some reason the words *Dei Gratia* were omitted on the first florin, which therefore goes by the name of the "godless florin." The mistake was rectified in the next and succeeding issues, in which the legends are in Old English characters.

From 1845 onwards the threepenny piece, of the same type as the Maundy money, has been issued at intervals for circulation.

In 1860 a change was made in the copper coinage, bronze (ninety-five parts of copper to four of tin and one of zinc) being substituted for copper, and the size of the coins being diminished. The bust was by L. C. Wyon. On the reverse the lighthouse and ship appeared for the first time.

The changes of the last few years are familiar to all, and need not be described, the more so as they have been almost uniformly for the worse. It may be noted that the striking of five-pound and two-pound pieces was revived in the year of the Jubilee (when the denomination of four shillings was also issued), and in 1893. The title of Empress of India first appears in the latter year.

Among the experiments of the reign may be mentioned the pattern five-pound piece of 1839 by W. Wyon, representing the Queen as Una with the lion. The piece is well executed, but when the design is considered it is a matter of congratulation that the piece remained a pattern. In 1855 and in 1872 mints were established at Sydney and Melbourne, and in 1863 and 1866 the coins issued from colonial mints, established or to be established, were made legal tender. The first Sydney coins bore AUSTRALIA across the field, SYDNEY MINT above, and the value below; but the later coins of Sydney and Melbourne are only distinguished from the others by the mint marks S and M. The mint mark H, which occurs on some of the bronze coins, is the mark of Heaton's mint at Birmingham.

Among the silver patterns the most interesting is the "Gothic crown" of 1846 and 1847 (Fig. 16), so called from the Old English lettering.

Patterns have been struck at various times for a decimal currency, some of them at the Mint, others by private persons. Of the former class very few are to be seen outside the Mint museum itself.

It has already been mentioned that the scarcity of small change had necessitated the production of a token coinage. The great mass of the tokens belong to the seventeenth and eighteenth centuries. Of the town tokens Fig. 17 represents a halfpenny of Wimborne (FOR THE VSE OF THE POORE OF WIMBORNE 1669; reverse, THEIR HALFPENNY; two women at a wash-tub). In London an enormous number of tradesmen issued their own tokens. Fig. 18 is a token of the Salutation Tavern (AT YE SALUTATION IN LOMBARD; two gentlemen saluting each other; reverse, STREET HIS HALFPENNY; in the centre the initial of the owner's surname is put above, H, those of his own and his wife's Christian names below, T M). Of eighteenth century tokens, those of the Paris Copper Mine Company, struck at Anglesea, are among the commonest. The obverse of the variety here illustrated (Fig. 19) bears a Druid's head; the reverse, the Company's initials in monogram, the date 1787, and WE PROMISE TO PAY THE BEARER ONE PENNY. On the edge: ON DEMAND IN LONDON, LIVERPOOL, OR ANGLESEY. The rarity of silver in the reign of George III. necessitated the issue of tokens to supply the place of silver coinage. Thus the Bank of England issued tokens for five shillings, three shillings, and eighteen pence (Fig. 21); the Bank of Ireland for six shillings, thirty pence, ten pence, and five pence. Besides these tokens, a large number of pieces, some with more or less fanciful designs and legends, some with political allusions, seem to have got into circulation, though there is little doubt that many of them were never meant to pass as coins, and were made for collectors. The production of private tokens for small change fell off after the issue of copper in 1806 and 1807, but the Bank tokens mentioned above are later.

The Scottish coinage ceases to have much interest from the time of the union of the two Crowns. There is a considerable variety of denominations with peculiar names, such as "bawbee" (derived possibly from the name of a mint master, the laird of Sillebawby), "bodle" (Bothwell?), "turner" (French *tournois*). The separate coinage ceases with the union in 1707.

In the reign of Charles I. a considerable amount of money was struck in Ireland. Not to mention the siege-pieces, we may note the so-called Ormonde money, which was struck out of silver plate, with C R crowned on one side and the value on the other.

Among the most interesting of the Irish coins are the St. Patrick's halfpence and farthings. The former represent a king kneeling and playing the harp, with FLOREAT REX; on the reverse, St. Patrick with his flock, ECCE GREX. The farthings (Fig. 22) have a similar obverse, but on the reverse the saint is represented driving out snakes and dragons; QVIESCAT PLEBS. These were struck in the reign of Charles II., but precisely for what purpose we cannot say.

The most important pieces in the later Irish coinage are undoubtedly the money of necessity issued by James II. after his abdication of the English throne. These are all made of bronze or gun-metal, and therefore known as gun-money. They were issued in the various denominations from the crown downwards. A peculiarity is that, besides the usual date of the year, they bear the name of the month in which they were struck. Thus the half-crown here illustrated (Fig. 20) was struck in March, 1689 (reckoning according to the civil year, which began on March 25th, for the order to coin this money was not issued till the 18th of June, 1689, of the historical year).

In spite of the union in 1800, the Irish coinage does not cease until 1823.

Here our sketch of the coinage of these islands must close. It has been impossible to do more than draw attention to the more important features in the history of our currency; while that of our dependencies we have had to pass over in silence. One point, it is hoped, has been made sufficiently clear: the Mint of our own days has a good deal to learn from the older coinage in the matter of technique. The Gothic crown showed a praiseworthy attempt to produce a decorative effect, but its archaisms were out of place. And if it is impossible to find a good design, it should be at least possible to strike the coins clearly. The Petition crown of Simon is sufficiently modern to serve as an indication of the spirit in which our coins should be decorated, and the finish with which they should be produced.

◆

OUR FUR PRODUCERS.—V.

THE CAT TRIBE, CIVETS, AND MONKEYS.

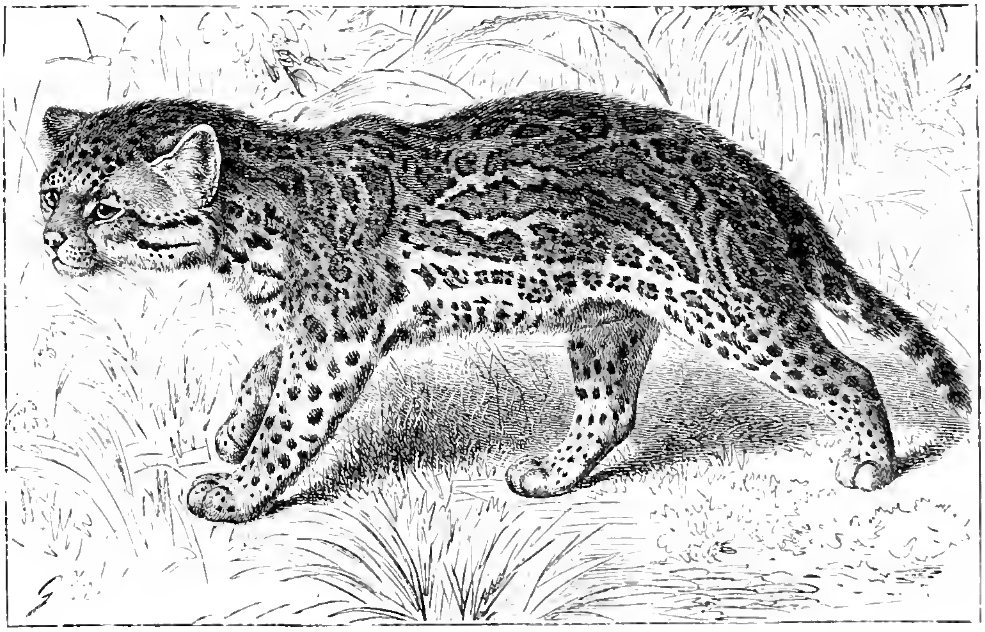
By R. Lydekker, B.A.Cantab., F.R.S.

THE whole of the four preceding sections of the present subject have been devoted to the furs afforded by the carnivora—either terrestrial or aquatic—but there still remain for consideration in the same great order the cat tribe (*Felidæ*), as well as the less important group of the civets and their allies (*Viverridæ*). Whereas the majority of the furs hitherto mentioned are more or less uniformly coloured, and are obtained from medium-sized or small animals, a considerable proportion of those yielded by the cat tribe have dark stripes or spots upon a light and frequently brilliantly-coloured ground, and many of these are of large size and the skins very thick. Consequently, such are much used as ornamental rugs or coverings.

As exceptions to the general type of coloration obtaining among the *Felidæ*, we may first of all refer to the lion of the Old World and the puma of America, in both of which the fur is normally of a uniform tawny hue (save the mane and tail-tip of many lions), although traces of spots may be detected in the young, and sometimes, under certain conditions of light, even in the adult. The beauty of a lion's skin depends almost entirely upon the degree of development and darkness of the mane; and it is a somewhat curious fact that this magnificent appendage attains larger and finer proportions in menagerie specimens than in wild animals, this being especially the case with regard to its extent on the under surface of the body. Still, captive animals lack that glossiness of mane which forms such a striking feature of the lion in its native haunts. That black-maned and yellow-maned lions belong to one and the same species, is, we presume, as well known as that there is no specific distinction between the African and the Asiatic lion. Black-maned skins are by far the most valuable. We are not aware of any instance of either black or white lions. With the puma the case is, however, different, black specimens being far from uncommon.

The skins of the ordinary Indian tiger are not of much value, but those of the long-haired and somewhat pale-coloured variety from Siberia and Mongolia command a much higher price. Turkestan tiger skins are also held in considerable estimation. Of the Siberian and Mongolian race, one hundred and thirty-five skins are said to have been imported into England in 1891. The scarcest and most beautiful variety is the white or buff tiger, in which the stripes are generally dark brown, although rarely dark drab.

In the pellage of the leopard, or panther (*Felis pardus*), there is even greater variation than in the tiger; this variation showing itself not only in regard to the size and form of the dark rosettes, but also in the length of the hair. African skins are nearly always distinguishable from Oriental; and whereas in Oriental countries a black variety is by no means uncommon, in Africa we only meet with races in which the rosettes on the back are agglomerated into a number of small spots, and the general tint of the fur is darker than usual. A few thousand skins of ordinary leopards annually find their way into the London market. In addition to being used as rugs, leopard skins are manufactured into trappings for the chargers of the officers and bandsmen of some of the British cavalry regiments, as well as for the aprons of the drummers of the infantry. By the Kaffirs, who prepare them in a remarkably excellent manner, they are used as karosses, or cloaks. In a variety of the leopard from China, described under the name of *F. fontanieri*, the fur is much longer and more woolly than in the ordinary form, while the dark spots of the rosettes tend to coalesce into more or less complete rings, recalling those of the jaguar, although the central dark spot of the latter is wanting. The ground colour is unusually light, and the tail very long and bushy. Another variety of the leopard (*F. tulliana*), with still longer and lighter-coloured fur, is an inhabitant of Persia.



The Ocelot.

Far handsomer than either of the two latter is, however, the snow leopard, or ounce (*F. uncia*), of the highlands of Central Asia, whose pellage excels in beauty that of all other members of the cat tribe. As shown in the plate accompanying an article on the coloration of animals published in the January (1895) Number of Knowledge, the spots form large interrupted rings or rosettes of irregular shape, and are superior in size to those of the typical form of the leopard. The ground colour is white, the entire fur very long (sometimes as much as two inches in length), and the bushy tail, which tapers but slightly, is nearly three-quarters the length of the head and body. Comparatively few skins of this splendid feline reach the English market.

The last of the larger members of the genus *Felis* is the American jaguar (*F. uncia*), readily characterized by the dark markings taking the form of nearly complete rings, with one or more black spots in the centre; the ground colour being some shade of tawny or orange. A black variety is not very uncommon.

In marked contrast to the wild species of true cats is the importance of the domestic cat as a fur producer, the number of skins annually used in the trade amounting to many thousands. The colours of the European races are too well known to need mention; and although to our mind dark tabby is by far the handsomest of all, pure black skins are those commanding the highest price.

More important than all other members of the family are the lynxes, the beautifully spotted or uniformly tawny skins being employed largely as what may be called personal fur—that is, fur used in dress. Of the number of species of true lynxes—that is, those in which the tail is very short, while the ears are each surmounted by a pencil of long hairs—there is much difference of opinion among naturalists. It will, however, suffice for our present purpose to say that there is the European lynx (*F. lynx*), which ranges over Northern Europe and Asia, and the closely allied North American lynx (*F. canadiensis*); while there is a more Southern American type termed the red lynx (*F. rufa*), and likewise a South European form known as the pardine lynx (*F. pardina*). Of the European lynxes it does not appear that many skins come into the market. On the other hand, American pelts form a very large item in the trade, the number sold yearly by the Hudson Bay Company usually varying between eight thousand and forty thousand, although in 1887 as many as seventy thousand were disposed of. Lynx fur may be used either of the natural colour, or dyed black, brown, "blue," or silvered. The longest fur is that on the under surface of the body; this being employed for boas, muffs, and trimmings. Lynx fur dyed brown is also the material employed in the busbies of the officers of the British Hussar regiments. Usually only the long winter fur shows the small black spots, the summer coat being short and uniformly coloured. Less common and of inferior value are the skins of the American red lynx. The bulk of this fur is stated to be exported to Eastern Europe. Of still less value is the skin of the uniformly red and longer tailed caracal of Africa, India, and Persia.

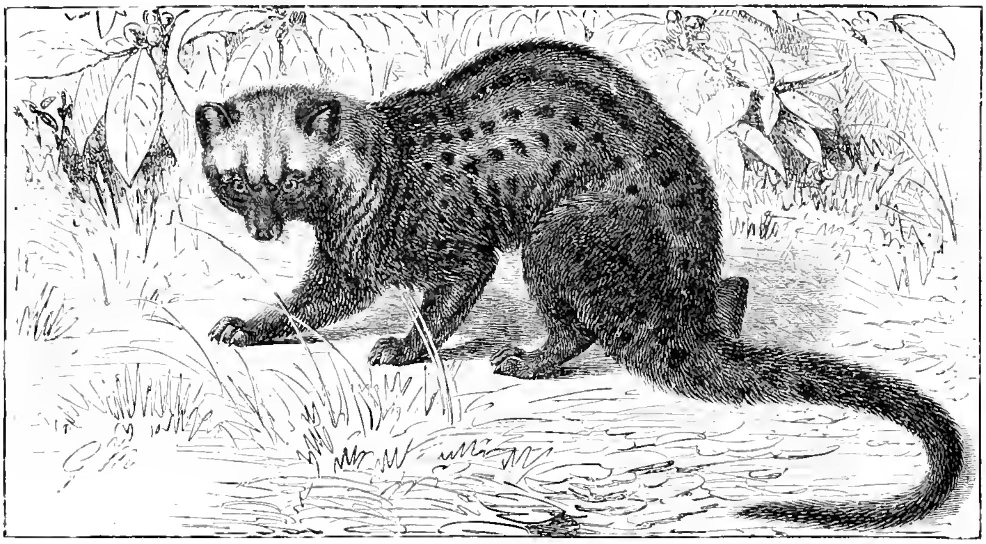
Of the hunting leopard, or, as it is commonly called, chita (*Cynælurus jubatus*), the black-spotted skins too seldom come into the market to be of any importance. This animal, which is one of the few species of carnivora common to India and Africa, is separated from the genus *Felis* on account of the claws being only partially retractile. Unlike those of the true leopards and jaguar, the black spots on the fur are solid, instead of forming rosettes with light centres.

The various species of the civet family (*Viverridæ*) occupy an unimportant position among the list of fur producers, the pellage being generally harsh, while many of the species are comparatively scarce animals. Of the African civet (*Viverra civetta*), not more than fifty skins are annually imported into this country.

The Indian species (*V. zibetha*), which has a nearly similar grey fur, marked with black streaks and blotches, seems to be still rarer. Much the same applies to the different species of the genets (*Genetta*), all of which have short, harsh fur. At a time when "pointing" furs (that is, introducing white-tipped hairs) was in fashion, there was some demand for the pellage of the Egyptian mungoose (*Herpestes ichneumon*). Even now a few hundred skins are imported.

Passing on to the monkey tribe (*Primates*), we find that all the skins used in the fur trade are obtained from various species of the Old World family *Cercopithecidæ*, not a single one of the numerous species of South American monkeys being even mentioned in commercial lists.

The species that yields the greater quantity of the pelts used in the fur trade seems to be the West African white-thighed thumbless monkey (*Colobus vellerosus*), which is abundant on the Gold Coast, and has the body clothed with a mantle of silky black hair measuring from two to four inches in length. Of this (and perhaps some allied) species as many as ninety thousand skins are annually brought to the London market. Considerable difference is stated to exist in regard to the texture of the fur of skins from different localities, which suggests that more than one species are included under the name of "black monkey." They are mostly brought down from the interior by native convoys, and exchanged at the coast for British produce. A large proportion find their way to Germany, although some are exported to Italy and America.


The Malay Palm Civet.

Most valuable of all are the skins of the beautiful guereza monkey (*C. guereza*) of Abyssinia and East Africa; a species characterized by the flowing mantle of elongated silky white hair depending from the black back down the flanks and hind-quarters.

Under the title of "common monkey" are imported skins of various species of another African genus (*Cercopithecus*), the most numerous of these forms being probably Campbell's guenon (*C. campbelli*) of West Africa. The importations of other African skins are too unimportant for mention; and we may conclude this section by adding that of the long-haired grey langur (*Semnopithecus schirtaceus*) of the Himalaya, from two to three hundred skins are annually received into this country.

THE HISTORY OF THE GREAT LAKES AND NIAGARA.

By Andrew J. Herbertson.

The problem of the origin of the Great Lakes and Niagara has always been an interesting one, and various theories have been put forward to explain it. Dr. J. W. Spencer, of the Geological Survey of the Great Lakes, has recently published a set of papers in which he attempts to reconstruct the past history of the Great Lake Region of America.*

Dr. Spencer believes that between the middle Miocene and early Pleistocene periods the region stood three thousand, perhaps even five thousand or six thousand, feet higher than at present. In support of this he appeals to the evidence of soundings round the American coasts, which reveal the existence of what appear to be ancient river channels. For instance, were the water to sink six hundred feet below its present level the banks to the south of Newfoundland and Nova Scotia would be dry land; but this would be traversed by a deep fjord over three thousand feet deep where it joined the sea, whose depth near its mouth would be five thousand feet. This channel, sixty miles wide at its mouth, follows for over eight hundred miles the bed of the present St. Lawrence River, growing narrower and shallower as it projects inland. Dr. Spencer supposes that previous to the existence of the present lake basins the continent was much higher, and was drained by a great river, which he names the Laurentian River, which excavated this deep channel. The depths of the various lakes afford corroborative evidence, the floors of Ontario and Superior being almost five hundred feet below the present sea-level, that of Michigan three hundred feet, and of Huron one hundred and fifty feet. The soundings of the lakes and borings in various regions reveal the ancient beds of this Laurentian River and its tributaries. Lake Michigan was drained by two rivers, one in the northern basin which flowed by the present outlet to Lake Huron, in the middle of which it was joined by a tributary running from the southern basin of Lake Michigan, across the present State of Michigan, and through Saginaw Bay. The united streams did not flow southwards towards Lake Erie, but first north-westwards to the present Georgian Bay, then south-eastwards near its western shore, and by Lake Simcoe, turning to the eastwards at a point in Lake Ontario nearer the southern than the northern shore, and thence to the sea by the present course. The Lake Erie basin was drained by another tributary which turned northwards by the Grand River and Dundas Valleys, and curved eastwards again at the western end of Lake Ontario, joining the Laurentian main stream at its bend opposite the mouth of the present Niagara River.

This river and its tributaries had eroded the region and formed broad valleys just before the Pleistocene period, and during that period, and particularly towards its end, parts of the old valley were gradually blocked. This blocking of the valley may have been due to the accumulation of glacial drift at some places, but Dr. Spencer believes that terrestrial warpings are a more important factor, and that these to a certain extent are measurable. The absence of glacial markings in the direction of the axis of the lakes goes to prove that they have not been hollowed out by ice.

Round the Great Lakes are found traces of terraces composed of waterworn pebbles, the result of the action of waves or of currents. These Dr. Spencer has examined and surveyed, and concludes that they are of marine origin at a time when there was a depression of the surface to over two thousand feet below its present level. He does not discuss the theory that they may have formed the shores of lakes retained by moraines, but he points out that glacial lakes retained by ice are neither large enough nor sufficiently long lived to account for such beaches. The depression of the continent at the time of the newest till is no more impossible than the generally admitted elevation of the pre-Pleistocene period, but the discontinuity of the terraces and the absence of salt-water deposits are difficulties in the way of the theory of their marine origin. The first of these objections is met by the answer that these terraces have not yet been perfectly explored, that subsequent terrestrial movements may have deformed them, and that erosive and other agents have been at work modifying the topographical features. As to marine deposits, these are found at a height of five hundred and twenty feet, but their absence at higher levels is not evidence of the non-marine character of these old shores, since there are many marine beaches in which no fossils are found.

When the depression of the land was greatest the region of the Great Lakes was then a huge ocean gulf, whose shores formed one of the raised beaches Dr. Spencer has surveyed. It is possible that at times the narrower parts of the gulf may have been filled up from giant glaciers, but these ice barriers could not retain a vast volume of water for any lengthened time.

But a close examination of the raised beaches leads to other conclusions. They do not lie parallel to the present water surface of the Great Lakes, but are usually higher above the lake level in the east than in the west, in the north than in the south. This affords important evidence of terrestrial deformation having taken place since the formation of these beaches; and these alterations of levels have resulted in the formation of the Great Lakes.

The first uplift seems to have taken place in the region to the south-east of the present Lake Huron, and when the land had risen one hundred and fifty feet the upper waters of the original gulf, covering Lakes Superior, Michigan, Huron, and Georgia, were separated from the lower waters which extended over the present Lakes Ontario and Erie. This great lake was at first joined to the sea by a broad strait covering the present Lake Nipissing and the Ottawa Valley.

The next event was the isolation of Lake Erie, and at first its waters, too, flowed to the Ontario Gulf without any perceptible fall. The upward movement of the land continued until there were three hundred feet of difference between the levels of the gulf and the lake, and the Niagara Falls came into existence. But the water falling over them was only that of Lake Erie, for the overflow of the upper lake still took place by the Ottawa Valley. This was the time when the beach round Lake Ontario (which Dr. Spencer calls the Iroquois) was formed approximately at the sea-level, and must have been after the uppermost drift was deposited, as it rests on mud covering the till. This beach is three hundred and sixty-three feet above the sea (one hundred and sixteen above the lake) at the western end of the lake, but it rises especially in the north, and at the east end it is six hundred feet higher than at the west end.

As the uplift continued more rapidly in the east than in the west the communication with the sea was gradually closed, save by the present channel of the St. Lawrence, and Lake Ontario was formed. The rising of the land

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* "The Duration of Niagara Falls and the History of the Great Lakes." By J. W. Spencer, A.M., Ph.D., F.G.S. Second Edition 1895. (Albany: The Commissioners of the N.Y. State Reservation at Niagara.)

went on, with some short pauses, until the level of the waters ultimately reached eighty feet below the present surface at the mouth of the Niagara Gorge, when the Niagara River was about four miles longer than now.

The Niagara River, which had first been a strait joining Lake Erie to the Ontarian Gulf, became a wide, shallow, rapid stream; and then, as the waters of the lower lake subsided, its bed narrowed and its fall increased to four hundred and twenty feet. But the river was soon greatly enlarged. The land was rising to the north of Ontario as well, and ultimately the outlet from Lake Huron to the Ottawa Valley was blocked, and the surplus waters of the three greatest lakes flowed by their present course to Lake Erie, and thence by the Niagara River.

With the continued rise of the land, especially towards the east of Ontario, the water-level rose until it attained its present elevation, and the fall of the river between the two lakes was reduced to the present three hundred and twenty-six feet.

Can dates be assigned to these events? The first estimate of the age of Niagara River was given by Ellicott over a century ago at fifty-five thousand four hundred and forty years; Bakewell, in 1830, gave twelve thousand; Lyell's estimate of thirty-five thousand was accepted for many years after 1841; but recent writers, using the mean rate of recession during forty-eight years as determined by surveys, make the value about nine thousand years.

Dr. Spencer has made a new and careful computation of the age of the Niagara River and Falls. He shows that the recent estimates have not taken into account the various changes that have occurred in the fall and volume of the river. His calculations result in a value nearly that of Lyell's. Dr. Spencer believes the Niagara River was formed thirty-two thousand years ago, and that a thousand years later the falls were in existence. For seventeen thousand two hundred years their height was about two hundred feet; thereafter the water fell four hundred and twenty feet. Seven thousand eight hundred years ago the drainage of Lakes Superior, Michigan, and Huron first flowed through the Niagara Gorge, and three thousand years ago the waters rose in Lake Ontario until the level reached that of to-day. The falls, then, are thirty-one thousand years old. This estimate, calculated from the rate of erosion, is confirmed by another made from the terrestrial movements.

Two deductions may be given—one as to the past, the other concerning the future.

The lakes came into existence after the glacial epoch, and Niagara after the lakes; and calculations based on the mean rate of rise of the beaches in the earlier period of the lakes' history show "that the close of the ice age may safely be placed at fifty thousand years ago."

As to the future. "With the present rate of calculated terrestrial uplift in the Niagara district, and the rate of recession of the falls continued or even doubled, before the cataract shall have reached the Devonian escarpment at Buffalo, that limestone barrier shall have been raised so high as to turn the waters of the upper lakes into the Mississippi drainage by way of Chicago. An elevation of sixty feet at the outlet of Lake Erie would bring the rocky floor of the channel as high as the Chicago divide, and an elevation of seventy feet would completely divert the drainage. This would require five thousand to six thousand years at the estimated rate of terrestrial elevation."

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"A CROCODILE MUMMY."—The reference to the reign of Ptolemy Philadelphus as B.C. 330, at page 211 of the September Number, should have read "B.C. 280."

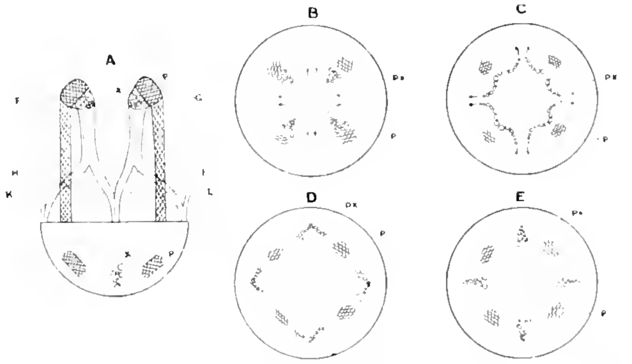
THE TRANSITION FROM STEM TO ROOT.

By A. MASLEN.

WHILST all students of botany may be presumed to be sufficiently acquainted with the minuter structure of the Phanerogamic members, and to know the fundamental anatomical distinctions between the stem and its direct prolongation downwards, the root, there still exists a region, viz., the hypocotyl—in which the actual transition takes place—about which their knowledge is perfectly *nil*. For information on this particular the student may search in vain in the ordinary smaller botanical text-books, excepting only the admirable little book of Dr. Scott ("Structural Botany." London: Adam & Charles Black, 1894), in which will be found a very clear though necessarily short account of the transition as it takes place in the Wallflower.

It seems opportune, therefore, now that a considerable amount of work has been done on this neglected subject, although very much still remains to be done, to endeavour to give a necessarily short but succinct account of our present knowledge.

It may, perhaps, conduce to clearness if we give just a brief *résumé* of the structure of a stem and root of a typical Dicotyledon or Gymnosperm. In a transverse section of such a stem we see around the pith an interrupted zone of vascular bundles, each of which consists of phloëm lying externally, *i.e.*, next the cortex, followed inwards by the xylem or wood, between which and the phloëm is a band of actively dividing cells—the cambium. Such an arrangement, in which the xylem and phloëm groups both lie on one and the same radius, constitutes what is known as a collateral bundle. But a point of great anatomical importance has been omitted, namely, that in the stem the first-formed xylem, or proto-xylem, which consists of smaller elements than either the later-formed primary xylem or the secondary xylem formed by the activity of the cambium, and which, moreover, is the only part of the xylem having annular or spiral thickening, *is always internal, i.e., next the pith.*



TYPE I.—A, Diagram showing longitudinal course of bundles through hypocotyl. P The phloëm. X The xylem (smaller elements the proto-xylem) B, C, D, E, Diagrammatic transverse sections through the hypocotyl showing transition from stem to root structure. P The phloëm. P X The proto-xylem. B, Through F G. C, Through H I. D, Through K L. E, Root structure. (The arrows indicate the way in which the rotation of the proto-xylem takes place).

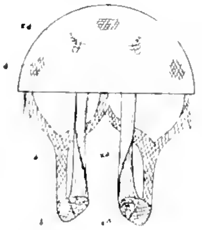
If, now, we turn to the root, differences are at once evident. If we examine a sufficiently young root (before secondary thickening has set in) we shall see that each bundle consists not of xylem and phloëm, but of only one of these constituents, and that, moreover, the xylem does not lie just inside a phloëm group as in the stem, but the two are arranged on alternate radii; hence such an arrangement of the bundles, which is typical of roots, is known as *radial*. Moreover, here the proto-xylem or oldest wood is *formed at the outside of the primary xylem.*

It is this position of the proto-xylem with reference to the primary xylem which constitutes the most valuable criterion in distinguishing between sections of stem and root—by no means an easy matter, especially after a deal of secondary thickening has taken place.

It is clear that the physiological necessities of the case demand perfect continuity of the corresponding tissues of stem and root, and we will now consider the structure of that part of the axis between the root and cotyledons, viz.: the hypocotyledonary stem or hypocotyl.

Transition from stem to root.—The work at present done enables us to distinguish at least four good leading types, which we will now proceed to consider in order—taking the simpler modes first:—

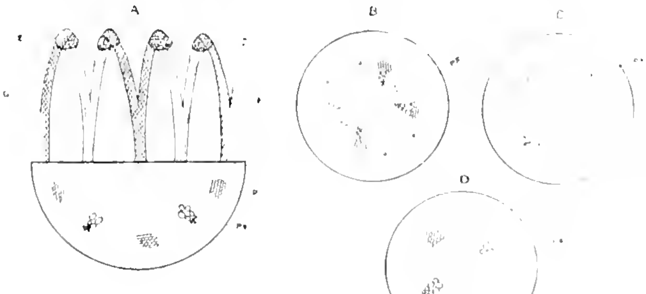
Type I. Ex Common Fumitory (*Fumaria officinalis*), Pinus, etc. Here the leaf-traces, as they come in from the cotyledons, place themselves in pairs, each pair lying tangentially across the stem with the proto-xylems facing one another. The phloëm (bast) then goes down into the root unchanged in position, whilst the xylem of each bundle divides into two portions, which diverge and ultimately coalesce with the corresponding segments of the xylem of its neighbours. Meanwhile *the proto-xylems have rotated* so as to be, not at the inner limit of the bundle, but at the most peripheral part of the primary xylem of the root.


Type II.—Diagram showing longitudinal course of the bundles through the hypocotyl. P The phloem. P X The proto-xylem.

In this way we get the transition from the nearly collateral bundles at the upper part to the typically radial arrangement of the bundles at the lower region of the hypocotyl, *i.e.*, where they enter the root.

Type II. Ex Biota (*Cupressineæ*), Medicago, etc. Here we have the converse case to the foregoing. It is the xylem which goes down unaltered except for the rotation of the proto-xylem, whilst the phloëm divides in a manner similar to the xylem of Type I.

Type III. Ex Phaseolus, Cheiranthus (wallflower), etc. This is a common type where there occur a relatively large number of leaf-traces; and whereas in Types I. and II. there are as many bundles in the root as there are separate groups of xylem and phloëm in the upper part of the hypocotyl, here there are only half as many.



Type III.—A, Diagram showing longitudinal course of the bundles through the hypocotyl. P The phloem. P X The proto-xylem. B, C, D, Diagrammatic transverse sections (four bundles only are shown). B, Through E F. C, Through G H. D, Root structure.

The two xylem strands of each pair fuse, whilst the phloëm strands of each pair diverge more and more from each other until ultimately they coalesce with the adjacent phloëm strands belonging to the pairs right and left of them. Meanwhile, the proto-xylem has rotated to the periphery of the xylem mass.

In the root, therefore, each xylem mass is the direct prolongation downwards of the two xylems of one pair, whilst each phloëm mass is the continuation of the phloëm of the adjacent bundles belonging to *two* pairs.

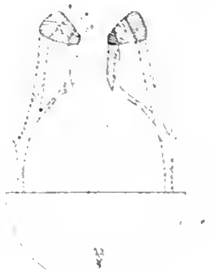
If we consider a series of transverse sections—in *Phaseolus multiflorus*—passing through the lower part of the stem, the hypocotyl, and the upper portion of the root, we see the following consecutive changes. At the base of the young stem we have typical collateral leaf-trace bundles. Lower, the cotyledonary bundles enter and join with the leaf-trace bundles, so that immediately below the insertion of the cotyledons we have eight vascular bundles in pairs; but in each pair the proto-xylem groups are not directed straight inwards, but are turned towards one another. Moreover, the primary xylem is not directly opposite the phloëm, but lies so that the two groups of xylem belonging to each pair are nearer to each other than are the corresponding phloëm groups. A section still lower will show that the xylem groups approach one another, and ultimately fuse at the same time that their proto-xylem turns more and more towards the outside.

Meanwhile the phloëm strands have undergone a similar change in the reverse direction. A section still lower will show that the xylem has closed up, the proto-xylem is directed straight outwards, and we have reached the typical root structure.

Type IV. Convolvulus, etc. Here matters are somewhat complicated by the structure of the vascular bundles, which are bi-collateral, *i.e.*, each bundle has two groups of phloëm, one being situated on the outside of the xylem and a second on its inner side. We have a similar transition to the *Phaseolus* type, with the internal phloëm superadded.

The internal phloëm joins the phloëm on the outer side of the bundle, passing in between the converging xylem groups.

It is evident that this phloëm must cross the cambium, but it is not at all clear how this is effected: whether it passes bodily through (which is improbable), or whether it is continuous through the cambium only in a metaphysical sense, *i.e.*, in the sense that a medullary ray is continuous through it.


Type IV.—Diagram showing longitudinal course of the bundles through the hypocotyl. P External phloem. P P Internal phloem. P X The proto-xylem.

In all the foregoing types, therefore, in spite of the different arrangement, the xylem and phloem of the main root are the direct downward continuation of the corresponding tissues of the stem, and this continuity is also preserved in the case of the pericycle as well as the endodermis and other cortical tissues. The only abrupt change is that of the epidermis of the stem to the piliferous layer of the root, *i.e.*, the layer which produces the root-hairs.

PHILOLOGICAL NOTE ON THE CONSTELLATIONS URSA MAJOR AND URSA MINOR.

By John H. Reynolds.

THERE is probably no constellation in the heavens which has excited such general interest amongst all nations and in all ages as the Great Bear. Its seven principal stars, nearly equal in magnitude, seem so conspicuously connected to the eye that even primeval man must have been impressed with their very definite appearance.[*] It is mentioned in the Rig Veda, perhaps the oldest piece of Aryan literature extant; it is recorded in Chaldæan and Egyptian monuments; Homer makes mention of it in the "Iliad" when describing the shield of Achilles:—

> "The Pleiades, the Hyades, the might
> Of huge Orion: with her Arctos called.
> Known also by the people's name, the Wain,
> That spins around the Pole."

And it is noticed in the works of Hesiod, Aratus, Ovid, Virgil, and Dante.

Its general name in Europe at the present time is "The Great Bear," which is simply a translation of the Latin "Ursa Major." However, it goes by several other names besides. It is known in the British Isles as "The Plough," "The Waggon and Horses," and "Charles's Wain"; in France as "Le Grand Chariot"; in America—that country of vulgarisms—as "The Great Dipper,"—*i.e.*, "ladle"; while the North American Indians call it "Paukimmwaw," which is said to mean "Ye stand alone."

Its likeness to a plough or waggon is very easily discernible, and it is only natural that we should find this idea generally adopted in all countries, ancient and modern. The Romans grouped the Great and Little Bear together and called them "Triones," literally "The Ploughing Oxen." The Great Bear by itself was called "Septentriones," or "The Seven Ploughing Oxen," the idea contained in this phrase being that the constellation known to us as "The Little Bear" was a plough, drawn by seven oxen, which were represented by the seven bright stars of the Great Bear. It was known to the Greeks also as ἅμαξα, the "Waggon" or "Wain." The Greek mariners always sailed by the Great Bear, which they called ἑλικη, "The Swinger," as it appeared to swing round the Pole once every twenty-four hours. The Phœnicians, on the other hand, used the Little Bear, which received from them the name of "Cynosura" ("The Dog's Tail").

The ancient Egyptians, fancying they saw a resemblance to the haunch of an ox, called it "Maskhaït," and depicted it as the detached leg, shoulder, and head of an ox; one of their "nomes" or provinces was named "The Nome of the Haunch" after it.[†] The Babylonians also had a name for it, but up to the present the constellation has not been satisfactorily identified.

The Latin *ursa* is of course the feminine form of *ursus*, and should be properly translated as "The She-Bear": the Greek word ἄρκτος, when Latinised, became *urctus*, contracted into *ursus*, and the idea of calling it "The Bear" came originally from the Greeks.

How it came to be called "The Bear" is a very interesting question. Virgil calls it "Lycaonis Arcton," or "Lycaon's Bear," which is explained by Ovid thus:—Callisto, the daughter of Lycaon, King of Arcadia, being beloved by Jupiter, was metamorphosed into a she-bear by Juno (or Diana), who was jealous of her; whilst in this shape she was killed in the chase, whereupon Jupiter transferred her to the stars. This legend, however, arose after the constellation was called "The Bear," and was invented simply to explain its presence in the sky. It is impossible that the Greeks should first have given it this name from a supposed resemblance to the animal, as they must have known what bears were like well enough not to have credited the animal with such a preposterous length of tail.

The most likely solution is that treated so eloquently in Max Müller's "Science of Languages." In the Rig Veda, before mentioned, there is the following passage:—"The Riksha, which are placed on high, and are seen by night, whither do they go by day?" The root *rich* means "to shine," and *riksha* meant primarily "the shining ones," and was applied to this constellation by the ancient Aryans; but the name *riksha* was also given to the animal with shining eyes and shining glossy hair, *i.e.*, the bear. By a natural confusion of ideas, the constellation itself ultimately became to be known as "The Bear," while the similar arrangement of seven smaller stars near Polaris was termed "The Little Bear." As Max Müller says in the book already referred to:—"The surprise with which many a thoughtful observer has looked at these seven bright stars, wondering why they were ever called 'The Bear,' is removed by reference to the early annals of human speech."

[I do not think it at all impossible that the Great Bear was so named by the ancients from a supposed resemblance to the animal. The distinguishing feature of the bear is its broad, flat feet, and these the celestial Bear certainly possesses in the three remarkable pairs of stars, ι and κ, λ and μ, and ν and ξ. If the name of any animal was to be given to the group, the bear was certainly the most natural to be chosen, in spite of the long tail which Ursa Major has to carry. On the other hand, Max Müller's explanation seems to me a little forced. Surely the ancient Aryans did not know the Polar bear; whilst the brown bear has no special claim to be regarded as "the animal with shining eyes and shining glossy hair."—E. Walter Maunder.]

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TOTAL ECLIPSE OF THE SUN.

THE following are the attendant phenomena that were observed during the total eclipse of the sun, occurring August 9th, and seen from the American line s.s. *Ohio*, off Stot Island, on the west coast of Norway, latitude 66° 57′ N., longitude 13° 30′ E.

According to Greenwich mean time, the first contact occurred at 8d. 14hrs. 58min. 22sec., and careful watch was made for the shadow bands. As the black disc of the moon slowly encroached upon the sun, a sombre, yellowish hue spread over the ocean and the hills on the Kunnen promontory near by, and just before totality a bank of grey clouds settled on the top of the hills. At the same instant the temperature fell two degrees, from 53° to 51°, whilst the seagulls flew affrighted from the approaching darkness. In the vicinity of the sun during totality the sky was cloudless, but of a dull greyish hue, and we were fortunate in having a perfect and uninterrupted view of the coronal streamers. A brief second before totality a faint outline of the inner corona could be seen, whilst during totality it was noticeable that the streamers directed from the solar poles were shorter and less brilliant than those extending along the eastern line. Along the western line a streamer reached to a distance equalling apparently three

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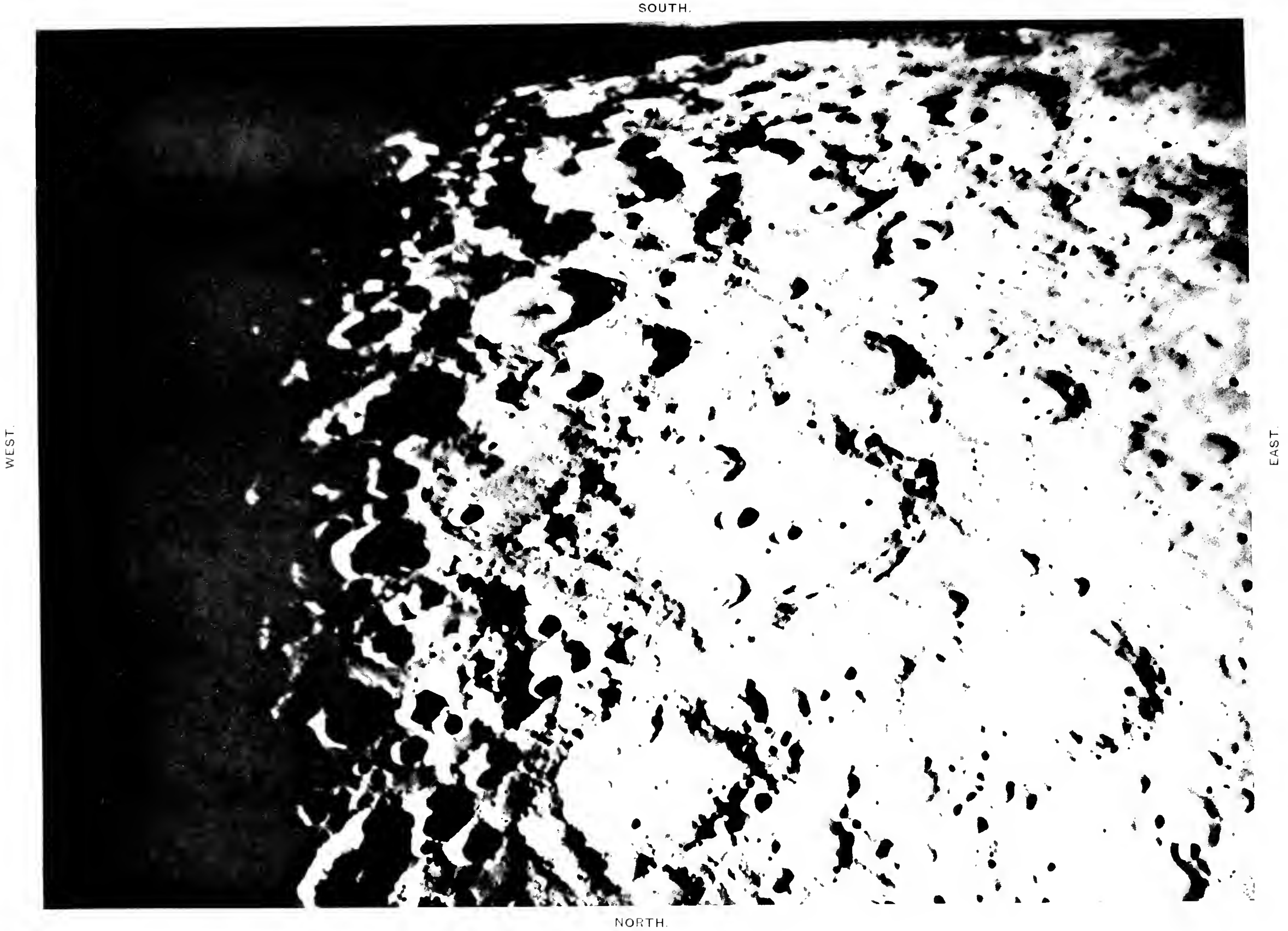
[*] Besides this apparent connection there seems to be a real physical one existing, as all the seven stars have been found to have a c.p.m. through space

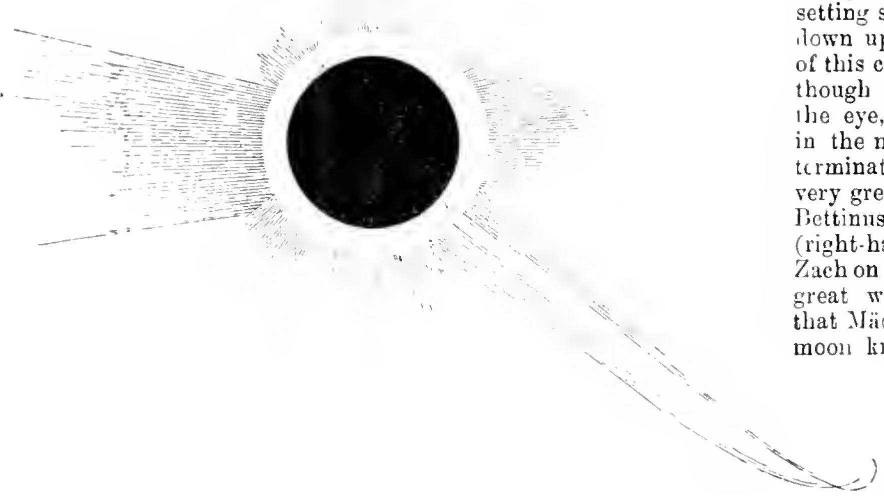
[†] This constellation is still known to the Arabs of the Pyramids as "Er-rigl" ("The Haunch").



CLAVIUS AND HIS NEIGHBOURS.

From a Photograph taken at the Lick Observatory, Mount Hamilton, California, 1895, October, 9d. 16h. 36m. 15s. 25s. Pacific Standard Time, with the 36-inch Refractor, and Brashear Enlarging Lens. Age of Moon, 21d. 15·5h. Scale, 44 inches to the Moon's Diameter.

times the diameter of the sun. Near the western edge there were two large prominences, whilst only a few smaller ones were to be seen on the eastern edge. Two or three seconds before totality ended, a narrow, dark streak of strong red light made its appearance on the western edge of the moon, and next moment the sun burst forth in a blaze of glory, and the corona vanished; but that impressive scene, occupying one minute and thirty-five seconds, is one that can never be forgotten. During totality, the planets Mercury, Venus, and Jupiter were plainly to be seen, and some of the well-known constellations. I could not spare the time to get a glimpse of Regulus, but it was seen by Captain Boggs and the chief officer of the ship, and also by some of the passengers. We closely observed the eclipse till the final contact, and within half an hour of totality clouds drifted across the sun resembling the cloud-belts seen upon the planet Jupiter. Just before the last contact the clouds were still drifting in that direction, so that we had to watch most carefully to detect the exact moment of the final contact.



The following are the data of the eclipse, furnished by Captain Boggs and E. Roberts, chief officer, and made according to the ship's chronometer and Greenwich mean time:—

	Days	Hrs.	Min.	Sec.	
August	8	14	58	22	First contact.
,,	8	15	53	25	Total obscuration began.
,,	8	15	55	00	Total obscuration ended.
,,	8	16	50	03	Last contact.

Mary Proctor.
(Daughter of Richard A. Proctor.)

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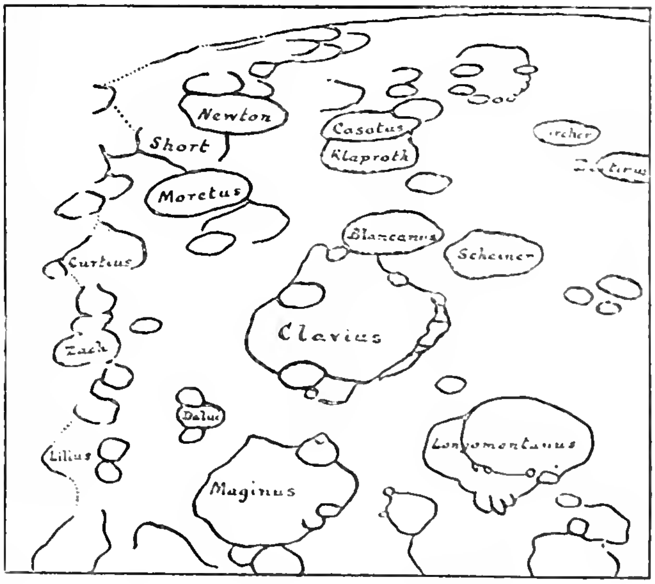
CLAVIUS AND HIS NEIGHBOURS.

By E. Walter Maunder, F.R.A.S.

The accompanying plate, which exhibits about the one-thirtieth part of the moon's apparent disc on the magnificent scale of forty-four inches to the lunar diameter, is reproduced from a fine photograph taken with the great refractor of the Lick Observatory, and which Prof. E. S. Holden, the director of the Observatory, has most kindly placed at our disposal. It represents sunset on perhaps the most broken and mountainous region of the entire moon, *i.e.*, that which has the great walled plain of Curtius as its centre. In the illuminated portion of the plate we find the giant-walled plain of Clavius, one of the princes of lunar formations, in a region of great walled plains only less striking than itself, some of them, though not equal to it in area, exceeding it in depth.

The region is one which undergoes the most striking change of appearance as the moon's age increases from the eighth to the twenty-third day of the lunation. For these broad and deep plains, so bold and striking, and with contrasts of light and blackness so intense under the rising or the setting sun, vanish almost completely when the sun shines down upon them from their meridian. Some indication of this contrast may be gained from the photograph itself, though it is less pronounced on the sensitive plate than to the eye, and the field here shown to us does not embrace in the main a greater arc than is traversed by the moon's terminator in three days. But even so, the difference is very great between the distinctness of such formations as Bettinus, Longomontanus, and Wilhelm I., on the east (right-hand) side of the plate, and Curtius, Moretus, and Zach on the west (left-hand). The disappearance of these great walled plains is so complete under a high sun that Mädler's words have passed into a proverb: "The full moon knows no Maginus." At such times the feature of the district is not the massive ramparts of the broad plains, nor the rugged and intricate mountain lands interlaced between them, but the long bright streaks radiating from Tycho—which lies just outside the present plate to the north—and extending to the very limb.

With such an infinite complexity of detail, and with such entire and rapid change of presentment, the region of our plate offers a fine field for the selenographical student. The careful and thorough scrutiny of each of the numerous formations here presented to us under all the variations of libration and illumination, would demand the fullest efforts of a large corps of observers. Under such circumstances it would be idle to attempt here anything like a full description of the entire district. A brief mention of the principal objects will suffice.



Key to Plate. Clavius and his Neighbours.

Clavius, by far the largest member of the group, has an area about equal to that of the six northern counties of England, and its wall, for the most part, considerably exceeds two miles in height, whilst two of its peaks would much overtop Mont Blanc. Two ring plains, themselves of great extent, occupy the south-western and north-western portions of the wall, and a chain of important but smaller ring plains follow a well-marked curve across the centre of the great plain. An infinity of minor details will reveal themselves to the student either at the telescope or upon examination of the photograph, and repay his scrutiny; whilst, as a mere spectacle, from its vast extent and the loftiness of its rampart Clavius is an object of extreme beauty when seen on either terminator.

The next in importance to Clavius is Maginus, the border of which is an object of the most complicated structure. As seen in the photograph, the western rampart appears as complete as that of any of the neighbouring plains, whilst it is much loftier. The eastern wall is honeycombed with craters and small ring plains of great depth. The region to the north-west of Clavius and south-east of Maginus is a mountain labyrinth of the greatest intricacy.

Third of the walled plains before us is Longomontanus, with an area about that of Yorkshire. This, from its higher illumination, appears a much shallower formation than the two already mentioned, and indeed its rampart is not quite so high; still, its principal peak, which is quite clearly seen on the photograph, rises to a height above the interior equal to that of Mont Rosa.

Of the smaller walled plains, Klaproth may be readily distinguished on the photograph by its smooth floor; Casatus, its companion, by a deep central ring plain and by a rampart of unusual height, its highest peak, which the photograph distinctly shows at the western angle, attaining a height of over four miles. Moving westward from Casatus we come to Newton, perhaps the deepest walled plain on the moon. On the western side of this, a bright projection is seen in the plate, marking the place of the chief peak of Newton, one of the very loftiest that the entire lunar surface presents. Moretus is distinguished by its superb central mountain, according to Beer and Mädler the highest central mountain on the whole moon.

Of the other formations, the most considerable are Scheiner and Blancanus, to the south of Clavius, and Curtius on the terminator. The northern wall still retains in its principal peaks the sunlight which has passed from the interior of the plain, for it towers some sixteen thousand feet high, and in its loftiest peak it rivals even the pinnacle of Casatus. Kircher, near the eastern edge of the plate, reveals its character very plainly as a very deep ring plain with a smooth floor. The south pole lies in the shadow where the limb appears broken at the top of the picture near the terminator. Lastly, if we follow the terminator to an inch and a half from the foot of the plate, we find the sunlight withdrawing itself from the ring plain of Lilius, an object which just came into the field of our last lunar reproduction, namely, that which appeared in Knowledge for April, 1896.

THE RECEPTION OF DR. NANSEN AT CHRISTIANIA.

When the news of Dr. Nansen's return with Lieutenant Johansen first reached Christiania it was scarcely believed. When the report was confirmed, however, and we read the account of his marvellous journey, the universal excitement and enthusiasm throughout the country were quite unprecedented. The news of the arrival of the *Fram*, with all on board well, a week or so later, of course added to the fire already kindled, and all Norway seemed to go mad. Preparations were soon begun for a national reception at Christiania. This took place, as the readers of Knowledge will remember, on September 9th, and a few details of the fête by an eye-witness may not be out of place here, since they concern one who has undoubtedly immensely benefited science by his wonderful journey.

It was a glorious sight that met our eyes as we steamed into the harbour in our little launch. Ship after ship, decked from bow to stern with flags, was taking up her place in the double line which was to steam up the fjord to meet the *Fram*. The ice breakers with their broad beams led the way, and these were followed in long lines, almost as far as the eye could see, by steamers of every sort and shape, each one having an assigned position according to her size. Glancing toward the shore one could see hundreds and hundreds of sailing boats and rowing boats—a mass of flags and bunting.

The Harbour before the arrival of the *Fram*.

At last we caught sight of some gunboats, and then the *Fram*, conspicuous by her tall mast and white crow's-nest, appeared from behind a distant point. Salute after salute was fired from fort and gunboat, as she passed up between the lines, while every steamer dipped her flag, and every man cheered until he was hoarse.

Then the boats turned and followed the *Fram* into harbour. Arrived there, Nansen and his brave companions were rowed ashore by a crew from the training ship. The reception on shore was quite as grand in its way as the reception on the sea. Speeches were made on the quay, and again at the University, as these thirteen men drove through the densely packed streets to the castle. The whole town was decorated in the most gorgeous fashion.

Such universal enthusiasm would indeed be difficult to match; the sharp hurrahs and the clapping of hands of the Norwegians, and every now and then, high above the general clamour, the "hip, hip, hurrahs" of a party of Englishmen, deafened all around.

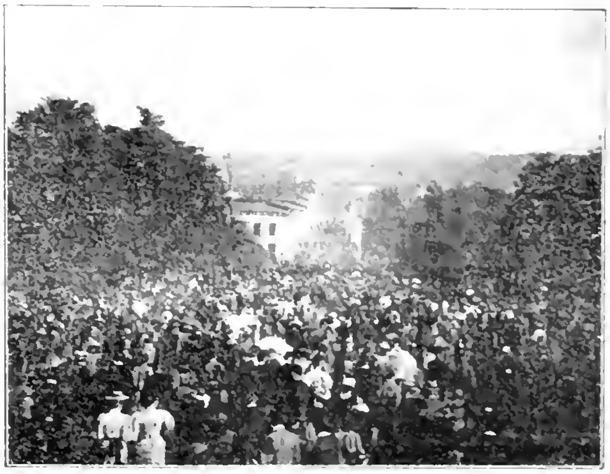
At length the procession arrived at the palace, and while Nansen and his comrades were being received by the King, a huge, expectant crowd gathered below. They were not to be denied another chance of seeing their champions. Continual cheering and clapping of hands went on, while one man cried out "All hands on deck." Almost immediately, as if in response, the King in person led out Nansen and Sverdrup to the balcony; then the rest of the expedition, and once more Nansen—this time alone—and never did the enthusiasm abate.

The *Fram* being towed into Christiania Harbour.

A great state dinner followed, and in the evening perhaps the most picturesque sight of all, though witnessed by comparatively few. Dr. Nansen lives in an elegant little house overlooking the fjord at Lysaker, some four miles from Christiania. Along the whole route, as he drove home, torches and coloured lights were blazing. Arrived at his house a pretty scene was enacted. In answer to the cheers of the crowd, Nansen came out, and with much feeling exclaimed, "Many thanks—many thanks to everybody." His fine figure silhouetted in the doorway, and a glimpse of those within preparing his coffee, formed a vivid contrast of peaceful home life with the hardships and dangers which he had experienced during the past three years.

Two days afterwards Lieutenant Johansen very kindly showed us over the *Fram*. It seems incredible that any boat could stand—at all events without injury—such pressure and knocking about as this wonderful boat has sustained. Yet she appears perfectly sound, and the only evidence of the rough usage by the ice is the paintless condition of her hull.

Getting on board, we were first attracted by some shaggy-coated, handsome sledge dogs, born up in the Arctic regions, with their mother, who is the only survivor of all the dogs taken out. Then we went down into the fore hold, and Johansen showed us the kayaks, sledges, and ski used by himself and Nansen on their memorable journey. A greasy dirty pot, too, blackened and covered with blubber, in which they boiled their soup. He also showed us their sleeping bag, made out of a Polar bear's skin, with the fur inside, remarking as he drew it out, "Many is the good time Nansen and I have had in that!" and one could well imagine it after toiling and straining all day. The sledges bore many traces of the hard work they had been put to, being tied and patched all over with consummate care. On their journey across the ice the sledges bore the kayaks, while the kayaks bore the sledges across the water, and one wondered that such frail craft could take such a load unless in the calmest sea. We visited the tiny saloon and cabins, and examined the rifles and other equipments, all of which had their interest when one considered that the fate, maybe, of both ship and crew depended on every little thing going right. An American organ in the saloon was not the least interesting



The Crowds in the Streets after the Procession object, and that it had been much used, and by no tender hands, to cheer those on board in the long Arctic night, was apparent.

In conclusion, let us heartily congratulate Dr. Nansen and his brave companions on their wonderful success, not only in reaching the furthest point north ever before attained by man, but in bringing back ship and crew safe and well, and with three years' provisions still on board.

H. F. W.

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Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

HOW TO OBSERVE THE INTERIOR OF ONE'S OWN EYES.

To the Editors of Knowledge.

Sirs,—In Knowledge for May, 1894, Vol. XVII., p. 117, a letter appeared describing how a man may see a cataract on his own eye by looking through a pinhole in a card held close to the eye. But there are many other and some better methods of seeing this and any other markings there may be, either in, on, or in front of the eye; eyelashes will be seen if they are allowed to come in the way, or drops of water on the surface, and muscæ volitantes are very clearly seen. Some methods of viewing the marks have one advantage, and others have another. One of the best is by looking at a bright star or distant lamp through a telescope, using a high power eyepiece very greatly out of focus. Instead of a star, the sun or moon may be used, especially if the aperture of the telescope be reduced to very small dimensions. Or an eyepiece alone, without the telescope, but looking through a pinhole diaphragm. Or one may look through a microscope at a concave reflector turned to the sky, the reflector being covered by a piece of paper with a small hole in it. Any point of light close to the eye will do, such as the sun's reflection in a small drop of water.

In some of these ways the marks may be seen quite sharply defined and very highly magnified; but they are necessarily bordered by diffraction lines and rings. By moving the eye, one can distinguish by the changing positions and apparent size of the marks the various depths from the surface at which they are situated; and by suitable experiments one can measure these distances when the focal length of the lens used is known. I thus calculate—without allowing for the refraction of the eye—that in my own case the principal marks are at a depth of about 0·26 inch from the surface, while the next in importance are at about 0·10 inch. These measurements are only rough, but I have no doubt it would be possible to make them with a high degree of accuracy. If the refraction of the eye were allowed for, the distance of the marks from the surface would come out greater.

I have made an estimate of the degree of magnification obtained by some of the methods named. One of the marks on the lens of the eye was found to be 0·017 inch across; and this was so magnified as to subtend an angle of seventeen degrees or more. If such an object were viewed at a distance of ten inches, which is considered a normal distance, its diameter would be six minutes of arc. Its magnification to a diameter of seventeen degrees is therefore equivalent to viewing it with a magnifying power of one hundred and seventy. The advantage of high magnification is partly neutralized by the difficulty of keeping one's eye steady, and the consequent great mobility of the image; also by the outlines being less sharp.

It is very interesting to observe the changes taking place in one's eyes from time to time, and to note how extremely slow most of such changes are.

T. W. Backhouse.

VARIABLE STARS.

To the Editors of Knowledge.

Sirs,—Chandler's Third Catalogue of variable stars has appeared, and is an invaluable document involving an immense amount of work and judicial calmness, both of which have been bestowed upon it to the great credit and honour of the author.

Turning to the stars in which the present writer and many of your readers have been interested during the past two years, Mr. Chandler, in his notes, says of Mira ο Ceti:—

"806. Discovered by Fabricius, 1596; recognized as periodically var. by Holwarda, 1638. Principal epoch of elements in catalogue corresponds to Ep. 227 of Argelander. Periodical terms given in Second Catalogue are here suppressed. Although they are undoubtedly real, complication with other unknown terms makes the accurate prediction of phases at present impossible. 9^{m} 1 foll. 7^{s} 7, 10″ N."

This satisfies my contention, and shows that the discussion on Mira in Knowledge last year was both timely and useful—in good season and with good cause.

It is remarkable now, at the close of the third centenary of its discovery, that such an announcement should be made, and the question naturally arises: Has a new term come in, or have the observations been more frequent and careful—the observers more numerous and self-relying? No doubt new blood, fresh thought working beyond the shadow of great minds, away from the influence of authority, is useful, if not essential to development and progress. Be this as it may, Mira the Wonder sinks to her third centennial minimum a greater wonder—a deeper mystery—than ever.

Before quitting this subject, it may be useful to say that full weight is not given by the writer to his estimate of the light of Mira, January 19th (Knowledge, June). The conditions were not quite normal.

In reference to R Leonis, which has also been mentioned in these notes, Mr. Chandler says:—

"3493. The periodical inequality of the elements in the Second Catalogue certainly exist. But the observations of the last few years show that it is complicated with other unknown terms. Until the law is developed by future observations, it seems best to use only the uniform period of the catalogue for prediction of phases."

In the last eight years the errors in maximum of this star have been as follows:—

1888.	Yendell ...	+ 6^{d}	1894.	H. M. Parkhurst	− 22^{d}
1889.	Yendell ...	+ 11	1894.	Sawyer ...	− 28
1890	Yendell ...	+ 8	1895.	H. M. Parkhurst	− 50
1893.	Gruss and Lasker	+ 4	1895.	Yendell ...	− 33
			1896.	Yendell .	− 38

Mr. H. M. Parkhurst has made no report on this star as yet. The present writer's figures, which have already appeared in Knowledge, are, for 1894, 1895, and 1896: − 22^{d}, − 42^{d}, and − 40^{d} respectively. The change, so sudden and so definite, is remarkable and suggestive of a new force of an unknown nature. And it will hardly escape attention that while a retarding force has operated on one of these stars, an accelerating force has acted on the other, and in nearly equal times; one being behind about as much as the other is ahead of time.

Of R Scuti, 6733, Mr. Chandler says: "Large irregularities." "Argelander found bright and faint minima, usually alternating, and this has been confirmed by all subsequent observers." He states the main period and gives no point of departure. A well-known observer writes me, "No elements yet devised will fit this star long." The maximum of R Scuti is due 26th July; but a week ago it was the faintest star in the little group and was close to minimum.

Much new matter has been added to the Third Catalogue, and it seems indispensable to observers of variable stars.

Memphis Town, U.S.A. David Flanery.

THERIDION LINEATUM.—A NEW VARIETY.

To the Editors of Knowledge.

Sirs,—At the beginning of August I found on a nut hedge at Elmsett, Suffolk, a bright-coloured yellowish-green spider, devoid of markings on the upper part of the body, and only marked by faint grey transverse lines under the abdomen. Having never met with this spider before, I shall be glad to know if any reader of Knowledge is acquainted with it. This variety appears of rather sluggish habit, and is not retiring; it drops by a short line, and then commences fresh operations among the leaves. I note that the colour has a strong "protective resemblance" to that of the leaves where I found it. Size rather smaller and abdomen more globular than the variety of theridion, Plate IX., I*b*, in Staveley's "British Spiders."

Samuel Barber.

SUNSPOTS.

To the Editors of Knowledge.

Sirs,—It would be very interesting to know, if those who make solar physics their study would tell us, whether they think the decline of sunspots and faculæ which is now taking place, in any way causes a decline of storms here.

It seems to be acknowledged that any sudden disturbance on their part (as September 1st, 1859) causes at once a corresponding electrical storm here.

We seem to have by no means had as many thunder-storms as usual this year. It would be interesting to know whether, on the average, the storms are less as a rule when the spots are at a minimum, or not.

Albert Collison.

[Both the late Mr. Whipple and Mr. Ellis, than whom there are no higher authorities, regarded the supposed correspondence between the solar outburst of September 1st, 1859, and the small magnetic movement observed at Kew and Greenwich on the same day, as a mere accidental coincidence. Magnetic movements are the only terrestrial phenomena which have as yet been conclusively shown to vary in connection with the changes in solar spots, and even in their case the relation is so far from being a simple one that, beyond a general correspondence in the two curves, and a rough coincidence as to the time of certain exceptionally large disturbances, we are unable to state anything as to its character. To trace a connection between terrestrial weather and sunspots, should it ever be accomplished, will be a far more intricate task, and it may safely be predicted that the complicated irregularities of English seasons will not furnish us with our first clues towards a solution of the problem.—E. Walter Maunder.]

THE THEORY OF THE TIDES.

To the Editors of Knowledge.

Sirs,—Will you allow me to notice briefly the letter of your correspondent Mr. G. H. Hill, in your September Number?

In the "weight" theory there is an undoubted cause for tide bulge, but an insignificant one, the actual amount of its insignificance not being worth dispute. Nor does it seem material whether one has in mind the full force of gravity or its diminished effective force, when one says that the tidal power of the moon can raise nothing towards herself in direct opposition to gravity. The numbers quoted in his third paragraph are now obsolete, the data having been changed since the calculations were made.

The quotation from the "Outlines" offers no explanation of how "the difference of the attractions" raises up the waters; but, reading further on, we find that the author, following up his analogy of perturbation, gives an explanation of the tide bulges which is remarkable among explanations for containing no trace of the ideas of "suction" and "slip." He shows that the tidal forces, with him the "disturbing force," when compounded as a whole with gravity, give for each particle of the water an effective gravity of altered intensity (1) and of excentric direction (2); and, applying to that state of things the law "which requires the direction of gravity to be everywhere perpendicular to the surface of a fluid in equilibrio," he deduces the form of an elongated ellipsoid.

The application of that law involves the admission, though it somewhat conceals the fact, that the agent in the change of form, or bulging, is water pressure due to the tidal forces.

J. Creagh.

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Notices of Books.

Report of the United States National Museum, 1893. Pp. 794. (Washington: Government Printing Office.) We are not among those who take every opportunity to belittle the systems of our mother-country, but with this ponderous and wonderful report before us the thought comes that British Governments could learn a lesson of liberality to science from across the Atlantic. The report is not merely a bald statement of work accomplished at the United States National Museum in 1893; it is a library in itself on museums and their administration. There is a section on recent advances in museum method, illustrated by sixty fine process-blocks representing specimens, groups, and methods of arrangement in the United States National Museum. There are also numerous long papers describing and illustrating collections in the museum, among the subjects being the poisonous snakes of North America, Chinese games with dice and dominoes, the onyx marbles, cowbirds, primitive American armour, the weapons and wings of birds, and the ethnology of Tibet. In fact, the report is a veritable mine of information which curators of museums know and treasure, and which naturalists generally should take the earliest opportunity of seeing.

On the Adjustment and Testing of Telescopic Objectives. (T. Cooke & Sons.) The first edition of this little work, published in the summer of 1891, met with such a favourable reception by the astronomical public—being deemed worthy of being translated into German by Dr. Rudolph Straubel, of Jena, and into Italian by Prof. Tocchini—that the authors felt justified in preparing a second and larger edition. This is all the more necessary since Messrs. T. Cooke & Sons, in the spring of 1894, introduced to astronomers a new objective, consisting of a triple lens, adapted for either photographic or visual observations, and superior to the double lens hitherto made in being perfectly achromatic. This form of object glass has proved so entirely satisfactory that it will probably be alone made at the Buckingham Works, York, to the exclusion of all other.

The first part of the book corresponds to the first edition, but it has been carefully revised, and a description of the new Cooke photo-visual objective added. Mr. Dennis Taylor's two valuable papers, read before the Royal Astronomical Society, on "Secondary Colour Aberrations" and "A Perfectly Achromatic Refractor," are added as supplements, and increase the completeness and value of what was from the beginning a most useful little manual.

Whilst cordially recommending the entire book to those who use the telescope, we would draw especial attention to some points in the chapter on the general treatment of objectives. The need, as great in the case of refractors as of reflectors, is emphasized of preserving the objective in dry pure air. In humid climates a fine film of moisture deposits or exudes from the interior surface of the crown lens, and on this moisture a minute thread like fungus spreads and decomposes the crown glass, resulting in the ultimate deterioration of the lens. The simple preventative is suggested of placing within the dew-cap some thicknesses of flannel, left toasting before the fire until perfectly warm and dry, after the observations for the night are finished. Curiously, this film does not invade the flint surface. The tarnish which appears on this glass in reality increases very greatly the transparency of the objective. Whereas a thin plate of dense flint glass will, when freshly polished, reflect back from its two surfaces about eleven per cent. of the light falling upon it, and transmit eighty-nine per cent.; the same plate, when tarnished to a sort of dull grey-brown or blue (as viewed by reflection), will reflect back only about five per cent., and transmit ninety-five per cent.

Southern Stars: a Guide to the Constellations visible in the Southern Hemisphere. By M. A. Orr. With a Preface by John Tebbutt, F.R.A.S. The Rev. James Gall's "Easy Guide to the Constellations" has been the first primer which has taught a great number of northern observers their stellar alphabet, and on the acquaintance with the forms of the constellations and the names of the stars to which they have been thus introduced, has followed the rise of a love for astronomy which has in many cases borne rich fruit. It is, therefore, with especial pleasure that we welcome Miss Orr's modest little book. For the southern heavens present a rich harvest which there have been very few labourers to reap, and hitherto it has seemed much more difficult to arouse a real interest in astronomy in southern latitudes than here in Europe. We trust that Miss Orr's book is at once an indication of an awakening interest, and that it will greatly foster it. It should do so, for the work is most clearly written, and, following on the well-chosen lines of Mr. Gall's book, is in every way a thoroughly worthy companion and supplement to it. With Miss Orr's neat little maps and lucid descriptions ready to his hand in so convenient a form, the South African or Australian will now be without excuse who looks upon the glories of his southern skies as a mere confused crowd of unknown and nameless stars. It should be added that the thirty maps are not confined wholly to the southern hemisphere, as six of them form a complete miniature star atlas for the entire heavens.

In the *Journal of Botany* for August there is a very instructive paper by T. Kirk, F.L.S., on "The Displacement of Species in New Zealand," showing the effects of introduced animals and plants upon the old fauna and flora of that island. Darwin's theory of the "survival of the fittest" receives further corroboration from the many interesting facts recorded in this paper. The author says: ". . . . the invading army of plants has brought in its train a still more dangerous host of animals. . . . . In the animal kingdom the invaders whose agency is most dreaded are members of the Invertebrata: the mussel scale, the black scale, and many others, together with numerous species of plant lice, will occur to you as belonging to lowly developed forms of Insecta. Higher in the scale are the Hessian fly, wireworm, turnip fly, and others, while numerous species of earthworms, molluscs, birds, and even mammals, affect alike both fauna and flora." Again, showing how plants adapt themselves to their environment, the author reports that "out of one hundred and three species of plants recently introduced with ballast from Buenos Ayres, eighty-six are already naturalized." In the same journal (pp. 319-351) there are some new species of marine algæ, from Natal, described by E. M. Holmes, F.L.S.

In the *American Naturalist* for July there is a paper on "The Classification of Diatoms" (*Bacillariaceæ*), by C. J. Elmore, in which the author discusses the various systems of classification employed by Kirchner, Kuetzing, Paul Petit, Van Heurck, Murray, and others. In the classification which this author adopts—that of Paul Petit, as approaching most nearly a natural one—several of our most cherished species (?) are shown to be mere varieties of the *Navicula iridis* (Ehr.). The author also temperately discusses the reasons of the imperfection of the geologic records of the early history of these Diatoms.

Entomologists who are interested in the flower-visiting habits of insects will find an interesting paper upon "The Bees of the Genus Perdita" in the *Proceedings of the Academy of Natural Sciences*, Part I., 1896; and though we do not believe that the number of species will be found to be correct on further examination (our author describes seventy species, of which he believes fifty-five to be new), still the results given in this excellent paper are well worthy of a more extended notice than can be given in these columns. The name of the author is T. D. A. Cockerell.

Evolutionists, and students of the history of the Mammalia, will do well to make themselves acquainted with one of the latest books upon the subject, viz., "The Primary Factors of Organic Evolution," by Prof. E. D. Cope, Pennsylvania. The splendid memoirs written by this distinguished palæontologist rival those of our own country upon these subjects. Those who have had occasion to refer to the works of this author know how thoroughly up to date the information is. In the present work the author gives his reasons for disagreeing with the classification adopted by Dr. Ameghino of a portion of the group of Ungulata. "Ameghino placed the group" (called by Dr. Ameghino "Litopterna") "under the Perissodactyla, but the tarsus and carpus are of a totally different character." The author further describes the different characters of the feet, and the dentition of these animals—found by Dr. Ameghino in the Cenozoic formations of Argentina—which leads him to indicate the origin of these species from a different order of the Condylarthra than of that adopted by Dr. Ameghino. If we remember rightly, Mr. R. Lydekker visited the museums of Buenos Ayres and La Plata to help revise the work of the Argentina palæontologists; but, as far as can be seen, with no success as to the classification of these animals. Prof. Cope writes with all the fire of Weismann in defence of the transmission of the germ plasma and of progressive evolution.

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RUNES AND OGHAMS.

By Gertrude Burford Rawlings.

Runes of war know thou
If great thou wilt be!
Cut them on hilt of hardened sword,
Some on the brand's back,
Some on its shining side,
Twice name Tyr therein.
Sea-runes good at need,
Learnt for ship's saving,
For the good health of the swimming horse;
On the stern cut them,
Cut them on the rudder-blade . . .

Word-runes learn well
If thou wilt that no man
Pay back grief for the grief thou gavest
Wind thou these,
Weave thou these,
Cast thou these all about thee,
At the Thing,
Where folk throng,
Unto the full doom faring.
Thought-runes shalt thou deal with
If thou wilt be of all men
Fairest-souled wight, and wisest.

Brynhild's Song: "Volsunga Saga."

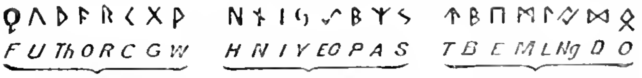
ALTHOUGH it is at present an exceedingly doubtful point as to whether those strange old-world characters known to antiquaries as "runes" and "oghams" respectively, are or are not connected with each other either collaterally or lineally, they form a most interesting subject of speculation. There are several points of resemblance between the two alphabets, and there are also several points of divergence.

Runes undoubtedly originated in the North of Europe, but from what, or at which period, no one knows. Mythologically, Odin is said to have invented them—the Northmen, like most other races, believing that all knowledge, wisdom, and arts originated with their divinities and traditional heroes. Hence the old saga:—

> Thought-runes shalt thou deal with
> If thou wilt be of all men
> Fairest-souled wight and wisest.
> These areded,
> These first cut,
> These first took to heart high Hropt (Odin).

Modern conjecture—conjecture only—refers the runic characters to the Phœnician, the prototype of the Greek and Latin alphabets. Runes, and oghams as well, were primarily intended not to be *written*, but to be *cut* (*see* quotation above) in wood, stone, horn, etc., as may be seen from the simple combinations of straight lines which make up both alphabets. A few books, however, exist, which are written in runes. The word "rune," Gothic *rûna*, signifies something hidden, secret (knowledge, more particularly), and, as M. Botkine, in his "Chanson des Runes," expresses it, not only science and power, but the means of communicating these. Runic inscriptions are comparatively frequent in England, and occur also in Scotland; but Wales and Ireland have not a single example, excepting a small coin bearing runic letters which was struck at Dublin. It is a curious fact, showing what bold adventurers the Northmen were, that actually in North America runic inscriptions have been discovered. One at Arrow Head, on the Potomac River, is cut in a rock, and commemorates the widow of a Norse chieftain. It runs:—"Here lies Syasi, the fair one of Western Iceland, the widow of Koldr, sister of Thorgr by her father, aged twenty-five years. God be merciful to her."

As remarked above, the time at which runes were invented is uncertain, but it has been thought that they should be attributed to the first or second century B.C. The alphabet, or "futhorc," as it is called from its first six letters, is divided into three parts, called "aetts" or families, and named after the first letter of each family: Frey's (F) Aett, Hagl's (H) Aett, and Tyr's (T) Aett. The oldest form of the futhorc, the Gothic, from which are derived the later local forms of the Scandinavian, the Anglian, and the Manx runes, is as follows:—



Frey's Aett. Hagl's Aett. Tyr's Aett.

The futhorc was introduced into Britain by the Jutes in the fifth century, soon after the departure of the Romans, and continued to be used till the tenth or eleventh century. Runes abound in Jutland and in Scandinavia generally, though they were quite unknown to the Saxons and Germans. Anglian runes are generally found on monumental or sepulchral slabs—some of them Christian—and on those large sculptured crosses still existing in different parts of our islands. As an example of the latter we may instance the Ruthwell Cross. This takes its name from Ruthwell, in Dumfriesshire, which in early times formed part of Northumbria. Its date is probably about 680 A.D. It is covered with carvings of Scriptural subjects arranged in panels, whose frames are cut with runes relating "The Dream of the Holy Rood," a poem ascribed to Cædmon, the miraculously-inspired poet of Whitby. In this poem a sleeper is supposed to dream of a marvellous tree, which speaks to him and tells how it was hewn down by men with axes, and set upon a "beetling headland." Seeing to what use it was to be put, it would have broken itself, but dared not "against the Dreetan's word." It describes the Crucifixion—the Saviour is fastened on it. "Rood was I reared now, Rich king heaving." And then: "Wept all creation, Wailed the fall of their King, Christ was on Rood."

Another object ornamented with runes is a casket of whale's bone in the British Museum, the history of which is unknown. It is of Northumbrian work, and is nine inches long by seven and a half broad, and five and one-eighth high. On the first side it shows carvings representing Romulus and Remus; on the second, Titus storming Jerusalem; on the third, the delivery of the head of John the Baptist; and on the lid a scene from the Teutonic legend of Egil. Of the fourth side only a fragment remains. The date of this casket is somewhere between 700 and 800 A.D. The carvings are accompanied by descriptive runes.

Although the greater number of British runic inscriptions are found in the North of England, the oldest extant specimen, assigned to the fifth century A.D., belongs to Sandwich, in Kent. Two headstones thus inscribed have also been found in London, in the neighbourhood of St. Paul's, one of which may be seen in the Guildhall Museum.

The ogham characters are found in great numbers in Ireland; there are some in Wales and the extreme South-West of England, and a few in Scotland. None are known outside the British Islands. They are formed by dividing the alphabet into four aicmes or kinds, of five letters each. The first contains BLFSN, the second HTDCQ, the third MGNgStR, and the fourth the vowels AOUEI. The letters are represented by one, two, three, four, or five strokes for each letter, according to its order in the aicme to which it belongs. A line is drawn, which may be either perpendicular or horizontal—we will consider it as horizontal in the present instance—and the strokes representing letters of the first aicme are placed *under* this line, those representing letters of the second aicme are placed *above* the line, those representing letters of the third aicme *diagonally through* the line, and those representing letters of the fourth aicme cutting the line at right angles. Thus, the Celtic word *maqi* (mac), meaning "son of," would stand . In the case of the main line or stem being perpendicular, the strokes of the first aicme would be placed at the right hand, and those of the second at the left hand, the others as before, and the inscription read upwards. As a rule the edge of the stone is used as the stem line, and the strokes are on one side of the stone, or its face, or both, according to the aicme they belong to. The oldest form seems to have been that in which a separate perpendicular line was taken for every letter, instead of one common line being used for all.

It is a curious and as yet unsolved problem as to whether these oghams were derived from the futhorc. One of the points in which the two alphabets resemble each other is that to the inventors of both the forms of the characters seem to have been suggested by trees—or, at any rate, they themselves suggested trees. Canon Taylor, in his interesting work, "Greeks and Goths," says that "both the runes and the oghams were regarded as constituting a mysterious alphabetical forest in which grew trees of twenty species;" and, moreover, the names of the Irish oghams were all names of trees, *e.g.*, A, *Ailm*, or Fir; B, *Beith*, or Birch, and so on; though certainly these names, which went by the name of the "Bethluisnon alphabet," could be given to ogham and Roman characters alike. The Irish peasantry have still an old verse concerning the oghams, beginning as follows:—

For B one stroke at your right hand,
And L doth always two demand;
For F draw three, for S make four,
When you want N you add one more.

And a case is recorded within comparatively recent years in which a man was summoned for having his name on his cart in ogham characters.

In support of his view that it was on the futhorc that the oghams were originally founded, Canon Taylor propounds a quaint theory as to the method of derivation, of which the following is a brief summary.

He suggests that the inventor of oghams, on examining the runes, would find that the latter could be resolved into five classes containing four letters each, viz.: (1) *Branch runes*, those with markedly tree-like forms, such as ᛉ, represented by oghams with one twig, ᚆ ᚁ ᚋ ᚐ; (2) *Fork runes*, such as Λ, represented by oghams with two twigs, ᚇ ᚂ ᚌ ᚑ; (3) *Loop runes*, such as ᚦ and ᛟ, represented by oghams with three twigs, ᚈ ᚃ ᚍ ᚒ; (4) *Crook runes*, such as ᛊ, by oghams with four twigs, ᚉ ᚄ ᚎ ᚓ; and (5) *Root runes*, such as ᛏ and ᚱ, by oghams with five twigs, ᚊ ᚅ ᚏ ᚔ. We may here remark that the original word for these "strokes" is *fleasg*, meaning twig. The prevailing idea is the resemblance to trees,—trees with branches, trees with forks, trees with looped or interlaced branches, trees with crooked branches, and trees with their roots visible. The result of such an arrangement, which it might be wearisome to the reader to give in detail, would be the order of letters as stated above, B, L, F, S, N, etc. "That this notion is fanciful," adds Canon Taylor, "is no objection to it, but rather an argument in its favour, when we remember the fancifulness of the whole system of oghams and their names."

Stones with ogham inscriptions may be seen in the British Museum, among them being the slab known as the Fardell Stone, found near Ivybridge, in Devon, which bears the Roman legend, FANONI MAQUIRINI, and, in oghams, SFAQQVQAS MAQI QICI, *i.e.*, SFAQQUQAS (or Sfaqqucci) son of QICI. Sir S. Ferguson surmises that such "uncouth designations may have been adopted as evidence of self-disparagement by some Christian ascetic."

As is the case with runes, the date of the invention of oghams is uncertain. Professor Rhys considers that it was not later than the fifth century A.D. The Irish tradition is that they were introduced by the "early half-mythical colony of the Tuatha de Danaan," who are supposed to have come by way of Scotland from the North. And this tradition is supported by the fact that only in those districts where the Northmen are known to have penetrated are ogham characters found.

British oghams, with but one exception, are always accompanied by a legend in Roman letters, which is not the case with runes.

It is possible that oghams are a later and greatly modified form of runes: the latter, having passed through the intermediate forms of tree and bind runes, finally resolving, under some at present unknown conditions, into oghams—although, at the same time, supposing this to be the case, the use of the old runes was by no means entirely abandoned in favour of the newer characters.

THE ASH.

By George Panton.

"There's something in that ancient superstition
Which, erring as it is, our fancy loves."

The ash (*Fraxinus excelsior*), one of the noblest of our forest trees, is known by its tall, graceful form and elegant foliage. It may be called the "Tree of Superstition," because we find, wherever it grows, and intimately connected with all kinds of ashes, superstitions, mythological lore, and legends without end. A glance at a few of these may prove interesting.

In ancient Scandinavian mythology the ash plays an important part. "Igdrasil, the ash tree of existence, had its roots deep down in the kingdom of Hela, or Death; its trunk reached heavens high, and spread its boughs over the whole universe. At the foot in the death kingdom sat three Nornas (Fates)—the Past, Present, Future—watering its roots from the sacred well. Its boughs, with their buddings and disleafings—events—things suffered—things done—catastrophies. On the summit was perched an eagle who watched the course of all earthly affairs, assisted by a squirrel who employed his time in descending

Fig. 1.—Leaves and Seed Vessels of the Ash.

and ascending to examine into and report upon what was happening beneath."

Although the following seems to us rather absurd, it is not such a very long time ago since such things were practised and believed in in many parts of the South of England. "To cure sickly or diseased children a split was made in the stem of a growing ash and held open by wedges; through this opening the child was passed naked. The tree was then bound up, and if it grew well together again that was considered a sure sign that the charm had worked and the child would recover."

A "shrew-ash" was made by entombing a live shrew-mouse in an auger hole made in the bole of the tree—no doubt with many spells and incantations long since forgotten. At any future time a few light strokes with a branch taken from such a tree would instantly cure cattle and horses that were believed to have been bewitched or cramped by the pernicious shrew touching them or running over their limbs while asleep.

The ash is a true native of Great Britain, abundant from John o' Groat's to Land's End. It is indigenous to Europe, North Africa, and North America. It grows to a large and handsome tree, eighty to one hundred feet in height, with a girth often approaching twenty feet. The leaves are pinnate, with five or six pairs of leaflets, serrated. The flowers, which appear before the leaves expand, are small, often numerous, and of a dark purple colour. The succeeding fruit, the well-known keys or "lock and keys," are long-shaped, thin, seed vessels (Fig. 1). On some trees these are very abundant, and being firmly attached to the twig often remain on the tree all the year round. These numerous bunches, turning brown to black in late autumn, when all the leaves have fallen, are very conspicuous; in fact, the ash may be readily distinguished even in mid-winter by these clusters. The wood, although the ash is a quick grower, is very valuable, on account of its toughness and elasticity; these qualities it possesses to a greater degree than the wood of any other British tree. Both Greeks and Romans made their spear handles from its tough saplings, and used it for agricultural implements; for the latter purpose it is still in demand. The carpenter, wheelwright, cooper, and turner, all find it excellent wood for their various purposes; cabinet makers value the knotty parts of the trunk and roots, which they call "green ebony"; for walking sticks, blocks, oars, etc., there is no better wood. In point of value it comes next to the oak itself, and before it in this respect—that it matures its wood at a much earlier period. An ash pole three inches in diameter is as durable and valuable for any purpose to which it can be applied as the timber of the full-grown tree.

The ash is one of the last of our trees to put on its summer robe—

"The tender ash delays to clothe herself
When all the woods are green."

It is also among the first to cast off its covering. Perhaps this is why it has been called the "Venus of the Wood," but we rather suspect it owes this title more to its gracefulness of form than to its love of nudeness.

The flowering ash, *Ornus*, is cultivated in Sicily principally on account of the sweet sap it exudes called "manna"; it grows twenty to twenty-five feet high. The sap flows spontaneously during the greater heats of summer from trees in the most favoured situations, but oftener it is obtained from incisions made through the bark. The clear sap speedily hardens on exposure to the air, and is the "manna" of commerce. When fresh it is nutritious and agreeable to the taste, and is used by the natives as food; but as it turns old it acquires laxative qualities.

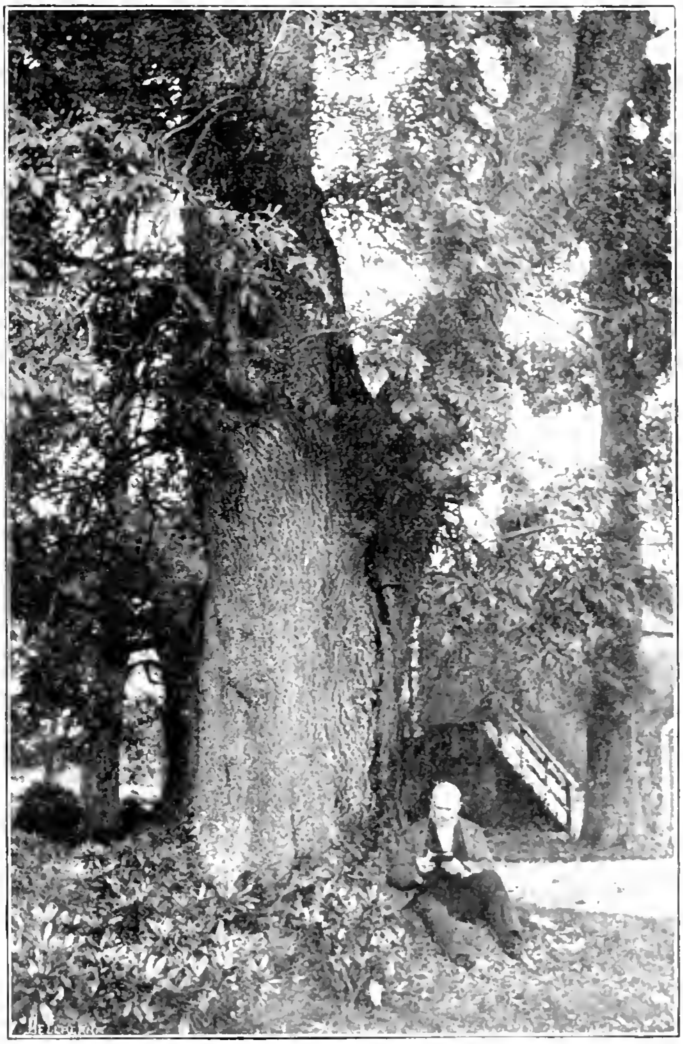


Fig. 2.—Ash at Hunterston, Ayrshire, known as "The Resting Tree."

Fig. 2, a fine ash with a girth of over sixteen feet at five feet from the ground, is growing at Hunterston, Ayrshire, and is known as "The Resting Tree." Popular weather lore has various sayings as to whether the summer will prove a dry one or the opposite, according as the ash comes into leaf before or after the oak; but these rhymes seem to be diametrically opposite in different parts of the country.

◆

WAVES.—X.

RIPPLING.

By Vaughan Cornish, M.Sc.

On shallow shores the sand is rippled by the waves, forming a regular series of ridges and furrows, ranged parallel to the wave front. The pattern often remains when the ebbing tide leaves a stretch of wet sand behind it, but the receding waters blur the ridges, rounding off the sharp edge of the perfect ripple marks. To see them in perfection one must look down through the clear water on a calm day. A pair of long wading boots enables one to examine in comfort the ridges nearest to the beach. In order to see those further out I sometimes float just beyond the breakers in one of these flat-bottomed coracles which are still used on the Wye. It draws scarcely any water, and is so light that one can carry it on one's back and launch it unaided. Sometimes, however, it capsizes.

In the clear waters of Lake Geneva, according to M. Forel, the ripple pattern can be seen at a depth of thirty feet. On our own coasts the ripple mark of Torbay is celebrated, and has been well described by Mr. Hunt in the *Proceedings of the Royal Society*, Vol. XXXVI., 1883-4.

The phenomenon has two aspects, according as we have regard to the motions of the water or to the tactics of the sand. The former have been studied in exquisite detail by Prof. G. H. Darwin, and stand recorded in the volume of the Royal Society's *Proceedings* to which reference has been made. The tactics of sand under rippling action were dealt with in two papers read at the recent meeting of the British Association by the present writer, and this article is confined to the fluid motions. If a trough or basin partly filled with water be gently rocked, a wave travels backwards and forwards from end to end of the trough, and sand placed upon the bottom of the trough soon becomes rippled. The experiment is readily tried, always succeeds, and is extremely pretty and instructive. Rippling, indeed, is so readily produced that it may commonly be observed when a little sediment has settled in a basin; the slightest disturbance of the water sets up an oscillation, and this almost inevitably ripples the sediment. The fine deposit which settles from hard water after heating readily ripples: the pattern may be seen at the bottom of a jug of shaving water. A glass trough with vertical sides is best for the experiments upon ripple marks, as they can then be seen in section, and the eye can be placed close enough to watch the movement of the sand grains. Having made some regular ripple marks by oscillation, Prof. Darwin tried the effect of exposing them to a current. He then observed that small particles lying on the surface of the sand climbed up the *lee* slope of the ripples, apparently against stream. This showed the existence of an eddy or vortex on the lee side of the ridge. By giving a sudden motion to the water he was able to see the sand piled up on the weather side by the direct current, and on the lee side by the eddy or vortex. In order better to observe the action of the vortices, a drop of common ink (not aniline ink), with a little sulphate of iron added to it, was squirted to the bottom of the water in the furrow between two ridges. On causing the current again to pass, the ink was seen to divide into two portions, one being sucked back up the lee side of the ripple mark, and the other being carried by the direct stream towards the next crest. Fig. 1 is Prof. Darwin's representation of the stream-lines during this action.

Fig. 1.—Action of Current upon Ripple Mark.

By the aid of a drop of the heavy ink it was found possible to watch the more complicated action of the vortices during oscillation of the water. Rippling is started by sand grains sticking, and thus causing little vortices or eddies on their lee side. If the agitation is so violent that the sand does not stick, but is simply swept along, no ripple mark is formed. A steady current, however, seems to be incapable of producing *regular* ripple mark, such as that of the seashore, which was found to be due to the periodic strengthening and weakening of vortices on either side of each ridge as the direction of oscillation changed. The drops of ink recorded almost perfectly the effect of each oscillation, for a pumping action, due to the upward motion of the vortex, separated the convolutions of the thread of ink, which formed a sort of tree. Fig. 2 shows the successive stages of the phenomenon for half an oscillation, the water swinging from right to left. The oscillation of the sand crest is shown, and the arrows at the base of the ink-spiral show the motion of the vortices which build up the ridges and scour out the troughs. "The only difficulty," says Prof. Darwin, "is in Stage IV., where the root of the (ink) tree is in the state of transference from one crest to

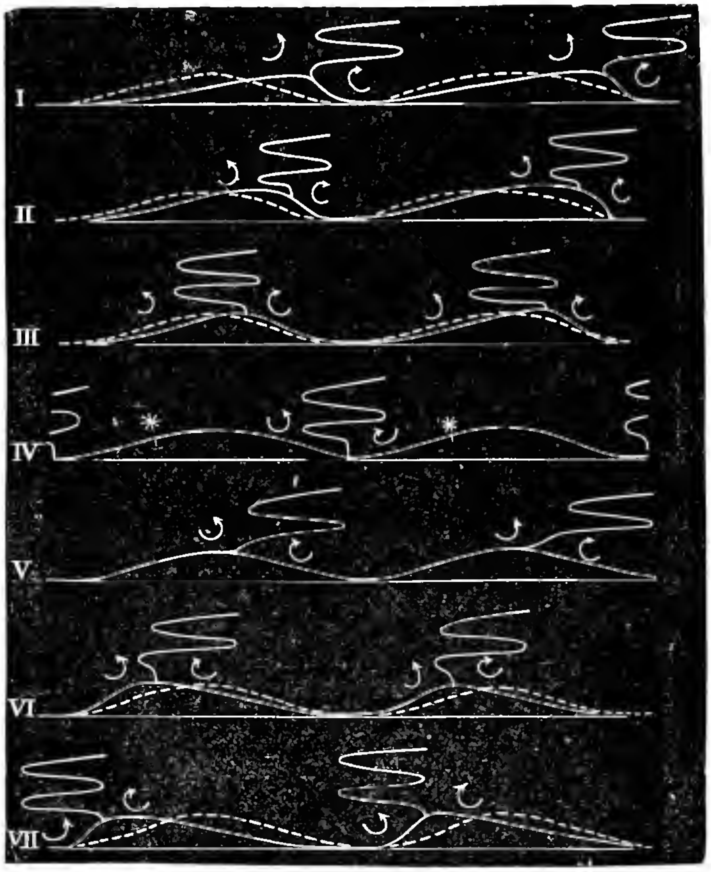


Fig. 2.—Action of the Vortices in Ripple Making.

the next. In this stage the vortices would seem to be in the act of degrading the ripple mark, but they are not either of them at their maximum of intensity, and the time during which this holds good is exceedingly short compared with the whole semi-period of oscillation." The form given in the figure (Stage IV.) of the ripple mark in the mean position of the crest is not exactly the true shape, which is flatter in the troughs and sharper on the ridge, with hollowed sides and a knife edge at the crest. The form at either end of the swing, a sloping back and a steep lee face, is like that of the rippling produced by wind when blowing over loose sand; the form is homologous with that of water waves raised by a wind which keeps constant in direction. On the other hand, I have frequently noticed the symmetrical ripple-mark form of the waves in a cross sea: for instance, when sailing round headlands. With an off-shore wind two sets of waves grow in the bays on either side, and, travelling seawards, meet and pass through each other just off the headland. The momentary combinations of the opposing billows give the steep, symmetrical waves. They make what sailors call a "nasty lop" off headlands, even when there are no tidal currents or rocky ledges to increase the turbulence of the water.

Rippling is generally produced at the surface of two fluids of different densities which are in relative motion. A curious example is that of tar and water. If water be poured upon the tar, and the vessel be rocked, the surface of the tar is quickly rippled, and the sticky crests of the ridges are jerked backwards and forwards in clumsy imitation of the dance of the sand in the seashore ripples. More important, however, is the rippling which occurs between layers of air of different density when the upper and the lower layer have different motions. The visible evidence of such rippling is the formation of beautiful parallel bars of cloud, in which, as Mr. Ruskin wrote long since, "the vapour . . . . falls into ripples like sand." ("Modern Painters," Vol. V., Part VII., chap. i.)

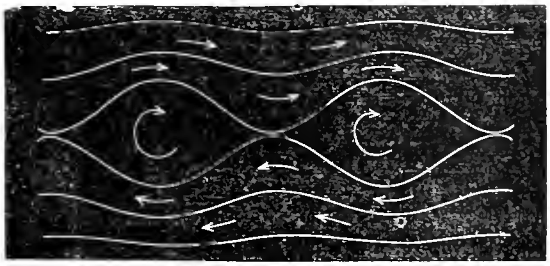


Fig. 3.—Formation of Cloud Ripples.

The condition at the flat surface of two fluids of different densities and capable of mixing, is unstable when the fluids are in relative motion, the form of the surface being liable to undergo great change in a sudden and perhaps tumultuous manner. The two surfaces become corrugated, and between them are interpolated vortices, which act as friction rollers, enabling one surface to glide smoothly over the other. In these vortices the two fluids mix (*see* Fig. 3).

Now the mixing of two airs of different temperature is a well-known method of producing condensation of vapour with formation of a cloud. Probably, therefore, the parallel bars of cloud mark the position of the vortices in air rippling—not, as some have supposed, of the crests of the waves of the lower layer of air (Fig. 3). Once the attention has been drawn to these bars one is struck by the frequency of their occurrence. They occur chiefly in the upper regions of the cloud world. The wave-length is remarkably constant in any one group of bars, but the scale of the pattern varies greatly. A distance of one degree to two degrees of arc from bar to bar is a common size for the smaller and better defined ripples, which, for a distance of thirty thousand feet from the observer, corresponds to a wave-length of two hundred and fifty to five hundred feet; but I have seen the larger sort of bars with a wave-length of probably half a mile or more.

The best defined cloud bars have a sharp edge at one side where the cloud looks thickest, so that the vortex is probably not usually symmetrical, as represented in Fig. 3. I have often noticed the densest part of the bars on the weather side, *i.e.*, the direction from which the clouds drift; but on some occasions it seemed as if the contrary were the case. Sometimes the bars form *in cœlo puro*, a beautiful phenomenon which I have seen on several occasions during the present year. As one bar after another appears, one learns to look in front of the lengthening group to catch the first beginnings of the next forming bar, fixing one's attention on the exact spot in the blue sky where its appearance is due. At other times the ripple bars are formed when a wind blows upon a cloud; this I have frequently noticed to occur in the fleecy clouds which form upon the tops of high mountains soon after the gathering power of the sun has begun to draw up moisture from the ice and snow.

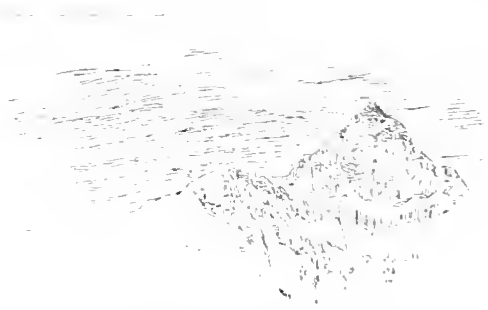


Fig. 4.—Cloud Ripples, as seen from Grindelwald.

Fig. 4 is from a sketch made at Grindelwald, April 17th, 1896, 7.15 a.m. The sky was quite clear at sunrise, then the snow slopes and glaciers began to "smoke," fleecy masses collected round the summit of the mountains, and these were then blown into ripples.

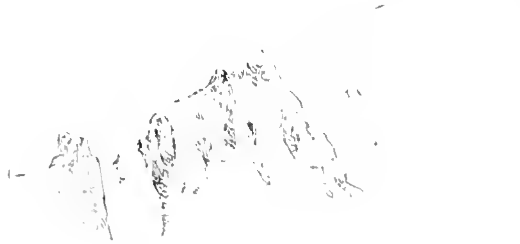


Fig. 5.—Banner Cloud above the Eiger, from Grindelwald.

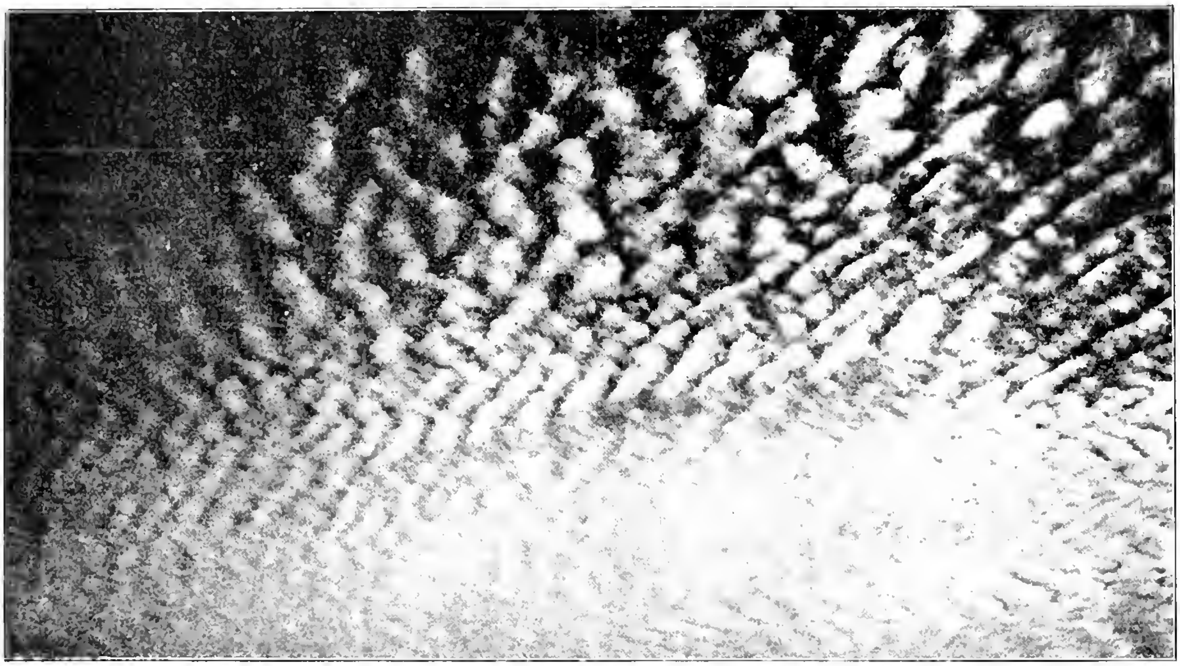
The perfect bar-like form with straight edges does not give one the impression of a swirling motion, but I have often seen swirls of cloud ranged in parallel rows, each swirl like a single puff of smoke, the swirls in each row growing in size and thus getting closer together until a continuous bar was formed.

With a veering wind the direction of rippling is changed, and a barred may be changed into a dappled sky, the existing clouds being furrowed and cut into diamond shape.

An air billow and an eddy, or vortex, is formed when wind blows over a sharp ridge—an instance of the rule that an eddy is formed behind any sharp-edged body which obstructs a current. In air, however, a single obstacle does not seem to give rise to a train of waves, such as is formed to leeward of a boulder in a shallow stream, but only to one, conspicuous, billow. Air diffuses more rapidly than water, and its inertia is much less, so that a gravitation wave in air must, I apprehend, die out quickly. The vortex in the lee of a mountain top exposed to wind produces the banner cloud, a phenomenon very characteristic of Alpine districts. Fig. 5 is from a sketch of the banner cloud of the Eiger taken at Grindelwald, April 21st, 1896, at 2 P.M. The swirling motion of the air was well shown in the convolutions of the cloud. Banner clouds frequently have the shape of long streamers. A well-known example in England is the "helm bar" often seen to the west of Cross Fell when the wind is from the east. The forms of cumulus cloud are the result of swirling motion of the air. Overhead the cumulus appears nearly circular, but when nearer the horizon it is seen to be an accumulation of kidney-shaped masses. These are sure evidence of vortices: an excellent example of this may be seen in the kidney-shaped masses of black smoke near the mouth of a steamer's funnel. This unsightly smoke also serves to show the strong wind-eddy abaft the funnel. At a certain position the smoke whirls violently towards the funnel, in the direction of the ship's motion.

I presume that the swirling motion of ascending currents of air accounts for the circumstance that the morning's sun does not spread a thin film of vapour over the sky, but, instead, produces balls of cumulus separated by blue sky. The interspaces are not regular as in the case of a wave motion, but there is a rough proportionality among the clouds.

The raising of the sea by wind is a case of rippling at the boundary of two fluids in relative motion. The difference of density, however, is so great that mixing of the two fluids cannot take place in the vortex in the usual manner, but is achieved by spraying from the crest of the water wave. In the lee of each water billow there is an eddy of air which, with a high sea, may become a source of danger to ships by taking the wind out of the sails. Above the water billows and the wind eddy the air is doubtless itself in undulations, as Helmholtz pointed out; but the peculiar character of sea waves, which are continually dying out and creating new ones behind them, as well as the complicating effects of their free run by gravitation, probably prevents the air billows from attaining any regularity.



Cloud Ripples. From a Photograph in KNOWLEDGE.

According to Helmholtz, undulations of air, not necessarily accompanied by cloud formation, are of ordinary occurrence, and with high winds their dimensions are very great, often some miles in wave-length. Such waves, even if originating at the height of a mile, would stir the air at the earth's surface, and this has been suggested as a cause of the gusts of wind, often accompanied by showers, which occur at intervals in squally weather.

The rippling of sand by wind has been alluded to. Deserts have often been compared to a sea of sand, and the likeness is real as well as apparent, for the sandhills are billows raised by the wind. Being more enduring, they grow to a greater size than ocean waves. In a strong breeze a stream of sand flies from the *crest* of each dune, just as the spray flies at sea.

The wind also ripples snow, an effect which has been shown by Mr. J. Wolff in a picture of "Ptarmigan in Winter," No. 430 of the Prescott Hewett Gift, South Kensington. I have even seen a gale of wind ripple the froth of the breakers when the return of the wave has left the froth nearly stranded on the shore.

THE FACE OF THE SKY FOR OCTOBER.

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

Sunspots are still very few in number.

Conveniently observable minima of Algol occur at 9h. 20m. p.m. on the **1st**, 11h. 2m. p.m. on the **21st**, and 7h. 51m. p.m. on the **24th**.

Mercury is visible as a morning star during the last half of the month. On the **17th** he rises at 5h. 2m. a.m., or 1h. 27m. before the Sun, with a southern declination of 2° 45′, and an apparent diameter of $8\frac{1}{4}''$, $\frac{24}{100}$ths of the disc being illuminated. On the **22nd** he rises at 4h. 50m. a.m., or 1h. 48m. before the Sun, with a southern declination of 3° 4′, and an apparent diameter of $6\frac{1}{2}''$, $\frac{48}{100}$ths of the disc being illuminated. On the **27th** he rises at 5h. 1m. a.m., or one hour and three-quarters before the Sun, with a southern declination of 5° 4′, and an apparent diameter of $6\frac{1}{4}''$, $\frac{7}{10}$ths of the disc being illuminated. On the **31st** he rises at 5h. 16m. a.m., or 1h. 39m. before the Sun, with a southern declination of 7° 20′, and an apparent diameter of $5\frac{1}{2}''$, rather over $\frac{8}{10}$ths of the disc being illuminated.

Mercury is in inferior conjunction with the Sun on the **8th**, and at his greatest western elongation ($18\frac{1}{4}$°) on the **24th**. While visible he describes a direct path in Virgo, without approaching any conspicuous star very closely.

Venus is an evening star, but owing to her southern declination is not well situated for observation; moreover, she is too near the Sun during the greater part of the month. On the **27th** she sets at 5h. 45m. p.m., or 1h. 3m. after the Sun, with a southern declination of 21° 41′, and an apparent diameter of 12″, $\frac{55}{100}$ths of the disc being illuminated. On the **31st** she sets at 5h. 45m. p.m., or nearly an hour and a quarter after the Sun, with a southern declination of $22\frac{3}{4}$°, and an apparent diameter of 12″. While visible she is near β Scorpii.

Mars is now a very conspicuous object in the evening sky. On the **1st** he rises at 8h. 33m. p.m., or 2h. 57m. after sunset, with a northern declination of 22° 55′, and an apparent diameter of $11\frac{1}{2}''$, the phasis on the preceding limb amounting to $1\frac{1}{2}''$. On the **14th** he rises at 7h. 53m. p.m., with a northern declination of 23° 28′, and an apparent diameter of $12\frac{1}{2}''$. On the **31st** he rises at 6h. 51m. p.m., with a northern declination of 24° 12′, and an apparent diameter of $14\frac{1}{4}''$. During the month he crosses from Taurus into Gemini.

Jupiter does not rise before midnight at the end of the month, and Saturn and Uranus have left us for the season.

Neptune is an evening star, rising on the **1st** at 8h. 26m. p.m., with a northern declination of 21° 41′, and an apparent diameter of 2·6″. On the **31st** he rises at 6h. 30m. p.m., with a northern declination of 21° 38′. He describes a very short retrograde path in Taurus during the month.

October is a fairly favourable month for showers of shooting stars, the most marked display being that of the Orionids on the **18th**, the radiant point being in R.A. 6h. 8m. and +15°.

The Moon is new at 10h. 18m. p.m. on the **6th**; enters her first quarter at 2h. 47m. p.m. on the **13th**; is full at 4h. 17m. p.m. on the **21st**; and enters her last quarter at 3h. 21m. p.m. on the **29th**. She is in perigee at 5h. a.m. on the **7th** (distance from the Earth, 221,910 miles), and in apogee at 6h. a.m. on the **21st** (distance from the Earth, 252,500 miles).

Chess Column.

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

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of September Problems.

No. 1.—1. Q to QR8, and mates next move.

No. 2.—1. Q to QB6, and mates next move.

[Owing to the omission of a Black Pawn at KR6, there is, unfortunately, a second solution by 1. B × P.]

Correct Solutions of both problems received from G. A. F. (Brentwood), Alpha, H. S. Brandreth, F. Hepburn, H. Le Jeune, A. S. Coulter, E. C. Willis, J. H. Carroll, Eugene Henry, G. J. Newbegin, J. M'Robert, H. W. Elcum, W. Willby, S. Cullen, A Norseman, W. Clugston.

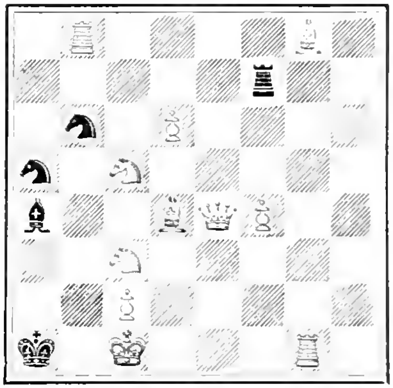
Eugene Henry.—Of the two positions which you enclose we prefer No. 2. Though it is clear that either the Rook or one of the Bishops must move (for otherwise the Rook is useless), both the key and variations are quite up to the mark. In the other the variety is hardly proportionate to the large force employed, and the stationary position of the White Queen is to be regretted. Your third position (now marked No. 2) has just reached us. The key is very pretty. Two of them shall appear in the next number.

W. Clugston.—Thanks. They shall be examined.

PROBLEMS.

No. 1.—By J. K. Macmeikan.

Black (5).

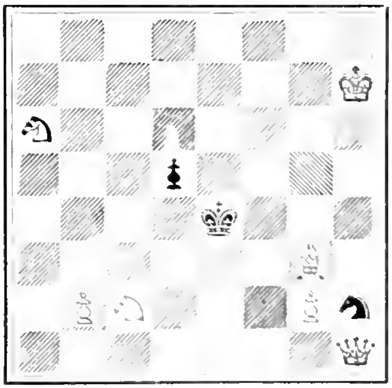


White (11).

White mates in two moves.

No. 2. By A. G. Fellows.

Black (3).



White (7).

White mates in three moves.

The following was one of the most brilliant games in the Nuremberg Tournament :—

"Four Knights Game."

White. (Maroczy.)	Black. (Pillsbury.)
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to KB3
3. Kt to QB3	3. Kt to QB3
4. B to QKt5	4. B to QB4 (*a*)
5. Castles	5. Castles
6. K × P	6. R to K1
7. Kt to KB3 (*b*)	7. Kt × P
8. P to Q4	8. Kt × Kt
9. P × Kt	9. B to K2 (*c*)
10. P to Q5	10. Kt to Kt1
11. B to KB4	11. P to QR3 (*d*)
12. B to QR4	12. B to KB3
13. P to Q6	13. P to QB3
14. B to QKt3 !	14. P to QKt4
15. Q to Q2	15. B to QKt2 (*e*)
16. Kt to KKt5	16. R to KB1
17. Kt to K4 (*f*)	17. P to QR4
18. P to QR3	18. Kt to QR3
19. QR to K1	19. P to QB4
20. B to Q5	20. B × B
21. Q × B	21. P to QKt5 (*g*)
22. R to K3	22. B × P (*h*)
23. R × B ! (*i*)	23. P × R
24. B to KKt5	24. Kt to QB2 (*j*)
25. Q to QB4 !	25. Q to K1
26. P × Kt (*k*)	26. Q to K4
27. R to Q1	27. KR to K1 (*l*)
28. R × P	28. K to R1
29. Q × KBP	29. Q × B
30. P to KB4	30. Q to KKt5
31. P to KR3	31. Q × R (*m*)
32. Q × Q	32. R × Kt
33. P to B8 Q's ch	33. Black resigns.

Notes.

(*a*) Admittedly inferior to 4. . . . B to Kt5, but chosen probably as being less drawish.

(*b*) Superior to 7. Kt × Kt, QP × Kt, 8. B to B4, as played by Paulsen against Morphy. 7. Kt to Q3 is also worth considering.

(*c*) 9. . . . B to Bsq is clearly better, having regard to White's next move.

(*d*) As pointed out by Mr. Ranken, 11. . . . P to QB3 is much superior. Certainly on his next move he should play . . . P to QKt4, followed by P to Q3. Allowing the Pawn to advance to Q6 is fatal.

(*e*) Obviously he cannot play 15. . . . P to QB4 on account of the reply, 16. Q to Q5. 15. . . . P to R3 is also very dangerous.

(*f*) Very well played, preventing P to B4 for a time.

(*g*) 21. . . . R to QBsq would be useless on account of 22. Q to Kt7, followed by Q × P.

(*h*) But now probably 22. R to Bsq is as good as anything under the circumstances.

(*i*) Having two Rooks and only one Knight, he prefers in such a position to keep the Knight.

(*j*) If the Queen moves, then 25. Kt to B6ch wins.

(*k*) Inferior to 26. Kt to B6ch. Possibly Herr Maroczy was enjoying the game and did not wish to bring it to a too rapid conclusion. He threatens now Kt to Q6.

(*l*) He cannot play the other Rook to Ksq, because of B to Q8.

(*m*) If 31. . . . Q to Kt3, 32. Q × Q, P × Q, 33. Kt to Q6 wins.

The whole game is very finely played by Herr Maroczy. Mr. Pillsbury's play at the start was very weak, and he never had time to recover from its effects.

◆

CHESS INTELLIGENCE.

It is stated that an International Tournament will be held at Buda-Pesth in the autumn; another at Berlin is projected for 1898. Between the two events a contest in Russia may be expected.

A match between Herr Lipke and Professor Berger, played under the auspices of the German Chess Association, has ended in a draw.

The tournament of the New York State Chess Association has been won by S. Lipschütz, who scored 5½ games out of a possible 6.

The return match between Lasker and Steinitz is due to begin this month.

The Amateur Tournament at Clifton was won by Mr. H. E. Atkins, with the fine score of 8½ out of 9. Mr. J. H. Blake was second with 7½.

Contents of No. 131.

Two Plates.—1. The Sooty or Brown Albatross. 2. Photograph of Nebulosities near Antares and Nu Scorpii.

NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

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KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: NOVEMBER 2, 1896.

CONTENTS.

THE GIRAFFE AT THE ZOO.

By Frank E. Beddard, F.R.S.

The plate illustrating this paper represents the young female giraffe which has recently become an inmate of the Zoological Gardens. Some years ago giraffes were among the most commonplace animals exhibited in that institution; they might almost have been said to be indigenous there, for they bred successfully and led a perfectly natural life. But about six years ago the last representative of the old state of affairs died, through sheer age, and in the meantime circumstances were conspiring to prevent the recruiting of the collection; hence for some years an *hiatus valde deflendus*. The conspiring circumstances appear to have been mainly a man and a fly. The man was the Mahdi, and the general turmoil in the Soudan and thereabouts due to his activity; the fly is the well-known tsetse. This latter animal is no more fatal to the giraffe than was the Mahdi, in itself; but giraffes were hunted upon horseback, and it is of the horse that the tsetse is so determined a foe. It is clear, therefore, that the young beast at the Gardens is a highly valuable acquisition, and it is to be regretted that so far no companion has been procured for her. It is, unfortunately, not only at the Zoological Gardens that the giraffe is getting near to extinction. Like most of the large game of Africa, the giraffe's days are probably numbered. The advance of civilization, so gratifying to the philanthropist and the trader, is a matter of abhorrence to the naturalist. We have seen in the last few years the practical disappearance of the quagga, the next to disappearance of the white rhinoceros; and all these great beasts are now retiring further and further away from contact with colonists, the retirement being naturally accompanied by diminished numbers. Yet the giraffe is stated to be well equipped for the battle of life by those who have studied it in Africa. To us it seems a somewhat ungainly beast, with an unnecessary length of neck and forelimb. The ungainliness is, perhaps, tempered by the beautifully conspicuous spots, which are especially sharply marked out in the animal at the Gardens, the representative, as it is, of a variety of the more abundant, or, at any rate, the more usual form. Unlike the stag in the fable, the giraffe can trust to its beauty spots as much as to what might be considered the more useful features of its organization. Like the individual who was unable to see the wood for its trees, an eminent observer is stated to have been quite near to a giraffe and unable to detect it on account of its spots; the dappled appearance due to these suggesting a broken stream of sunlight falling upon a withered tree trunk, the tree trunk being clearly the animal's stout neck. A recent traveller in Africa, Mr. Scott Elliot, makes an ingenious suggestion about the giraffe's neck which we have not seen put forward elsewhere. It is commonly held that this disproportionate part of the body is important to the creature as a natural ladder whereby to reach the tender twigs of a tree inaccessible to the common herd of bush-living ruminants; but Mr. Elliot points out with some acuteness that in the grass-covered plains of eastern tropical Africa, with scattered trees, there are other beasts with long necks which do not depend upon the trees for their nourishment; there is, for instance, the ostrich, longest necked of birds. By means of this long neck the giraffe can take a wide survey of his environment, and perhaps detect a lion or pard with prying head in time to retire with success—"what time she lifteth herself up on high and scorneth the horse and his rider." The giraffe, in fact, is fairly fleet, though its progress is not elegant, having, indeed, been compared to that of a frog. The neck, which was so inconvenient a feature in conveying the animal to the Zoological Gardens, is apparently, so far as giraffes are concerned, quite a recent acquisition. It is true that extinct forms of giraffe, differing only specifically from the animal which we are considering, formerly existed in Asia, and even in Europe, so that the diminution of giraffes is not a thing of yesterday; but the earlier creatures which have been referred to this group of hoofed animals had comparatively short necks. The *Samotherium* and *Helladotherium*, whose habitats are recorded in their names, were giraffes to all intents and purposes, but with necks on the plan of the ordinary Ungulate. It may be that in this lengthening of neck we can trace the gradual change from a browsing, plain-living animal to the present bush-frequenting camelopard.

In its present situation the giraffe cannot exercise its capacity for plucking by the help of its long extensile tongue the twigs of the few trees that are scattered through its enclosure, its predecessors having done what could be done in this direction; but the customary method of feeding is kept up by means of a very high manger.

We have seen the important place that the giraffe occupies in the Zoological Gardens, which is emphasized by its tenancy of an entire house to itself: what is its place in nature? Curious though it may seem, it is not far off in the scale of nature from its near neighbour the apoplectic hippopotamus, and like it occupies (in more senses than one) a very high place. Both animals are, in fact, the only representatives alive of distinct families; the hippopotamus leans towards the pig, the giraffe is a deer with a dash of antelope. In its general structure it is not markedly different from either. Its horns are most interestingly intermediate. They are but small, considered as functional horns; but the smallness in size is made up by numbers, for the giraffe has three horns, one in the middle and one on each side. The latter are bony projections covered with a persistent skin. In being bony projections they are like the horns both of deer and antelopes. In being covered with hairy skin they are like deer, whose "velvet" everyone knows; but in the fixedness of this velvet, which is not shed, the giraffe is an antelope.

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PARASITIC LEAF-FUNGI.

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

About the time when the blackberries are ripe, after a short search one can generally find a bush the leaves of which have a paler appearance than ordinary; closer inspection shows the under surfaces of the leaves flecked here and there as if with specks of soot. With the aid of a pocket lens each speck is seen to consist of tufts of little club-shaped bodies, and if we scrape some off, mount them on a slide, and place it under the microscope, we see that they are cylindrical cells, each made up of from three to eight joints, and supported by a short stalk. Their form is so characteristic that, once seen, there is no difficulty in recognizing it again. These are the telutospores of the bramble brand (*Phragmidium violaceum*), a parasitic fungus belonging to the order *Æcidiomycetes* (or *Uredines*), all of which inhabit living plants.

The leaves of various species of mint are in autumn often dotted over in like manner with dark-coloured spots, due in this case to the telutospores of *Puccinia menthæ*, each composed of two joints of hemispherical form. By this two-celled character the Puccinia genus is distinguished from Phragmidium, which has telutospores usually consisting of more than three joints. On the meadow-sweet a brand, *Triphragmidium ulmariæ*, occurs, having three-celled telutospores; those of the brands which affect the bean, pea, clover, and lady's-mantle, species of Uromyces, are unicellular. *Gymnosporangium* (*Rostelia*) growing on junipers has them two-celled, closely packed, and embedded in gelatinous substance: they are prismatic, and form a compact layer in Melampsora infesting the leaves of the willow and sunspurge; and the species of Colesporium living on the colt's-foot and eye-bright have four-celled telutospores united to form a compact, waxy stratum, surrounded by a gelatinous mass. The characters presented by their telutospores thus form the basis of the classification usually followed in this group of fungi, the spores of which, indeed, constitute the principal feature.

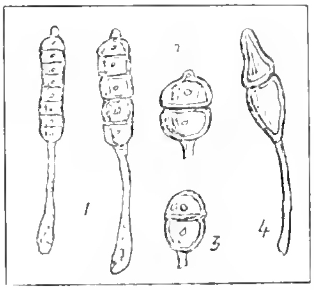


Fig. 1.—Telutospores. 1. *Phragmidium violaceum*. 2. *Puccinia menthæ*. 3. *P. violarum*. 4. *P. graminis*.

Telutospores are resting or winter spores; only in a few cases are they capable of immediate germination. The name, derived from *telos*, "end," indicates that their production is regarded as completing the life cycle of the fungus. Unlike other spores, which on germination give rise to a branching mass of thread-like cells known as a mycelium, which is really the vegetative body of the fungus, a telutospore only develops a short filament or promycelium, on which arise small reproductive cells, the sporidia; the latter are able at once to germinate and form mycelia.

Minute yellow streaks may be observed during the latter half of the year on the leaves of all our common grasses, especially on the lower leaves, by anyone who will take the trouble to look for them. On examining these with the pocket lens they are found to be chinks in the epidermis of the leaf filled with orange-coloured dust. Under a microscope of low power, with direct light, a small piece of grass-blade so affected presents a charming appearance. The dust is seen to be composed of orange-red globules, having a waxy lustre or bloom, reminding one of artificial fruits, and forming a splendid contrast to the bright-green chlorophyll grains of the leaf. With careful focussing under a higher power, minute projections studding the surface of the spores become visible, giving them a bristly appearance. These are the summer or uredospores of a parasitic fungus now designated *Puccinia rubigo vera*, one of the corn-rusts which occasionally inflict so much damage on cereal crops. *Puccinia graminis* injures the wheat; allied species occasion the orange and scarlet patches of rust seen on the rose, barren strawberry, eye-bright cow-wheat, sow-thistle, groundsel, thistle, harebell, nightshade, dog's-mercury, and many other native plants. The name uredospore (*uro*, "I burn") has reference to the conspicuous disfigurement and often burnt appearance of leaves attacked by these fungi. Unlike telutospores, the uredospore germinates at once if placed on a suitable host, and gives rise to a filament which penetrates the epidermis and develops into a mycelium, extending through the intercellular passages of the leaf. Uredospores commonly appear somewhat earlier in the season than telutospores, though the two often grow together.

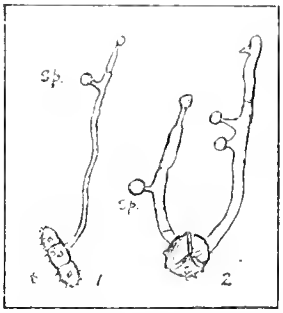
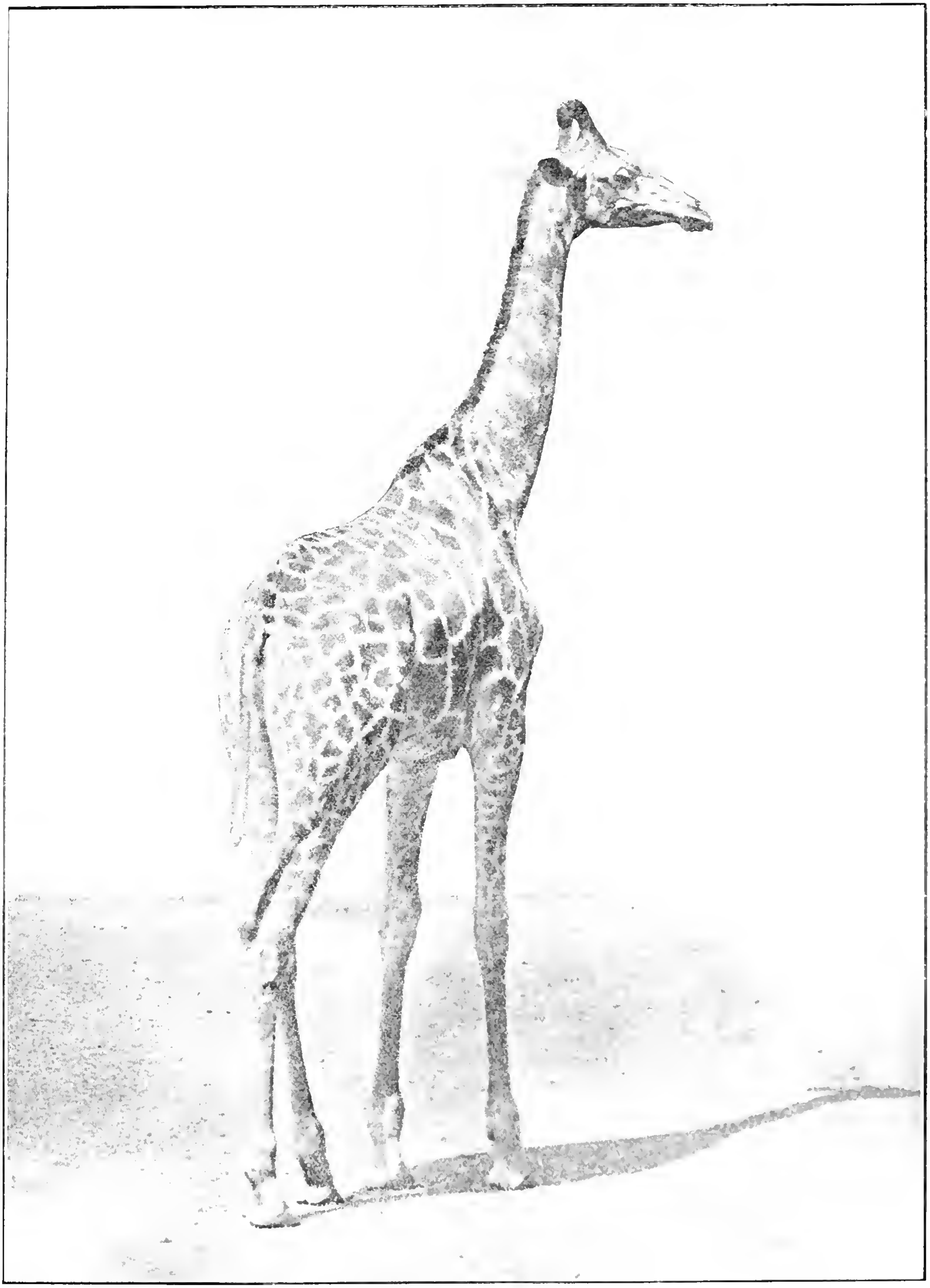


Fig. 2.—Germinating Telutospores, with promycelia and sporidia (sp). 1. *Phragmidium*. 2. *Triphragmidium*.

On gooseberries our readers may sometimes have remarked a bright yellow spot about the size of a sixpence. Similar spots occur on the leaves of gooseberry and currant bushes. The lens shows that they consist of a number of small round openings full of orange powder; these are the cluster-cups and æcidiospores of *Æcidium grossulariæ*. An exceedingly common species, *Æ. compositarum*, is found on the lower surface of the colt's-foot leaf, a plant abundant on every railway embankment. Plants may possess more than one species of parasite; on the colt's-foot there also occurs a species of Colesporium, and nearly a score of different fungi are stated to take up their quarters on the leaves of the nettle. Each species of æcidium confines itself, as a rule, however, to plants of a particular family, or even selects its hosts from a single species; thus the æcidia of the berberry, hawthorn, honeysuckle, Scotch fir, mountain ash, anemone, buttercup, nettle, primrose, violet, willow-herb, bedstraw, dock, and many other plants are all different and belong to distinct species. Seen with the lens the cluster-cups present the appearance of a group of



FEMALE GIRAFFE AT THE ZOOLOGICAL SOCIETY'S GARDENS, LONDON.

From a Photograph by Mr. GEORGE WITHERBY.

miniature volcanoes. At first the æcidium fruit is a small spherical body formed beneath the epidermis of the leaf whereon it grows, which it ultimately ruptures; the æcidium itself, when ripe, bursts, and the yellow spores are discharged. The section of an æcidium shows a cup-like cavity with the spores arranged in vertical rows like short strings of beads; they are developed by budding, and become detached in succession. Externally the æcidium is in most species invested by a membranous envelope, the peridium, usually cup-shaped, but occasionally, as in the cluster-cups of the pine, prolonged into a tube. The peridium may open irregularly or split up in a definite manner, giving its margin a toothed appearance. An æcidiospore can germinate when sown on a suitable host. The cluster-cups appear earlier in the season than the uredo or telutospores, and are very often associated with smaller cups called spermogonia, which appear on the upper surface of the leaf (Fig. 5, 1 spm.), from which issue minute spermatia, which have never been known to germinate, and are therefore generally regarded as male reproductive cells.

All the three kinds of spores above described, it must now be explained, are produced in succession by some of the Uredines on the same mycelium. The Puccinias of the mint, primrose, violet, goat's-beard, and onion develop all three forms; teluto, uredo, and æcidiospores occur on the same plant. Had we examined the bramble Phragmidium earlier in the season we should have found, not the many-celled telutospores, but unicellular uredo or æcidiospores. The rose rust, *Ph. subcorticum*, and that of the barren strawberry, *Ph. fragariæ*, in like manner bear three kinds of spore on the same host. The rusts of the knot-grass, beet, geranium, and valerian, caused by species of Uromyces, also possess spores of three kinds. Others, like *U. alchemillæ* and *U. rumicis*, have teluto and uredo but no æcidiospores. Only telutospores are known to be produced by the Puccinias parasitic on the gout-weed, speedwell, mallow, harebell, and saxafrage. Uredospores are wanting in the Puccinias of the ragwort and earth-nut; telutospores are absent in the rusts of the figwort and fern, while neither the uredo nor telutospores are known which correspond with the æcidia of honeysuckle, meadow-rue, and gooseberry. The three kinds of spore are not formed simultaneously; further observations may therefore be expected to reduce the number of these exceptions. Before it was known that a cluster-cup, a rust, and a brand might be merely successive stages of the same fungus, specific names had been assigned to each of the forms, with the result that some of these parasites have three names; and this inconvenience is still unavoidable in cases where the connection between the different stages has not yet been demonstrated.

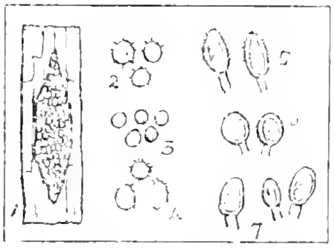


Fig. 3.—Uredospores. 1. Portion of grass blade, with rust. 2. Spores of bramble rust. 3. Spores of barren strawberry. 4 and 5. Spores of corn rusts. 6. Spores of rose rust. 7. Spores of thistle rust.

But what invests this group of fungi with peculiar interest is the fact that many of them spend their first or æcidium-bearing stage on a different species of host-plant from that which they inhabit at a later period of their life history, when they develop uredo and telutospores. Thus there are several kinds which produce æcidia on the leaves of firs and pines, and then migrate to plants of the heath order. To this changing of hosts the name Heterœcism (*heteros*, "other"; *oikos*, "house") has been given. Analogous phenomena are observed among animal parasites. The same organism which occasions "measles" in pork, afterwards gives rise to the tapeworm in man; the tapeworm of the cat is but a more advanced form of one that inhabits the intestines of the mouse; and the liver fluke of the sheep passes one part of the cycle of its development in the body of a pond snail. Farmers long suspected that the presence of berberry bushes in their hedges had something to do with the rust that destroyed their wheat. This idea was verified by the discovery that *Puccinia graminis* is merely a later stage in the development of *Æcidium berberidis* which infests the berberry. As the alternation of generations was first traced in this species, it is the example of heterœcism usually given in text-books, but a similar connection has been made out in many other instances. The cluster-cups of the Scotch fir belong to the same Uredine which bears teluto and uredospores on the groundsel; those of the colt's-foot correspond to telutospores on the meadow grass of *Puccinia poarum*: *Æcidium urticæ* of the nettle develops uredospores on species of Carex; the æcidium fruits of *Gymnosporangium cancellata* occur only on the leaves of the mountain ash and other Pomaceæ, the telutospores only upon those of species of juniper. The æcidium of the buckthorn is related in the same way to *Puccinia coronata*, not uncommon on grasses. Again, the æcidia of the orchid, onion, dock, and dandelion appear in their uredo forms on various grasses and sedges, while the parasites of certain Composites seem to migrate to other plants of the same order. The corn rust, *P. rubigo vera*, turns out to be the second stage of an æcidium that grows on the leaves of Anchusa and other plants of the borage family.

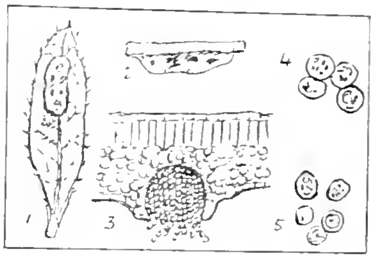
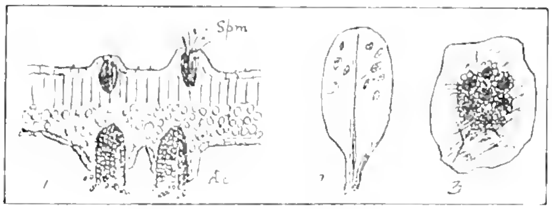


Fig. 4.—Æcidia. 1 Leaf of berberry, with cluster-cups. 2. Side view of group of æcidia. 3. Leaf of sunspurge spotted with *Melampsora euphorbiæ*. 4. Cluster-cups of bedstraw seen with lens.

From these examples it will be seen that in fungi of this description each generation of each species has its own form of fructification and its own peculiar host-plant. The brands of the mint and bramble are not heterœcious, but produce all three sorts of spore on the same host, or even on the same mycelium; the Uredines of the honeysuckle, meadow-rue, and gooseberry, of which only the æcidium forms are known, are likewise restricted to one species of host. In this country *Æ. grossularia* only produces æcidiospores; telutospores are stated to have been observed on the gooseberry itself on the Continent. Should this be confirmed, it would appear that the fungus in question is confined during its whole existence to the same plant, and does not, therefore, possess the heterœcismal character.

In the life history of one of these migratory fungi we have then the following phases: The earliest form inhabits the leaves of a plant such as the berberry, where it exhausts its energies and completes its career by the production and discharge of the æcidiospores; the latter are incapable of germinating on the berberry, but on being transferred to wheat, at once germinate and form a mycelium which develops the uredo and telutospores. The uredospores continue to propagate the uredo form of the fungus indefinitely upon the wheat, but the telutospores or sporidia arising from them will only grow mycelia if sown on the leaves of the berberry.

In not a few instances these relationships have been established by direct experiment. Dr. C. B. Plowright succeeded in producing æcidia on the hawthorn and mountain ash by infecting their leaves with telutospores taken from the juniper, and on the nettle with telutospores from a species of Carex. Conversely, with æcidiospores from the nettle he obtained the uredospores of *Puccinia caricis* on Carex, and spores from the colt's-foot cluster-cup placed on the meadow grass developed the uredo form of *P. poarum*. The æcidium of the berberry gave rise to *P. graminis* on grass, and berberry leaves infected with telutospores from the latter developed æcidia of the usual form. Check plants which in these experiments were not inoculated yielded negative results; the possibility of error was thus eliminated. It may therefore be taken as conclusively proved that many of these leaf fungi exist in alternate generations as parasites on distinct plants, with forms so unlike that the successive phases in the life cycle of one and the same fungus were for long regarded as different species and classified in separate families. The brilliant orange and scarlet tints exhibited by so many Uredines are due to the presence in their cells of drops of highly-coloured oil. They differ from the Peronosporeæ in their septate mycelium, and are less destructive, as the mycelium does not extend through the entire body of the host, but the damage is usually restricted to the small affected areas of the leaf. Sexual reproduction has not been observed in the Uredines; there are, however, grounds for the belief that a process of fertilization really takes place, but the consideration of this question must be reserved for another occasion.



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DAY-FLYING MOTHS.

By L. N. Badenoch.

A popular division of the *Lepidoptera*, or scale-wings, in England, is into butterflies and moths; the former being termed *Diurni*, the latter *Nocturni*. In most Continental languages one principal word serves for the two great Lepidopterous groups. Thus, *papillon*, in French, may stand for either a butterfly or a moth, and they are distinguished respectively as *papillon de jour* and *papillon de nuit*.

But since, in fact, many of the species of the nocturnal *Lepidoptera* are day-fliers, and, *vice versâ*, not all the diurnal *Lepidoptera* fly by day, the habits of these insects do not seem to prove a good basis for separation. In order to avoid the misconceptions produced by the terms "diurna" and "nocturna," Boisduval, a French entomologist, proposed to substitute *Rhopalocera* (club horns) for the butterflies, and *Heterocera* (different horns) for the moths.

At first glance few distinctions appear more happy than this few classifications more natural. It was no sooner announced than it was recognized as a most convenient arrangement, and it quickly came into general use. It is founded on the structure of the antennæ. A marked thickening towards the end almost universally characterises the antennæ of the *Rhopalocera*. Such being the case, it is undoubtedly a character of primary importance. But a certain family of moths (*Sphingidæ*), by their antennæ thickening towards the end, though terminating suddenly in a point, bring the two groups into near relationship, and lessen their value, while the most interesting *Castniidæ* and *Uraniidæ* (of which more anon) so intimately connect them that these families have sorely perplexed systematists as to whether their rightful position was with the one group or with the other.

In a word, though we may speak of Rhopalocerous and of Heterocerous characters, there is no one character which infallibly severs the two divisions. The more intimate our knowledge of animal forms, past and present, becomes, the more our demarcations give way. As we arrive at a true conception of the relations of animals we realize the closer approach of the different groups, until we perceive an almost continuous chain.

Let us glance at the curious and abnormal collection of pretty insects, *Castniidæ*, which, in some respects, combines the characters of both Lepidopterous divisions, but in modern opinion has most affinities with the moths. Linnæus and all the writers of the last century regarded the species of the genus with which they were acquainted as butterflies, including them in the great group *Papilio*, on account of the clubbed structure of their antennæ. At the beginning of the present century, when this group was broken up, the genus *Castnia* was established, though Fabricius still retained it among the butterflies. But when the antennæ are carefully examined, they do not exhibit the real Rhopalocerous structure. In like manner, the Castnians differ from other groups of Heterocerous *Lepidoptera* in the complicated arrangement of the veins of the wings, and in various ways.

Thaliura Phipheus (Madagascar). Two-thirds natural size.

In general appearance they vary much, but, typically, they have large wings, with loose and remarkably large scales, and a position in repose deflexed or incumbent, being furnished with a wing-guide or guides; and the antennæ, though club-like at the tip, are generally long and more or less supple. All these characters are constant, and are Heterocerous characters. As a rule the head is broad, and the body large and somewhat pointed. The Castnians resemble butterflies in this particular, in their evidently diurnal habits, as evinced by the brilliancy of their colours. Numerous species are reckoned within their number, many of large size, and generally adorned with beautiful colours, a rich effect heightened by the metallic gloss of the prominent scales with which most of them are covered. In respect of colour the sexes may differ widely.

Turning to their preparatory stages, the larvæ are endophytous, boring, with strong mandibles, the interior of stems and roots of cacti, of orchids, and other plants—a habit which, though found in butterflies, is very exceptional. Likewise, they are provided with the ordinary horny piliferous spots or tubercles that characterize Heterocerous larvæ, and have a horny anal plate, whereas butterfly larvæ rarely possess these warts. In keeping with all Heterocerous borers, the pupæ are supplied with minute spines on the hind borders of the abdominal joints, affording the pupa power of moving in the tunnel bored in the tree, and assisting it out of its cocoon.

The *Castniidæ* are essentially proper to the warm equatorial regions; their geographical range, in fact, extends only to Mexico and Central and Southern America, finding their greatest development in Central America and Brazil. The few *Castnioides*, or species of *Megathymus*, known, inhabit the southern portion of North America, hailing from the Southern States, from Florida, and from Arizona. The genus *Synemon* appears to represent the *Castniidæ* in the vast continent of Australia.

Of these aberrant forms *Megathymus yuccæ*, the Yucca Borer, is one of the most interesting. Although placed with the *Castniidæ*, it has none the less given great trouble to systematists, having been bandied from the butterflies to the moths; and, it must be owned, some still regard it as a genuine butterfly. This species is common in the Gulf States of America over extended regions, where its larva commits serious depredations of the nature that its popular name implies.

It is a dull-coloured moth, and rests with wings elevated—thus differing from the typical *Castniidæ*—its antennæ generally directed forwards; also in smaller wings, in smaller closer scales, in unarmed hind-wings, and in stiffer, relatively shorter, antennæ, it diverges in character from the *Castniidæ*. Its flight, which is diurnal, is an extremely rapid darting motion as it passes from plant to plant, principally in open spots. During April and May, and earlier, it may often be seen in the morning where the yuccas abound, darting hastily about after its customary fashion, on laying thoughts intent; and as it pauses for a few seconds at one place, it fastens an egg to some portion of a leaf. The eggs are laid singly, though more than one may be put on the same leaf. The larva, which is reddish brown, with a black head, shelters itself in a web between some of the young terminal leaves. Usually it starts proceedings near the tip of a leaf, working gradually downwards, eating the while, and rolling and shrivelling the blade as it goes. It lives thus among the leaves till about one-fourth grown, when it enters the trunk, commencing the devastation for which it is famed. Along the axis the trunk becomes bored and tunnelled out into a cylindrical burrow, wherein the larva makes its home, extending often to two or more feet below the ground, and at its upper end lined with silk, generally intermingled with a white, glistening, powdery material, soapy to touch, and analogous with that of Hymenopterous and many Homopterous larvæ. At what stage of larval development this powder is secreted is not known, but the full-grown larva is always covered with it more or less copiously, and doubtless it protects the invader against the mucilaginous liquor which the yucca freely exudes on maceration.

The funnel-like tube outside the burrow, made by the twisting and webbing together of the tender leaves, when partially devoured, is quite characteristic of the larva of *Yuccæ*. The tube is, indeed, built and extended often several inches beyond the trunk or stem: from it the builder, especially when young, emerges to feed, and the small amount of matter besides silk used in its construction—the remnants of leaves and such-like substances—have been obtained and worked into the exterior from the outside. Pupation generally takes place at the top of the burrow, just below the funnel-like projection, but without the preparation of a well-formed cocoon. The pupa is of a brown-black colour, and, like the mature larva, is more or less densely covered with a white powdery bloom.

Urania fulgens (Central America). Two-thirds natural size.

It has long been a problem with systematic writers what is the true situation in nature of the highly interesting group of insects *Uraniidæ*. The day-flying habits of the insects, together with their airy forms and the extraordinary brilliancy of their colours, naturally led to their being at first classed among the *Rhopalocera*, but later acquaintance with their transformations proves them to belong to the Heterocerous division of the order.

They are among the most richly ornamented *Lepidoptera* of that very brilliant order. It would be difficult for art to effectually represent the changeable and resplendent golden green of the numerous bars which contrasts with the velvety black of the wings, and varies with every change of light. The posterior wings are prolonged into a single elegant pointed tail, closely resembling that appendage in many swallow-tailed butterflies; or there may be present at the hinder extremity of the wings no fewer than three distinct tails. The typical species of these superb insects are natives of tropical America, where they fly so high, and with such amazing rapidity, that it is almost impossible to catch them, and the only way, therefore, to obtain good specimens is to rear the caterpillar.

Urania boisduvalii, which inhabits Cuba, may be considered as one of the most beautiful *Lepidoptera* known. It attains an expansion of wing of from four to four and a half inches, with an undulated rim, the hollows of which are more or less sparsely tipped with white: otherwise its colours are velvety black and green. While the black of the superior pair of wings is relieved with golden green transverse lines, and their under side is nearly all black, with transverse lines of a bluish green, on the black of the inferior wings we note a longitudinal broad discal green band, a mark easily distinguishing this beautiful species from all its congeners.

On approaching from the sea any open sandy shore in the Isle of Cuba a copse wood is perceived, above the coral reefs, forming a close and nearly impenetrable belt, maybe ten or twenty yards wide, and composed of almost one kind of tree, of aspect strange to the European eye, the *Coccoloba uvifera*, the so-called *Uvero* of the Spaniards. Immediately behind this belt an immense variety of vegetation grows in the parched sand, the plant of chief interest to us being that technically titled *Omphalea triandra*.

This, the Cob or Hog nut of Jamaica, the *Arellano* of the Island of Cuba, sometimes reaches the dimensions of a tree fifteen feet high. The part that concerns us is the leaves—great, thick, heart-shaped things of leathery texture, and a scabrous surface of a pale green; the young leaves and the leaves of the young plants, although of the same texture and colour, are of different form, being deeply incised.

During the heat of the day, on the upper side of the mature entire leaves of this tree the caterpillar of *U. boisduvalii* may often be discovered torpidly reposing, screened from the fierce rays of the sun within a thin transparent silky web. At night, no longer sluggish it quits its cover, greedily stripping *Omphalea* of its foliage, so that trees are left with scarcely a single leaf; nor is it inactive in the daytime when disturbed, but can run about quickly, and shows little affinity to the caterpillars of other diurnal *Lepidoptera*, which usually have a slow motion.

In February, and the ensuing months of spring and summer, the perfect insect deposits its eggs on the tender incised leaves, laying them singly. The young larva is of a pale green, with a yellowish head; but ere it reaches maturity its appearance undergoes considerable alteration. It is then about two inches long, and moderately hairy; and while the body varies in tint from a pale yellowish green to a flesh colour, the head now is red, irregularly sprinkled with some black spots, and the prothorax of a velvety black. The head is polished and sessile. But these larvæ differ much from each other in size, marking, and colour, more so than ordinarily occurs with larvæ of the same species.

Urania leilus. Two-thirds natural size.

Eventually the larva spins an oval cocoon of dirty yellow silk, of which the threads are so few, and so loose, as to allow the inmate to remain visible through the meshes; within the cocoon it changes to pupa. The chrysalis is not at all angular, and, moreover, reposes in a horizontal position. Yet it agrees with that of most diurnal *Lepidoptera* in being rather gaily coloured.

The flight of the imago is truly diurnal, swift, always strong, and in starts. The interior of the island it does not seem to haunt, but may be found plenteously in gardens at a distance of two, and even three, leagues from the shore. But it is by far the most common near the sea, because there grows its favourite *Omphalea*. As a matter of fact, however, it prefers flitting about the leaves of the *Coccoloba uvifera*, unless when employed in depositing its eggs.

As the genus *Omphalea* is common in Brazil and Guayana, in all probability it affords pabulum to *Urania brasiliensis* and *U. leilus*, species whose habitats are Brazil and Cayenne and Surinam respectively: for, as MacLeay remarks, "the minor natural groups of *Lepidoptera* often keep very constant to the same natural group of plants." In a word, the gorgeous Madagascar *Chrysiridia madagascarensis*, the species of the East India isles, and many more, may likewise feed on leaves of seaside *Euphorbiaceæ*.

Remark the habit of these day-flying moths of performing migrations. The very beautiful *U. fulgens* migrates annually, from east to west, in August and September, across the Isthmus of Panama. Flights have been observed by a naturalist in the Isle of Caripi, near Para, in the Brazils, at Pernambuco, at Rio Janeiro, and in the Southern States: but he saw them nowhere so abundant as on the Amazons. From early morning till nearly dark the insects passed along the shore in amazing numbers, but most numerously in the evening, and mainly from west to east. Swainson, speaking of *U. brasiliensis*, a species almost the exact counterpart of *U. leilus*, states that he witnessed a host flying during the whole of a morning in June past Aqua Fria (Pernambuco), in a direction from north to south—not one deviating from this course, notwithstanding the flowers that were growing around; and though they flew near the ground they mounted over every tree or other high object which lay in their path, and it was impossible to capture a single specimen, so rapid was their flight. For three or four days they continued to pass in this manner. On the occasion of the flights over the city of Panama, in some cases the insects are attracted into houses by the light, so as to almost fill the rooms. At night they are accompanied by goat-suckers, and during the day by swallows and swifts, which probably destroy large numbers. As will be gathered, these migrations of *Urania*, though regular, are confined to comparatively narrow limits in the tropics.

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THE SPECTROSCOPY OF ARGON.

Translated from the French, with Additions,

By T. L. Alger, LL.D., Ph.D.

Mr. Crookes found, on examining this gas with a very powerful spectroscope, that it gives, like azote, two distinct spectra, according to the intensity of the induction current employed, but that these two spectra are both constituted of fine lines.

He used ordinary Plücker tubes having a capillary part in the middle, which are quite suitable for this particular investigation.

At the commencement, the bands of azote are always seen, even with argon which is supposed to be perfectly pure, but they disappear at the end of a certain time.

At the pressure of three millimètres the most brilliant spectrum is obtained, and in this case the light is red. On diminishing the pressure and placing a Leyden jar in the circuit, the colour of the discharge is seen to pass from a beautiful blue to a steel blue, and then we get the second spectrum.

The first is composed of eighty lines, the second has one hundred and nineteen, and there seem to be twenty-six lines in common.

The analogy that argon presents with other simple gases lies in the hypothesis that it is itself considered to be a simple body.

Mr. Ramsay has also been able to detect the presence of argon and also of helium in clèveite, a mineral discovered by Nordenskiold, and found to be formed from oxide of uranium, uranate of lead, and other rare minerals. Except in a meteorite in Augusta County, Virginia, U.S.A., helium had only been observed in the spectrum of the sun.

M. Bouchard, again, has found that the lines which are characteristic of the spectra of argon and of helium exist in the spectra of the mineral waters of Cauterets.

M. Deslandres has also observed in clèveite another line which is found in the solar spectrum, and which bids fair to announce to the scientific world the presence of a new element common to the atmospheres of the sun and the earth.

Lastly, M. Berthelot, in his study of the spectra of fluorescence, has discovered, with argon charged with the vapour of benzine and submitted to moderate magnetic action under certain conditions which appear to correspond to a particular state of equilibrium, that this absorbed vapour does not pass away even after a considerable time has elapsed. First a violet tint is obtained with a sprinkling of fiery red, then a beautiful green fluorescence which is visible in broad daylight even at a distance. The clearest, most characteristic, and most brilliant line is green; of the rest, almost as brilliant are a yellow line and two violet lines, the latter less visible than the others; but there is one line, the last of the series, which can only be seen in total darkness. These lines correspond to the brilliant lines of argon considerably rarefied.

The appearance of the lines due to fluorescence at atmospheric pressure seems to indicate the existence of a combination of hydro-carbonate of argon of the same order as hydrocyanic acid.

From certain lines coinciding with the lines of the vapour of mercury rarefied, M. Berthelot concludes, that he has produced a complex equilibrium—or, rather, a condensed compound, originating when the mercury and the elements of benzine come between at the same time as the argon.

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ALKALI-MAKING BY ELECTRICITY.

By C. F. Townsend, F.C.S.

THERE is hardly a single industry, from the cottage laundry to the mill where the paper is made on which this article is printed, in which alkali, in some form or other, is not used in large quantities. Under the term "alkali" we include ordinary washing soda, and soda ash, caustic soda, and caustic potash. Until the end of the last century all the alkali used by the world was obtained from vegetable or mineral sources. Of the former, potashes or the ash obtained by burning wood or vegetable matter is still a product of commercial importance, being used in the manufacture of soft-soap. Barilla, which is the ash of a plant that grows plentifully on the salt marshes of Spain and the neighbouring parts of France, was of considerable importance in soap-making and kindred industries fifty years ago; but a very small quantity is imported into this country at the present day. Kelp, which is obtained by burning seaweed on the coasts of Scotland and Ireland, contains a small proportion of soda, but is chiefly valuable as the source of iodine and bromine. As regards mineral sources, soda is obtained from the various deposits of alkali in the more tropical regions of the world.

It was not until just before the French Revolution that a process was devised for making alkali by artificial means. The discovery came about in this way. Some years previously it had been discovered that the base of common salt was the same as that of mineral alkali, and in 1775 Scheele, the poor apothecary's assistant who did more for the progress of science than almost any man before or since, had found that litharge would convert common salt into caustic soda. About this time the French Academy of Science offered a prize for a method by which salt could be converted economically into soda. The successful competitor was Nicolas Leblanc, and his process, with a few modifications, is in use at the present day. Nicolas Leblanc, like all the great benefactors of humanity, got little out of it himself. He secured a patent and commenced operations at St. Denis. His patron, the Duke of Orleans, however, was executed in 1793, and Leblanc's works were closed; whilst in 1794 a decree of the Committee of Public Safety deprived Leblanc of his patent for the benefit of his country, the magnificent sum of six hundred francs being awarded to him by way of compensation. The works were restored to him in 1801, but his capital was gone and he was unable to make headway against competitors who were using his invention. In 1806 a committee reported on his case, but the sum awarded to him was so trivial that Leblanc, in despair, committed suicide.

In converting common salt into caustic soda its atom of chlorine must be replaced by the elements of water, and carbonic acid must be added to this to produce washing soda or carbonate of soda. What is ordinarily called carbonate of soda is the bicarbonate, which contains twice as much carbonic acid as washing soda. In the Leblanc process the salt is first treated with sulphuric acid, which causes an interchange, the elements of sulphuric acid taking the place of the chlorine to form sulphate of soda or Glauber's salts, whilst the chlorine is carried off in the gaseous form as hydrochloric acid. This acid is now condensed in water instead of being allowed to escape into the open air to blight the whole surrounding country as it used to do, and in its unpurified form is called muriatic acid or spirits of salt. From this acid the chlorine is recovered and passed through chambers containing lime to make bleaching powder. The sulphate of soda is mixed with chalk and fine coal and heated in a revolving furnace. In the end this produces a solution of carbonate of soda, and the sulphur in the tank waste is nearly all recovered. To make the soda crystals used for washing clothes this is evaporated down by the waste heat from the furnace. If soda ash is required, a much stronger heat is applied to deprive the crystals of the water they contain; and if caustic soda is wanted, the solution is boiled with lime.

For many years the Leblanc process had the whole field to itself, but now it has a hard struggle to compete successfully with the ammonia soda process. The principle of this method is said to have been known since 1822, but although many worked at it the engineering difficulties proved too formidable, and it was not until about 1863 that the problem was solved by a Belgian chemist named Solvay. For many years after that the process did not seem to gain much ground, but since 1872 it has been making great strides, so that by this time nearly as much alkali is made by the ammonia process as by that of Leblanc. The principle of the ammonia process is very simple. Ammonia and carbonic acid are blown through brine, and bicarbonate of soda, which is comparatively insoluble in water, falls to the bottom. From this bicarbonate, soda ash, soda crystals, or caustic soda are made. The weak point about the ammonia process is that all the chlorine, forming more than half the weight of the salt used, is wasted. If it was not for this, the Leblanc process would have been defunct long since.

Until recently all the sulphur of the sulphuric acid used in the Leblanc method was thrown away to form the filthy heaps of tank waste which disfigure the country and poison the air in the alkali-making districts, but all this is recovered now by a method described in Knowledge a few years ago.

By whatever means we accomplish the separation of the chlorine from the sodium in common salt, all that we have to do is to supply the energy necessary to effect the change. Heat, the attraction of the chemical atoms for one another, and the electrical current are the different forms of energy. In the Leblanc process the first is used; in the ammonia process the second; and in the latest method the third form of energy is brought into play. In pumping water up to a reservoir on the top of a hill the work done will be the same whether we employ a steam engine, a windmill, or a hand pump; but the amount of power expended will depend on the efficiency of the pump. A pump with leaky valves that let half the water back again every time the piston is moved would require twice as great an expenditure of energy as a properly constructed machine. It is just the same in manufacturing chemistry. An ideal method on paper may prove very unsatisfactory in practice. Now, the electric current is the ideal way of applying energy for effecting chemical changes, although in practice we have been able to apply it very little at present. When a current of electricity is passed through a solution of common salt the effect produced on the chemical atoms is exactly similar to the "ladies' chain" in the dance known as the "lancers." All the sodium atoms commence to travel in one direction and all the chlorine atoms in the other, joining hands as they meet. Instead, however, of moving in a circle, as the dancers do in the "ladies' chain," the atoms move towards the two poles or ends of the conductors along which the electrical current reaches and leaves the solution. The chlorine travels towards the positive pole and the sodium to the negative pole. When they reach the poles the atoms are set free, so that from one pole the chlorine gas is given off and from the other sodium, which combines with elements of water to form caustic soda. If this action went on perfectly the electrical process would supplant the others in a very short space of time. Unfortunately, however, the sodium and chlorine atoms have a strong tendency to join hands again after they have been separated; and although there are other difficulties that are too technical for us to enter into here, nearly the whole of the work done in this field of investigation has been devoted to perfecting a means of preventing the atoms in the electrical dance from becoming partners again.

The principal contrivances that have been used for this purpose are porous partitions or diaphragms extending across the middle of the cell containing the solution of salt. The amount of ingenuity that has been expended on these diaphragms has been very great, but none of them are really perfect. The recombination of the atoms is never entirely prevented, and, as we might expect, the diaphragm gets in the way of the electric current to some extent, so that a higher power is required to drive the electricity through the solution. The most successful of these processes have been the Greenwood and the Le Sueur, which is said to be used extensively in America and on the Continent, where water power is available to drive the dynamos that supply the electric current. In the Hargreaves-Bird process, explained recently in a paper read before the Society of Chemical Industry, the difficulties of having a partition in the middle of the solution have been overcome in a most ingenious way. The brine is placed in the middle compartment of a vessel, divided into three parts by two diaphragms stretching across it. The diaphragms are supported on the outside by copper cloth, which forms the negative pole of the electric current. The two outer compartments, instead of containing brine, are filled with a mixture of carbonic acid and steam. As soon as the current begins to pass, caustic soda is given off at the copper cloth. The soda combines immediately with carbonic acid to form carbonate of soda, which dissolves in the water condensed from the steam and flows to the bottom of the partition, where it is drawn off. The chlorine gas passes off in the meanwhile through an opening in the top of the partition containing the brine, so that the partners, when once they have left the electrical dance, never come near one another again. By this process it is claimed that pure alkali and the strongest bleaching powder can be made at less than five-sixths the cost of the best of the older processes.

Besides the methods in which a diaphragm is used, other ways have been invented for removing the atoms from the neighbourhood of one another. In two of these, mercury forms the negative pole, towards which the sodium atoms travel. Instead of combining with the elements of water to form caustic soda, the sodium unites with the mercury. This quicksilver is kept in rapid circulation, so that as soon as the amalgam of mercury and sodium is formed it is removed from the vessel where the action is going on. The amalgam is treated in a separate vessel to recover the sodium in the metallic state, or it is run into water, where caustic soda is formed and the mercury is set free. One of these processes is known as the Castner-Kellner process, and the other has been devised by Mr. Claude Vautin. The last-named inventor is responsible for another ingenious method, in which fused salt is used instead of brine. The action goes on in a crucible kept hot by the electric current itself. The negative pole in this case is formed of a layer of molten lead at the bottom of the crucible. The sodium amalgamates with the lead in the same way as it does with the mercury in the process just described. In all the different methods the positive pole or electrode is formed of a rod or plate of gas carbon.

The non-technical reader may be inclined to regard this account of electrical alkali-making as somewhat dry, and of no particular interest to himself. It is really astonishing, however, to think of the vast revolution the introduction of electrical energy will effect in our industrial life. The whole conditions of life in the country will be changed. Water power will replace coal as the prime source of energy. The cohorts of factory chimneys, belching forth black smoke, which wanders over the sky in ever-increasing folds, like some evil genius just arisen from the bottomless pit to shut out the light of day from the workers, will disappear in a great measure. We are not blessed in this country with large rivers, but the water power of the tides running to waste round our coasts is enormous. The power of the tides running past Bristol is sufficient to drive all the alkali works in the kingdom half a dozen times over. The task of providing this water power might well be undertaken by our great maritime municipalities or county councils. All that is required is to build large storage reservoirs at the level of the top of the tide. They would fill at the flood, and gradually run down to reservoirs on low ground, which would be emptied at the ebb. By means of turbines and dynamos this power could be transformed into the energy of the electric current, which would turn all the machinery in the city—if not in the whole county—besides lighting and heating the private houses and public buildings. Another important point is that our stores of coal are by no means inexhaustible. In fact, they are diminishing rapidly, and the most liberal estimate does not give our coal supply more than one hundred and fifty years' duration at the present rate of consumption. Long before that time the depths of the existing shafts will have to be increased so much that the cost of getting the coal will be very much augmented, and we shall be placed at a great disadvantage as compared with countries that have not drawn largely on their hidden store. If we are able to utilize the natural powers of the tides and rivers we shall be able to eke out our supplies of fuel to an almost indefinite extent, and the countries like our own with a large coast-line, round which run strong tides, will still lead the van in industrial progress.

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OBSERVATIONS DE L'ÉCLIPSE TOTALE DU SOLEIL DU 16 AVRIL, 1893.*

M. DESLANDRES' report comes at a most appropriate time, and it will be the more welcomed since M. Deslandres has taken so prominent a part in that rapid advance in solar physics which has been so marked during the last few years, and since in the 1893 eclipse he attacked an entirely new department of the solar problem.

The report opens with remarks on the importance of eclipses, on the special conditions of that of 1893, on the necessity for using the photographic method in the study of coronal forms, and on the threefold character of the coronal spectrum. This is: first, continuous, from incandescent solid or liquid particles; second, bright line from the coronal gases; third, a feeble solar spectrum from reflected sunlight. M. Deslandres then speaks of his design to push his researches into the ultra-violet region of the coronal spectrum, and to determine the speed of rotation of the corona by the relative displacement of its lines east and west of the sun. This latter was not only a new investigation, but one of the highest importance; for if the corona be composed of a vast network of meteoric streams, its rate of motion would be much more rapid than if it turned with the sun.

The description of the instruments employed, and of the manner in which they were arranged, which follows next, is of great interest, but need not detain us now. The most striking detail was the use of a double polar heliostat in connection with three of the principal spectroscopes. The day of the eclipse was not particularly fine, the sky being by no means so clear as on the preceding days. However, twenty-seven photographs of the corona and of its spectrum were secured.

The photographs of the corona itself were obtained with three objectives of different ratios of aperture to focus, all mounted on the same equatorial. It is, M. Deslandres points out, practically impossible to fix what will be the best exposure beforehand; this combination of three lenses of very different relations gave him, however, a very wide range, and the greatest extension seems to have been secured with a telescope of *f/a* 12½, an exposure of forty seconds, and a plate of medium sensitiveness. In all, seven plates were obtained with each of the three telescopes; but the last plate of each set was spoiled by the return of sunlight. The evaluation of the depth of deposit caused by the coronal light shows that for the region between 3′ and 9½′ from the limb, the light equalled 0·18 of a "decimal bougie" placed at one mètre distance.

Comparison of the West African photographs with those taken in Brazil and Chili show no great change in the corona in the interval of time; but the comparison with those of earlier eclipses enforces the conclusion long since arrived at that the corona changes its form with the sunspot cycle. The threefold character of the coronal light, alluded to above, was again manifested: the bright line spectrum being strongest in the lower regions, the central region showing rather a continuous spectrum, and a feeble spectrum of reflected sunlight being given from remoter districts.

In spectroscopic work M. Deslandres was anxious to push his researches far into the ultra-violet, thus breaking up new ground. Five slit spectroscopes in all were employed, but two yielded no results. The other three gave good spectra, yielding the means for determining the positions of a large number of bright coronal lines, and the spectrum of the greatest dispersion enabled M. Deslandres to obtain the first determination of the speed of rotation of the corona. This, by far the most striking result of his work, and worthy of the strongest emphasis, gave a relative motion of the corona, east and west of the sun, of 6·8 km.; approaching, that is to say, the relative motion of particles rotating with the sun. This result would alone have been worth all the heavy labour M. Deslandres devoted to the eclipse; and though the more powerful spectroscope he designed for this research gave no result, and though we must hesitate to base theories on a single set of observations, as yet unconfirmed and not incapable of misconstruction, he is abundantly to be congratulated on the success obtained with his second weapon.

Other spectroscopic results were: the demonstration that the continuous spectrum, which forms the major part of the coronal light, is intensest towards the red, relatively to the light of the disc, and this is more marked the higher from the limb the point examined; that the dark line spectrum due to reflected sunlight cannot be detected at 5′ from the limb; and that the bright lines vary in different parts of the corona and at different heights, and do not usually correspond to known terrestrial elements. The concluding chapter of the report is one of especial interest. It is a review of the progress of our knowledge of the solar atmosphere up to the present day, with suggestions to which the long and careful consideration of solar problems has given rise in M. Deslandres' own mind.

The first point touched upon is the relationship of the periodic changes in the sun and its atmosphere, as, for example, the association of a particular type of coronal form with a solar spot minimum. The cause of this periodicity is still unknown, but M. Deslandres favours the sunspot theory of M. Faye, which regards sunspots as having analogies to terrestrial cyclones, and explains the differences in the surface speeds of the photosphere by great movements of gas in the vertical direction. For the corona an electric origin is favoured; M. Schaeberle's "mechanical theory," which is discussed somewhat at length, being irreconcilable with the results mentioned above as to the coronal rotation. In propounding an electric theory, M. Deslandres, as he points out, follows in distinguished footsteps, Tacchini, Fizeau, Secchi, Huggins,

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* Par M. H. Deslandres. (Paris: Gauthier Villars et Fils.)

and many others having expressed opinions more or less in consonance with such an idea. (Dr. Brester's name is, by a slip, no doubt, given as Brewster.)

It would be entirely unfair to attempt to summarize in a few words the theory here expounded. It may suffice to say that M. Deslandres finds a very close analogy between solar and terrestrial meteorology; prominences, for example, being, according to him, the solar representatives of our electric storms.

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A VERY EXTENDED STREAM OF SUNSPOTS.

The years 1893 and 1894 were markedly the epoch of the sunspot maximum. 1895 showed a steep descent of the curve of spotted areas, and, indeed, on four days in April and three days in May of the current year the sun was entirely free from spots. Drawings of the solar corona of August, 1896, made at Bodö and Nova Zembla, added strong testimony of the near approach of the sunspot minimum. Nevertheless, on September 9th, 1896, a small solitary umbral spot was observed close to the east limb, which on the following day was seen to be the precursor of a group hardly surpassed in area even by the great group of February, 1892, and equalled by none in length. September 11th and 12th were cloudy; but on September 13th the photograph showed it well advanced on the disc, a sinuous length, a narrow band of almost constant breadth, with central and segmented nucleus and faintly continuous penumbra. To the north of the final spot of the riband, itself curved, there was a semi-elliptical ring of nebulosity with three or four small nuclei situated on the inner side of the ring, whose apse points north. In fact, the whole stream formed a series of curves whose concavities lay to the sun's equator. Little change was to be noted on September 14th and 15th, and by September 16th the great procession of spots was passing the central meridian, and its fair proportions were spread unaltered by foreshortening before our eyes. The sharply nucleated preceding spots of the group showed a tendency to shed indefinitely shaped nebulosities on their southern side, the centre of the stream was itself nebulous and ill-defined, and the regular following spots had broken on their northern edge into irregular penumbral patches. Thus though the band had quite lost the waved appearance which was its characteristic on September 13th, and the nuclei of the spots all lay towards the median line of the stream, a faintly spiral formation seemed indicated. But the chief feature of the group was now the form and method of segmentation of its separate spots. One type recurred again and again in many stages, and its form closely resembled the opening shells of a bivalve. The herald spot had lessened its distance from the great group very considerably. By September 20th the spots had aggregated to form three distinct groups, and as the stream had now nearly approached to the west limb its form and character could not be so easily recognized. On September 22nd only the final spots were to be seen on the sun's edge.

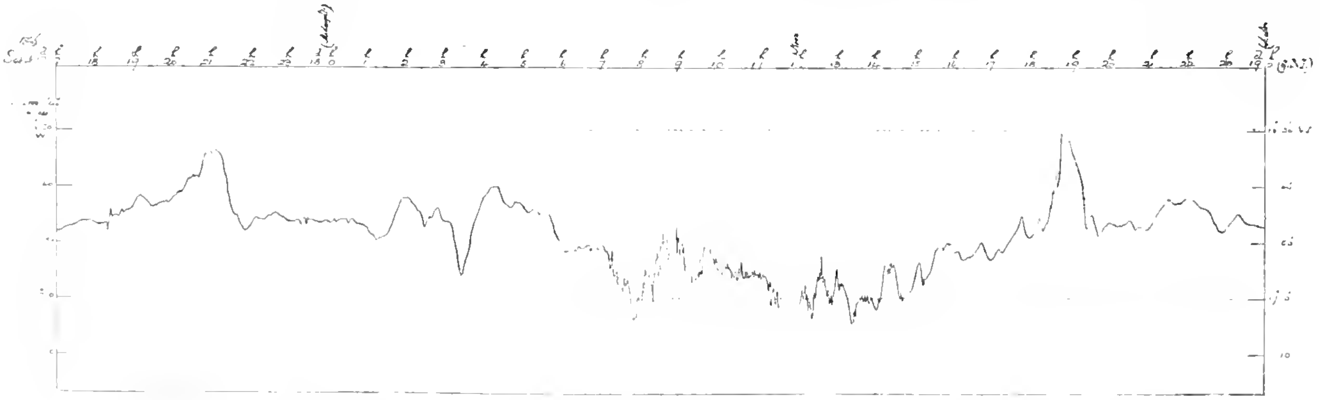
The accompanying plate will give, however, a better idea of the form and changes of the group than much verbal description. The photographs, which we are enabled to reproduce by the kind permission of the Astronomer Royal, were taken with the Dallmeyer photoheliograph of four inches (three inches effective) aperture, and five feet focal length, of the Royal Observatory, Greenwich, on September 13th, 16th, 19th, 21st, and 22nd respectively. The primary image is enlarged fifteen times in the telescope itself, and has been further enlarged for reproduction twice more, so that the scale of the photographs here given is half an inch to a minute of arc, or about sixteen inches to the solar diameter.

The leading spot of the group on September 16th was in hel. long. 66° and in hel. lat. 10° N.; the last spot in hel. long. 42° and hel. lat. 16½° N. This gives a total length to the group of more than 24° of solar longitude, or fully one hundred and eighty thousand miles. Its breadth, on the other hand, did not exceed one-fifth of this at its broadest part.

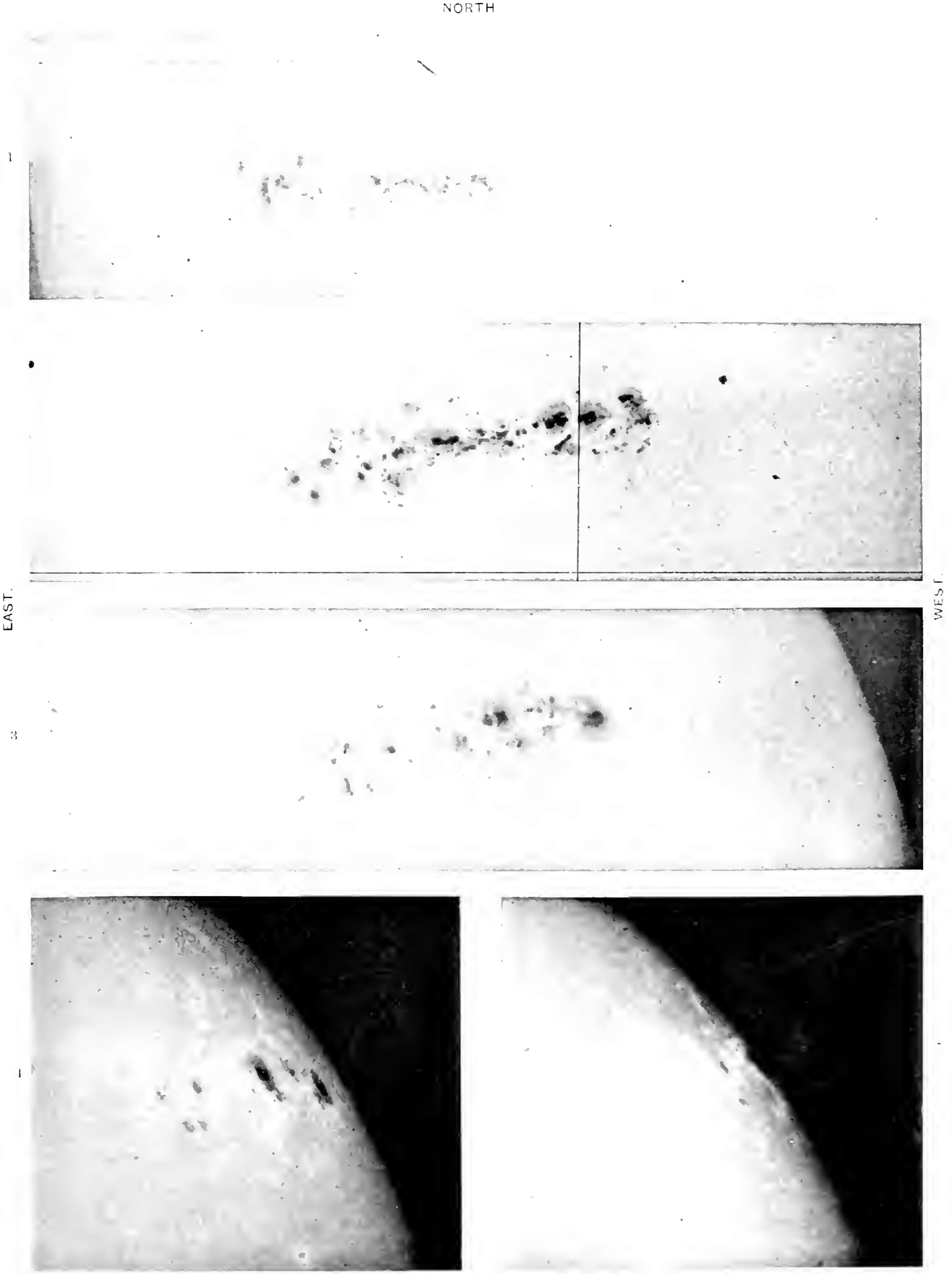
The tendency of long groups is *eventually* to range themselves parallel to the solar equator, but it is not at all uncommon to find streams inclined at a very considerable angle to it in their earlier days. The present group was an illustration of the latter relation, being inclined at an angle of about 15° to the equator, the preceding end of the group being at the lower latitude.

The total area of the group when fully on the central meridian, which it took forty-four hours to cross, amounted to two thousand four hundred millions of square miles.

This stream was not of the type that is usually accompanied by magnetic disturbances. Nevertheless, as the accompanying diagram, which represents the photographic trace of the declination magnet at the Royal Observatory, Greenwich, will show, the quiescence of the magnets was disturbed soon after sundown on September 17th by the sharp, sudden twitch which is so typical of the commencement of a cosmical magnetic storm. If this trace be compared with the photographs given in Knowledge for May, 1892, p. 92, it will be seen that the succeeding oscillations were of a much milder type than those that accompanied the giant spot of February, 1892. Yet they were quite considerable, a wave of 13′, which finished



Copy of the Photographic Trace of the Declination Magnet (Royal Observatory, Greenwich), 1896, Sept. 17d. 17h.—Sept. 19d. 0h., G. Civil Time.



THE GREAT GROUP OF SUNSPOTS OF SEPTEMBER 10th 22nd. 1896, as Photographed at the Royal Observatory, Greenwich

(Reproduced by p[illegible])

d. h. m. s.
1 Taken 1896, September 13 16 13 51 G. Civil Time.

d. h. m. s.
4. [illegible] 1896 September 21 11 49 30 [illegible]

abruptly at two hours before midnight, following the first significant twitch. Two double waves occurred during the night, followed by a steady increase at sunrise, and a series of small but rapid fluctuations which lasted all day. A strong double wave of 17′ occurred soon after sunset, and the disturbance then gradually died away. In some parts of England considerable auroral displays were noticed during the nights of September 17th and 18th.

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It is with great regret that we learn, at the time of going to press, of the sudden death of the distinguished Director of the Paris Observatory, M. François Félix Tisserand, in his fifty-second year. M. Tisserand had only been in command of the observatory four years, succeeding to that post on the death of Admiral Mouchez.

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Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

PRISMATIC LUNAR RAINBOWS.

To the Editors of Knowledge.

Sirs,—On the 21st September, at 7.26 p.m., I noticed a very fine lunar rainbow. It appeared to be similar to a solar rainbow, except that it was fainter. The prismatic colours were distinctly visible. It gradually faded away, and by 7.41 p.m. it had completely disappeared.

I again witnessed a similar phenomenon on the 23rd September, at 7.30 p.m. The bow was, however, less bright than on the preceding occasion, but the red and blue were faintly visible. It had disappeared by 7.33 p.m.

J. M. Wadmore.

To the Editors of Knowledge.

Sirs,—On September 20th, at twenty minutes to ten, I had the opportunity, in company with another, of witnessing a very beautiful phenomenon.

A dark and massive rain-cloud, which was travelling rapidly towards the east, was seen to have a peculiarly vivid prismatic corona on its western edge. The position of this cloud seemed very much in advance of another thin cloud of pearly whiteness which was seen to surround the moon's disc; the two clouds seemed, nevertheless, continuous.

This bow was twelve moons' breadth in length, and we experienced no difficulty in distinguishing the various colours. The red, green, and blue were seen to best advantage at the middle of the arch, whilst their intermixture with yellow and violet at each end of the bow resembled the colours reflected from moonstones or pearly shells; the violet was innermost, and the sharp boundary line between it and the shiny white was very beautiful.

The whole phenomenon lasted about four minutes, and was totally different from the rather common coronæ and cloud edges seen at this season of the year, and which I have been watching for some time past.

There were no other clouds in the immediate vicinity of the moon—indeed, the whole sky seemed at the time remarkably clear—whilst the dark blue appearance of the west might have had something to do with the unusual appearance which I have endeavoured to describe.

The prismatic edges of clouds are generally regarded as a sign of stormy weather, and judging from what we have experienced lately the phenomenon which we had the privilege of watching amply justifies this conclusion.

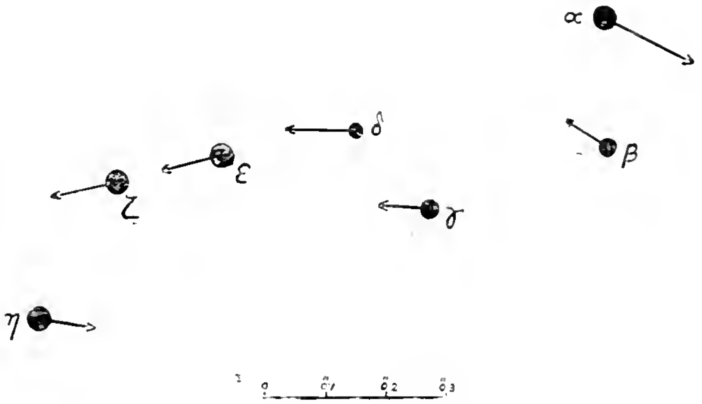
Portmadoc. Walter Williams, M.B.

PROPER MOTION OF CONSTELLATION URSA MAJOR.

To the Editors of Knowledge.

Sirs,—At the foot of the article on the constellations of Ursa Major and Ursa Minor which appears in the October Number of Knowledge, it is stated that all the seven principal stars in the former group have been found to have a common proper motion. Is this correct? In Proctor's "Other Worlds" appears a diagram showing that α and η are travelling in almost the opposite direction *across* the line of sight as compared with the other five. I believe that the spectroscope also confirms this grouping as regards their motion *in* the line of sight. If any recent observations have tended to contradict Proctor's deductions, I should be very glad if you would give the information in an early issue. Lawrence B. Tappenden.

[Mr. Tappenden is quite right in taking exception to Mr. Reynolds' statement that "all the seven stars have a common proper motion through space." As the accompanying diagram will show, ε and ζ have almost exactly the same proper motion, and γ and δ are similar in direction. But the motion of β differs considerably from that of the four above-named, and α and η are moving, as Proctor quite correctly stated, almost in the opposite direction. It is certain that these two do not belong to the same system as the other five, and I scarcely think the evidence warrants us in following Proctor, and asserting the physical connection of all the five.



Annual Proper Motion.

The spectroscopic evidence is inconclusive. The Potsdam results for the motion in the line of sight of these stars give practically the same motion of approach for β, γ, ε, ζ, and η, and a smaller motion in the same direction for α. Dr. Huggins found about the same speed for all the five stars, but found that they were receding from us.

The proper motions adopted in the diagram are those derived by Prof. Auwers from his new reduction of Bradley's observations.—E. Walter Maunder.]

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MACQUEEN'S BUSTARD (*Otis Macqueeni*).

On October 17th I was walking along the sea-bank at Easington, Yorkshire, in company with Mr. Eagle Clarke, the well-known ornithologist, and Mr. Bendelack Hewetson, Jun. We all at once noticed a large bird flying low over the fields like an owl, and being pursued by small birds. It skimmed across a high bank and went down in a field beyond. We immediately followed it, and on arriving at the bank crept up to the top and cautiously looked over. There, in the middle of a stubble field, about one hundred and twenty yards from us, was what we took to be a great bustard.

We lay down and watched it with our field glasses. It seemed quite at home, and behaved perfectly naturally. It strutted about with a stately gait somewhat like a peacock, and pecked at the ground here and there in an almost disdainful way. Then it began to dust itself, drawing in its head and ruffling its feathers, and spreading wings and tail. We watched it closely for quite ten minutes, and were fascinated by its interesting ways, probably never observed in England by ornithologists before, for this grand bird was a Macqueen's bustard, and only the third example which has visited our shores.

Meanwhile two men had come on the scene with guns, and after a little manœuvring George Edwin Chubbley shot the bird as his brother Craggs Chubbley put it over to him. Whilst being followed it never seemed flurried.

When flying, the wings of the bird were a striking black and white. The long black tufts on the sides of the neck appeared as black streaks at a distance, and were very conspicuous as the bird stood in the field.

Macqueen's bustard is a desert-loving species inhabiting the steppes of Asia, and why it visits us at all is merely a matter of conjecture, but probably certain young birds wander far from their course and thus manage to reach our coasts.

When the feathers of the bird were turned up we found them to be of a delicate blush pink at the base, contrasting beautifully with the speckled sandy colour of the bird's back. The beak is brownish black, the legs and feet light straw colour, and the eyes very pale straw and very bright.

The length from beak to tail is twenty-eight and a half inches, the tarsus four and a half inches, and the flexure sixteen inches.

The bird was a young male, and its stomach contained vegetable matter and three beetles.

Mr. J. Cordeaux and Mr. H. Bendelack Hewetson, M.R.C.S., arrived on the scene a few minutes after the bird was shot.

Harry F. Witherby.

Notices of Books.

Voxometric Revelation: the Discovery of the Human Voice. By Alfred Augustus North (Examiner in Music to the New Zealand Government for thirteen years). Published by the Authors' and Printers' Joint Publishing Co. Pp. 206. Price 10s. 6d. Of all the problems that vex the soul of the practical musician those connected with voice production and development are the most perplexing. The act of singing is a supremely difficult one to investigate. It is an unknown combination of physical, physiological, and psychical phenomena. It is not hard to get at some of the truth, especially on the physical and physiological side; but beyond this there is, it appears, unlimited scope for speculation and dogmatism. The latest exponent of an absolutely complete and "scientific" explanation of the whole art of singing is Mr. A. Augustus North. If we may believe the author there is really nothing now left for posterity to discover. The hitherto hidden processes of nature are revealed for the benefit of the whole race of mankind. Singing (which must mean fine singing, to be worth mention) is declared to be a spontaneous and natural act "incident to all humanity," and not merely the special gift of the few. "Those who will rightly use their voices" (*i.e.*, of course, on the voxometric method) "and follow out faithfully the general conditions in doing so, hold within themselves the power of commanding health, strength, happiness, and longevity, and will assuredly be laying the foundation of a stronger, a finer, and a more magnificent empire than the world has *ever* seen!" (p. 178).

The "revelation" seems to involve the acceptance of Dr. A. Wilford Hall's theory that sound is not the result of vibration, but is an emanation. Mr. North says: "The human voice, as also every other form of manifestation of a *cause* which we have hitherto been taught to consider a *phenomenon* merely, is not produced in any way according to the general hypotheses on the subject. And vibration is not the cause of sound, but only an effect when sound is made appreciable to mortal conceptions. Sound is, unquestionably, a living, immaterial, substantial force in nature" (p. 65). The italics are the author's.

The features of the "revelation," as regards the theory of voice production, may be summarized as follows:—

1. There is only one register in the whole voice from top to bottom. The laryngoscopists, with their head, throat, chest, upper thin, thick, and lower thick registers, each the product of special behaviour of the vocal cords, are entirely and wofully wrong.

2. Full, pure, round tone results from the reciprocal action of the resonating cavities, not only above the larynx, but indispensably below the larynx, where the compressed air echoes and reinforces the tone rebounding from the hard palate. The pupil is besought continually to "think of the sternum bone as the sound-reflecting element."

3. The larynx must always be kept as *low* in the throat as possible. It *must never be allowed to rise.*

4. The speaking voice of civilized people is declared to be false and unnatural. Voice trainers have erroneously based their singing training upon this false voice.

5. The vowel "ē" (ee) is asserted to be the all-important voice-training vowel. The vowel "ah," which is so generally used by trainers, is "a perfect fiend incarnate."

6. It is asserted that a very large majority of the whole of the civilized race, and especially the inhabitants of the towns and cities all over the world, are not breathing naturally.

In some of Mr. North's teaching we find ourselves in agreement, especially in his pertinacious insistence that resonance should be the chief study of the singer. Whether his theories as to how resonance is caused be right or wrong, there is no question that some of his practice at least would be beneficial. But we are very far from recommending the whole "revelation" as a practicable scheme of voice cultivation. The author, and those who are assisting him to promote the method, show great lack of judgment in their plan of campaign. Thoughtful and earnest enquirers after scientific truth are repelled by prospectuses that might serve for pills or soap. In a matter pre-eminently practical the public cannot be convinced by a mere book, but by the voice trainer who presents to us accomplished results. Until this happens we are compelled to feel, in this, as in many other mundane affairs, that "man never is but always to be blessed."

Results of the Stonyhurst Meteorological and Magnetical Observations for 1895. By Rev. W. Sidgreaves, S.J., F.R.A.S. Statements of the instruments used and the observations made during the year 1895 have come from several observatories, both British and foreign. This year, it will be remembered, was noted for its low winter temperature, and accordingly the Stonyhurst observations show that on two occasions the year gave a minimum thermometer reading when compared with the corresponding months of the previous forty-eight years. One of these occurred on February 18th, when the thermometer registered 8·0°, and the other on October 28th, when the reading was 17·8°. An appendix is contributed by Father Dobson on the results of meteorological observations taken at St. Ignatius College, Malta; and when compared with the preceding twelve years we again find the lowest temperature registered was 34·2°, on February 19th, 1895.

Argon and Newton: a Realization. By Lieut.-Colonel W. Sedgwick. (W. B. Whittingham & Co.) "The universe is a building put together with materials shaped for building purposes, so as to fit together in certain positions, and in certain positions only: but, at the same time, so hard and solid as to be unbreakable and unalterable under any conditions which obtain now." The purport of this may not be quite clear, but that is our misfortune, as Lieut.-Colonel Sedgwick's intentions are good, and his style is peculiarly original.

The isolation of argon and the identification of terrestrial helium were important, but Lord Rayleigh and Prof. Ramsay little suspected that their discoveries were just what Lieut.-Colonel Sedgwick needed to substantiate the conclusions arrived at in his epoch-making work, "Force as an Entity." Yet Lieut.-Colonel Sedgwick says they were, and who would venture to oppose his view?

We learn that the atom is a sphere with flat places—the form of the monovalent atom being a chipped sphere with one flat place, two for a divalent atom, and so on. Argon and helium probably have spherical atoms; but the inner meaning of this latter characteristic is only clear to Lieut.-Colonel Sedgwick, and we suppress our desire to explain their part in the universe in order to let the words of wisdom appeal directly to our readers. "We build, indeed, nothing upon argon and helium," the gallant author writes, "or with them. In truth, it is their general unsuitability for employment in any kind of building whatever which makes their support of so much importance; though at the same time we recognize that such unsuitability does not go to the length of complete inability to form part of any structure whatever. . . . Though marked unsuitability for building purposes is their characteristic feature, it is, from our point of view, quite possible that they may in some cases be worked into buildings." To prevent possible misconception, we have the temerity to add that Lieut.-Colonel Sedgwick's remarks refer, not to the construction of merely mundane edifices, but to the building of the universe. Before the discovery of argon and helium, all materials were regarded by Lieut.-Colonel Sedgwick as suitable for his purpose; but this was not altogether satisfactory, for his theory called for the existence of materials "unsuited for building operations," and the two new elements met this requirement.

Only one thing more remains to be said. The reader may ask what Newton has to do with the matter? Well, Newton's views on the nature of atoms are practically the same as Lieut.-Colonel Sedgwick's, but he was not able to develop them into a proof of the "first cause"; and it was left to Lieut.-Colonel Sedgwick to accomplish the task which Newton assigned to science. "Force as an Entity," according to Lieut.-Colonel Sedgwick—and who should know better?—is "perhaps unique." "Argon and Newton" is its sequel, and is just as wonderful.

Roads and Pavements in France. By Alfred Perkins Rockwell, A.M., Ph.B. (New York: Wiley & Sons. London: Chapman & Hall.) Illustrated. This account of the mode of construction and maintenance of stone roads in France, where are to be found the most highly educated and able road engineers in the world, should do something towards the improvement of our highways. The methods and practice in one country are not necessarily applicable to another, but there is always something to be learned from the results of experience; therefore contractors and civil engineers will find this contribution to the literature of road making handy and serviceable.

Moorland Idylls. By Grant Allen. (Chatto & Windus.) 6s. Whatever Mr. Grant Allen writes about natural objects and scenes is worth reading. He is a pleasant philosopher, who walks through the beautiful woodlands of Surrey with his eyes wide open, appreciative of everything that lives upon them, and with the breadth of mind required to build up impressions into word pictures which shall be attractive to all nature lovers. This score of essays may seem trifling to the student full of knowledge of idioblasts, epigenesis, and similar profound problems, and critics may take exception to the anthropomorphism which forms the basis of most of the observations; but naturalists who understand the poetry of nature will find their hearts in unison with everything in the book.

The Studio. October. 1s. monthly. To the student treading the maze of modern art, this publication is at once an inspiration and a guide. An outcome of decadent æstheticism, it gives us the best of the new in art. This month, the article on "Japanese Floral Arrangements" is extremely interesting and useful to all desirous of adding new beauties to their surroundings. The observations on the work of C. J. Watson, and the first notice on the "Arts and Crafts," are sincerely written and well illustrated. In fact, all the reproductions are as good as they could possibly be.

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BOOKS RECEIVED.

An Archæological Survey of the United Kingdom. By David Murray, LL.D., F.S.A. (Glasgow: James Maclehose & Sons.)

Index to the Genera and Species of the Foraminifera. By Charles Davies Sherborn. Part II. (Smithsonian Institution.)

Elements of Astronomy. By Sir Robert Stawell Ball, LL.D., F.R.S. (Text Books of Science.) (Longmans, Green, & Co.) New edition. 6s. 6d.

Thirteenth Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution. By J. W. Powell, Director. (Washington: Government Printing Office.)

Humphry Davy, Poet and Philosopher. By T. E. Thorpe, LL.D., F.R.S. (Century Science Series.) (Cassell & Co., Ld.)

The Unsolved Riddle. By Victoria Woodhull. (Blades, East, & Blades.)

A Baltic Cruise to the Capitals of Northern Europe. By "Red Cross." (Phipps & Connor, Ld., Tothill Street, S.W.) 1s. Third Edition.

Rocks and Minerals. By J. W. Tutt, F.E.S. (Gill's Practical Series of Object Lesson Books.) (George Gill & Sons.) 1s.

Insects and Spiders. By J. W. Tutt, F.E.S. (In same Series.) 1s.

Model of a Horizontal Steam Engine, with Description of the Parts. (George Philip & Son.) 2s. 6d.

Argon and Newton: a Realization. By Lieut.-Col. W. Sedgwick. (W. B. Whittingham & Co., Ld.) 7s. 6d.

Natural History of Australia. By Frederick G. Aflalo, F.R.G.S., etc. (Macmillan & Co.) 6s.

Elementary Geology. By G. S. Boulger. (William Collins, Sons, & Co., Ld.) 1s. 6d.

Practical Work in Physics.—Part III., Light and Sound. By W. G. Woollcombe, M.A. (Clarendon Press.) 3s.

Evil and Evolution. By the Author of "The Social Horizon." (Macmillan & Co.) 3s. 6d.

Edinburgh Review for October. (Longmans.) 6s.

The Reliquary and Illustrated Archæologist. Vol. II. New Series. (Bemrose & Sons.) 12s.

Everybody's Medical Guide. (Saxon & Co., London.) 6d.

The Wonders of Modern Mechanism. By Charles Henry Cochrane. (J. B. Lippincott Co.) 7s. 6d.

The October Number of *Science Progress* commences a new series, having been converted from a monthly magazine to a quarterly, of a hundred or more pages. The contents of the present number are decidedly technical, but the subjects are varied and soundly dealt with. The most prominent articles in the number are "The Natural History of Igneous Rocks," by Alfred Harker, M.A., and "The Nervous System of Cœlentera," by Prof. Hickson.

Messrs. Smith, Elder & Co. have in the press a work by the Rev. H. N. Hutchinson, author of "Extinct Monsters" and other works, entitled "Prehistoric Man and Beast." Sir Henry H. Howorth, M.P., F.R.S., contributes a preface. The book will be illustrated with original drawings by Mr. Cecil Aldin.

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BIRD MIGRATION IN GREAT BRITAIN AND IRELAND.

Report of the Committee of the British Association.

Bird migration, although a subject about which very little is known, has always proved an extremely fascinating one to ornithologists, and, as a consequence, a large amount of literature on the subject has resulted, some of it dealing with acts, but more often it has been of a speculative character.

The British Association determined to give their careful attention to the subject, and accordingly a committee was appointed to investigate the matter. This committee consisted of the following well-known ornithologists:—Prof. Newton, Messrs. John Cordeaux, J. A. Harvie-Brown, R. M. Barringtou, W. Eagle Clarke, and Rev. E. P. Knubley.

By a system of schedules all the birds observed at two hundred and three lighthouses and lightships round the coasts of Great Britain and Ireland, from the years 1880-1887, were accurately recorded, as well as the times and dates of their passing. One hundred thousand records, culled from several thousand schedules, were thus obtained. It can easily be imagined what an enormous task it was to reduce this mass of information to an intelligible form, so as to make it of real scientific value. This, however, has now been done by the energy of Mr. W. Eagle Clarke, and the outcome of his years of labour is the report which was read at the Liverpool meeting of the British Association.

I propose here to give a brief summary of this report, and to extract from it the most salient and important facts elicited by the inquiry. "The migration of birds, as observed in the British Islands, is a very complex phenomenon; more so, perhaps, than in any other region of the globe." This may readily be seen. By their geographical position the British Isles form, not only a main and much accustomed highway, but convenient resting quarters for legions of migratory birds, which annually make a double journey between their northern summer and their southern winter quarters. Again, we have a vast bird population of our own, and the majority of these are purely migratory species, while nearly all are migratory to a certain extent. We have a further complication in the fact that our variable climate causes much irregular migration. Having said so much, to show with what an extremely complicated but fascinating problem we are dealing, let us pass on to review it in some detail.

Mr. Clarke has confined himself entirely to facts, which are discussed under the following sections: geographical, seasonal, and meteorological. It may be explained here that the terms "immigration" and "emigration," used below, mean respectively migration to, and migration from, our shores, while the term "migration" is used in a general sense.

Geographical. — *Intermigration between Britain and Northern Continental Europe.*—Between Britain and Northern Continental Europe travel a host of migrants, which are either birds of passage on, or winter visitors to, our shores.

"These immigrants and emigrants from and to Northern Europe, pass and repass between this portion of the Continent and Britain by crossing the North Sea in autumn in a south-westerly direction, and in spring in a north-easterly one, and while the limit to their flight in the north is the Shetland Islands, that on the south extends to the coast of Norfolk."

"After arriving on our eastern shores, these immigrants from the north, some of them after resting for awhile, move either down the east coast, *en route* for more southern winter quarters, or, if winter visitors, to their accustomed haunts in Britain and Ireland."

"The west coasts do not receive *directly* any immigrants from Continental Europe."

Intermigration between the South-East Coast of England and the Coast of Western Europe, or the East and West Route.

"During the autumn, day after day, a stream of migrants, often of great volume, is observed off the coast, flowing chiefly from the south-east to the north-west at the more northerly stations, and from east to west at the southerly ones, across the southernmost waters of the North Sea. . . . . These important immigrations set in during the latter days of September, reach their maximum in October, and continue at intervals until November."

"It is satisfactory to find decided evidence that the birds retrace their flight to the north and east along precisely the same lines as those along which the autumnal southerly and westerly journeys were performed. Thus in the spring these birds depart from the same sections of our eastern seaboard as witnessed their arrival in the autumn. . . . . Whether this east to west stream is a branch of one that passes down the coast of Continental Europe, or whether it has its source in Central Europe, is a matter of conjecture."

This interesting migration route is one of the discoveries of the inquiry. Formerly it was thought by some that in the northern hemisphere there was no migration route trending north in autumn, or south in spring. So convinced was Mr. Charles Dixon of this, that he actually founded a *law of dispersal* on the supposed fact. The present enquiry has now abolished this *fact*, and with it Mr. Dixon's "plausible" theory. Another remarkable fact brought to light is that Heligoland and England draw their migratory hosts from different sources. Herr Gätke, who has done so much valuable and practical work in connection with migration in Heligoland, thought that the birds passing over that island were on their way to England. Mr. Clarke, however, comes to the conclusion, by careful comparison between our observations and Herr Gätke's, that this is not so.

Besides the routes already discussed there are others, but want of space compels me to pass them over without comment. They are:—

"*Intermigration between Britain and Färoes, Iceland, and Greenland: Intermigration between Great Britain and Ireland and the South: East Coast of Great Britain: West Coast of Great Britain: Irish Coasts: South Coast of England: Channel Islands.*"

We now come to the seasonal section of the report.

"In the autumn the birds, when they appear on our shores, have accomplished *the* great business of the year—procreation. Food is still abundant in their favourite resting haunts, and hence there is no particular hurry to move southwards. Thus many species tarry on our coasts or in their vicinity, some for a considerable period. Their numbers are, of course, incomparably greater than during the northward journey, as they are swelled by the numerous young birds, now a few weeks old. All these circumstances and conditions combine to make the autumn movements comparatively easy of observation."

"In spring the all-absorbing duties of the season and the procreative influence are upon the voyagers, and the birds usually hurry on after a short sojourn for rest and food only. Thus the spring movements do not afford much facility or opportunity for observation."

Autumn Immigration.—Birds which have migrated north for the summer, seem to begin to return south towards the end of July, when a few reach our shores. Immigration does not set in in earnest, however, until August, while in September it increases, and in October the flood of migratory birds reaches its highest level, and there are experienced those vast "rushes" upon our shores so often described. . . . . "The immigratory movements occurring in November are not only on a very much reduced scale, *but after the middle of the month the immigration of such birds as spend the summer in the north entirely ceases*, with the exception of those of certain marine species (duck, gulls, grebes, swans), whose late movements to the south are dependent upon severe weather conditions. This is entirely contrary to the views hitherto propounded regarding the limits of these movements, but it is, nevertheless, a fact well established by this inquiry."

Except that they do not begin until the end of September, the immigration from the west by the east and west route nearly coincides with that from the north.

"During immigration our shores are reached during the late night or early morning on the part of migrants from the north. On the contrary, the immigratory movements from the east, across the narrows of the North Sea, appear to be performed during the daytime."

Autumn Emigration.—A few of our summer visitors leave us in July (*e.g.*, swifts and adult cuckoos). In August emigration increases, while "September witnesses the height and close of the emigration of the bulk of the smaller British summer visitors. The movements of forty-two of these emigrants appear in the records for the month; while those of the partial migrants are also considerable, over forty species being recorded. . . . . The October emigrants among the summer birds are not numerous. The partial migrants, on the other hand, are much on the move." These movements of partial migrants are often pronounced, and "rushes" are recorded during October, but they cease by or during the first half of November. A partial migrant is a bird which, although it may be sedentary in our islands as a species, yet many individuals of the species are strictly migratory. Thus many birds, such as the thrush, blackbird, robin, leave us in the autumn, and their places are taken by Continental individuals, and so we do not miss them.

Winter movements are of a very different nature, and are entirely due to a fall in temperature, as is proved by the fact that "in mild winters the only movements recorded are a few local migrations, which strictly coincide with the occasional periods of cold from which hardly any season is entirely exempt."

Spring Immigration.—The first bird-harbingers of spring are recorded for February, and a considerable number return in March. During both these months, however, but few summer visitors appear, the immigrants being chiefly partial migrants, "which had fled the country through the winter cold." "April is a month of pronounced immigration on the part of summer visitors. In connection with the arrival of these earliest immigrants among our summer visitors during March or April, a remarkable and interesting fact remains to be mentioned—namely, that the great majority of these birds are recorded first for the south-western area of the British region—the south-west coast of England and Ireland. It thus seems probable that the first arrival of the spring migrants not unnaturally occurs on those parts of our isles which are the warmest so early in the season." During May the stream flows on, while "during the first half of June several species whose breeding range extends to the Polar regions, appear in considerable numbers on our shores on their way to the far north; a few appear even still later. In connection with the spring immigration, it has to be remarked that the observations are all in favour of the theory that the earliest arrivals among the summer visitors to our islands are British-breeding birds," and that the "migrants bound for the north are the last of their kind to appear in the British area."

Spring Emigration.—Birds that have wintered with us, or further south, begin to leave our shores in February. "The chief emigratory movements of this month are the departure of larks and rooks along the east and west route to the Continent. During March these south-easterly movements become more pronounced, and emigration for the north also commences. During April and May, emigration is in full swing, and even in June a few birds leave us for their northern breeding stations.

Meteorological.—Special attention has been bestowed upon this section of the report, since the actual relationships between migrational and meteorological phenomena have not hitherto received the attention they deserve. The daily weather reports for Western Europe have been closely studied in connection with migration. Ordinary weather has no influence on migration. Extraordinary weather may influence bird migration in two ways. It "may act either (1) as barriers to the ordinary movements, or (2) in diametrically the opposite direction as incentives to great movements or 'rushes,' as they have been termed."

During a cyclonic spell, a weather barrier "dams back, as it were," the ordinary seasonal migratory stream. The formation of an anti-cyclone removes the cyclonic weather barrier, and so releases the flood of migration. "The movements just described take place when gentle pressure-gradients bridge, as it were, the North Sea with fine weather between Scandinavia and Britain. Such an extension, however, of the favourable conditions does not always prevail for the entire journey—that is to say, they do not always reach to the British side of the North Sea. Indeed, it not unfrequently happens that the birds reach our shores under more or less unfavourable weather conditions. When such is the case the immigrants arrive in Britain in a correspondingly exhausted condition, and, no doubt, many sometimes perish during the journey."

There are other meteorological conditions to be considered in connection with the subject. Outbursts of ungenial weather in summer or winter often produce migration, but this form of migration is only of a partial kind. It is in early autumn and early spring that migration is hastened or held back by extraordinary weather.

"*Winds.*—The importance attached to winds in connection with bird migration has hitherto been much over-estimated by popular writers, and their influence, such as it is, mis-understood. "The conclusions to be drawn from a careful study of the subject are: (1) that the *direction* of the wind has no influence whatever *as an incentive to migration*; but that (2) its *force* is certainly an important factor, inasmuch as it may make migration an impossibility, arrest to a greater or lesser degree its progress, or even blow birds out of their course. . . . . It is, however, a fact that particular winds almost invariably prevail during the great autumnal movements, and these have hitherto been considered by some as the direct incentives to such migrations. Such is not the case, and it may be at once stated that these supposed favourable breezes are simply another direct result of the pressure distribution favourable to the movements."

In conclusion, I may say that Mr. Eagle Clarke's report is merely a summary of the results obtained with regard to migration as a whole. For this the author deserves the heartiest thanks from every ornithologist in the land. There yet remains a vast amount of information to be culled from the schedules so carefully and keenly kept by the lighthouse and lightship keepers. We hope, and indeed believe, that Mr. Clarke is going to continue his labours; and in the near future, when he has worked out the migration phases of individual species, we may look for a monumental and trustworthy account of the fascinating subject of the migration of birds in the British Islands.

Harry F. Witherby.

Copies of the Report on Bird Migration can be obtained at the British Association, Burlington House, London, price 6d.

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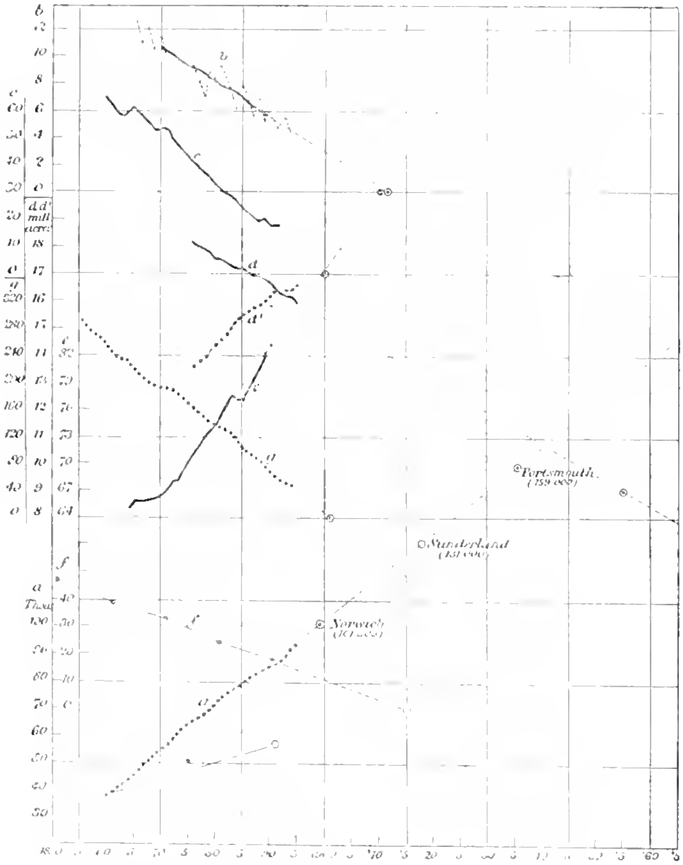
FORECASTING BY CURVES.

By Alex. B. MacDowall, M.A.

There are some curves of social data which, extending through a series of years, are approximately straight lines. There are others not so regular, but the general course of which, after some smoothing or averaging process has been applied, is shown to be approximately a straight line. One is tempted to extend such curves in the same direction, by way of seeing what may happen in the future.

I propose to apply this rough-and-ready method of forecasting to such unlike things as the following:—Lunacy, the army death rate, coal mine explosions, acreage under crops, illiteracy, and suicide.



The degree of confidence (or diffidence) with which one makes these conjectures is, of course, different in different cases. Thus it is, perhaps, easier to forecast the future of illiteracy than that of agriculture. Even if a forecast be rejected as worthless, it may still be instructive to study the unextended curve.

In our very promiscuous diagram it is to be understood that each curve stands by itself, having its own vertical scale, indicated by a letter (*a*, *b*, *c*, etc.). A smoothing process has been applied in the case of *b*, *c*, and *e*.

A few words on each of the curves. Commencing with lunacy (*a*), we have a curve showing the number of insane persons under restraint in England and Wales in each year from 1860 to 1894. This has risen with steady rapidity from about thirty-eight thousand to ninety four thousand, a rate of growth much more rapid than that of population; a lower line, drawn from 1861 to 1891, shows what the growth would have been at the population rate.

Does this mean that insanity is increasing among us? Not necessarily; and certainly the curve does not measure such growth (if there be growth). It is well known that more lunatics are now put under restraint than formerly, and a process of accumulation has been going on in asylums, owing to removals, by death or discharge, being generally less in number than the admissions. On the other hand, the growing tension of modern life, and the growth of nervous diseases, seem to render an increase of insanity very probable, and some figures relating to lunacy might be cited which favour the belief in its increase.

Extending this curve with a dotted line, we come, by about the end of the century, to a figure equal to the population of Norwich (one hundred and one thousand); twenty years later to a Sunderland of lunatics; and about 1936 to a Portsmouth!

Whatever the future growth, it is in any case an ugly fact that we have nearly one hundred thousand "officially known lunatics, idiots, and persons of unsound mind" among us, *i.e.*, about one in three hundred (and how many free?).

As to the causes of insanity, hereditary influence bulks most largely. To intemperance is attributed 20·9 per cent. in males, and 8·1 per cent. in females.

In curve *b*, the dotted one, we have the fluctuation in the death rate of the army in the United Kingdom since 1866. This has been brought down to 4·2 per thousand in 1895 (from 12·6 at the outset). The continuous curve is the result of smoothing with averages of ten, *i.e.*, each year's point represents an average of ten years.

Now it would be a mistake to attribute this rapid decline wholly to sanitary and medical improvement. Part of it is no doubt due to the fact that the army has been growing younger on the short-service system. Thus, the number of men over thirty has declined steadily in the last twenty years.

If we extend the smooth curve we find it to reach the zero line about 1911. It seems impossible to suppose the army death rate quite extinguished, though it may very likely continue to decline for a time. A death rate of only one would mean over one hundred deaths in this country. The curve may be usefully compared with general death-rate curves as showing what has been accomplished with a segregated class of men of a given age-group under strict regulations.

Our next curve, *c*, relates to coal mine explosions in the United Kingdom. The annual numbers of these since 1858 have been smoothed with averages of five. These explosions numbered seventy in 1858, but only twenty-two in 1894, and the figure has been as low as twelve. Extending the curve, it would appear that by the beginning of next century, if the same rate of progress is maintained, this destructive form of accident should at least be reduced to a very small figure, if not wholly prevented.

The shrinkage of land under the plough in Great Britain is a remarkable feature of our time. In *d* we have a curve showing how the arable land has diminished since 1876. This curve goes down steadily from about eighteen to sixteen million acres. The reduction of wheat-growing alone accounts for most of the loss. Let us extend the curve. By the middle of next century we get to about one-half of the initial acreage. But, of course, "much may happen before then." In curve *d'* is represented the growth of "permanent pasture." Some care is required in its interpretation; but we need not here stop to explain.

We have made rapid strides of late in national education, and the number of those persons who take up the responsibilities of matrimony without being able to write their own names is now small and dwindling. Here we have a pretty straight curve (*g*), showing the annual numbers of men in one thousand marriages in England who signed the register by mark (from 1855 to 1894): from two hundred and eighty-eight it descends to forty-six. Extending, we come to zero about the beginning of next century. From this and other signs we seem to be getting within sight of universal education (or what may be called so): that millennium in which (by prospectus) we were all to have become virtuous and happy!

Ireland is, of course, behind us in the matter of education. The curve *f* indicates the percentage of persons five years old and upwards who could neither read nor write in the census years 1851, 1861, etc. Its general course conducts us to zero about 1915, when, it may be hoped, illiteracy should be approximately extinct.

These signs of progress are, no doubt, gratifying, so far. But there is "another side to the shield." Let us look at the death rate of suicide in England. The figures are here (*e*) smoothed with averages of ten. Note the rapid rise. In 1860 the rate was sixty per million persons living: in 1894 it was ninety-one!

Following the general course of the smoothed curve as extended, we come to a rate of one hundred about 1910. Is it not a startling comment on our civilization that so many persons (about fifty-two a week in England, and nine a week in London at present) elect to have done with it by putting out the light of their earthly life!

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SOME CURIOUS FACTS IN PLANT DISTRIBUTION.—V.

By W. Botting Hemsley, F.R.S.

I WILL conclude my remarks on insular floras with a brief account of the flora of the British Islands, which will, perhaps, be more easily followed by the majority of readers, because popular names can be introduced more freely. Persons who have visited adjacent parts of the Continent will have noticed nothing strikingly different in the vegetation in localities where it is least affected by cultivation; that is to say, where it has been least disturbed by man. The aspect of the vegetation may be very different in some districts, consequent on the extensive planting of certain kinds of trees—the Lombardy poplar in the North of France, for example; but the wild flowers and the weeds of cultivation are much the same, according to soil, situation, and elevation. This indicates a recent connection, geologically, with the Continent, and convincing evidence is not wanting to establish the fact.

The British flora is only a fragment of a flora whose elements have a very wide range; wider, indeed, than any other. A large proportion of the species extend across Northern Asia to the Pacific, and many are spread all round the northern hemisphere. This applies more especially to those inhabiting the colder parts of the kingdom, but by no means exclusively, as I shall presently show. A few recur in the mountains of tropical Asia, Africa, and America, and some, as I have already pointed out, reach the southern limits of vegetation. Coming to the genera, a very large number of them are of worldwide distribution. For example, the buttercup genus (*Ranunculus*), the willow-herb genus (*Epilobium*), the speedwell genus (*Veronica*), and the sundew genus (*Drosera*), belong to this category: and each is represented in New Zealand by a much larger number of species than it is in our own country. But before giving further examples of distribution I will give a few comparative statistics bearing on the composition and extent of the British flora. Excluding the so-called critical species—that is to say, species founded on very slight differential characters—of such genera as *Rubus* (brambles), *Rosa*, and *Hieracium* (hawkweeds), the number of species of flowering plants and ferns native of the British Islands is less than fifteen hundred, belonging to about five hundred and forty genera and ninety-seven natural orders. The number of natural orders, or families, as they are sometimes termed, in the whole world is about two hundred and ten, so that nearly half of them are represented in this very small area. The total number of genera and species in the whole world is not so easily calculated; but approximately the former amount to between eight thousand and ten thousand, and the latter to between one hundred thousand and one hundred and twenty thousand. The differences between the highest and lowest of each of these respective totals in a way represents the diversity of opinion among botanists as to the degree to which subdivision should be carried. Further, I may explain, this diversity of opinion is due to the fact that vegetable organisms, as well as animal, are not mathematically definable quantities, but a series or chain of beings, ranging from microscopic one-celled individuals to the most complex and highly organized members of the whole system. Some of the orders, genera, and species of this system are so distinct from their nearest allies as to be easily defined, suggesting the extinction of connecting links; whilst in other parts of the system the gradations are so slight and the relationships so complex that their classification is necessarily, to a greater or less extent, artificial and arbitrary.

I have already alluded to the cosmopolitan character of the genera of British plants and the wide range of many of the species, and I will now give some further illustrations of these facts. In the first place there is not a single genus peculiar to the islands, nor even one well-defined species; I mean an easily recognized species such as the daisy or dandelion, and like them easily distinguished from their nearest allies in the native flora. A score or two of critical species have been founded on British specimens, and they have not been actually identified with Continental forms; but it does not follow that they do not exist on the Continent.

Before going further I ought to explain that my remarks refer to the natural distribution of plants as distinguished from colonization consequent on their introduction through human agency. A person going from England to the United States or Canada would see numbers of our corn-field and roadside weeds, apparently as much at home there as here; but there is good evidence that they were introduced accidentally or intentionally by man, though

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[*] It should be borne in mind that these numbers do not include the exceedingly numerous mosses, seaweeds, funguses, and other low organisms.

they are now spread all across that vast continent, from Atlantic to Pacific. At the Cape of Good Hope, in New Zealand and Australia, the same plants have established themselves. But besides these comparatively modern emigrants, the Canadian flora, for example, includes among its aboriginal plants such familiar ones as the wood-anemone, water-crowfoot, ladies'-smock, scurvy-grass, wood-sorrel, purple avens, strawberry, agrimony, sundew, willow-herb, valerian, harebell, whortleberry, crowberry, cranberry, sea-lavender, thrift, and scores of others, to say nothing of closely allied species of other genera. Some of these plants may be commoner there; others here. Of course the aspect of the vegetation of a locality depends upon the predominating species, and varies, according to physical conditions, in places contiguous to each other; the change often being very abrupt.

In a former paper I mentioned the recurrence of the crowberry (*Empetrum*) in the southern hemisphere. As already stated, many northern plants reach the southern hemisphere, but they usually inhabit suitable intermediate localities, including the mountains of the tropics. Isolated localities of other northern plants in the south are occupied by the bird's-eye primrose (*Primula farinosa*)—or a species so near it as to render the fact equally remarkable—at Cape Horn and the Falkland Islands; and by the lady's-mantle (*Alchemilla vulgaris*) in the Australian Alps. A parallel is offered by the existence of the long-leaved sundew (*Drosera longifolia*) on the mountains of the remote Sandwich Islands.

The first botanical explorers of the peaks of Fernando Po, St. Thomas Island, and the Cameroons in western tropical Africa, discovered quite a large colony of European (chiefly British) plants, associated with types more peculiarly African. Thirty-eight out of the fifty-six genera collected are common to Britain, and upwards of twenty species. Among the latter are the sanicle (*Sanicula europæa*), the navelwort (*Cotyledon Umbilicus*), the devil's-bit scabious (*Scabiosa succisa*), the common goose-grass or cleavers (*Galium aparine*), and such comparatively rare little plants as *Sibthorpia europæa* and *Limosella aquatica*.

Now a few particulars concerning some of the trees of the British Islands. We have one species of oak (of which there are several more or less distinct varieties), one species of beech, one of ash, one each of alder, elm, hornbeam, holly, yew, fir, and so on. Of willows there are two large arboreous kinds, besides several that are large shrubs or small trees. The distribution of the British species of these trees, as well as the distribution and development of the genera to which they belong, outside of Britain, is exceedingly interesting. The British oak (*Quercus Robur*), for instance, is spread nearly all over Europe, almost from the Arctic Circle to the Mediterranean, and it extends to Asia Minor; so that we have no right to regard it as specially British. In this wide area it varies considerably, and one of the most striking varieties is found in the Pyrenees. It so closely resembles the Lombardy poplar as to be easily mistaken for it at a short distance. There are trees of it in Kew Gardens.

But our oak is only one out of at least three hundred species of *Quercus* spread over Europe, Asia, and North America, extending southward in America almost to the Equator, and in Eastern Asia through the Malay Archipelago to New Guinea, the only part in which the genus reaches the southern hemisphere.[*] In Africa oaks occur only in the countries bordering the Mediterranean. The variety of foliage and fruit exhibited by this long array of species is surprising, and they are not less beautiful than varied. Imagine an oak with glossy, shining leaves eighteen inches in length, and elegant acorns three to four inches across!

The distribution of beech trees (*Fagus*) is very different, the greatest concentration of species being in the southern hemisphere, where, in the extreme south of America, in New Zealand, in Tasmania, and in the mountains of South-Eastern Australia, they form large forests. In New Zealand, where there is the greatest development, they are universally called birch trees.

Willows (*Salix*) are specially numerous in north temperate and cold regions, and about twenty small shrubby species are found within the Arctic Circle, forming a good part of the woody vegetation. But willows are not restricted to the regions named; they are also found in hot and dry regions, and, curiously enough, they inhabit just those countries in which there are no oaks. In America there is one species which ranges from North Mexico, through Central America and the West Indies, to Chili and Argentina. In Africa there are several species, one being common on the banks of the Gariep or Orange River and elsewhere in South Africa. In Asia, willows are not found south of the Malay Peninsula, where, however, one species descends the rivers to the tidal forests of tropical Pegu and Tenasserim. The genus is altogether unrepresented in the Malay Archipelago, Polynesia, and New Zealand.

Our holly (*Ilex*), again, is one species out of about one hundred and fifty belonging to the genus. It has a wide range in Europe, from Southern Scandinavia to the Mediterranean, and eastward to the Caucasus. The genus is widely spread in warm and temperate countries, though rare in Africa and Australia, and not reaching New Zealand. In China and Japan hollies are numerous, there being about fifteen species in the latter country.

The mention of Japan suggests a few comparisons between the floras of the British and Japanese Islands. Similarly situated with regard to the nearest continent, though in a considerably lower latitude, Japan enjoys about the same average winter temperature as England, with a higher summer temperature. The approximate number of species of flowering plants and ferns inhabiting Japan is three thousand, or double that of the British Islands. I have mentioned that there is a zone of vegetation stretching from the Atlantic across Europe and Asia to the Pacific, in which a large percentage of the plants are specifically the same. China Proper and Japan lie just without this zone, though it is true that a considerable number of species are common to those countries and Britain; but they are lost among the very numerous species peculiar to the region. Upwards of forty per cent. of the species are peculiar to Japan, besides a number of genera. Instead of one species of each of the various kinds of forest trees, it has twenty-two species of oak, as many of maple, fifteen hollies, fifteen pines and firs, six birches, four hornbeams, four alders, and three elms, to say nothing of a host of others belonging to natural orders not represented in the British Islands. There is also an abundance of shrubs and trees, both evergreen and deciduous, which bear showy flowers; and the herbaceous plants, taken as a whole, are more brilliantly coloured than our own. Fortunately our climate, with all its faults, is favourable to the development of many of the ornamental plants of the Far East. I need only mention such genera as *Pæonia*, *Aster*, *Chrysanthemum*, *Clematis*, *Berberis*, *Aucuba*, *Wistaria*, *Camellia*, *Magnolia*, and the numerous evergreen members of the cypress and fir family.

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[*] In the Kew Herbarium there is a leafless branch, bearing male flowers, which are exactly those of an oak. The specimen is from the Pilcomayo River, between Paraguay and Argentina.

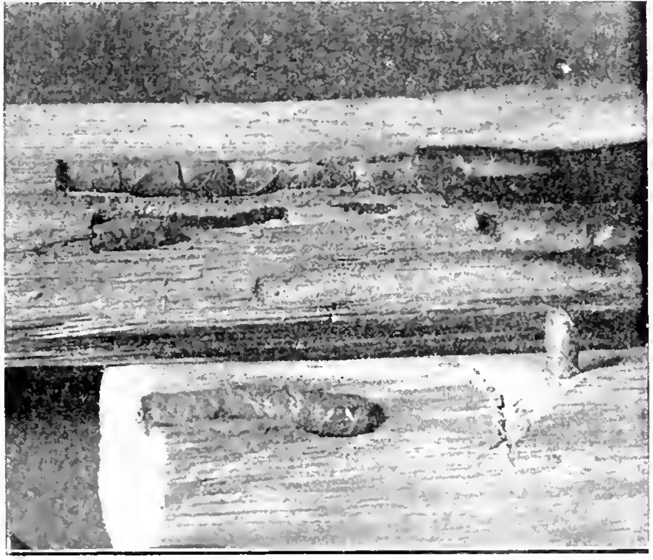
THE LEAF-CUTTING BEE.

By Francis M. Duncan.

The leaf-cutting bee (*Megachile centuncularis*) is by no means a remarkable looking insect, and from its humble exterior no one would imagine it to be gifted with a high sense of intelligence; it does, however, display a surprising amount of ingenuity in the construction of the cells in which it places its eggs.

These bees are black in colour, with reddish hairs on the thorax, and white down upon the head. They are somewhat smaller than the hive bee, and are to be seen in most gardens during the summer months busily engaged cutting rose-leaves with their strong four-toothed mandibles.

The bee burrows a hole in the ground or in decaying wood, forming a tunnel in which to place the cells: it then flies away to the neighbouring rose-bushes, and, selecting a leaf, cuts a portion from it, which it carefully rolls up and flies off with to the burrow. This manœuvre is repeated several times, until ten or twelve pieces have been cut; the bee then enters the tunnel, and begins to twist and fold the leaves, making them fit together into a sort of funnel-shaped cone, something like a thimble. So perfectly are these cells constructed, that they may be removed from the burrow without falling to pieces, although the leaves of which they are made are neither sewn or gummed together.



As soon as the cell is finished, the bee proceeds to make a cake of honey and pollen, on which the future inhabitant will live. It then lays an egg beside the cake, and flies off to find another leaf wherewith to close the entrance of the cell.

A circular piece is cut from a leaf, and the bee flies home with it, and so nicely has this little circle been cut that it exactly fits the opening, into which the bee pushes it, closing the cell completely. So that there may be no fear of any honey leaking out, the bee flies off again and cuts two more circular pieces from the rose-bush, which it fixes securely over the first one. When this cell is finished a second is constructed which joins the first, so eight or ten cells are usually to be found together in one burrow. When all is finished the leaf-cutter closes the perpendicular shaft leading to the burrow and flies away.

The larva, when full grown, spins a silken cocoon within and united to the sides of the cell.

The illustration shows the nest of a leaf-cutting bee found in the decayed wood of an old gatepost; one of the cells has been placed in an upright position to show its compact and thimble-like form.

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WAVES.—XI.

THE SEA OF ETHER.

By Vaughan Cornish, M.Sc.

Far away in the ether the sun is a storm centre, ever creating waves which beat upon the earth as the waves of ocean beat upon our coasts. The much-sounding sea is silent save where the billows break; so, too, the ocean of ether is cold and dark, but its waves give light and heat when they beat upon the earth.

A mirror shining in the sun gives back his light and gets but little warmth. The dark, rough surface of the soil, which gives back little light, grows warm in the sun's rays. The mirror, like the vertical face of a stone pier built out into deep water, prevents the waves from breaking and reflects them back upon their path. A dark surface acts like the dead resistance of the beach, absorbing nearly all the energy of the waves and giving but little back. The energy which was in the wave, changed in form, becomes the warmth of the dark body. In the ether the wave travels smoothly on, each part of the elastic medium taking up the motion as the pulse arrives, and in one complete swing passing on all the energy to the next part, returning itself to rest—ready, however, to take up the motion of the next oncoming pulse. The wave-length of light is simply the distance between two pulses; there is no physical connection due to lagging of energy behind the wave as in the wind waves of the sea, and if the sun be screened or a flame be extinguished the ether does not glow.

If the pulses of ether follow one another somewhat slowly, they excite our eyes so as to produce the sensation of redness. If the pulses succeed each other more and more quickly, the sensations are those of yellow, green, blue, and violet. If the pulses follow one another at still shorter intervals, the light passes slowly into darkness. So, also, sound pulses succeeding one another too quickly are not heard. Our organs of sense, "beautifully delicate," as we like to call them, are too coarse to detect the minuter ripplings of air or ether; neither does the scope of our vision enable us to detect those pulses of ether which follow each other at comparatively great distance, any more than the eye can distinguish the long, flat billow which we call the flood tide. The widely separated pulses of ether are, however, detected by their warming power. The pulses of ether which succeed one another more rapidly have generally little warming power, their energy being comparatively small. The effects they produce resemble those of rapid tremors or jarring. They shake things to pieces—not big things which swing slowly, but such things as molecules, which vibrate in about the same time as the interval between two pulses.

It seems that every body of which we know anything—at any temperature which we have ever reached—is always disturbing the atmosphere of ether in which all things are immersed: for every body is warmed by the mere neighbourhood of a warmer body. This occurs even when the warmer body is nearly at the lowest temperature of

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* The *evidence* of an ether is dealt with in Chapter VIII. of my "Short Studies in Physical Science."

artificial cold. No heat, however, travels; what travels is a wave which, beating upon the colder body, warms it. It is not to be thought that the mere neighbourhood of a colder body causes waves to start from the hotter; one must suppose rather that the action is always going on, but that the warming effects only become sensible when one body is colder than the other. The effect, too, is reciprocal, for the hotter body is cooled when a colder is in its neighbourhood. It is almost obvious that a body cannot go on making waves which carry energy through the ether without itself losing energy. In the neighbourhood of a similar but colder body the hotter loses more energy than it receives from the colder until their temperatures become equal, when the waves which they mutually emit and absorb are of equal heating value and there is no further change of temperature. Thus, as long as a body has any heat at all, as long as the molecular parts are dancing (whether rhythmically or with jostling), the body sends out ether waves. When the temperature of the body is being raised, vibrations of greater rapidity are set up, while the slower movements do not die, but, on the contrary, increase in amplitude as more energy is put into the body. The slower movements begin first, and at any given time theirs is the greater part of the energy which the body possesses in virtue of its temperature. This is why the production of an intensely bright light always involves the expenditure of so much energy. The brightest rays, which have little energy, will only come after the others have been produced, and they are also the first to die out.

As the slow succeeding pulses of ether emitted by a hot body have more energy than the others, and as all the pulses traverse ether at the same rate, one must conclude that the amplitude of the vibrations of the ether is greater in the case of the slower pulses, much as in a storm those waves whose crests are most widely separated are also higher from trough to crest than the shorter waves which have been formed later. The vibration in ether is different, and is kept up in a different way from the swing of the water in the waves of the sea. The free undulation in water is maintained by mutual attraction between the water and the earth, and by the inertia of the water, which causes it in each half-swing to pass the position of equilibrium. There are, however, other kinds of waves in fluids which seem more nearly to resemble the ether waves in the mechanism of vibration, namely, the elastic waves, such as sound waves, which, when once set up, run freely by the mutual action of the parts of the fluid. The particles jump forward a little way, forcing themselves in between the particles in front. They produce thus a compressed layer, which in its turn compresses the next layer by a similar action, itself quickly recovering from the pressure by the spring-back of the particles. The loudness of a sound depends upon the amount of compression, or upon the difference of pressure between the condensed and the rarefied part. Amplitude in the case of sound means, therefore, the amount of a compression, not the length of the excursion of a vibrating particle. There is, again, another kind of elastic wave—for there is an elasticity of shape as well as an elasticity of volume. Fluids offer an elastic resistance to change of volume, and can therefore transmit a wave of compression or of rarefaction; but change of shape calls out no elastic resistance in fluids. It is otherwise with solids, which spring back if de-formed and vibrate elastically, the shape of the solid going through a repeating series of changes of form, the vibrations diminishing quickly or slowly according as the solid is more or less viscous. This kind of vibration is transmitted by solids in the manner of a wave, as the following example shows. Let a long wire or cord be hung vertically, the upper end being forcibly clamped so that it cannot move, and a weight being attached to the lower end so as to keep the wire taut. If the weight—that is to say, the lower end of the wire—be twisted, each part of the wire follows the twist. If the substance be very rigid (as iron, for instance) the longitudinal transmission of the effect of the twist is very rapid. With a less rigid body—say, an india-rubber cord—the parts lag more behind. If, now, the end of the wire or cord be let go the end untwists, twists up again in the reverse direction, untwists again, and so on for a longer or shorter time according as the body is less or more viscous. In twisting or in untwisting each part of the wire is a certain definite time behind the lower end, for the effect is transmitted from point to point at a definite speed which is constant for each substance, and is the rate of transmission of a wave of transverse displacement in that substance. The rate is greater in more rigid bodies, for rigidity is the transmitting force, but is diminished by greater density, for the mass to be moved is proportional to the density.

Dismissing as inapplicable the case of waves, such as those of the sea, which run by attraction to an external body, we have to enquire whether ether waves, such as produce the sensation of light, are elastic waves of longitudinal displacement (like sound waves) or of transverse displacement, or whether they are of both kinds? The fundamental experiment which shows that light is produced by waves is that of interference. If the light from a point reach a screen by two paths of slightly different length, a series of light and dark bands is produced upon the screen where the rays overlap. This shows that two portions of light may either give a double illumination or no illumination, according to the difference of the distances traversed by the two rays from their common starting point. Where the vibrations of the ether are in the same phase of motion the amount of motion is doubled, giving increased illumination; where the vibrations are in opposite phases there is no illumination. Longitudinal waves are always capable of interference, but two parallel or coincident waves of transverse displacement, of which the vibrations are in (fixed) directions at right angles to one another, could not interfere so as to give diminished motion (*i.e.*, dark bands), for no part of the motion of vibration in one ray is at all in the direction of the vibrations of the other. This case of non-interference has been shown to occur in ether waves when subjected to the treatment called "polarization." It is therefore concluded that the waves of ether, which give heating, lighting, and chemical effects, are waves of transverse displacement, whence follows the corollary that ether resembles a solid in possessing rigidity. The enormous velocity of light waves, which is thousands of times greater than the rate at which ordinary solids transmit wave motion, shows that the rigidity of ether is extremely great in proportion to its density.

The intensity of light in a vacuum diminishes with the square of the distance from a luminous point which is radiating in all directions. Now the wave front in such a case is a spherical shell whose centre is the luminous point. The area of surface of the shell increases as the square of the radius, hence it follows that the total illuminating effect over the whole surface of the shell is always the same whatever be its radius; or, in other words, light travels through ether without loss. This shows, within the limits of experimental error, that ether is perfectly free from viscosity, the wave motion undergoing no diminution through any sort of frictional resistance. The energy which sets out from the sun on its journey to the earth is passed on to us intact, no part, apparently, being held back from us by the ether.

The ether is all-pervading as well as all-encompassing, for ethereal wave motions are passed on through solids and liquids at a velocity far exceeding that proper to the elasticity of the substances themselves. This is readily shown in the case of bodies transparent to light, and can also be shown by special devices in the case of bodies transparent to the longer waves, which are detected by their heating effect. Other bodies which cannot be penetrated by these means are transparent to the very long waves produced by electric surgings. That the medium which transmits electric waves is the same as that which transmits illuminating rays is inferred from the fact that the velocity of electric waves is the same as the velocity of light. Moreover, electric waves can be polarized, showing that they are waves of transverse displacement.

No evidence has been obtained of the transmission of longitudinal waves in ether, from which it seems that ether is incompressible, or nearly so. Were it otherwise one would expect to get compression waves of ether when light is reflected.

The use of lenses is to modify the wave front of lighting waves. Their transmission is slower in glass than in air, the ether in a solid being weighted or clogged, or else having its stiffness relaxed. Light which passes through the thick part of a lens is retarded more than that which passes through the thin part, and the wave which emerges from a convex lens has therefore a concave front. The area of the wave front consequently contracts to a point at a certain distance from the lens, and here the amplitude of the wave, and consequently the illuminating effect, is enormously increased.

The mode of vibration of the ether in the plane at right angles to the direction of propagation of the wave cannot properly be said to be *known*, for we are ignorant of the ultimate constitution of ether. There is no doubt, however, that the motions are *successfully represented* by the ordinary wave theory of light, which assumes a mechanical displacement such as occurs in the vibrations of the rigid sorts of molecular matter. According to the wave theory of light, the ether receives from a glowing solid, motions which vary from instant to instant. There is no regularity in the succession of these motions, owing to the confused jostling of the particles of the heated solid. Consequently, if we consider the vibrations in a fixed plane cutting the ray of light at right angles, the excursions of the ether particles in successive instants undergo such permutations as the following. At the first instant the particle is moving clockwise in a circular orbit. This changes to an ellipse of constantly increasing eccentricity, which presently closes up till it becomes a straight line. At this moment the particle has the rectilinear harmonic motion which best satisfies the ordinary conception of a "vibration." Presently, however, the line opens out into an ellipse, in which the motion may be counter-clockwise, and this broadens out into a circle with counter-clockwise motion which closes up again, and so on through the whole round of changes. This is ordinary light. If the orbit of the ether particle be fixed, we have polarized light. A polarized ray excites in the eye the ordinary sensation of light, but the interaction of rays of polarized light is distinct from the interaction between rays of ordinary light.

Suppose ordinary light to pass perpendicularly through a slice of a non-isotropic crystal cut parallel to a plane which contains two axes of different elasticity. Any force acting in a direction other than that of an axis cannot set up a vibration in such direction, for the force of restitution does not act in the direction of displacement. The motion is therefore resolved in the directions of the two axes, and two waves are propagated independently through the crystal, the vibration in one being a simple harmonic motion in the direction of the first axis, and in the other a similar motion in the direction of the other axis. Each ray in the crystal is a ray of rectilinearly polarized light. If one ray be stopped in its passage through the crystal, the other, on emergence, gives us a ray of rectilinearly polarized light travelling in air, the direction of vibration remaining after emergence just as it was fixed in the crystal. If another slice of crystal, similarly prepared so that only light vibrating in the direction of the one axis can pass, be placed in the path of the ray emerging from the first crystal, then, if the position of the second slice be similar to that of the first, the ray passes freely through. If the second slice be then rotated about the axis of the ray, less and less light passes through, until, when the slice has been rotated through a right angle, the light is completely stopped.

If both the rectilinearly polarized rays be allowed to emerge from a slice of crystal, they may compound together to produce a ray of elliptically or circularly polarized light. In this the excursion of the ether particle is a circle or ellipse in which the particle follows a fixed orbit.

In such waves of light the motion of the particle resembles the motion of the particle in a water wave, except that the plane of motion is at right angles to the direction in which the wave travels.

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THE LIVERPOOL MEETING OF THE BRITISH ASSOCIATION.

LIVERPOOL is not an ideal city from an æsthetic point of view, but a considerable amount of scientific work has been carried on there in the past, and its University College is a great centre of "light and leading," with a professoriate of world-wide renown, actively engaged in the advancement of knowledge. The sixty-sixth annual meeting of the British Association could hardly be anything else but a success when held in a town owning so many men of scientific eminence. So far as numbers go, the meeting ranks high in the history of the Association. The largest meeting was held in Manchester in 1878, the total then being three thousand eight hundred and thirty-eight; Newcastle comes next with an attendance of three thousand three hundred and thirty-five in 1863, and the Liverpool meeting reached practically the same figure.

The scientific meetings of the Association were held this year in ten sections, viz.:—(A) Mathematical and Physical Science, (B) Chemistry, (C) Geology, (D) Zoology, (E) Geography, (F) Economic Science and Statistics, (G) Mechanical Science, (H) Anthropology, (I) Physiology, (K) Botany. The president of each of these sections delivered an address, and fifty or sixty papers were read and discussed in each section. Several evening lectures and discourses were also delivered during the meeting, so that it is hopeless for us to attempt to describe the work accomplished. All we can do is to give a statement of the general features of the meeting, and call attention to some of the most interesting points raised.

Sir Joseph Lister, the President of the Association this year, is also President of the Royal Society. The work for which his name is honoured is the antiseptic method of operating and treating wounds, and it constitutes the greatest advance which surgery has ever made. Without dwelling unduly upon the investigations which led him to introduce antiseptic surgery, Sir Joseph Lister traced, in his presidential address, the bacteriological researches of Pasteur and others bearing upon it. Pasteur found that putrefaction was a fermentation caused by the growth of microbes, and the inference was that if a wound were treated with some substance which, without doing too serious mischief to the human tissues, would kill the microbes already contained in it, and prevent the access of others in the living state, putrefaction might be prevented. Acting upon this suggestion, Sir Joseph Lister began to apply carbolic acid to wounds, and was overjoyed to find that by so doing compound fractures healed as easily as simple fractures, in which the skin remains unbroken. More recent work has shown that it is not necessary to use carbolic acid, or any other irritating antiseptic, in the treatment of wounds. All that is required is scrupulous cleanliness. The surgeon washes his hands in disinfecting solution, and boils his instruments in water, or a weak solution of sodium carbonate, in order to free them from microbes. With the same end in view, his outer garments and the bandages are sterilized by being heated in a steam chamber. Everything likely to come into contact with a wound is carefully freed from germs, and nature is thus given the conditions to carry out undisturbed her best methods of repair. This change of operational technique does not, however, belittle the antiseptic method. Lister opened up the new era of surgery by showing that wounds would heal "by first intention" if kept entirely free from infection, and that is the principle now borne in mind by surgeons. The result is that, whereas in pre-antiseptic days a frightful proportion of patients succumbed to the inflammation of wounds, wound fevers, and hospital gangrene, at the present time scarcely a death is due to these sequelæ, however complicated the wound or difficult the operation.

The Physics Section of the Association was honoured by the presence of Prof. Lenard, whose name, though not so widely known as that of Prof. Röntgen, is held in just as high esteem in the scientific world. It was Prof. Lenard who showed that the kathode rays produced in high-vacuum tubes, and first studied by Dr. Crookes, could be brought out into the air by making a tube with an aluminium end opposite the disc from which the rays emanated. As Prof. Fitzgerald eloquently remarked in the discussion upon the paper in which Prof. Lenard described his researches, "he was the first to cross the Rubicon which separated us from the domain of what is now known as X-ray photography." Two years before the publication of Prof. Röntgen's startling results, Lenard had shown that kathode rays passed through opaque substances, and were capable afterwards of exciting a phosphorescent screen and of acting upon a photographic plate. A number of other papers on kathode rays, and Röntgen or X rays, were communicated to the section, and Prof. J. J. Thomson's address to the section was largely devoted to these subjects; but there was no consensus of opinion as to the nature of the rays, whether they were matter projected with high velocities or whether they were waves in the ether.

Prof. J. J. Thomson referred in his presidential address to the great improvement which has taken place in the teaching of physics in our public and secondary schools during the past ten years. At the same time he cautioned teachers and students against the temptation to take up too many subjects. He thought that physics was best begun with a course of mechanics, the students to do innumerable experiments of a simple kind leading to numerical results, and their work not to be shaped according to the dictates of the examinational fiend. The subject of scientific education came up also in the chemistry section, and the general opinion was that science should be more widely followed as a means of mental culture, in which aspect it can be made a subject of the greatest educational value. A long discussion took place on a paper by Sir Henry Roscoe on "Chemical Education in England and Germany," and the opinion was expressed that much more attention should be paid to scientific research both in the higher technical schools and in manufactories.

In his presidential address to the Section of Geology, Mr. J. E. Marr dealt at great length with the present state of knowledge of stratigraphical geology. Few papers of general interest were presented, and limits of space will only permit us to mention two of these—an account by the Coral Boring Committee of the unsuccessful attempt to bore through Funafuti, in the South Pacific, and a paper by Mr. Vaughan Cornish on the ripple-marks produced by the sea, streams, and wind. The address of Prof. E. B. Poulton to the Section of Zoology was of a somewhat disjointed character; but the chief point with which it dealt was the age of the earth, as estimated by geologists and physicists respectively. The Geographical Section was very largely attended, perhaps because most of the papers were descriptive of travels and explorations, and were illustrated by lantern slides. Africa and the Arctic were the chief themes brought before the section. To the Section of Mechanical Science very little of importance was communicated. Mr. C. Worby Beaumont gave an explanation of the apparently anomalous fractures of railway rails, and a valuable report was presented on the effect of wind and atmospheric pressure on the tides. A paper by Mr. W. H. Preece, giving the results of tests of a large number of glow lamps, must also be mentioned.

Mr. Arthur Evans dealt with "The Eastern Question in Anthropology" in his address to the Anthropological Section, and showed that "Eurafrica," in its widest sense, is the birthplace of the highest civilizations that the world has yet produced, and the mother country of its dominant peoples. Several very interesting discussions took place in the meetings of this section upon such subjects as the formation of an Ethnological Bureau, the origin of the knowledge of copper and iron in Europe, and the early civilization of the Mediterranean.

In the Section of Botany, Dr. D. H. Scott delivered an erudite presidential address on "The Present Position of Morphological Botany." The chief paper communicated to this section was on the ascent of water in trees, by Mr. Francis Darwin. Within the last few years this problem has entered upon a new stage of existence, and Mr. Darwin brought together the results of the researches which have led to this new development; the two questions considered being—(1) What is the path of the ascending water? (2) What are the forces which produce the rise?

Dr. W. H. Gaskell's address on "The Origin of the Vertebrates," delivered before the combined Sections of Physiology, Zoology, and Anthropology, provoked a large amount of discussion. The central pivot on which the theory put forward turns is the central nervous system, especially the brain region. The striking factor of the ascent of vertebrated animals, from the lowest fish to man, is the steady increase of the size of the central nervous system. However much other parts may suffer change or degradation, the brain remains intact, steadily increasing in power and complexity. The same law holds good in the invertebrate kingdom. These and many other considerations have led Dr. Gaskell to conclude that the central nervous system of the vertebrates must be considered as derived from the conjoined central nervous system and alimentary canal of an arthropod. The brain is hollow, he holds, because it has grown around the old cephalic stomach, and our cerebral hemispheres are but modifications of the supraœsophageal ganglia of a scorpion. "The time is coming," he concluded, "and, indeed, has come, when the fetish worship of the hypoblast will give way to the acknowledgment that the soul of every individual is to be found in the brain, and not in the stomach; and that the true principle of evolution, without which no upward progress is possible, consists in the steady upward development of the central nervous system." The theory is very pretty, but unfortunately, as was pointed out at the meeting, there is very little actual evidence for it. No traces of the series of Limulus-like animals, having imperishable skeletons, are known to occur in the fossiliferous rocks. But whatever the ultimate decision may be as to the soundness (or otherwise) of Dr. Gaskell's conclusions, the hypothesis is startling enough to make zoologists and physiologists examine the foundations upon which other theories of the origin of vertebrates are based.

The most important object of the British Association is to bring together investigators in various branches of science for the mutual exchange of ideas. By this means a wider view is obtained, and directions in which researches can be profitably made are indicated. The recent meeting was not remarkable for the announcement of any great discoveries, and we venture to say that some of the presidential addresses were too diffuse and technical to be of interest to even the members of the sections in which they were read; but, at the same time, men of many branches of science mingled together, and went away more anxious than before to assist in the advancement of knowledge.

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THE FACE OF THE SKY FOR NOVEMBER.

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

SUNSPOTS show a very gradual increase in number and size. Conveniently observable minima of Algol occur at 9h. 33m. P.M. on the **13th**, and at 6h. 22m. P.M. on the **16th**. A maximum of the remarkable variable ο (Mira) Ceti is due on the **3rd**.

Mercury is visible as a morning star during the first half of the month. He rises on the **1st** at 5h. 20m. A.M., or 1h. 36m. before the Sun, with a southern declination of 7° 21′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{83}{100}$ths of the disc being illuminated. On the **6th** he rises at 5h. 45m. A.M., or 1h. 21m. before the Sun, with a southern declination of 10° 29′, and an apparent diameter of $5\frac{1}{4}''$, $\frac{9}{10}$ths of the disc being illuminated. On the **11th** he rises at 6h. 13m. A.M., or about one hour before the Sun, with a southern declination of 14° 19′, and an apparent diameter of 5″, $\frac{96}{100}$ths of the disc being illuminated. After this he approaches the Sun too closely to be visible. He describes a direct path in Virgo to the confines of Libra. He is in superior conjunction with the Sun on the **28th**.

Venus is an evening star, but owing to her great southern declination is by no means well situated for observation. On the **1st** she sets at 5h. 15m. P.M., or about one hour and a quarter after the Sun, with a southern declination of 22° 57′, and an apparent diameter of 12″, $\frac{87}{100}$ths of the disc being illuminated.

Mars is now the most conspicuous object in the evening sky. He rises on the **1st** at 6h. 47m. P.M., with a northern declination of 21° 13′, and an apparent diameter of 15″, the phasis on the preceding limb amounting to 1″. On the **5th** he rises at 6h. 30m. P.M., with a northern declination of 21° 24′, and an apparent diameter of $15\frac{1}{4}''$. On the **11th** he rises at 6h. P.M., with a northern declination of 24° 41′, and an apparent diameter of $15\frac{3}{4}''$. On the **15th** he rises at 5h. 42m. P.M., with a northern declination of 24° 53′, and an apparent diameter of $16\frac{1}{4}''$. On the **25th** he rises at 4h. 48m. P.M., with a northern declination of 25° 19′, and an apparent diameter of $16\frac{3}{4}''$. On the **30th** he rises at 4h. 18m. P.M., or 25m. after sunset, with a northern declination of 25° 29′, and an apparent diameter of $17\frac{1}{4}''$. During the month he describes a retrograde path in Taurus.

Jupiter does not rise till 11h. 13m. P.M. on the last day of the month, and Saturn and Uranus are, for the observer's purposes, invisible.

Neptune is an evening star, rising on the **1st** at 6h. 26m. P.M., with a northern declination of 21° 38′, and an apparent diameter of 2·6″. On the **30th** he rises at 4h. 28m. P.M., with a northern declination of 21° 34′. He describes a very short retrograde path in Taurus during November.

November is a very favourable month for shooting stars. The most marked display are the Leonids on November **13th** and **14th**, the radiant point being in R.A. 10h., 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., and northern declination 43°.

The Moon is new at 7h. 27m. A.M. on the **5th**; enters her first quarter at 5h. 41m. A.M. on the **12th**; is full at 10h. 25m. A.M. on the **20th**; and enters her last quarter at 2h. 41m. A.M. on the **28th**.

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Chess Column.

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

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of October Problems.

No. 1.

(J. K. Macmeikan.)

1. Q to R8, and mates next move.

[This is the first published problem of this promising young composer.]

No. 2.

(A. G. Fellows.)

Key move.—1. Q to QBsq.

If 1. . . . Kt or P moves, 2. Kt to B5ch, etc.
1. . . . K to Q6, 2. Kt(B2) to Kt4ch, etc.
1. . . . K to B4, 2. Q to R6, etc.

Correct Solutions of both problems received from Alpha, H. Le Jeune, G. A. F. (Brentwood), L. Pfungst, J. T. Blakemore, A Norseman.

Of No. 1 only from H. S. Brandreth, A. S. Coulter, G. G. Beazley, J. M'Robert, W. Clugston, W. Willby, H. W. Eleum, G. J. Newbegin, E. C. Willis.

Various incorrect solutions have been sent for No. 2, which has been greatly admired by those who solved it correctly. The favourite error has been 1. K to Kt6, which seems to be met only by 1. . . . P to Q5, 2. Kt(R6) to Kt4, Kt to Kt4.

A. S. Coulter.—After 1. Q to Ksq ch, K to Q6, there is no mate in two more moves.

H. S. Brandreth.—1. Q to QKtsq will not solve No. 2. The King finds safety at KB3.

Mrs. L. Strange.—Your card evidently applies to the September Number. Solutions should be sent in by the 12th of the month. The October Number will show you that your solution is correct, though not the author's intention.

J. T. Blakemore.—Shall be glad to receive the three-mover.

H. W. Elcum.—Your criticisms are much to the point.

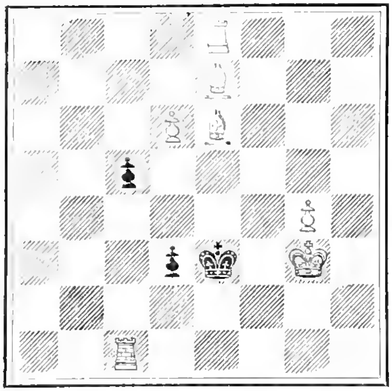
W. Clugston. Many thanks for the enclosures. Your two-mover is a great improvement in strategy on the rather elementary set received last month. At the same time it seems capable of further simplification, and, furthermore, in urgent need of it, the variety being hardly proportionate to the large force employed. To take one point only, why not remove the Pawn which guards the Black Knight? The omission would leave two excellent tries by Q × Kt and Q to R2, both threatening immediate mates, to which Black has in each case only one defence. The thirteen-variation problem is excellent, as you say, though these "flights of Rooks" are an old theme. What is the solution of Mr. Loyd's problem No. 37?

PROBLEMS.

By Eugene Henry.

No. 1.

Black (3).

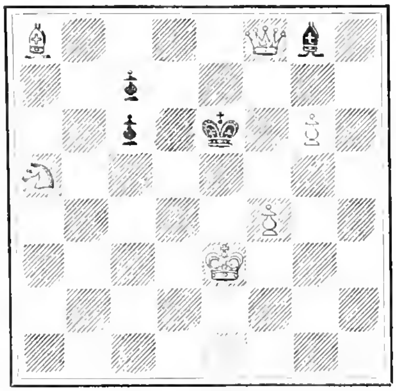


White (7).

White mates in two moves.

No. 2.

Black (4).



White (6).

White mates in two moves.

CHESS INTELLIGENCE.

We notice with regret an announcement in the *Chess Monthly* to the effect that that magazine closes its present career with the current number. Mr. Hoffer has edited the *Chess Monthly* for seventeen years; first in conjunction with Dr. Zukertort, and since his death by himself. Competition with the now numerous chess columns in the daily press, and lack of time for so arduous an undertaking, are the reasons given for what, we are glad to see, may prove only a break in continuity. The feature of the present double number is a diagram by Mr. W. H. Cubison, illustrating the "Knights' Tour" on a board of 4096 squares; truly a marvellous piece of patient work!

An International Tournament was begun at Buda-Pesth in the first week of October. The competitors were thirteen in number, viz.:—Albin, Marco, and Schlechter of Vienna, Dr. Tarrasch of Nuremburg, Herr Walbrodt of Berlin, Mr. Pillsbury of America, M. Tchigorin of St. Petersburg, Herr Winawer of Warsaw, Herren Maroczy, Charousek, and Popiel of Hungary, and M. Janowski of Paris.

At the time of writing, Herr Winawer, who seems, after the practice he had at Nuremburg, to have recovered his old form, has a clear lead. Dr. Tarrasch again started disastrously, his fate now in three successive tournaments. Messrs. Lasker and Steinitz were expected to compete, but evidently preferred to reserve themselves for their match, which is announced to begin early this month.

We regret to announce the death of Mr. E. Freeborough, of Hull, for many years one of our leading amateur players and analysts. He was a valued contributor to the *British Chess Magazine*, and the author of numerous works on the theory of the chess openings and endings. In conjunction with Mr. Ranken he compiled the well-known "Chess Openings, Ancient and Modern."

Contents of No. 132.

NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

Bound volumes of Knowledge, New Series, can be supplied as follows:—Vols. I., II., III., and VIII., 10s. 6d. each; Vols. VI., VII., IX., and X. (1895), 8s. 6d. each.

Binding Cases, 1s. 6d. each; post free, 1s. 9d.

Subscribers' numbers bound (including case and Index), 2s. 6d. each volume.

Index of Articles and Illustrations for 1891, 1892, 1894, and 1895 can be supplied for 3d. each.

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For all places outside the Postal Union, 6 shillings in addition to the postage.

Communications for the Editors and Books for Review should be addressed Editors, "Knowledge" Office, 326, High Holborn, London, W.C.

KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE & ART.

LONDON: DECEMBER 1, 1896.

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EDITORIAL NOTE.

In completing the Volume for 1896, the Editors desire to record their satisfaction at the favourable reception accorded to the Magazine in its extended area of work during the year. It is intended to pursue the same course in the new year, and while keeping abreast of the highest scientific achievements and aspirations of the time, every effort will be made to render the columns of Knowledge of abiding interest to its readers. "Simply worded—exactly described" will be the aim in the future as it has been in the past.

With the January Number will be commenced a series of illustrated papers on the Progress of Science during the Queen's unique reign, a period of time unexampled in the world's history for the scientific advancement of the nations. Arrangements have been made to enlist the aid of leading men in the various branches of science, and no pains will be spared to render the series complete in every particular.

The same Number will contain the first of a series of illustrated articles on Practical Entomology assisted by the Microscope, to be contributed by Mr. Frederick Enock, F.E.S., F.L.S., the well-known entomologist.

During the year, Mr. G. F. Hill, M.A., will continue his interesting contributions on Numismatics, dealing first with English Medals. These papers will be illustrated with full-page photographic plates. Mr. W. Botting Hemsley, F.R.S., will also contribute a series of articles on the Vegetable Products of our Australasian Colonies.

In the Natural Sciences, although no long series of connected articles, other than those mentioned above, is contemplated, the Editors have promises of many valuable papers from both old and new contributors. Mr. E. Walter Maunder, F.R.A.S., who will continue to edit the astronomical columns, has received several photographs from Dr. Isaac Roberts, F.R.S., while many other friends have promised their aid. These, together with several drawings of planets by well-known artists in this work, will be issued monthly in the form of collotype plates as heretofore.

FORECASTING FAMINES IN INDIA.

By Douglas Archibald.

The scarcity which is now developing into famine in India, caused by an unusually early withdrawal of the monsoon, draws attention to the possibility of forecasting such events.

The crucial test and ultimate aim of every true science is accurate prediction.

In physical problems, when all the antecedent causes and operative laws are known, it is usually easy to predict the result. Where, however, as in meteorology, both the causes and the laws are only partially known, and where the intrusion of unforeseen factors and combinations may occur both in time and space, prediction must at present be based more or less on empirical relations and analogy. If carried beyond the time limits of direct observation, it must be of a broad and general character, in direct proportion to the time covered by the forecast.

So far, in England, and in most European countries, weather prediction has never advanced beyond the twenty-four hour limit, and is based almost entirely on an examination of contemporaneous data and empirical relations founded on past experience, together with a modicum of rational law. In America, owing to the wide area traversed by ephemeral weather changes, the time limit is extended to thirty-six hours; and in Australia, disturbances reaching Western Australia are forecasted to arrive in Victoria about three or four days after, but this is the extreme limit.

It is beginning at the wrong end to predict the particular; but so long as the method is confined to what is taking place within the area of observation, though the deductions are made on empirical bases, they can hardly fail to reach a certain percentage of accuracy, sufficient for practical purposes.

When we extend the time limit to several months instead of hours, and, ignoring the minor fluctuations, take note merely of the general average prevalent character of the weather during the whole period, a marked departure has to be made in the system employed.

Monthly averages take the place of hourly means; contrasts and analogies between the conditions for six monthly periods preceding and embracing the monsoon periods have to be studied. The area of observation also has to be extended beyond the limits of the district dealt with, in order to determine the subsequent effects of ascertained general conditions prevailing in surrounding areas.

On such principles the Indian six monthly forecast has been founded, and its success has been sufficient to induce the Indian Government not merely to grant the funds necessary to establish fresh observations in the Persian area, but also to arrange for the transmission of cablegrams from Mauritius. By these means, the conditions which prevail in the South Indian Ocean may be reported to the office at Simla in time to be utilized for the forecast.

Although within certain limits, the summer monsoon—which bursts, after being ushered in by heavy thunderstorms, about June 6th in Bombay, and arrives at its northernmost limits some two or three weeks later—is a tolerably regular phenomenon, it is not nearly so regular both in time and quality as is commonly supposed. Its date of arrival, for example, occasionally varies as much as thirty days, while the amount of its attendant rainfall has varied from a deficiency of six inches in 1868 to a surplus of nine inches in 1893. Concentrated in one spot this latter excess would equal two hundred and eleven cubic miles of water. To give an idea of what such an amount really means, let us suppose the excess rainfall of 1893 to be collected in a tank with a square base of eight miles a side. Then if its altitude were that of the snow line of the Himalaya, viz., seventeen thousand feet, such a tank would barely contain the total volume of excess water which fell over India during that year. Similarly, if in order to supply the defect in 1868 we imagine a hose pipe to stretch all the way from the earth to the moon, of half an acre in section and full of water, it would represent a trifle more than the above defect. If it were required to irrigate the country with this hose, in order to keep up the supply to the normal during the six months of the monsoon, the water would have to issue from the hose at the rate of fifty-five miles per hour continuously.

Moreover, although such variations, spread over the entire area, reach this gigantic amount, their local effect is relatively much greater, and produces much more disastrous effects in the dry zone inland than near the coast, where the rainfall is normally high. In this zone, which comprises the Deccan, Mysore, South Madras, Central and South Punjab, and the western section of the North-West Provinces, variations often occur amounting to several hundred per cent. of the normal supply. It is this district which, as at present, is most liable to famine-producing droughts or floods.

The method of long period prediction began some years back under the late Mr. Blanford, F.R.S., by the recognition of certain sequences which were observed to occur in the summer monsoon rains, according as the snowfall of the preceding winter on the Himalayan slopes was heavy or otherwise. A heavy winter snowfall was usually found to be followed by a light summer monsoon rainfall, and *vice versâ*.

Although this factor has latterly been found to be liable to some uncertainty and modification, owing to variations in the absolute strength, quality, and duration of the monsoon current itself, it still forms one of the leading principles by which the extension of the current to its full northerly limits is predicted.

Heavy and untimely snowfall, especially in April or May, exercises a powerful influence in preventing or delaying the extension of the monsoon over Upper India.

Another factor is afforded by the local peculiarities which are manifest in the hot weather period immediately preceding the arrival of the monsoon, and which are best estimated by means of the synoptic variations of the current barometric pressure from the normal.

At one time it was thought that these local anomalies of pressure were the chief cause of the monsoon itself, on the principle of the sea breeze towards a heated area. This was formerly alluded to as the "furnace theory." It is now, however, clearly recognized that the advance of the massive current itself is not directly the result of the hot weather over the Indian area, but that it forms part of a larger system of circulation. Its forward extension across the Equator is as much due to a *vis a tergo*, effected in the South Indian Ocean, as to a *vis ad frontem*, in consequence of changes over the Indian land area following the northward march of the sun. As soon, however, as the current is once established over India, it is found that it tends to concentrate its rainfall energy mostly over those districts where the pressure was lowest during the ante-monsoon months.

Hence this second factor is of great service in determining the local or provincial variations of rainfall, though, like the snowfall factor, the deductions have to be modified in correspondence with the precise character of the incoming current.

The last factor is the condition of the south-east trade wind of the South Indian Ocean, which is now found to be nothing else than the direct parent of the monsoon.

The *modus operandi* by which the southern trade wind crosses the Equator in May and rushes across the Indian Ocean as the south-west monsoon, which breaks on the Indian coasts early in June, has been graphically described by Mr. Eliot in a recent paper in the *Quarterly Journal of the Royal Meteorological Society* (January, 1896). We need not here allude to it further than to say that while a feeble sea breeze develops along the Indian coasts for some time previous to the monsoon burst, the latter is evidently in no sense its culminating stage. On the contrary, as Mr. Eliot substantially puts it, it is plainly due to the breakdown of the upflow over the equatorial calm belt, which allows the south-east trade wind to continue its horizontal flow across the Equator. It thus brings the vapour accumulated during its southern journey in a massive sheet, which condenses when carried up the Indian ranges and plateaux.

The only direct means of estimating the probable strength and character of this vapour current is to ascertain the character of the south-east trade wind of the Indian Ocean, south of the Equator, during April and May. It is found that this is usually maintained comparatively unaltered for some months, and is transmitted, *pari gradu*, to its defluent extension, known as the south-west monsoon of India.

Up to the present time the information has usually been derived either from the logs of ships arriving at the Indian ports from the southern seas or else by letter from Mauritius, the Seychelles, etc. Latterly, however, the Indian Government has sanctioned the establishment of cable communication to the Seychelles, and is preparing to do everything in its power to accelerate the transmission of news from the Mauritius, Zanzibar, etc.

Meanwhile, as a supplement to the direct observation of the trade current, it has been found that the monthly average barometric pressure over India is subject to periodic, long oscillations, above and below the mean. These vary from six to twenty-four months, and are usually some multiple of six months.

These waves of pressure are found to be connected with the development of the monsoon current in such a way that if the wave is rising during the month or two (April and May) preceding the south-west monsoon, the rainfall will be scanty, and the reverse if it is falling. On the other hand, if it is just beginning to rise during the month preceding the winter monsoon (November), the rains which fall in December and January will probably be above the average, and *vice versâ*. These waves occur, reversed in phase, on the south side of the Equator, and indicate, as Mr. Eliot (the head of the Indian Weather Bureau) says, checks and accelerations in the seasonal mass transfer of air across the Equator between the Indian Ocean and Southern Asia.

Twelve such waves have occurred during the past twenty years, and their careful study seems destined to open out a new departure in meteorology by permitting seasonal forecasts to be projected on a rational basis.

Regarding the forecast this year, though no direct reference was made to the possibility of a famine-producing drought, attention was drawn to the signs of a weak monsoon from the observations, particularly at the Seychelles.

Up to the present time the probability of a break in the middle of the rains or their early termination in any year are admitted to be difficult to determine with accuracy. The latter is, perhaps, one of the most important relations to be able to forecast, since the present disastrous scarcity is directly traceable to an unusual scorching in September, when the monsoon ought still to have been exercising its moist and sheltering influence.

At the existing rate of progress, however, there is little doubt that the possibility of predicting an early stoppage as well as a diminished strength in the monsoon will be shortly within the power of the Indian Meteorologist-in-Chief; and it is to be hoped that the successful example of the bold experiment of predicting weather conditions half a year ahead in India, will stimulate European weather bureaux to advance beyond their present unsatisfactory position.

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GREEK VASES.—IV.

C.—RED-FIGURED VASES (FINEST PERIOD.)

By H. B. Walters, M.A., F.S.A.

In the last article (*see* July Number) we dealt with the history of Greek vase painting down to the end of the sixth century B.C., with some allusions to the changes in the art that were taking place towards the end of that century. In the present article this question must be discussed at greater length, although the sudden reversal of technical method involved in the change from black figures on red ground to red figures on black ground is not at first sight easy of explanation. We are also met with chronological difficulties, owing to the results obtained from the recent excavations on the Acropolis of Athens. Into the details of this question, however, it would be inadvisable to enter; suffice it to say that it is now acknowledged on all hands that the first appearance of vases with red figures is not, as was formerly supposed, subsequent to the Persian Wars (*i.e.*, after 480 B.C.), but must be pushed back to the time when the Peisistratidae ruled as tyrants in Athens, about 520 B.C.

As to the origin of the red-figure technique, it is susceptible of more than one explanation. We must remember that it had no development from the black-figure style, as no intermediate stage between the two is possible. There is, however, a small class of vases in which the figures are painted in *opaque* red colour on a black ground, with which the whole surface of the vase has been covered. We know from excavations that these vases belong to the period 500-480 B.C., and some may be even earlier; it is, therefore, conceivable that it occurred to the painter that it was more effective to let the red clay of the background appear through the black, wherever he would place a figure, than to paint the red on to the black. But these vases are few in number, and there is no doubt that the red-figured vases sprang at once into very great popularity, and that the new invention, however brought about, was too generally adopted at first to derive its origin from a comparatively rare method. The transformation is usually associated with a certain group of painters, who appear to have used the two methods indiscriminately, either painting whole vases with red or with black figures, or combining them on one vase.

Briefly, the method of vase painting during the period under consideration is as follows:—The artist sketches his design on the red clay with a fine pointed tool; he then surrounds this outline with black varnish, laid on with a brush to the extent of about an eighth of an inch all round, this being done to prevent the varnish when laid on over the rest of the ground from running over into any part of the design. Finally, details, such as features or folds of drapery, are added with a brush in black lines on the red; and further details are often expressed either in a thinned black pigment which becomes brown, or by application of white or purple as in the last period.

Thus we see that the technical process of the preceding method is exactly reversed, and that the figures now stand out in the natural colour of the clay against the black ground.

Throughout the period there is an extraordinarily rapid advance both in artistic conception and power of execution, due, no doubt, to the contemporary impulse given to the more dignified art of fresco-painting by the rise of Polygnotos and the other great Athenian painters of the fifth century. Yet this improvement was finally to prove the vase-painter's ruin. At first the large and simple compositions of the fresco-painters exercise a praiseworthy influence on the conceptions of the vase-artists, besides providing them with new hints for technical improvement, such as additional colours or variety of ornament. But the more truly pictorial the scenes on the vases become, the more do they tend to deteriorate in merit; the love of over-refinement and the newly-acquired skill in drawing drive the artist to produce hurried, careless compositions, and to forsake archaic severity for crowded scenes or groups of figures without meaning or interest.

Contemporary with the red-figure method is one which we have already not infrequently met, in which the figures are painted on a white slip; and this method also receives a fresh impetus in the period before us, and even more than the other brings before us the methods and processes of the great painters. It must be remembered that in the fifth century fresco painting was a comparatively simple process, three or four colours alone being employed on a white ground resembling that used on the vases. The ground in either case being of the same character, it was but a short step for the vase painter to employ the same method of colouring, even though on a vastly smaller scale.

Fig. 1.—Lekythos (Oil-Flask) of "Strong" Period. Niké (Victory) pouring Libation at Altar. About 460 B.C.

It is true that we only possess a very few vases with designs in colours on a white ground; but such as we have are of such exceptional excellence that we are fully justified in seeing in them the best results of the influence of which we have spoken. In this connection we may note that there is evidence that at one time it was the practice to paint tombstones (*stelae*) with the effigy of the dead person in colours on a white slip, and we shall see later on that this method was by the middle of the fifth century almost exclusively adopted for a class of vases destined particularly for sepulchral purposes.

We now first find attempts to render the human body in positions other than purely profile, and to throw off the trammels of conventional archaism (such as that of Egypt), which forbade to render the chest and shoulders in profile or the face and limbs in front view. Thus the way is prepared for the development of perspective and foreshortening, which tends, as we have seen above, to the rapid perfecting of linear drawing, as exemplified in the vases of the latter half of this century.

Another circumstance which led, as in the case of sculpture, to a greater facility in rendering the human figure, was the growing familiarity with the perfections of nude male forms brought about by the increased popularity of the Olympian and other games. The prevailing tone of the subjects on the vases is no longer now mythological, but the *ephebos*, or full-grown youth, that peculiarly Attic creation, reigns everywhere supreme.

It may be convenient to pause here for a moment, and note the various stages of development through which the red-figure style passed. (1) The *archaic* shows all the stiffness and want of technical freedom characteristic of the last stage. (2) The *severe* style shows a marked attention to detail and greater technical freedom, but not as yet without stiffness. (3) The *good* period has several subdivisions: (*a*) the *strong* style, dry and vigorous, delighting in difficult subjects; (*b*) the *large* style, aiming chiefly at breadth of effect and dignity of composition; and (*c*) the *fine* style, showing the perfection both of technique and composition. (4) Finally we have the *late fine* style, introducing mannerisms and refinements, which tend to nothing more than pictorial prettiness, and degenerate into merely careless and florid work which at last fails to arouse any interest.

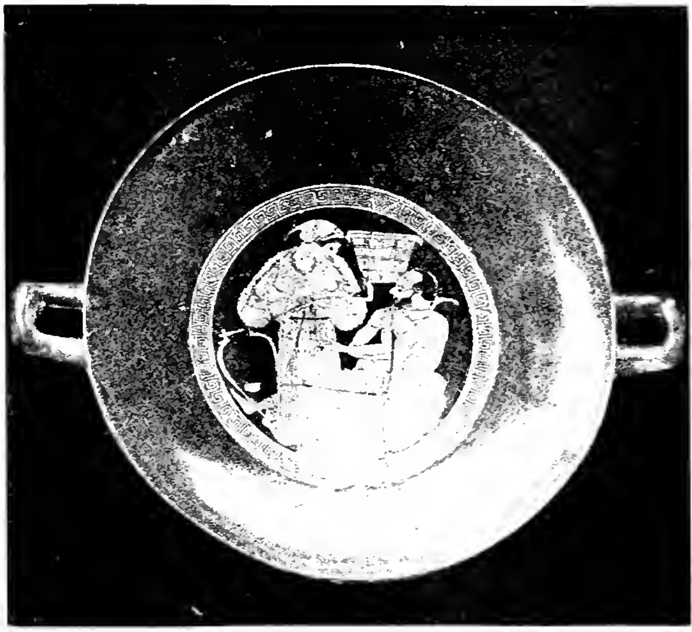
The shapes of the vases are, roughly speaking, the same as those of the last period, but certain developments of form can be traced, and some shapes are more in demand at certain stages. For the first half of the century the most characteristic form is the kylix or two-handled cup, with wide shallow bowl on a high stem. Another important shape is the hydria or three-handled pitcher, which exchanges its somewhat angular outline and flat shoulder for a gracefully curved form, in which the neck merges in the shoulder, and that again in the body, making one single curve throughout. Instead of two subjects, as in the last period, we now only have a group of two or three figures on the body. The amphora loses much of its popularity, with the exception of some early examples which reproduce the character of the black-figured amphorae; but a new and very charming variety appears. This is known as the Nolan amphora, from the fact that it appears to have been a popular shape with the inhabitants of Nola in Campania, as many examples have been found there, imported from Greece. Its characteristics are: a slim body and long neck, handles reeded and often twisted, a very fine and lustrous black glaze, and a design confined to one or at most two figures on either side. A second popular variety of the amphora is the *pelike*, in which the foot disappears, and the body swells out from the handles downwards, with a somewhat clumsy effect. Another characteristic shape of this period is the *stamnos*, a wide-necked full-bodied jar with small side handles, which only found favour for a short period, but that the time of the best artists.

In the later stage of the red-figure style the larger and bolder varieties appear to be discarded in favour of small and elegant shapes, among which we may mention the *aryballos* or *lekythos* with globular body; the *pyxis*, a cylindrical box with cover; and the *askos*, a small oil-flask with handle and spout, which did not afford much scope for decoration. But the aryballos and pyxis (*see* Plate, No. 6) supply some of the finest examples of the "late fine" period, even though the subjects are sometimes fanciful or the drawing over-refined; moreover, considerable effect is gained by the judicious addition of gilding, white or blue, and other colours.

Fig. 2.—Lekythos (Oil-Flask), with Polychrome Figures on White Ground; made for use at a Funeral. Subject: the Deceased Person at her Toilet.

The subjects on red-figured vases may not, perhaps, be regarded as so varied or interesting as those on the black-figured, but still are worthy of all attention. At the very outset we see a tendency towards scenes of real life, instead of the old mythological repertoire. At the same time, scenes from epic legend and mythology hold their own with almost as much variety as before, but it is remarkable to note how the well-worn types, which we discussed in the last paper, are promptly discarded, and how, with his new-born capacities of drawing and free scope for composition, the painter is led to form his own idea of the subject he wishes to depict, without regard to the lines on which his predecessors worked. In the next stage, or "strong" style, the patriotism of the Athenian artist finds expression in the growing importance which he attaches to purely

1.—Kylix (Goblet), signed by Epiktetos.

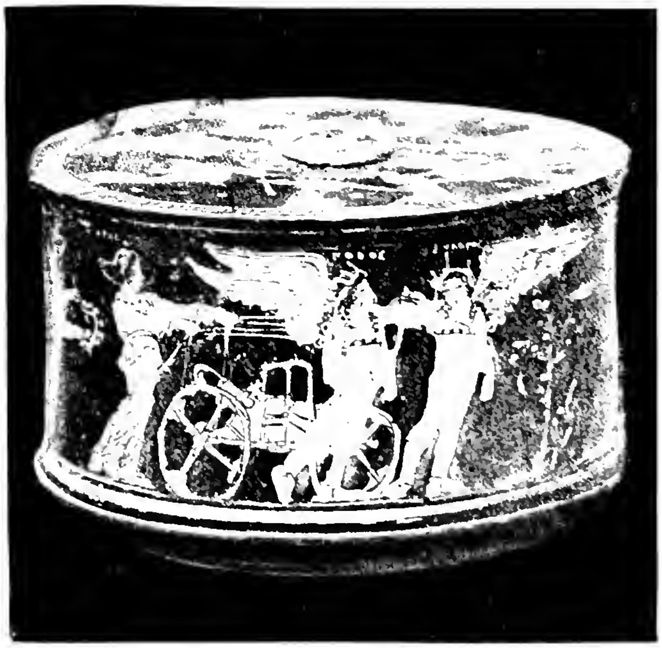


2.—Kylix, signed by Euphronios.

5.—Krater (Mixing Bowl), of Fine Style.

4.—Kotylé (Beaker), signed by Hieron.

3.—Kylix, signed by Brygos.



6.—Pyxis (Toilet Box) of Late Fine Style.

Attic legends, especially those of Theseus, the typical Attic hero. Two causes combined at this time to bring Theseus prominently forward among the Athenian people. Firstly, that he was supposed to have appeared in aid of their side at the battle of Marathon; and, secondly, that in 469 B.C. his bones were brought by Kimon from the island of Skyros, and buried with great solemnity in the Theseion, which building was decorated with paintings also celebrating the hero. It is also probable that Theseus was regarded as the typical athlete and the typical Attic *ephebos*, and his contests as analogous to successes in the *palæstra*. Hence the grouping of scenes from the labours of Theseus after the manner of groups of athletes variously engaged.

In the "fine" style the athletic subjects reach the height of their popularity, and Dionysiac subjects are also fairly common; but there is a certain reaction in favour of mythological subjects, such as battles of gods and giants, or the sending forth of Triptolemos from Eleusis by Demeter (a very characteristic subject of this period; *see* Plate, No. 4). Scenes of banqueting and revelry, or mere groups of figures conversing, are more popular on the cups of this period—the mythological subjects on the amphoræ and other large vases.

In the "late" style the popularity of athletic subjects begins rather to wane, and the private life of women comes more to the front. Again, we have many merely fanciful scenes, or figures with fanciful names drawn from mythological sources at haphazard.

But, for the student at any rate, the inscriptions on red-figured vases offer even more interest than the painted designs. Besides those that we may call descriptive, *i.e.*, which relate to the subjects depicted, we find numerous inscriptions which have a wider and more external interest. These fall into two classes: artists' signatures, and names of favourites. The special value of these inscriptions to the student is that he is thereby enabled by comparison of signed and unsigned vases to attribute many of the latter to known artists; while in the case of vases which merely bear the names of favourites, the fact that certain of these names are elsewhere associated specially with certain artists allows these vases to be assigned to their sources with even more certainty.

It should be explained that a favourite name denotes the name of some personage with the word καλός, "fair" or "noble," attached; implying that the painter wished to celebrate either some popular man of the day or some much-admired youth. The exact meaning of this practice has been much discussed, the chief difficulty arising from the fact that though many names famous in history, such as Miltiades, Alcibiades, and Hipparchos, occur among the favourites, it is impossible to discover whether they really refer to the historical personages or not. It is clear that if this identity could once be proved, we should have certain chronological data which would be of immense value for the history of vase painting; at present, however, we must be content with using the favourite-names for the identification of particular artists.

The artists whose signatures are known to us fall into three well-defined groups, corresponding to the divisions of style given above. They are as follows:—

(1) The group of Epiktetos, corresponding to the "archaic" style, and including several artists who employed both black and red figures.

(2) The group of Euphronios, corresponding to the "strong" style, and including the best work of the period, especially as far as the kylikes are concerned.

(3) The later Attic group, corresponding with the "fine" style.

The best work of these artists is, as a general rule, to be seen on the kylikes. The productions of Epiktetos and his fellow craftsmen are chiefly characterized by simplicity of conception, the natural consequence of the recent change from the old method. (*See* Plate, No. 1.)

Euphronios, as we have indicated, is usually associated with the most perfect work of this period. His style is characterized both by grandeur and beauty, combined with elegance and ease in composition, and a careful attention to the smallest details. (*See* Plate, No. 2.)

Among his contemporaries, Duris, Hieron, and Brygos take front rank, each, however, being an artist of marked individuality. The chief feature of Duris' work is a preference for quiet gracefulness rather than violence of action, and a love of slim nude figures. The vases of Brygos are comparatively rare, but we are able to see that he stands on the threshold of the next stage, and while still retaining certain traces of archaism, yet shows in his fondness for realism and copiousness of detail a rapid advance towards the freedom of the fine style. (*See* Plate, No. 3.) Hieron, again, is not a man of much originality; his tendency is chiefly to sentimental figures and idealized scenes of daily life. (*See* Plate, No. 4.)

The later group need not detain us long. Hardly any of these artists have left more than one specimen of their work, but Aristophanes has signed a beautiful kylix, with scenes from the battle of the gods and giants; and Sotades has produced several very delicate drinking-cups of various fanciful forms, some painted with designs of great beauty and refinement. A hydria, the work of Meidias, is also justly celebrated for the richness of its decoration and delicacy of execution.

We have alluded above to a class of vases with paintings on white ground which was produced exclusively for sepulchral purposes. With a few exceptions from Gela in Sicily, Locri in Southern Italy, and Cyprus, these vases have been all found at Athens or Eretria in Eubœa, and there is little doubt that they were all made at Athens. Their development is parallel to that of the sculptured tombstones, of which such a great number have been found at Athens, and the subjects are similar, but more varied. The commonest type of subject is that of mourners bringing offerings to the tomb of the deceased, represented by a tall monument on a raised base; the offerings take the form of vases, sashes, etc., for the decoration of the tomb. Other scenes depicted with less frequency are: mourners bending over the death-bed; the deceased person conveyed in Charon's boat over the Styx; a dead warrior laid in his tomb by Death and Sleep. In another group the funereal purpose of the vase is only hinted at: the deceased is represented, if a man, hunting or in armour: if a woman, engaged in some feminine occupation; the idea being, as we see it on the sculptured tombstones, to suggest the dead person as he was wont to be occupied in his daily life. (*See* Fig. 2.)

The period covered by these vases ranges from about 450 to 300 B.C.; many of the later examples are carelessly executed with rapidly-applied patches of colour, and suggest that the vases had been hurriedly produced "to order" on the occasion of the funeral. They were placed round the bier at the laying-out of the corpse, and then buried with it.

For all practical purposes the red-figured style may be said to have an end with the fall of Athens in 404 B.C. It is true that many existing vases can be dated later, as, for instance, the sepulchral lekythi, of which we have just been speaking; but they are exceptional, and all other vases which cannot go further back than the fourth century must be regarded as belonging to the period of the decadence, even though many of them were made at Athens, or directly under Athenian influence. But none of the finer examples of red-figured vases can be later than B.C. 400, while historical evidence taken in conjunction with the results of excavations in Sicily and Rhodes, and at Naukratis, points to the fact that apparently late red-figured vases found in those places cannot be later than the fifth century.

Description of Plate.

1. Kylix (goblet), signed by Epiktetos. In interior, man playing flutes and girl dancing. About 500 B.C.
2. Kylix, signed by Euphronios. In interior, elderly man and girl conversing. About 480 B.C.
3. Kylix, signed by Brygos. In interior, woman giving drink to departing warrior. About 460 B.C.
4. Kotylé (beaker), signed by Hieron. Subject symbolical of the introduction of agriculture into Attica: Triptolemos sent forth by Demeter from Eleusis. About 470 B.C.
5. Krater (mixing bowl), of fine style. Subject: Sunrise, represented by the sun-god in his chariot and four boys diving (indicating stars setting). About 440 B.C.
6. Pyxis (toilet box), of late fine style. On the top, the death of Pentheus; round the side, the chariot of Aphrodité drawn by two attendant genii. About 420 B.C.

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SOME CURIOUS FACTS IN PLANT DISTRIBUTION.—VI.

By W. Botting Hemsley, F.R.S.

In the first of this series of articles (February, 1896) some particulars were given of the latitudinal distribution of flowering plants. It was shown that, with one possibly doubtful exception, no flowering plants existed in the remote islands of the southern hemisphere within thirty-five degrees of the Pole, and probably nowhere within thirty-four degrees; whereas in the northern hemisphere about seventy species had been collected between latitude 80° and 83°, or within seven degrees to ten degrees of the Pole. It was further pointed out that the plants of the southern limits of vegetation have very small green or dull-coloured flowers; whereas, in the north, showy flowers are not uncommon, coexisting with bees and butterflies. Everybody knows that plants, like animals, are affected by temperature, and it has been ascertained by observation and experiment that a certain amount of temperature is necessary for the perfect development of a plant, the amount varying for different plants. Some trees and shrubs that thrive in this country rarely, if ever, flower; others flower, but never, or very seldom, produce seed. This difference in constitution is a problem difficult of solution. The dahlia and heliotrope, the potato and kidney-bean, all attain full development in this country during the warmer months, but their constitution appears to be the same as when they were first introduced, or the same as newly-imported strains, for a very slight frost destroys their tissues, and a healthy plant is thereby reduced, in less than twenty-four hours, to a black decaying mass. To look at, a seedling groundsel is as delicate and tender an organism as a seedling cucumber; yet the seed of one will germinate and grow in a temperature a few degrees above the freezing point, whilst the other requires a considerable amount of heat, and only really flourishes in the open air in England during our most favourable—that is to say, our warmest—summers. On the other hand, there are some plants of a hardy nature that will grow under widely different atmospheric conditions. In other words, the difference between the maximum and minimum sums of temperature under which they will fully develop is very large. Other plants will bear one or more sharp frosts without much injury, but a long continuation or succession of sharp frosts will kill them. Perpetual frost would, of course, eventually destroy all plant life, because it prevents growth. But in Arctic and Alpine regions—in fact, in nearly all cold countries—vegetation is protected by snow, and it may be said in a general way that the temperature of the soil is higher in cold weather and lower in hot weather than that of the air. Other plants are prevented from dying out, through exposure to excessive heat, or cold, or drought, by the fact that, although they flower only once, they produce seed in abundance. The seeds of such plants will bear exposure to the greatest solar heat, or to intense frost, or to the most prolonged droughts, without losing their vitality. These general explanations will render intelligible the existence and reproduction of plants under conditions that one might otherwise consider destructive of living organisms, whether animal or vegetable.

Generally speaking, the same causes determine the character and composition of vegetation in high altitudes as well as in high latitudes.

In the extreme land limit reached by the British Polar Expedition in 1876 flowering plants were found, and there is every reason to suppose that if there were land at the Pole itself there also plants would exist. Ward Hunt Island, 83° 4′, and Cape Columbia, 83° 8′, were the most northern points at which plants were collected. In the latter locality grew *Saxifraga oppositifolia*, a charming little plant that inhabits the mountains of the British Islands, and also grows freely under cultivation down to the sea-level in the South of England. It is found throughout the Arctic zone, and has an exceedingly wide range outside of the Arctic regions, in the mountains of Europe and Asia, including the Himalayas, up to an altitude of seventeen thousand feet.

In this connection it is worthy of note that a saxifrage (*Saxifraga Boussingaultii*) has been found at as great an altitude—namely, sixteen thousand five hundred feet—if not greater, than any other flowering plant in the Andes of South America. When this discovery was made, it was supposed that there was little probability of any flowering plant being found at a greater elevation in any part of the world, especially as the locality is close under the Equator; but, as will be presently shown, plants have since been discovered at much greater elevations.

It is singular, too, that another member of the same genus (*S. bicuspidata*) reaches the southern limit of flowering plants in Hermite Island, Cape Horn. This species is remarkable for its very small flowers, and the forcep-like appendages at the tips of the leaves, very similar to those of an earwig.

Papaver nudicaule, commonly cultivated and known as the Iceland poppy, was collected on Ward Hunt Island. This also ranges all round the northern hemisphere, but it is not wild in the British Islands.

Altogether, thirty species of flowering plants were collected north of the eighty-second parallel of latitude, and about half of them are British.

As to the conditions under which plants grow in these high latitudes, and the forms they assume, it may be stated generally that they gradually diminish in size and frequency; that they never produce ripe seed, and therefore only increase by their creeping stems, above or below the surface of the soil. The vegetation on the northern slopes is more luxuriant than on the southern, because it gets more sun on that side. Observations on the vertical range of plants in Discovery Bay (81° 42′) gave two thousand as the maximum. To this altitude the poppy, two species of saxifrage, and a kind of whitlow grass ascended. Indeed, vegetation is limited by the line of perpetual snow, varying greatly in different localities.

Scanty as the herbage is, a variety of animals subsist entirely on vegetable food, such as the lemming, hare, goose, musk ox, and reindeer.

Although no seed is produced in the higher latitudes, seed taken there germinated and grew during the summer in a temperature almost constantly as low as thirty-three degrees Fahrenheit. As no seed is produced, it follows that the present Arctic vegetation must be the remnant of a former more extensive flora; but, apart from this fact, there is abundant fossil evidence, both animal and vegetable, of very different conditions from the present.

Another curious point in connection with Arctic vegetation is the fact that only the surface of the soil thaws during the short summer, so that the roots of plants are in a medium bordering on the freezing point. This phenomenon may occasionally be seen exemplified in this country, where one portion of a grape vine, for example, is under glass and the other out of doors. The sheltered part, in spite of external cold, will grow and produce fruit, whilst the exposed part will remain dormant until spring.

I have not much space left for the discussion of the altitudinal limits of flowering plants, but a few of the leading facts will suffice. Contrary to what might have been expected, considering the latitude, it is in the region of the greatest elevation—in North India and Central Asia—where flowering plants reach the highest levels of any part of the world. The comparatively recent explorations of Conway, Rockhill, Thorold, and others, have yielded some highly interesting results. The collection made by Dr. Thorold may be taken as an illustration of this high-level vegetation. Dr. Thorold accompanied Captain Bower across Tibet from west to east, from Ladak to China. The route lay between 30° and 34° north latitude, at an average altitude of fifteen thousand feet, or about the same as the summit of Mont Blanc. As may be imagined, the climate is very severe and the vegetation exceedingly scanty; yet upwards of a hundred species of flowering plants were collected, with few exceptions belonging to genera represented in the British flora. Considering the altitude, this number is large as compared with what is found in other parts of the world; but when we reflect that as many species may be found on an acre of ground in this country, and that those hundred or so species were the fruits of five months' march through twenty degrees of longitude, we begin to realize the extreme poverty of the flora. Throughout this long journey, not a tree, not even a bush, was seen; none of the plants were more than a foot high, and most of them not more than two or three inches. They nowhere formed a carpet, but occurred singly or few together, and at long intervals. Plants having large descending roots, a rosette of leaves flat on the ground, with flowers nestling close in the centre, are characteristic of this region. Many of these belong to the thistle family. There are also buttercups, larkspurs, poppies, scurvy grass, saxifrages, asters, dandelions, wormwoods, primroses, gentians, and grasses. Contrary to what is the case in the Arctic regions, about half of the species are peculiar to this great upland country. About sixty of them were collected at altitudes between seventeen thousand and nineteen thousand feet, and of these half a dozen were found above eighteen thousand feet. One only was met with at nineteen thousand feet. This is *Saussurea tridactyla*, a plant densely clothed with woolly hairs. A species of the same genus inhabits the mountains of the North of England and Wales.

[In the series of articles of which this is the last, I have almost confined myself to a statement of facts of the present distribution of plants over the surface of the earth. I have pointed out that the domestic weeds and cornfield weeds of Europe have spread in temperate and sub-tropical countries almost as widely and rapidly as man, for the greater part unintentionally introduced by him with the seeds of his cultivated plants; and I may add that there has been no counter current to speak of. This is to be accounted for by the fact that in the uncivilized countries now colonized by European races, there was little or no cultivation and there were no roads; consequently there were no plants that had adapted themselves to the conditions of life connected with civilization. It is true that a few exceptions might be named, but they prove the general statement. Many readers, doubtless, will remember the American water-weed (*Anacharis canadensis*), which invaded this country about fifty years ago, and spread at such a surprisingly rapid rate that it soon choked ponds, ditches, and brooks from one end of the country to the other. This has since lost much of its former vigour, and is now more easily combatted.

I also alluded to the planting of remote islands by means of oceanic currents, tidal waves, and birds conveying seeds which retain their vitality after long immersion in sea water, or after passing through the intestinal canal of a bird. But these agencies, much as they may have effected, count for little as against the great physical changes which our earth has undergone during the countless years which must have elapsed since the first fossil remains were deposited and petrified, which now serve as history—undated, it is true—of a past that is unfathomable.]

OUR FUR PRODUCERS.—VI.

RODENTS, UNGULATES, AND MARSUPIALS.

By R. Lydekker, B.A.Cantab., F.R.S.

NUMERICALLY a high position in the fur trade is occupied by the skins of certain species of the order of rodents, or gnawing mammals, although several of these are of little value individually, and their importance in the market is solely due to the numbers in which they are collected. Among such rodents we may first notice the common squirrel, which has an extremely wide geographical range, extending from England in the West to Japan in the East, and reaching northwards to Siberia. In the first half of the century the trade in squirrel skins was enormous, over two and three-quarter millions having been imported into this country in the year 1839. Since that date the numbers have declined, although it is at present impossible to obtain exact data; but that the trade is even now very considerable may be gathered from the fact that the annual import from Ockotsk alone to London varies from fifty to a hundred thousand. Squirrel skins are subject to considerable variation in colour according to locality, those from the Russian province of Kazan having the red tinge very strongly pronounced, while to the east of the Urals greyer species are met with; and in parts of Siberia and Japan the general colour is slaty blue or blackish, the ears and tails being almost entirely black. The darker the fur the greater the value of the skin. The great squirrel-dressing centre is Weissenfels, in Germany, where some establishments prepare half a million skins annually. The skins are cut up into backs, bellies, and tails; and while the first of these are used for capes, trimmings, and the linings of gloves, the second form the bluish white linings of opera and other cloaks. Tails, on the other hand, are made up into fringes for mantles, or into boas; while the hair, when removed, is used for the manufacture of the so-called camel's-hair paint brushes. Although a few of the larger skins are dyed in imitation of marten, squirrel fur is nearly always used of the natural colour; but, as it will felt, it is occasionally employed in the manufacture of hats.

Although a few skins of the small Indian striped squirrel (*Sciurus palmarum*) and of the American grey squirrel (*S. carolinensis*) find their way into the market, the next species of any commercial importance is the red squirrel, or chickari (*S. hudsonianus*), of North America. Like the next, it is chiefly used for the cheaper kinds of mantles.

Head of Bull Musk Ox.

The small, burrowing, Russian animal, allied to the squirrels and known as the suslik (*Spermophilus citillus*), has only recently come to form an item in the fur trade, but we have no record of the amount of the import.

The harshness of their fur renders the skins of the marmots (*Arctomys*) but ill adapted to the requirements of the furrier. Nevertheless, as many as fifty thousand pelts of the Russian marmot (*A. bobac*) have been imported in a single year, while of the American species (*A. monax*) some four or five hundred come into the market. Some thousand skins of Arctic marmots are also sometimes imported. They are generally used for rugs, although some are dyed brown and made up into capes.

In the old days, when its fur was used in the manufacture of "stove-pipe" hats, the American beaver was one of the most important of all mammals in the fur trade, but this manufacture has almost entirely ceased. Still, the importation of skins is even now very considerable, and would doubtless be larger were it not that the numbers of the animal have been so reduced by constant persecution. In the year 1891, Mr. Poland states that over sixty-three thousand beaver skins were sold by the Hudson Bay Company. At the present day the skins are used either in the natural state, or with the longer hairs removed so as to display the under-fur, while in some cases they are dyed brown or black. Sometimes they are "painted" by the introduction of white hairs to imitate sea-otter, and in some instances they are silvered at the tips by means of acid. When finished, they are usually worked up into trimmings, cuffs, or muffs, but a few clipped skins are used for glove-tops. In Europe the beaver is too nearly exterminated for its fur to be of any commercial importance.

Although a few skins of the Australian water-rat (*Hydromys*) are from time to time imported, the next animal on our list is the well-known European hamster (*Cricetus frumentarius*), which is a member of the great mouse tribe (*Muridæ*). Many thousands of pelts are yearly imported into England, which may be recognized by their varied colours, the upper parts being mostly brownish grey, with blue under-fur, while the lower surface is black. Of far more importance is the American musquash, or musk-rat (*Fiber zibethicus*), which is a near ally of our own water-rat, and yields a beautifully soft fur varying in colour from umber brown to black. Upwards of three or four million skins yearly come into the market, the Hudson Bay Company having alone sold more than half a million in 1891. Twenty years ago nearly four shillings each were paid for the best black skins, but the present price is less than two. They are made up either in the natural state or dyed black, or some shade of brown; while a certain number are "pulled" and dyed to imitate sealskin.

The next important rodent in the fur trade is the South American coypu (*Myopotamus coypu*), a large animal with somewhat the habits, colour, and appearance of a beaver, but with a tail of ordinary proportions, and bright red incisor teeth. It is, however, no relation to the beaver, but belongs to the great family of the *Octodontidæ*, most of the members of which are South American, although a few are African. Both in its native land and in the fur trade the animal is known as *nutria* (the Spanish name for otter); and the skins are removed by slitting up the middle of the back, so as to preserve intact the fine fur of the under surface. From three hundred thousand to half a million skins are annually collected. Either in the natural condition or "pulled," the fur is dyed dark brown or black; and in the latter condition forms one of the best imitations of sealskin. Sometimes the "pulled" fur is silvered to imitate sea-otter.

The most beautiful and, for its size, the most valuable of all South American rodent furs is, however, that of the little chinchilla (*Eriomys chinchilla*) of the Andes, which belongs to the exclusively South American family of the *Lagostomatidæ*, typically represented by the viscacha of the Argentine pampas. Chinchilla fur is the finest and most delicate of all furs, and is generally of a pearly French grey tint, although white, and less commonly drab, varieties occur. The animal is, however, but small, measuring only about nine inches to the root of the rather long tail; so that many pelts are required to make a garment of any size. From five thousand to eighty thousand is stated to be the number of skins annually reaching this country; and many more are used in South America. Tippets, capes, and muffs of chinchilla fur are highly appreciated, and nearly always in fashion. Viscacha fur, although soft in texture, is not durable, and therefore unfit for the purposes of the furrier.

The only other rodents of importance in the fur trade are the various species of hares and the rabbit. Of the number of skins of the common hare (*Lepus europæus*) that annually come into the market, it is impossible to form any accurate estimate, although it is certain that it must be enormous. The value per skin is, however, trifling. More valuable are the pelts of the mountain hare (*L. timidus*) of Northern Europe, and of the nearly allied Polar hare (*L. arcticus*) of the northern regions of the New World, in both of which, when the cold is sufficiently intense, the fur turns white in winter. From Russia alone between two and five million pelts of the European species are imported, a large proportion of which are in the white winter coat. In regard to these, Mr. Poland writes that a large number "are used for fur purposes, both natural white, in imitation of white fox, and dyed lynx colour, brown, dark brown, black, and snowflake. The peculiar dye called snowflake is produced by passing a solution of wax over the points of the fur, and then dying the under-fur a beautiful brown. The tips of the hairs thus retain their natural white colour. The wax covering is removed, the skins are cleaned, and the fur has then a beautiful appearance somewhat like silver fox." Of the brown American hare (*L. americanus*), which is a more southern form than the Polar hare, nearly ninety thousand skins were imported in 1891.

Reindeer. One-fifteenth natural size.

On account of its extreme cheapness, rabbit fur is one of the most widely used for common purposes of all, although it is by no means durable, and soon begins to show signs of wear. The total annual collection from all parts of the world must be something enormous, France and Belgium accounting for about two millions, while the English skins are stated to average thirty millions. With the exception of that of the musquash and squirrel, the fur of the rabbit is used more extensively than that of any other animal. When clipped and dyed, it is used in imitation of various other furs of much higher value—such as seal and beaver—while some white skins are dyed snowflake.

Of mammals belonging to other orders whose fur is of any commercial importance, space compels our notice to be of the briefest. The Insectivora lay claim to only two species that come within this category, the first of these being the common mole. Although mole fur is exceedingly soft and beautiful, the small size of the skin renders it much less valuable than would otherwise be the case, and consequently only a few thousand skins are annually collected. The other species is the Russian desman (*Myogale moschata*), an aquatic animal, with a long trunk-like muzzle and dark purplish fur, which may be compared in size to a large water-vole. Between six and twelve thousand skins is stated to be the annual collection of this species. They are chiefly used as trimmings for mantles, and less commonly for glove-tops, but find more favour in America than on this side of the Atlantic.

Although many members of the hoofed, or ungulate, order are fur producers in the widest sense of the word, their products are in several cases mainly employed in the manufacture of textile fabrics, and accordingly do not come within our province on the present occasion. Of the species yielding a true fur, one of the most important was the American bison, or, as it is incorrectly called, buffalo. Although formerly the annual collection of "buffalo robes" amounted to between one hundred and fifty thousand and two hundred thousand, while as late as 1879 fifty thousand were obtained in the United States, and nearly three thousand robes and skins imported into London, the trade, owing to the practical extermination of this fine animal, has entirely come to an end. From their warmth—greater than that of any other fur—buffalo robes proved by far the best of all sleigh wraps. An excellent substitute is, however, now found in the skin of the musk-ox (*Ovibos moschatus*) of Arctic America. Although there is a very large trade in antelope skins for leather, but few of these are used as fur. Handsome rugs are, however, made of sprinbuck pelts, the line of long erectile white hairs down the middle of the back forming a pleasing contrast to the general chestnut tint of the fur. Of late years a considerable trade has sprung up in rugs made of grey goats' skin, which come from China; and the pelts of the long-haired Russian goat, when dyed, are employed for a similar purpose. More valuable are those of the Angora goat, in which the pellage is still longer and softer. The trade in China goatskin rugs is, however, still more extensive, four hundred thousand having been imported in a single year, and these representing more than double that number of animals. Mongolian goat-skins exceed even these in number, the import reaching to between thirty and eighty thousand.

To give any adequate account of the use of the pellage of the various breeds of sheep in the fur trade would far exceed our limits, and a few words must accordingly suffice. Those skins with the longest and curliest wool are used, when dyed, for fringes and tassels; such as have a shorter staple are made into mats and rugs; whilst the shortest of all are made into saddle-cloths for our cavalry. Even more extensive is the use of lambskins—especially those of newly-born animals—these being employed for glove-linings, the trimmings of coats, and the lining of those Eastern coatlike garments known as postins. The finest of all are the Persian and Astracan skins, both of which take a brilliant black dye, and are soft, short, and beautifully curled. Canada and the United States are now the great marts for astracan, this fur not being in fashion at home.

Of the deer family, the only one of much importance from our present point of view is the reindeer, the skins of which furnish the entire dress of the Lapps and Eskimo. Some eight hundred skins of the American variety are yearly imported into London, and are sent to be dressed in Germany. Of these the youngest and finest find much favour in Russia as linings. The other fur-bearing ungulates are all South American, and include the domesticated llama and alpaca, and their wild allies the guanaco and vicuña; all being near relatives of the camels of the Old World. The domesticated kinds are mainly kept as beasts of burden, and for their wool; but the guanaco and vicuña yield a beautiful pale fawn-coloured fur, much esteemed as rugs.

But few lines remain for the consideration of marsupials as fur producers. Most important of all are the so-called opossums of Australia, which, as our zoological readers are doubtless aware, are not opossums at all, but phalangers (*Trichosurus*). The beautiful soft grey fur of an opossum rug is too familiar to need any description, and it must suffice that the total import of opossum skins into London in 1891 reached the enormous total of three millions. These comprise varieties from different districts.

Koala. One-sixth natural size.

Although the name of opossum has been usurped in the fur trade by phalanger skins, the true American opossums (*Didelphys*) are by no means unknown. Of the common opossum, between two hundred thousand and three hundred thousand skins are annually imported. Although somewhat coarse, the fur is thick and durable; and, either in the natural state or dyed of some dark hue, or grey, is largely employed for such articles as muffs and capes.

Of the other Australian marsupials, the most important in the trade is the koala, or native bear (*Phascolarctus*), a climbing creature with greyish fur, and the longer hairs tipped with white. In 1889 no less than three hundred thousand skins were imported, although the number is generally considerably less. Next to the koala comes the carnivorous spotted dasyure (*Dasyurus viverrinus*). The chief use of this fur is for linings. Another group of Australian fur-yielders are the ring-tailed phalangers (*Pseudochirus*), of which from two to three thousand pelts are imported. Of the various kinds of kangaroos and wallabies an enormous number of skins are collected, but as a very large proportion of these are consigned to the tanner, it would be useless to give any numerical details. Of the younger and smaller kinds the fur is employed for rugs and coats.

Had we more space at our disposal much fuller details concerning the fur trade might have been given. Sufficient has, however, been stated to show how the earth is ransacked from Pole to Pole in order to obtain the most beautiful of these lovely products, and also to indicate how enormous is the destruction of animal life due to this trade alone. May we hope that, while there is yet time, civilized Governments may unite in taking measures to prevent the extermination of any more species by a foolish greed?

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

STAR SYSTEMS.

To the Editors of Knowledge.

Sirs,—Considering the great distance which must separate the second-magnitude stars in the Great Bear (for the parallax does not seem to be in any case considerable), it seems very improbable that they constitute a system. Determinations of small proper motions are always unreliable, and with none of these stars is the proper motion large. But agreement, even in large proper motions, is often found (though, of course, not quite exact) in cases where the stars do not form a system. Thus the proper motions of three of our first-magnitude stars are as follows (I take them from the Cincinnati Catalogue):—

	Proper Motion.	
	R.A.	Declination.
Sirius .	− 0·037	− 1·20
Procyon	− 0·047	− 1·03

And Arcturus is not very dissimilar, viz., R.A. −0·080, declination − 1·98. Looking through the Cincinnati Catalogue I get the following smaller stars with motions very like the foregoing, all of which are much over the average:—

	R.A.	Declination.
Lalande 30044 . .	− 0·030	− 1·39
Lalande 30694 ...	− 0·049	− 1·49
Lalande 31055	− 0·062	− 1·15
36 Ophiuchi	− 0·039	− 1·18
Oeltz-Arg. 17415	− 0·069	− 1·25
W. 23h. 175 ..	− 0·035	− 1·21

There is a small star near 36 Ophiuchi whose proper motion is almost identical with it. Can we suppose that all of these stars, or even any considerable proportion of them, belong to the same system? The proper motion of the last-named star and of 36 Ophiuchi agrees almost exactly with that of Sirius, but their situations in the sky are as follow:—

	R.A.	Declination.
Sirius ...	6h. 41m.	16 37
36 Ophiuchi ..	17h. 9m.	26 27′
W. 23h. 175	23h. 12m.	− 14 22′

The three Lalande stars 30044, 30694, and 31055 are probably really nearer to each other than the stars in the Great Bear. I might, perhaps, have added 61 Virginis to the foregoing list.

Probably a very considerable part of the apparent proper motion of a star is due to the sun's motion in space. The effect of this will be different when the stars differ in position. The apparent motion will moreover be, *cæteris paribus*, increased in the same proportion as the parallax; and of two stars which apparently agree one may be at double the distance of the other with half the parallax. But until we know the motion of each star in the line of sight we are further at sea. The effect of this may be to render the real motion of the two stars which we are comparing altogether different.

Among the proper motions of many thousands of stars there must be a large number of chance coincidences. It is only when there is something exceptional in the proper motions, or in the position of the stars which we are comparing, that we can draw any inference. Thus, I think, though no satisfactory orbit has yet been determined for 61 Cygni, we may conclude that the pair are physically connected. For the motion is exceptionally large, the stars lie close together on the sphere, and it seems to be ascertained that they have almost the same parallax. Indeed, they seem to be in reality so near each other that their mutual attraction must seriously affect the motions of both.

W. H. S. Monck.

A VERY EXTENDED STREAM OF SUNSPOTS.

To the Editors of Knowledge.

Sirs,—I have been much interested in the article on "A Very Extended Stream of Sunspots," in the November Number of Knowledge, and in the exquisite illustrations accompanying it.

Perhaps your readers may like to know that this wonderful outburst did not return when due after rotation, with the exception of a very small spot in the same position, or nearly so, as the "herald spot" alluded to in that article, although a vast expanse of faculæ, visible on the eastern limb of the sun's disc, and again on the western limb, testified to the dying embers of the great disturbance.

If I may be permitted to criticize, I should like to enquire the special meaning attached in this case to the term "nebulosity," which does not seem quite applicable to the small fragmentary spots indicated, yet can hardly be intended to signify the faculous light sometimes apparent even when the spots are far advanced towards the centre. The word "bivalve," on the other hand, as applied to segmented spots, is singularly appropriate in describing a type very distinct and of frequent occurrence.

This stream was observed, and drawings, as well as photographs, secured, by the members of the Solar Section of the British Astronomical Association during eleven days out of the thirteen during which it was visible.

E. Brown.

[By "nebulosity" I wished to indicate the ill-defined, faint, dusky markings seen in some parts of the great group in its earlier days.—E. Walter Maunder.]

VARIABLE STARS.

To the Editors of Knowledge.

Sirs,—Since the article on the above subject, which appeared in the August Number of Knowledge, was written, Dr. Chandler's "Third Catalogue of Variable Stars" has been published. It may therefore be interesting to note the progress recently made in this branch of astronomy, by comparing this catalogue and the preceding one. The total number of variable stars in the Third Catalogue is three hundred and ninety-four, against three hundred and forty-three in the Second, and one hundred and eighty-seven in Mr. Gore's Catalogue of 1886. Thus fifty-one stars have been discovered or confirmed in the interval between the Second and Third Catalogues, a noteworthy addition to our knowledge in this department. In fact, if we go on advancing at the same rate in the future, it is very probable that the number of variables may exceed the number of the known asteroids.

The comparison in the classification of the stars is as follows:—

	Cl. I.	II.	III	IV.	V.	Total.
Second Catalogue and Supplement	11	239	31	47	15	343
Deduct not confirmed	–	4	–	1	—	5
	11	235	31	46	15	338
Add since discovered . ..	2	47	—	6	1	56
Third Catalogue ...	13	282	31	52	16	394

The classes have the same signification as in the article alluded to, viz.:—

I. Temporary or new stars.
II. Variation of one hundred days and upwards.
III. Irregular.
IV. Variations of less than one hundred days.
V. Algol type.

The long-period variables continue their superiority in numbers, while only two new and one Algol type have been added.

As regards distribution in hemispheres, there are now one hundred and ninety-six in the northern hemisphere and one hundred and ninety-eight in the southern hemisphere. Thus the distribution by hemispheres is practically equal.

It is obviously unsafe to generalize on the distribution of the variables in space, seeing how rapidly their number is increasing. Anyone who examines the new catalogue cannot fail to observe how many stars there are whose periods are not yet determined, and consequently what a large field of work is here open to the industrious observer, especially in the southern sky. The amount of labour spent in compiling this epoch-making catalogue must have been enormous, considering how observations of variables are scattered over the scientific periodicals of different countries, and it is clearly far and away ahead in fulness and accuracy of anything of the sort previously produced.

I may now state the small errors which have crept into the article in the August Number. Class II. should be two hundred and thirty-nine; Class III., thirty-one; Class V., fifteen, instead of the numbers there given. The tables of analysis of II. and IV. are quite correct, but it was omitted to be stated that a large number of stars had no period assigned, and consequently could not be analyzed. In the article such doubtful stars were included in the enumeration in Class II., or long period, as it is most reasonable to suppose they will—most of them at least—turn out to have long periods of variation. A short-period star will reveal its variation quicker than a long one. The same remark applies to the Third Catalogue.

It is a great question whether it is possible to bind down some of these long-period stars by mathematical formulæ. Surely the maximum of such a star is a phenomenon intimately connected with chemical changes, the behaviour of gases under conditions unknown to us, and with electrical forces. Have we any formula to enable us to predict a sunspot maximum? *When* we have, then we may have some hope about a changing star; but at present it cannot be treated in the same way as we would the perihelion passage of a comet, where the laws and conditions are definitely known and can be applied in the study. As Mr. Flanery says, Mira, the most interesting star of the class, is as great a mystery as ever.

E. E. Markwick, Lieut.-Col.

Gibraltar, October, 1896.

MIRA CETI.

To the Editors of Knowledge.

Sirs,—A maximum of Mira ο Ceti was due, according to Chandler's "Second Catalogue," and the "Companion," on November 3rd, the night before last; but the star had not quite reached 7·5 magnitude. My search for Mira this season began September 1st, but not until September 28th was a sight of it obtained. It was seen definitely then at or near ninth magnitude, an unusually clear night. Two or three views of it were obtained on as many nights following, but it was then lost and not seen again. Moon large and clouds interfering till October 28th and 29th, when it was about 7·8 magnitude. November 2nd it was 7·6 magnitude. R Leonis is also on the rise, visible in the early morning. It was 7·3 magnitude this morning. Its maximum is due in December.

Memphis, Tenn., David Flanery.
5th November, 1896.

LUNAR RAINBOW.

To the Editors of Knowledge.

Sirs,—On the night of the 25th October, at 9.35 p.m., I was fortunate enough to observe a third fine lunar rainbow. The bow was this time quite complete, and about one-third of the circumference of the circle long. It shone with a silvery white light, but showed traces of colour, especially green, at its extremities. It gradually faded away, beginning at the middle; and at 9.43 it had completely disappeared. It is remarkable how many lunar rainbows have been seen during the last few months.

Exmouth. J. M. Wadmore.

THE THEORY OF THE TIDES.

To the Editors of Knowledge.

Sirs,—I trust that Mr. Cornish will acquit me of any desire to gain an academic victory. My sole desire is to elicit and to spread a tolerably accurate knowledge of a very abstruse subject. I do not for a moment doubt that he has a knowledge of all that is known on the subject; but I think that anyone reading his original words would receive the impression that the "second" tide is caused by the moon drawing the earth from under the water, which is just the old stock fallacy of popular tidal literature. I might apply a similar remark to Sir R. Ball, whose "Time and Tide" is so often quoted by amateur disputants.

Mr. Cookson's letter, which appeared in the August Number, raises an ingenious and, as far as I know, a novel speculation. It would seem very natural to suppose that the huge barrier wall of the west coast of the Americas must *reflect* the tidal wave impinging against it; but how far it actually does so, and, still more, whether this is in any degree responsible for the "second tide," is a question which I at least cannot answer.

The study of the "establishment of the port," as derived from practical observation, is a very complicated affair indeed.

We know that where there is an irregular coast-line there may be two ports, relatively near to each other, at one of which the "primary" tide may be almost simultaneous with the "secondary" tide at the other. But, as far as I am aware, all ports that have any tide have two tides each day, nearly equal in height, and pretty accurately twelve hours apart.

Let us consider the case of the Galapagos Islands, which lie some eight hundred miles off the west coast of Ecuador, and roughly ten thousand miles from the east coast of Asia. Now, if Mr. Cookson's speculations are accurate, the "secondary" tide (rebounding from the west coast of Ecuador) ought to occur only about an hour later than the "primary" tide which has followed the moon from the coast of Asia. But is this the case? Will someone who has a comprehensive list of tide tables answer this question?

I am glad that this fascinating problem is interesting so many readers. May I, in conclusion, draw their attention to a small book on the "Elementary Theory of the Tides," by Prof. Abbott? This is the only book I have met with that gives an accurate idea of what is known about the tides, expressed in terms that are intelligible to anyone who possesses a knowledge of elementary mathematics. I am of opinion that no one (apart from trained mathematicians) who has not read this book can be in a position to grasp the theory of tide production. It does not claim to be original, but is a simplified extract from Sir George Airy's treatise.

C. Robinson.

August 1st.

THERIDION LINEATUM AND NOTES ON SPIDERS.

To the Editors of Knowledge.

Sirs,—With reference to the Rev. S. Barber's letter and article appearing in Knowledge for September and October, if the Rev. S. Barber has any doubt about "a new variety" of *T. lineatum*, I would advise him to send it to the Rev. O. Pickard-Cambridge, Bloxworth Rectory, Wareham.

From the account of the shooting lines, etc., I should imagine Elmsett to be a *very* wonderful place for spiders, though I much doubt if anyone could rise from his seat, go to the window, etc., without creating enough draught to float a spider's thread.

The second "marvellous illustration" loses all its charm from the fact that there are so many draughts about a dinner party, which might account for the strange lines being seen.

A Spiderman.

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RUNES AND OGHAMS.

To the Editors of Knowledge.

Sirs,—In the October Number of Knowledge, page 233, I notice that "runes" were found on the Potomac River. I happened to be in Washington when this hoax was started in a local paper, probably as an advertisement for a storekeeper in whose window the copy of the alleged inscription was exhibited. The thing was so palpably absurd that few were deceived. The translation, no doubt, was perfect. This happened nearly thirty years ago, and is a specimen of the survival of the unfittest.

Washington, D.C., U.S.A.
October 18th, 1896.

Chas. A. Schott.

On page 251 of Knowledge for November, Prof. Auwers' name was, by a printer's error, spelt "Amvers."

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Notices of Books.

Applied Magnetism. An Introduction to the Design of Electromagnetic Apparatus. By J. A. Kingdon, B.A. (Alabaster, Gatehouse, & Co.) Illustrated. 7s. 6d. In mathematical works it has been usual to discuss the phenomena and laws of magnetism from the point of view of a unit magnetic pole. But a magnet has two poles, and the result of building upon the idea of the work done by or upon isolated poles is a mass of theory of little practical value. A simpler and much more satisfactory way to treat the subject is to consider a magnet as a conductor of a flow or flux of magnetism, and thus analogous to an electric conductor. The force or agency—it may be an electric current or a permanent magnet—which sets up magnetic flux is called the magnetomotive force, and is similar to electromotive force, while the magnetic current or total magnetic flux is found by dividing the magnetomotive force by the magnetic resistance, or reluctance, as it is called. The work before us is distinguished by the fact that this magnetic resistance method of dealing with magnetism is followed. The result is a clear and simple description of modern ideas of magnetism applied to the design of dynamos and other electromagnetic apparatus. In sixteen chapters the author deals with the general principles of magnetism, electromagnetic units, magnetomotive force, magnetic traction, generation of electromotive force, qualitative magnetism, the alternator, the dynamo, magnets and magnetic leakage, commutators and collectors, hysteresis, alternating magnetic flux, electromotors, polyphase currents and rotary fields, and magnetic measurements.

The nomenclature of magnetic units is still in a somewhat undefined condition, but the difference of opinion that exists as to the names to be given to practical magnetic units does not, of course, affect the character of Mr. Kingdon's work, which is excellent in text and arrangement, and will serve to give students of electrical engineering exact ideas on the science of magnetism without the use of higher mathematics.

The Wonders of Modern Mechanism. By C. H. Cochrane. (Illinois: Lippincott.) The author has given in this book wonderfully clear and simple explanations of a great many inventions and mechanical appliances. It is essentially a popular account of the wonders of modern mechanism, and the author has been eminently successful in imparting a great deal of knowledge in simple terms. In order to show the scope of the book, we may mention that it treats of the following, amongst a large number of subjects:—Bridges, electricity, ships, horseless vehicles, mining and many other kinds of machinery, printing, and other industries. It will be read with the greatest interest by everyone, and will prove useful as a book of reference, although a complete index would have made it much more valuable in this respect.

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BOOKS RECEIVED.

Worms, Rotifers, and Polyzoa. By F. W. Gamble M.Sc.; Miss L. Sheldon; A. E. Shipley, M.A.; and Others. (Macmillan.) Illustrated. 17s.

Prehistoric Man and Beast. By Rev. H. N. Hutchinson, B.A., F.G.S. (Smith, Elder.) Illustrated. 10s. 6d.

Habit and Instinct. By C. Lloyd Morgan, F.G.S. (Arnold.) Illustrated. 16s.

The Clue to the Ages. By E. J. Page. (Baptist Tract and Book Society.)

Autobiography of Sir George B. Airy, K.C.B., M.A., LL.D., F.R.S. Edited by Wilfrid Airy, B.A. (Cambridge University Press.) 12s.

Life in Ponds and Streams. By W. Furneaux, F.R.G.S. (Longmans.) Illustrated. 12s. 6d.

Round the Year. By Prof. L. C. Miall, F.R.S. (Macmillan.) Illustrated. 5s.

Joseph Thomson, African Explorer. By his Brother. (Sampson Low.) Illustrated.

Alternating Currents. By D. C. and J. P. Jackson. (Macmillan.) Illustrated. 14s.

Higher Mathematics. By Mansfield Merriman and R. S. Woodward. (New York: Wiley. London: Chapman & Hall.) 21s.

The Gases of the Atmosphere. By William Ramsay, F.R.S. (Macmillan.) Illustrated. 6s.

Structural Botany. Part II.—Flowerless Plants. By D. H. Scott, M.A., F.R.S. (A. & C. Black.) Illustrated. 3s. 6d.

The Elements of Physics. Vol. II.—Electricity and Magnetism. By E. L. Nichols and W. S. Franklin. (Macmillan.) Illustrated. 6s.

Fuel and Refractory Materials. By A. H. Sexton, F.I.C. (Blackie.) Illustrated. 5s.

Bell's Reader's Shakespeare. Vol. II.—The Tragedies. (Hodder.) 3s. 6d.

The Model Locomotive Engineer. By Michael Reynolds. New Edition. (Crosby Lockwood.) Illustrated. 3s. 6d.

Elementary Decoration. By J. W. Facey. Third Edition. (Crosby Lockwood.) Illustrated. 2s.

Induction Coils and Coil-Making. By F. C. Allsop. (Spon.) Illustrated.

Problems of Biology. By George Sandeman, M.A. (Swan Sonnenschein.)

The Literature of Music. By J. E. Matthew. (Elliot Stock.)

A New Course of Experimental Chemistry. By J. Castell-Evans, F.I.C. (Thomas Murby.) 2s. 6d.

Physiography for Beginners. By A. T. Simmons, B.Sc. (Macmillan.) Illustrated. 2s. 6d.

British Patent Law. By H. Hals. (Whittingham.) 1s. 4d.

Physics Note Book, with Spaces for the Pupil's Drawings of Experiments. (Macmillan.) 2s. 6d.

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SHORT NOTICES.

The Report of the City and Guilds of London Institute for 1895-6. In this report of the work of the London Institute on behalf of "the advancement of technical education," one cannot but feel pained that the artizans fail to realize the benefits provided for them by this department. We find that only twenty-nine thousand four hundred and ninety-four students attended these classes last year, out of the multitudes of young workers who require technical training. A second difficulty is experienced in finding competent teachers for these trade classes, and it seems to be generally admitted that the best instructors have yet to be found, as witness many of the reports of the examiners at the end of this report.

William Wesley & Sons send us their useful catalogue (No. 126, 1896) on invertebrate zoology. All those who desire to study the biology and morphology of the invertebrates would do well to send for a copy of this catalogue of scientific books and monographs.

In the *Quarterly International Journal of Microscopy and Natural Science* (October, 1896) is to be found a short paper upon "The British Hydrachnidæ"—Genus VI., Diplodontus—by Charles D. Soar. The drawings are very good, but the descriptions are very meagre considering the literature which has been published upon the genus by various microscopical societies.

In the *Observer* (Portland, Conn.) for September there are several very interesting articles; one, on "First Steps in the Study of Fishes," by Dr. R. W. Shufeldt (Washington), is illustrated by a plate giving twenty-three types of fins and forms of fishes. It is full of suggestion to the young ichthyologist. Those who are desirous of studying the habits of the trapdoor spiders will find an article on "The Ctenzia Californica," by F. E. Gray, who is evidently a practical observer.

The Journal of Physical Chemistry (October, 1896). Edited by Wilder D. Bancroft and Joseph E. Trevor, of Cornell University. This is the first number of what promises to be an important addition to chemical literature when the magazine is settled into working order. There are three highly technical articles in this number—one, on irreversible cells, by A. E. Taylor, giving ten tables of valuations of the electromotive forces of the cells in the various chemical solutions described in the text; the second article is a translation of Prof. F. Wald's (Austria) manuscript on "Chemistry and its Laws"; and a paper on "Ternary Mixtures" by W. D. Bancroft.

Those interested in the rise and progress of mining cities will find an illustrated paper on "Nevada Silver," by Charles H. Shinn, in the October number of *Appleton's Popular Science Monthly*. It describes the finding of the gold and silver, and how "Old Pancake" (H. T. P. Comstock) "bluffed the good-natured discoverers into taking himself and Manny Penrod as equal partners." The history of the men who discovered the mines first is graphically described. The lawsuits cost one-fifth of the products of the mines (five million dollars) during 1860 to 1865. The pitched battles, forts, and the armed men drilling, all find a place in the history of this famous corner of Utah.

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A POSSIBLE CAUSE OF CHANGE ON THE MOON'S SURFACE.

By Charles Davison, Sc.D., F.G.S.

In spite of the fruitless search of many years, astronomers have not yet apparently given up hope of discovering changes on the moon's surface. And the hope does not seem to be altogether without foundation. In the great changes of temperature which take place on the moon, changes which are untempered by any atmosphere such as we possess, there resides a cause capable perhaps of producing effects that may in time become perceptible to our telescopes.

The suggestion that such may be the case is due, I believe, to Messrs. Nasmyth and Carpenter. During the long lunar day, they remark, the surface attains a temperature of about 500° F., and during the equally long lunar night one of about - 250° F. "Such a severe range of heat can hardly be without effect upon some of the component materials of the lunar surface. If there be any such materials as the vitreous lavas that are found about our volcanoes—such as obsidian, for instance—they are doubtless cracked and splintered by these extreme transitions of temperature; and this comparatively rapid succession of changes continued through long ages would, we may suppose, result in a disintegration of some parts of the surface, and at length somewhat modify the selenographic contour." On the other hand, "it is possible," they add, "that the surface matter is mainly composed of more crystalline and porous lavas, and these might withstand the fierce extremes like the 'fire-brick' of mundane manufacture, to which in molecular structure they may be considered comparable. Lavas as a rule are (upon the earth) of this unvitreous nature, and if they are of like constitution on the moon, there will be little reason to suspect changes from the cause we are considering." They think it conceivable, however, "that the alleged changes in the crater Linné may have been caused by a filling of the crater by some such crumbling action as we are here contemplating."*

In making this suggestion, Nasmyth and Carpenter are appealing to no imaginary agency. Several instances might be given of the splintering of terrestrial rocks by more or less sudden cooling. It will be sufficient to mention one case, observed by Livingstone in the valley of the Gova, a river flowing into Lake Nyassa. "Several of the mountain-sides in this country," he says, "are remarkably steep, and the loose blocks on them sharp and angular, without a trace of weathering. For a time we considered the angularity of the loose fragments as evidence that the continent was of comparatively recent formation, but we afterwards found the operation actually going on by which the boulders are split into these sharp fragments. The rocks are heated by the torrid sun during the day to such an extent that one is sometimes startled on sitting down on them after dusk to find them quite too hot for the flesh, protected by only thin trousers, to bear. The thermometer placed on them rises to 137° in the sun. These heated surfaces, cooling from without by the evening air, contract more externally than within, and the unyielding interior forces off the outer parts to a distance of one or two feet. Let anyone in a rocky place observe the fragments that have been thus shot off, and he will find in the vicinity pieces from a few ounces to one or two hundred pounds in weight, which exactly fit the new surface of the original block; and he may hear in the evenings among the hills, where sound travels readily, the ringing echo of the report, which the natives ascribe to Mchesi or evil spirits, and the more enlightened to these natural causes."†

If changes of temperature can produce such effects on the earth, they must act still more powerfully on the moon. There, especially on the mountain-sides, large areas are *suddenly* exposed to, or withdrawn from, the action of the sun's rays. Moreover, the range of temperature, as we have seen, is enormously greater. Thus, if the rocks which compose the lunar mountains resemble even approximately those which are found upon the earth, there must evidently be much fracturing and splintering; level or inclined surfaces must in places be covered with loose fragments of rock, while against the steeper hillsides slopes of loose rocks, or "screes," must be piled up.

It appears to me that these screes, if they exist and are perceptible, are the regions where signs of change should be especially looked for. As fresh fragments fall down from the crags above, the slopes of the screes increase until they attain, or nearly attain, their maximum inclination. The surface blocks are then in a highly unstable condition, and every newly-fallen rock showers down numbers of others all round it before it finally comes to rest.

Thus, if screes are found at all upon the moon, they will continually increase in size until they mask the parent cliff. So far as we know, there is little to check their rate of growth, except that growth itself, which gradually lessens the area from which new blocks are to be derived. The blocks themselves may splinter still further until the spaces between them are filled up with small fragments and dust, and this may perhaps retard their movement; but there can be no vegetation to find a root in this soil and so bind the surface stones together.

While changes of temperature furnish the materials of screes, and gravity rearranges them, these two agencies in concert are capable of producing a further movement of

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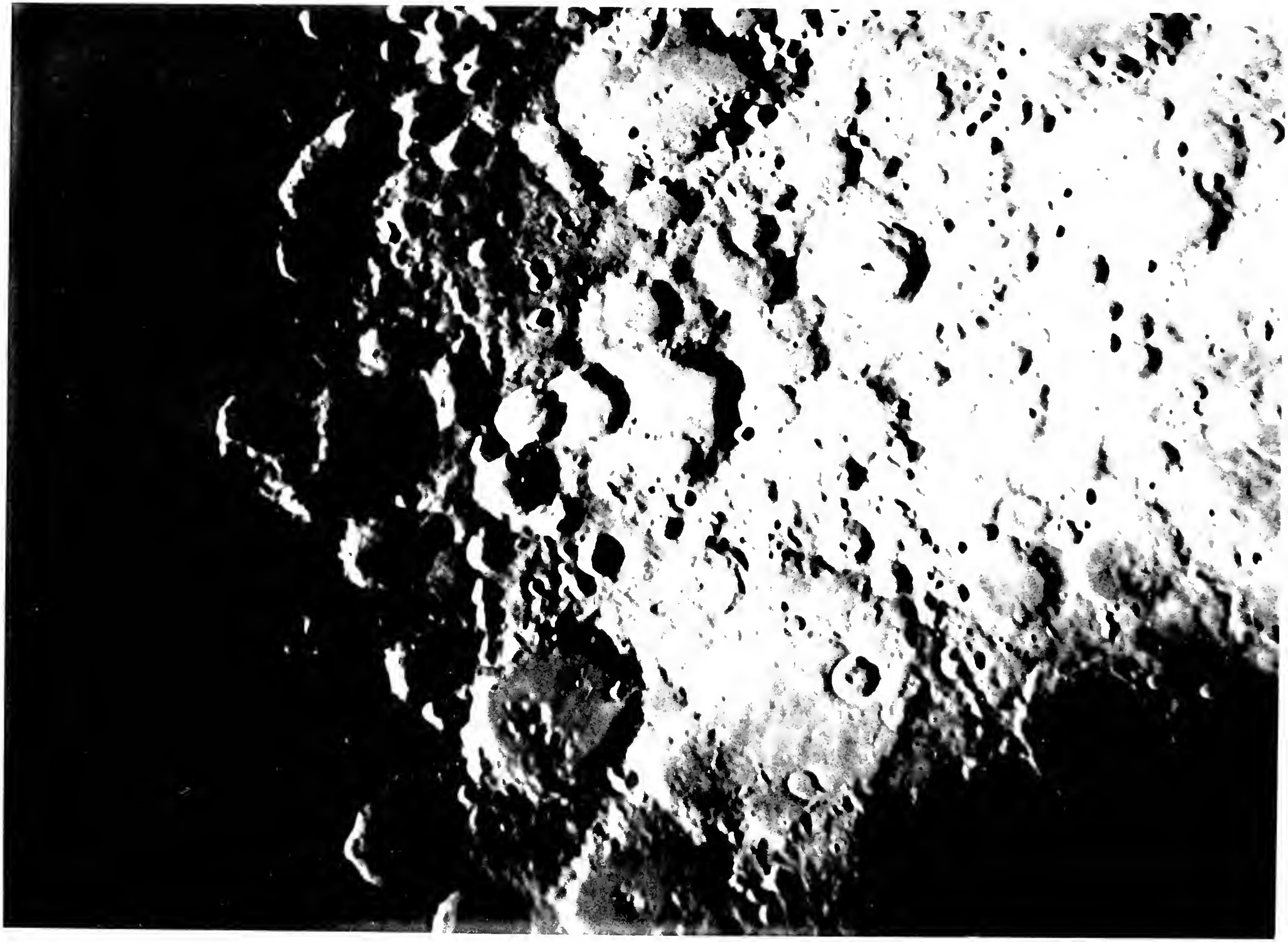
* "The Moon: considered as a Planet, a World, and a Satellite," 1885, pp 172-174.

† "The Zambesi and its Tributaries," pp. 492, 493.



THE LUNAR METROPOLIS.

From a Photograph taken at the Lick Observatory, Mount Hamilton, California, 1895, October, 9d. 16h. 26m. 15s. 25s. Pacific Standard Time, with the 36-inch Refractor, and Brashear **Enlarging Lens. Age of Moon, 21d. 15.5h. Scale, 44 inches to the Moon's Diameter.**

the blocks, to which it is my principal object in this paper to draw attention.

A little more than forty years ago, part of the lead on the roof of Bristol Cathedral was found to have crept slowly downwards, the total descent being about a foot and a half in two years. Soon afterwards the now well-known explanation of the movement was given by Canon Moseley. When the lead is heated it expands, but it is easier to move down the slope than up it; so that, while some of the lead at the top of the sheet moves upwards, a far larger part moves down. When the lead is cooled it contracts; part near the lower edge moves up the slope, but a far larger upper portion moves downwards. Thus, on the whole, with every change of temperature to and fro, the whole sheet of lead makes a short creep down the slope.

In this case, since the sheet lead is thin, the movement is principally due to the fact that the lead and wooden surface on which it rests have unequal coefficients of expansion. If they had been of the same material the creep would have been almost imperceptible. When, however, one stone rests upon another of the same kind, the two are unequally heated on account of the small conductivity of rock, and the ultimate result is the same.

A few years ago I made some experiments on the creeping of stones arising from changes of temperature.* In the first, one brick was placed on another inclined to the horizon at an angle of twenty degrees. On the upper edge of the upper brick, and on another independent brick support, a level was placed with the bubble in the centre of the tube. The level was read frequently, and it was found that while the upper end rose slightly during the day, it descended by a greater amount during the night, so that at the same time each day it stood at a lower level. This experiment showed that the stone did creep in the manner supposed by Moseley, though it gave no idea of the extent of the movement, as the angular value of the scale-divisions of the level was undetermined.

The object of a second experiment was to ascertain how far a stone would creep in a year under given conditions. I had two slabs of York stone cut, each three feet long, five inches wide, and two inches thick. One face and one side of each stone were smoothed, and the stones were placed with their smoothed surfaces in contact, and inclined at an angle of seventeen degrees to the horizon. The smoothed sides of the two stones were continuous and three fine scratches were made on them, in the middle and at each end, so as to be at starting in the same straight lines. At the end of a week the displacement of the upper stone, though exceedingly slight, was quite perceptible, and it continued so throughout the year, the total creep in this interval being thirteen and one-sixth millimètres, or a little over half an inch.

So small a movement may be considered hardly worth taking into account. But it must be remembered that it affects every stone free to move and resting on an inclined surface. Moreover, the creep is proportional to the length of the stone and to the range of temperature to which it is subjected, and the length of the lunar compared with that of the terrestrial night, is probably more than counterbalanced by the magnitude of this range.

If changes in the manner here described do take place upon the moon, it is evident that they must be exceedingly gradual. Years must elapse before they become perceptible to us; but as the changes would take place always in one direction, it seems not impossible that a careful scrutiny of a few selected districts would in time reveal their existence.

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* "Note on the Movement of Scree Material," *Quart. Journ. Geol. Soc.*, 1888, pp. 232-237, 825, 826.

THE LUNAR METROPOLIS.

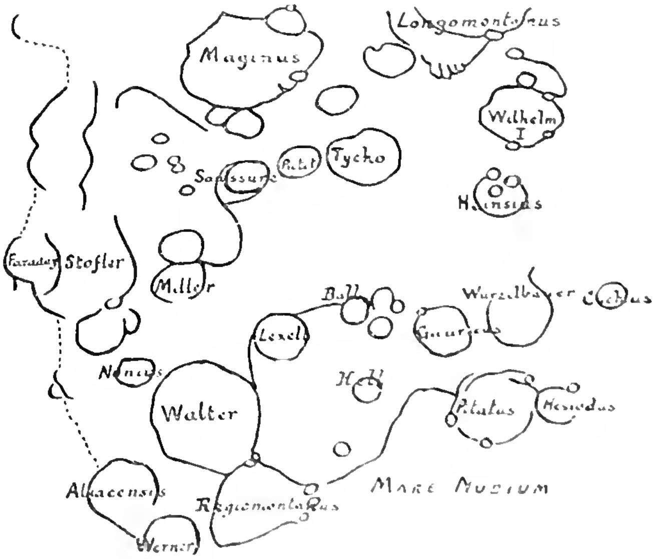
By E. Walter Maunder, F.R.A.S.

The lunar photograph we give this month is from the same negative as that which appeared in the October Number of Knowledge, and forms a continuation of it; indeed, it overlaps it to a small extent. It likewise slightly overlaps at the terminator the photograph given in our April Number of Cuvier and Licetus. The general characteristics of the district are the same as around Clavius. If anything, the complexity of detail and the intricacy of overlapping formations is greater in the region now presented than in the one shown in October.

The interest of the district centres in Tycho, not on account of its size, though this is very considerable, as it is over fifty-four miles in diameter—almost as large as Copernicus; but whereas Copernicus is so placed as to have attention drawn to it, Tycho is dwarfed by many of the neighbouring objects, such as Clavius, Longomontanus, and Maginus, shown in our October photograph, and the extraordinary complexity of the region surrounding it takes off the due effect of its proportions.

It is important, however, as being in the very centre of the most disturbed region of the moon—a land of the wildest and most rugged character, and sown so thickly with crater pits and bowl-like depressions that it is hard to refrain from adopting the hypothesis of some theorists, that the moon, when in a plastic state, has been subjected to a fierce bombardment by great meteorites, who have left the tokens of their assault in these thickly clustered scars upon its surface.

The great claim, however, of Tycho to distinction—the circumstance which has won for it the apt title of the "Lunar Metropolis"—is the streak system which radiates from it in all directions. This system—the most striking feature of the moon at full—is, of course, not visible in our present photograph, which shows the moon at her third quarter. On the photograph, therefore, the broad and lofty rampart, deep floor, and bold central peak of Tycho are the features that most distinguish it.



The other walled and ringed plains shown in our photograph are far too numerous to describe in detail, and, indeed, the photograph itself will yield more information than could be given by much writing. Longomontanus and Maginus, of the October plate, are seen in this—the first, partly; the second, wholly. Heinsius, to the east of Tycho, is very easily identified from the remarkable way in which three great parasite ring plains have invaded and destroyed its southern wall. On the opposite side of Tycho is Pictet, a walled plain as irregular as Heinsius is regular; beyond it, the regular ringed plain, Saussure. West of Saussure, the photograph shows beautifully a mountain range which makes on this side, as it were, a second rampart to the plain. Three ringed plains follow to the north. In the last of these, Miller, the central mountain, which almost exactly marks the prime meridian of the moon, still just rises above the shadow of the eastern wall. Further north is Walter, the largest walled plain of the district, one hundred miles in diameter. The region to the east contains several very regular objects: Lexell, a regular walled plain; Ball and Hell, two ringed plains with five central mountains, well shown in the photograph. Walter, Lexell, Ball, and Regiomontanus, the latter an irregular walled plain on the edge of the photograph, border a considerable area less broken than most of this district. In this more open country Hell is the principal formation.

East of Hell is Pitatus, a great walled plain, which, with its companion Hesiodus, end in this direction the highlands of Tycho. Beyond them, to the north, lies the great grey plain, the Mare Nubium, the waters of which—if, indeed, it ever contained water—seem to have eroded part of the northern wall of Pitatus, and to have lowered that of its companion.

The terminator is occupied, proceeding from the south to the north, by Licetus, Faraday and Stofler, and Aliacensis, the great wall of which shines out in a fine arch at the foot of the plate.

Science Notes.

It has been recently discovered that iodine exists in combination in the human body. It occurs in the thyroid gland, and may be concerned as the essential chemical substance in the internal secretion of the gland. The proof of the occurrence of iodine in the living structures of animals is of great scientific interest and importance, and is the most remarkable discovery made by chemical physiology for some time.

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The annual production of gold from all the various sources is at present about £42,000,000. This is twice the amount produced seven years ago. It is greater than at any previous period in the history of the world, the next greatest annual output being that of the year 1853, when the river gravels of California and Australia were in their most productive state. The amount extracted in the year was then estimated at £38,000,000. More than half of the total yearly amount is now got by the amalgamation process from crushed vein stuff.

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Through the courtesy of Messrs. Beck, we have been able to examine and practically test their new Frena Camera of the memorandum size. This is an excellent little instrument, and is capable of producing good work. It is simple and effective in mechanism, and should prove very useful to amateurs, especially as its price is a popular one. The serrated edges of the celluloid films are a disadvantage, as on this account a considerable portion of the picture is lost. On the other hand, by this means the process of changing the films is greatly simplified.

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An X-ray tube has lately been brought out by Messrs. Watson with greatly increased distance between the terminal attachments outside, and having also a palladium ring as anode placed above a platinum anticathode, the principle of which is that, when warmed, this palladium ring gives up some of its occluded hydrogen. In this way, when the vacuum gets too high it is possible to bring it down again at will. We have had one of these tubes in daily use for the last fortnight, a ten-inch spark coil being used. The vacuum has not perceptibly altered, and we have not, as yet, had occasion to warm it. It can only be supposed that the palladium ring has given up some hydrogen without warming. The results attained with a screen are particularly good. But in case warming should be necessary, the tube, as now arranged, would have to be disconnected to carry this out. To avoid this it might be suggested that the ring might be done away with, and instead that a small bulb be attached to the exhaust tube containing a *small* quantity of spongy palladium (which occludes about two hundred times its volume of hydrogen). The vacuum could then be adjusted while the tube was in action.

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Investigations have been made by different observers to determine whether the Röntgen rays are homogeneous or not. The methods employed consisted in testing whether substances placed in the path of the rays exhibited selective absorption, and distinct indications of this were found, showing that Röntgen rays are not all of one kind, but that the effects are produced by radiations of different wave-length. Dr. Famm, by means of diffraction experiments, has found that the greatest wave-length of the Röntgen radiation is about one-fifteenth that of the shortest ultra-violet waves hitherto measured. Herr Arnold finds that the Röntgen rays can be applied to detect adulteration in various articles of food; the foreign substances added frequently greatly altering the transparency of the article tested, and thus changing the character of the shadow picture thrown on a fluorescent screen.

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In France, where so much has been done by M. Moissan in the way of the production of small artificial diamonds by means of his electric furnace, a recent observer, M. Rossel, has detected the presence of small diamonds in certain specimens of hard steel. By suitable treatment, insoluble fragments were got from the steel which possessed all the properties of natural diamonds. M. Moissan's method of preparing artificial diamonds consists in saturating iron with carbon at a high temperature in the electric furnace, and cooling the fused metal under a high pressure. The carbon present thus assumes the crystalline form of diamond. In M. Rossel's specimens the steel had been subjected to a similar treatment in the course of its manufacture, and the diamond crystals were produced from the carbon always present in steel and cast-iron.

◆

The most ancient copper mines in the world are those of the Sinai peninsula, near the Gulf of Suez. M. Berthelot gave an account of them to the French Academy of Sciences in August. They were abandoned about three thousand years ago, after having been worked for some hundreds of years. The process used for the reduction of the ore was similar in principle to that used at the present day.

◆

In the recent researches on light and ethereal vibrations of all sorts, the interesting fact has been discovered that the light emitted by glow-worms is able to penetrate blackened paper, and affects a sensitive photographic plate placed underneath.

◆

Messrs. Newton & Co. have just issued a new list of some very useful series of lantern slides. Amongst others may be noticed the series on astronomy taken from photographs which have appeared in Knowledge, a series on British birds' nests, and another on the X-ray photography.

WAVES.—XII.

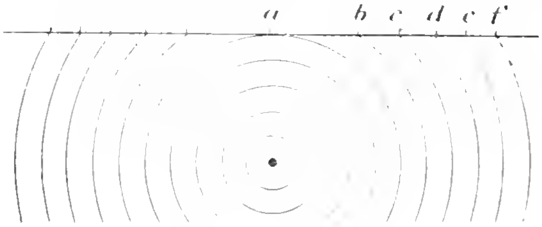
EARTHQUAKES, THE PULSE, NERVE WAVES, AND TELEPATHY.

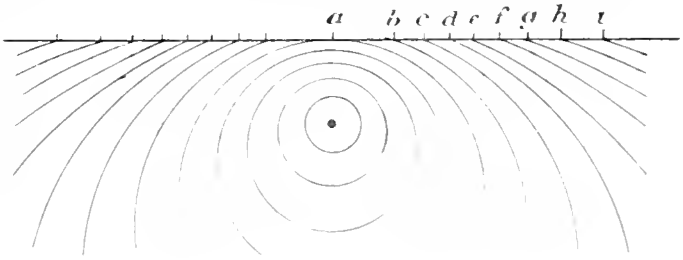
By Vaughan Cornish, M.Sc.

THE earth trembles with the shock of displacements which occur from time to time in those superficial parts which are termed the earth's crust. These displacements are the bending, crumpling, cracking, or slipping of the rocks, and, occasionally, volcanic outbursts or upheavals. The most general description of the original disturbance is a wrench: that is to say, a single movement which may be analysed into two components, a pull and a twist, or a shear. Most earthquakes originate at a depth which is rather great compared with the depths of mines, but very small compared with the diameter of the earth. The vibration which they produce at the surface is generally that corresponding to a wrench. The movement which goes on between the origin and the surface is probably, as in other cases of transmission by waves, different from the disturbances where the wave is set up, and where it ends. A wrench both compresses and distorts the rock, and two waves appear to be set up—a wave of compression and a wave of distortion—which travel with different velocities. The elasticity of volume of the rock—the force with which it tends to recover elastically from compression—enables the solid earth to transmit a wave of longitudinal displacement, which is similar in character to the sound-producing waves which are elastically transmitted in fluids. The rigidity of rock, the force with which it elastically recovers its shape after distortion, enables the solid earth to transmit a wave of transverse displacement, which may be compared to the light-producing waves transmitted by the ether. When these two waves break simultaneously at the earth's surface, the shock (as has been said) may resemble the complex disturbance which originated the waves; but if one wave travel quicker than the other, the character of the surface disturbance at its commencement may be simpler. In practice it is found that when the origin of the earthquake is at a great distance the preliminary tremors precede the main shock by a considerable interval, which indicates that some part of the disturbance travels more quickly than the rest.

The interval which elapses between a shock at the surface near the origin and its arrival at a point near the antipodes is often so short that, according to Prof. Milne, the wave cannot have had time to travel round the earth by transmission through the superficial layers of rock, having regard to the rate at which these are known to transmit wave motion. It appears, therefore, that the seismic wave can be transmitted right through the earth. Delicate seismographs show an almost continual trembling and quivering of the earth's surface, the tremors at any point being generally due to local causes, but occasionally caused by distant shocks. The surface of the earth, being the boundary of the transmitting medium, experiences a maximum amount of disturbance. The familiar experiment with a row of glass marbles illustrates this point. If a shock be given at one end of the row, it is the marble at the opposite end of the row which moves most, the intermediate marbles transmitting the shock but moving scarcely at all. At the boundary of the transmitting medium a wave *breaks*, and the energy takes on a new and violent form. Thus is the shore battered by the sea, and thus is the earth heated by the breaking of the ether waves sent to us by the sun.

The "speed of an earthquake," like the speed of electricity, is a term which may have several different meanings. The most important speed from a practical point of view is the quickness with which the shock reaches successive points throughout a country exposed to the visitation. This is a variable velocity which depends not only upon the speed of the earthquake wave, but also upon the position of the origin. If the wave radiates in circles from the origin, and if the circles in Fig. 1 represent the wave front at successive minutes, then the positions *a*, *b*, *c*, *d*, etc., are the points on the earth's surface where the shock is felt at the successive minutes. It is seen at a glance that the apparent surface speed of the earthquake is much greater nearly above the origin, and that at a distance it tends to reach a constant value which is nearly that of the true rate of the wave. If, however, as is probable, increase of pressure so much increases the elasticity of rock that the speed of the wave is greater at greater depths, the wave front will not be spherical, and the "rays" drawn from the origin at right angles to the wave front will not be straight lines, but will be curved towards the surface, as Dr. A. Schmidt has pointed out.[*] The effect upon the surface speed is shown in Fig. 2; it first diminishes rather rapidly until it reaches a velocity equal to that of the wave at the origin, but afterwards increases gradually. The progressive visitation of the localities *a*, *b*, *c*, *d*, etc., as shown in these figures, is not the travel of a surface wave but the arrival of an obliquely-moving breaker. The disturbance of level which is produced by the breaking earth-waves does, however, set up a true surface wave, the ground undulating much as the surface of water will undulate if a submarine mine be exploded. The surface earth wave is said to be a gravitation wave: that is to say, one which travels by the attraction which subsists between the disturbed parts and the remainder of the globe. The amplitude of the surface earth wave is very small. Seismic sea waves, on the contrary, are often of terrific height. In these the surface wave is often due more to ruptural displacement of the sea bottom than to mere oscillatory movement. The great sea waves which traversed the southern oceans during the convulsions at Krakatoa were presumably due to such displacement.





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The pulse is produced by a peculiar wave which demands

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[*] See *Nature*, October 24th, 1895.

a brief mention in this concluding article. To fix our ideas we will suppose that we are dealing with the familiar artery which gives the pulse of the wrist. At each beat of the heart, blood is pumped into the near end of the artery and the valve is quickly shut. Very quickly afterwards an extra quantity of blood is forced from the artery into the veins and capillaries. This is not the particular dose of fluid which has just entered the artery, but a discharge from the other end of the stream, where a pulse is felt almost immediately after the throb of the heart. The push, or impulse, is transmitted from point to point along the artery, not as hydrostatic pressure is transmitted by an incompressible fluid, but after the manner of a wave. For the blood is not enclosed in a rigid pipe, but in a flexible tube, so that, although the fluid does not yield to pressure, the tube does, and the end nearest the heart expands to accommodate the extra dose of fluid. Expansion of the tube is, however, followed by contraction, for the tube is elastic though yielding. The next portion of the tube then expands, and so on, a billow travelling down the artery. When the billow reaches the wrist it can be both seen and felt. It has passed the wrist before the next dose of fluid is delivered from the heart, so that only one billow is ever traversing the artery. The profile of the billow is recorded in an exaggerated manner upon the well-known pulse tracings. These provide a permanent record of the condition of a patient's pulse which is convenient for reference. Each of the pulse tracings shown in Figs. 3 and 4 records a number of beats ; the wave is travelling to the right ; from trough to trough is a complete pulsation.

Fig. 3.—Pulse Tracing of Diseased Heart.

* * * * *

The brain is kept in touch with the external world by some kind of wave motion, the mechanism by which the sensory nerves transmit their message. The velocity of the wave, which is always considerable, varies to some extent in different people, as one would naturally expect. Responding to the wave of feeling, transmitted by the sensory nerves, is the wave of will, whereby the motor nerves transmit to the muscles the message of the brain.

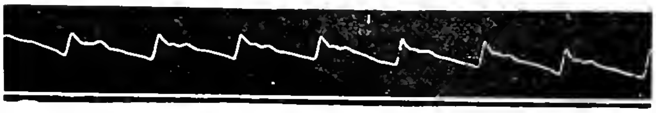

Fig. 4.—Pulse Tracing of Fairly Normal Heart.

Whether mind can act upon mind, otherwise than by means of the ordinary senses, is a much debated question. Some aspects of this question of telepathy come within the proper scope of physical science. It comes within the province of physical science, for instance, to inquire into the possible extra-sensual means of action of one brain upon another. Space is filled with a medium, known to science, which has a wonderful power of transmitting very various disturbances without loss and with great swiftness, and one would naturally inquire first whether the known modes of motion of ether are such as might account for telepathic phenomena, on the supposition that the active brain is capable of disturbing the ether. Now one of the most remarkable points about the narratives of, say, phantasms of the dying, is that the intensity of the recorded impressions scarcely diminishes with distance, even though the distances vary from one mile to eight thousand miles. Waves *radiating* from the brain will therefore not explain the recorded phenomena, for even if the motion be transmitted without loss, the expansion of the wave front would rapidly diminish the intensity. Nothing else than a motion or disturbance confined to a channel will do, as happens, for instance, in the disturbance and reproduction of disturbance between the sending and receiving parts of a telephone. These are connected by the telephonic wire. I am not aware that anything has been found corresponding to a telepathetic wire.

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THE BEECH.

By George Paxton.

The beech (*Fraxinus excelsior*) is a magnificent tree, which vies with the oak, in some respects, for the proud title, "King of the Forest." Although not "every inch a king," he may be styled a noble forest prince.

The beech is only a doubtful native of England, and is not indigenous to Scotland or Ireland, although now so common in these islands. It is found in forests in Central and Southern Europe, Asia, North and South America, and even in Australia. In Switzerland it occupies the south sides of the mountains, and it is the national tree of Denmark. In Britain it grows to a large size, occasionally attaining a height of one hundred and twenty feet, but is oftener seen from sixty to eighty feet, with a girth of twelve to sixteen feet. Fig. 1 represents a beech growing on the banks of the River Ayr. This tree has a girth of over eighteen feet at five feet from the ground, with a height of about ninety feet.

The leaves, which appear in the beginning of May, are shining, oval, veined underneath, and slightly notched (Fig. 2). In spring they are of a pale green tint, turning darker as they increase in size, and in autumn they assume a beautiful russet hue; then, as Dr. E. Lees so eloquently puts it, "the splendour of every other tree fades before that of the beech, which continues the longest of all, and under particular circumstances is of the most brilliant description. This arises from its lucid leaves, which vary in hue from auburn to gold colour and umber, reflecting back the level rays of the descending sun, and thus burning with a pre-eminent lustre, like a sudden illumination." The flowers appear soon after the leaves and take the form of globular clusters, the male on longer and more slender drooping stalks than the female. The fruit—the well-known brown nuts—are of a sharply triangular shape and enclosed in pairs in a prickly husk. They ripen in October; the husk, opening in four sections, allows the nut to drop out while it remains for a time attached to the tree.

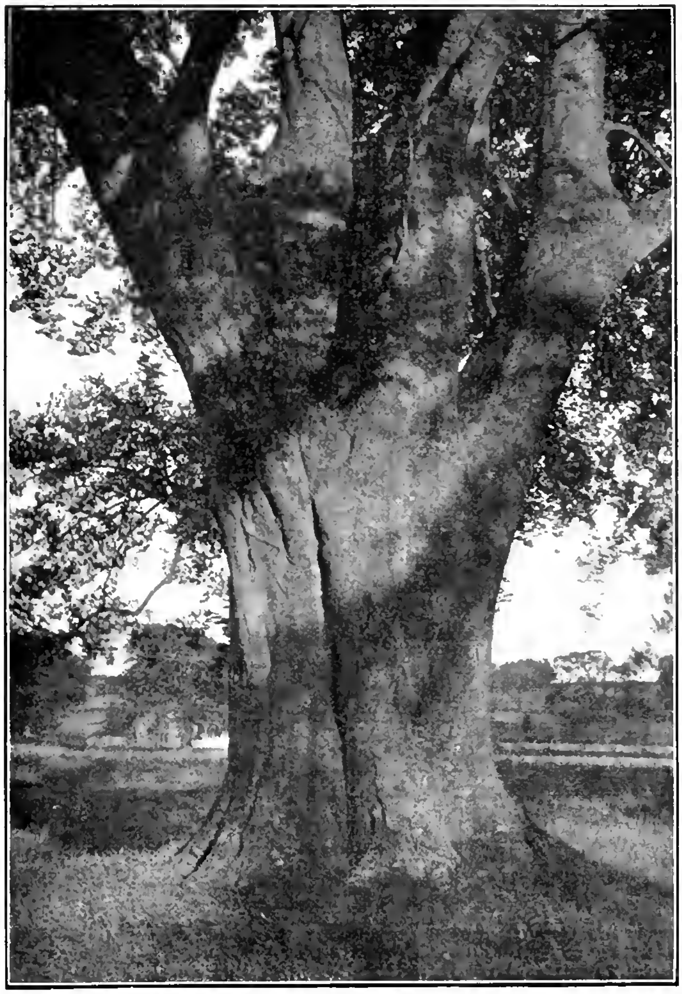

FIG. 1.—A Beech Tree growing on the Banks of the River Ayr.

The beautiful smooth olive-grey bark, although not glossy like that of the birch, gives the bole of the beech a peculiar charm of its own. This is best seen when strolling through a beech wood on a bright winter day; the pale fluted trunks, which stretch on all sides as far as the eye can reach, appear as if carved in stone, like the lofty columns of some grand cathedral, but infinitely more varied, while the sun lights up the stems and shows off their beauty. On these trunks may often be seen scattered excrescences, called "knurs," varying in size from a pea to a large marble; they may be knocked off by a sharp blow with a stick, and are found to be composed of a solid ball of wood, surrounded by a layer of bark. What causes these knobs does not seem to be well known; they are said to grow if planted, and are sometimes seen shooting while attached to the tree.

The wood of the beech is used for an immense variety of purposes. It is heavier when green than that of any other of our timber trees, but loses nearly one quarter of its total weight in drying; it is tolerably hard and somewhat brittle, close and even in texture, with a fine silky grain and not difficult to work. Although not very lasting when exposed to the air, if kept submerged it lasts well, and is therefore in use for keels and planking of boats, mill wheels, sluices, etc. Turners find it useful wood, as do cabinetmakers. As a fuel it is superior to the wood of most other trees, and from its charcoal gunpowder is manufactured. The branches and sprays are distilled for the production of pyroligneous acid.

FIG. 2—Branch, Leaves, and Fruit of the Beech.

The "mast," once so valuable a source of rustic wealth, is still the favourite food of swine, deer, and poultry; and in France large quantities of an excellent burning and cooking oil are made from the nuts.

Little or no vegetation will flourish under beech trees; the carpet of dried and decaying leaves and husks will be found much the same all the year round, seldom enlivened by anything green. This is the result of the dense shade, and the light, dry nature of the soil in which the tree delights, being drained yet more thoroughly by the closely matted roots spread near the surface. Two remarkable edible fungi, however, grow well under beech trees: these are the morel and the truffle. Both are much sought after in France and Germany, being highly prized for the table.

Several interesting varieties of the beech are in cultivation. The best known are the purple beech—originally discovered in a wood in Germany—the copper-coloured beech, and the fern-leaved beech, which has its leaves cut almost like a fern.

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HELIUM AND PARHELIUM.

By E. WALTER MAUNDER, F.R.A.S.

IN the April Number of KNOWLEDGE an account was given of the very beautiful researches which led Profs. Runge and Paschen to the belief that the gas which Prof. Ramsay had extracted from clèveite was not a simple substance but a mixture of two distinct elements. The force of their conclusion may be better appreciated if we glance at the adjoining diagrams, wherein the spectrum of clèveite gas is analyzed in the same manner as the spectra of lithium and sodium were in the earlier paper.* In the first diagram the complete spectrum of the clèveite gas appears in the first line, except that double lines are shown throughout as single, the scale of the diagram not permitting the members of the doublets to be shown separately. The second line shows the complete spectrum of the parhelium constituent; the third, fourth, and fifth lines, its resolution into its three series; the sixth and three following lines show the complete spectrum of the helium constituent, and its similar resolution.

There is a point to which it was not possible to refer in the earlier paper and which should be noticed. Of the six rhythmical series of lines into which the clèveite gas was completely resolved, two approached one limit, two another, and were hence regarded as subordinate series. Of the other two—from their greater brightness and wider stride evidently principal series—one was taken as being associated with one pair of subordinate series, the other with the other. But in default of any known relation between principal and subordinate series, this association might have been as reasonably reversed. There is, however, an intimate relation which clearly marks out how in this instance the spectra are connected.

Referring to the April paper, we find that the limiting wave number of the principal series of lithium is 4351930, and the mean of its two subordinate series 2862672. The difference of these gives 1489258, very close to the wave number of the first line of the principal series. So with sodium: we have for the limit of the principal series 4149634, for the mean limit of the subordinate series 2452128, and for the first line of

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* The formulæ employed by Profs. Runge and Paschen, *Astrophysical Journal*, January, 1896, for the six series of the clèveite gas are as follows:—

Helium:—

Principal .. $\frac{1}{\lambda} = 3845532{\cdot}4 - 1{\cdot}098919 \times \frac{10^7}{n^2} - 1{\cdot}4507 \times \frac{10^6}{n^3}$

Subordinate I. $\frac{1}{\lambda} = 2922435 - 1{\cdot}098363 \times \frac{10^7}{n^2} - 1{\cdot}67 \times \frac{10^4}{n^3}$

„ II. $\frac{1}{\lambda} = 2919796{\cdot}7 - 1{\cdot}061524 \times \frac{10^7}{n^2} - 8{\cdot}656 \times \frac{10^6}{n^3}$

Parhelium:—

Principal .. $\frac{1}{\lambda} = 3202986 - 1{\cdot}09537 \times \frac{10^7}{n^2} + 1{\cdot}9636 \times \frac{10^6}{n^3}$

Subordinate I. $\frac{1}{\lambda} = 2717516 - 1{\cdot}097587 \times \frac{10^7}{n^2} - 2{\cdot}726 \times \frac{10^4}{n^3}$

„ II. $\frac{1}{\lambda} = 2716859{\cdot}5 - 1{\cdot}088256 \times \frac{10^7}{n^2} - 3{\cdot}596 \times \frac{10^6}{n^3}$

It will be noticed that the third power of n is used instead of the fourth, as in the formula given on page 88. Probably the exact formula would contain an indefinite number of terms, with increasing powers of n.

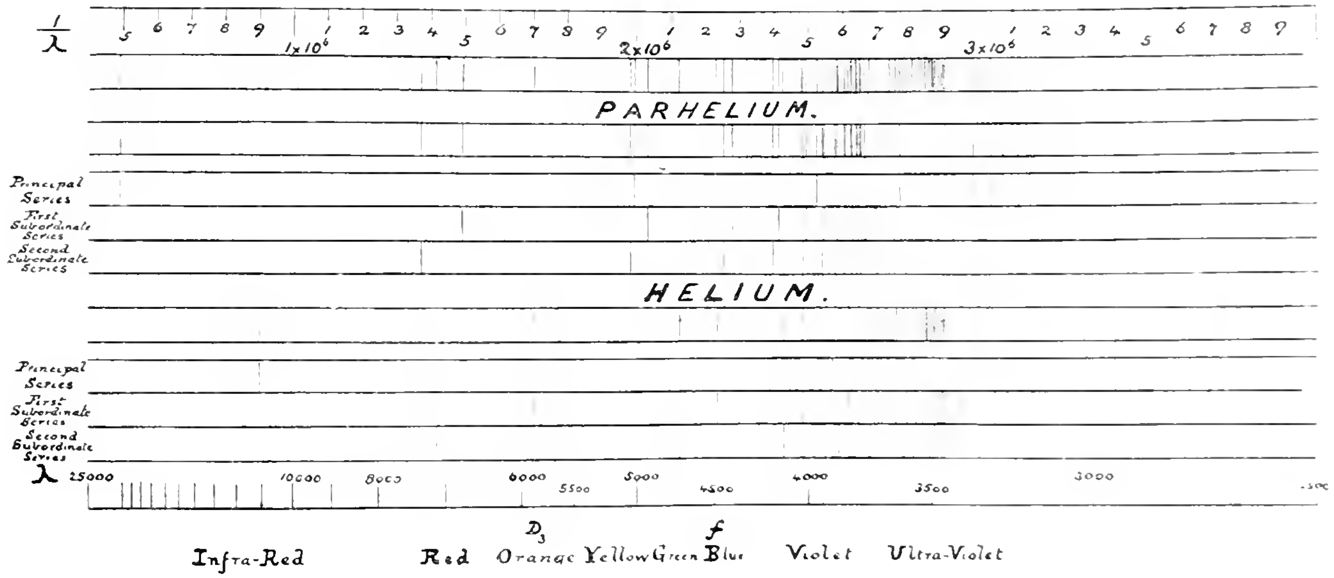
The lines in the two spectra are as follows, the wave lengths being given in tenth-mètres, the wave numbers in oscillation frequencies to the mètre:—

SERIES.	N.	HELIUM.		PARHELIUM.	
		Wave Length.	WaveNumber.	Wave Length.	WaveNumber.
Principal.	2	11170·	895100	20490	490100
	3	3888·785†	2570782†	5015·732	1993181
	4	3187·830	3136041	3964·875	2521448
	5	2945·220	3394359	3613·785	2766409
	6	2829·173	3533582	3447·734	2899641
	7	2763·900	3617028	3354·667	2980082
	8	2723·275	3670983	3296·900	3032296
	9	2696·230	3707804	3258·336	3068183
	10	2677·2	3734158	3231·327	3093828
	11	2663·3	3753645	3211·626	3112806
	12	. ..	...	3196·81	3127232
	13		.	..	. ..
	14	. . .	.	3176·6	3147127
First Subordinate.	3	5875·870*	1701413*	6678·37	1496965
	4	4471·646*	2235697*	4922·096	2031098
	5	4026·342*	2482956*	4388·100	2278263
	6	3819·751*	2617244*	4143·919	2412507
	7	3705·151*	2698192*	4009·417	2493437
	8	3634·393*	2750723*	3926·678	2545975
	9	3587·426*	2786734*	3871·954	2581957
	10	3554·594*	2812473*	3833·710	2607713
	11	3530·646	2831519	3805·900	2626768
	12	3512·65	2846056	3785·031	2641250
	13	3498·78	2857337	3768·95	2652520
	14	3487·87	2866274	3756·24	2661495
	15	3479·10	2873500	.. ...	......
	16	3471·93	2879433	... .	...
	17	3466·04	2884327	....	... ..
	18	3461·4 ?	2888193	......	... ..
	19	3456·9 ?	2891943	....	.....
Second Subordinate.	3	7065·48*	1414948*	7281·81	1372913
	4	4713·252*	2121094*	5047·816	1980512
	5	4120·973*	2425939*	4437·718	2252789
	6	3867·613*	2584855*	4169·131	2397918
	7	3733·604*	2678061*	4024·136	2484316
	8	3652·121*	2737371*	3936·064	2539904
	9	3599·472*	2777408*	3878·330	2577712
	10	3563·125	2805739	3838·210	2604636
	11	3536·963	2826492	.....	... .
	12	3517·48	2842147	3787·64	2639431
	13	3502·47	2854327	3770·72	2651274
	14	3490·77	2863893	... ..	......
	15	3181·6	2871437	... ..	... ..

The lines marked with an asterisk are double, each having a faint companion on the redward side, with wave number on the average 100·7 smaller than that of its primary. The line marked with a dagger is possibly double, the companion having a wave length 0·05 larger than that of its primary.

the principal series 1696019, almost exactly the difference of the two. If we turn now to the clèveite gases we find the limits of the two principal series to be 3202986 and 3845532, and the limits of the two pairs of subordinate series 2717188 and 2921116. If we take the difference of the first and third of these numbers, and also of the second and fourth, we have 485798 and 924416 approximating closely to the wave numbers of the first lines in the two principal series. But to take together the first and fourth, and the second and third, would give us wave numbers not represented in the clèveite spectrum at all.

These two leader lines were not discovered until after the six series had been identified. Photography had shown the ordered clusters of lines far in the unseen regions of the ultra-violet, and the sequences so detected evidently had their initial members deep in the equally invisible regions of the infra-red. As the diagrams show, and as the formulæ require, the lines in the violet are crowded together; proceeding towards the red the intervals become very wide. Hence there is no danger in the region of long wave lengths of confusing a line of one series for one of another. The lines here are few, widely separated, and very intense. So when Profs. Runge and Paschen, following the formulæ which the ultra-violet lines had given, found that $n = 2$ for the principal series of "helium" and of "parhelium" would indicate a line in each case far below the limits of visibility in the red, and on searching with the bolometer found each line close to its predicted place, bright, strong, and intense, there was no ambiguity about the result. The actual spectra corresponded to the theoretical, and were complete from their rise far in the obscure regions of the infra-red, till they died away in the darkness which lies on the other side of the visible spectrum. One point which the diagrams fail to indicate is of great significance, viz., the way in which the brightness of the lines in any particular series diminishes as the violet end of the spectrum is approached. The smaller the value of n the brighter the line. Then, too, the principal series is line for line brighter than either of the secondary series; whilst in the particular case of the clèveite gas the various lines of the "helium" spectra are brighter than the corresponding lines of the "parhelium" spectra.



The belief which the two great German physicists had thus reached, that the clèveite gas was a mixture of two elements, had been arrived at considerably earlier by several astronomers from quite different grounds. Prof. Norman Lockyer had been supplied with a helium tube by Prof. Ramsay immediately the latter had made his discovery, and Mr. Lockyer soon provided himself with other tubes filled with gas from bröggerite and uraninite. Then, as he set to work on the examination of the spectrum of the new gas, he found line after line to correspond with lines of unknown origin in the spectrum of the solar chromosphere, and of certain stars and nebulæ, till he concluded that "this gas is really the origin of most, but certainly not of *all*, of the unknown lines which have been teasing astronomical workers for the last quarter of a century."[*]

But the chromospheric lines thus identified fell into two very different categories. Of the six strongest lines of the clèveite gas spectrum, three, viz., λ 7066, 5876 (D_3), and 4472, are given the frequency number 100 in Young's table of the chromospheric lines; whilst those at λ 6678, 5016, and 4922 have the numbers respectively 25, 30, and 30. Prof. Lockyer, therefore, from the first expressed his opinion that the clèveite gas was not a simple one but a mixture,[†] and M. Deslandres was scarcely behind him in arriving quite independently at the same conclusion.[‡]

It will be observed that the division which solar physicists were led to make was precisely the same as that which Profs. Runge and Paschen had reached by so different a method. Those lines of clèveite gas which Young found "always visible" in the chromosphere are all helium lines, the lines "sometimes visible" are all parhelium lines.

The evidence of stars and nebulæ, so far as it goes, tends to support the same division. Perhaps the strongest instance is afforded us by the early spectrum of Nova Aurigæ. Here, lines λ 5016 and 4922 (both parhelium lines) shone out with great distinctness, whilst the helium

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[*] Lockyer, "The Story of Helium." *Nature*, Vol. LIII., No. 1372, p. 345.

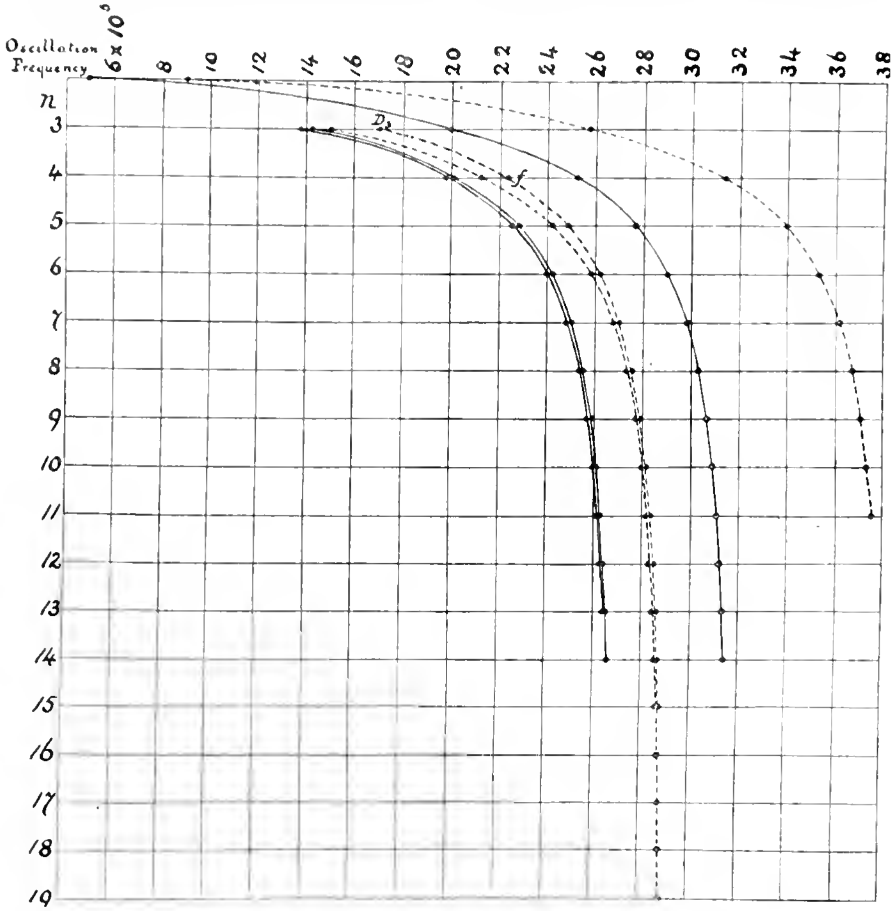
[†] Lockyer, "On the New Gas obtained from Uraninite;" Second Note. *Proc. Royal Society*, Vol. LVIII., No. 349, p. 113.

[‡] Deslandres, "Comparaison entre les Spectres du Gaz de la Clèveite et de l'Atmosphère Solaire." *Comptes Rendus*, Tome CXX., p. 1112.

lines were weak. On the other hand, the spectra of nebulæ, rich in lines of origin unknown until identified with those of the clèveite gases, appear to give all the lines of helium within the region thoroughly explored, but only some of its companion element.

The striking peculiarity of the D_3 line, that it is not ordinarily seen dark in the spectrum of the solar disc, is shared by the other lines whose origin has been revealed to us by Prof. Ramsay's discovery. We might reasonably expect, therefore, that those stars where the photosphere alone reveals itself, but not the chromosphere, would fail to show us any indication of these gases. And, accordingly, the Sirian and solar stars, Secchi's first and second types, as a rule, show no indications of the spectra we are considering, though, of course, hydrogen is strongly marked. The two types of fluted spectra, those like α Herculis and the red star type, give little or no indication of hydrogen ordinarily, and hence we should scarcely look to them for the two new gases. But directly we deal with the bright line stars—stars, that is to say, where the chromosphere is able to make its presence felt—then helium and parhelium at once begin to show themselves. β Lyræ, γ Cassiopeiæ, P Cygni, are rich in both gases. In β Lyræ, indeed, the hydrogen lines are outnumbered by those of helium, and parhelium is strongly represented. The Wolf-Rayet stars, on the contrary, are not prolific in the lines of either of the new elements, four only having yet been identified, all apparently belonging to helium.

One subdivision of Secchi's first type shows the helium lines dark on a bright ground. These are the stars in the constellation of Orion, the spectra of which have long been known to be, to so great an extent, negatives of the nebular spectrum; indeed, the line λ 4472, one of the chief helium lines, has been known for some time as, *par excellence*, the Orion line, from its prominence in these spectra. And a careful scrutiny of some hundred and fifty of the brighter stars has yielded to Profs. Vogel and Scheiner about thirty examples of helium spectra outside the constellation of Orion; Spica, Algol, β Tauri, η Ursæ Majoris, γ Pegasi being among the number.* Parhelium is also represented in these stars, but less fully.



To sum up, the spectrum of the new gas proves divisible into two parts, each analogous to the complete spectrum of a distinct element. The behaviour of the two spectra in the laboratory, in the sun, and the other celestial bodies, strongly suggests that they belong to two distinct elements—elements evidently only less light than hydrogen, and having a very similar distribution in nature.

But there is still something to be said on the other side. The two gases have not yet been separated, and the various sources from which they have been prepared have given so nearly the same density for the derived gas—the gas from samarskite giving a density of 2·118, and that from bröggerite of 2·181—as to show that, if they are really two distinct elements, there must be little difference in density between them, and their intermixture in nature must be peculiarly thorough.

There are other points to note. It has been found that by merely varying the pressure it is possible to diminish the brightness of the entire helium series of lines as compared with the entire series of parhelium. Green vacuum tubes—that is, tubes wherein the parhelium giant λ 5016 is predominant—can be prepared in this way, as well as yellow tubes where the helium line D_3 reigns supreme. More curious still, Prof. Ramsay has found that by allowing the gas to diffuse slowly into a vacuum, it was possible to obtain from it a portion of density as low as 1·874 and another as high as 2·133, but in this case the spectrum of the lightest portion was identical with that of the densest. This result appears so puzzling that Prof. Ramsay raises the question as to whether we have the right to assume that the molecules of a gas are homogeneous, and suggests the possibility that he may have separated between the lighter and heavier molecules of a single element.†

We may not, therefore, consider that the existence of the two distinct elements, helium and parhelium, is as yet fully proved. But we certainly may take it as very probable, and in this case Profs. Runge and Paschen give a hint as to the probable density of helium. It will be remembered that D_3 proved to be a close double, and, so far as can be ascertained, the entire helium spectrum is one of close doublets, whilst that of parhelium is of single

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* Vogel, "On the Occurrence in Stellar Spectra of the Lines of Clèveite Gas." *Astrophysical Journal*, Vol. II., No. 5, p. 333.

† Ramsay and Collie, "The Homogeneity of Helium and Argon." *Proc. Royal Society*, Vol. LX., No 362, p. 206.

lines. Now, as mentioned in the April paper, any subordinate series of double lines will have a constant difference in wave number between the two members of each doublet, a difference equal to that given by the first doublet of the principal series. This for helium is 100·7, far too small to be shown on the chart. With the alkaline elements the distance apart of the doublets is roughly proportional to the square of the atomic weight. This would give helium an atomic weight between 5·2 and 5·7; parhelium would necessarily be lighter—a view Lockyer challenges, but which would seem borne out by the position of its spectrum, which as a whole lies slightly on the more refrangible side of that of hydrogen; helium lying further in the same direction, and lithium, the next lightest element, further still.

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THE FACE OF THE SKY FOR DECEMBER.

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

Sunspots are increasing in number and magnitude. Conveniently observable minima of Algol occur at 11h. 15m. p.m. on the **3rd**, 8h. 4m. p.m. on the **6th**, 9h. 46m. p.m. on the **26th**, and 6h. 35m. p.m. on the **29th**.

Mercury is an evening star towards the end of the month, but his great southern declination will prevent any useful observations in these latitudes.

Venus is also an evening star, but with great southern declination: still she may possibly be observed towards the end of the month. On the **16th** she sets at 6h. 55m. p.m., or more than three hours after sunset, with a southern declination of 21° 11′ (at noon), and an apparent diameter of 15″, just three-quarters of the disc being illuminated. On the **23rd** she sets at 7h. 17m. p.m., or nearly three and a half hours after sunset, with a southern declination of 18° 52′, and an apparent diameter of 15½″. On the **31st** she sets at 7h. 41m. p.m., with a southern declination of 15° 45′, and an apparent diameter of 16¼″, $\frac{7}{10}$ths of the disc being illuminated. During the latter half of December she describes a direct path through Capricornus.

Mars is an evening star, and is very well situated for observation, coming into opposition with the Sun on the **11th**. On the **1st** he rises at 4h. 12m. p.m., or twenty minutes after sunset, with a northern declination of 25° 31′, and an apparent diameter of 17¼″. On the **9th** he rises at 3h. 27m. p.m., with a northern declination of 25° 39′, and an apparent diameter of 17″. On the **16th** he rises at 2h. 48m. p.m., with a northern declination of 25° 39′, and an apparent diameter of 16¾″. On the **23rd** he rises at 2h. 10m. p.m., with a northern declination of 25° 33′, and an apparent diameter of 16″. On the **30th** he rises at 1h. 36m. p.m., and souths at 10h. 7m. p.m., with a northern declination of 25° 25′, and an apparent diameter of 15¼″. During the month he describes a retrograde path in Taurus.

Jupiter is an evening star, and becomes well situated for observation towards the end of the month. On the **23rd** he rises at 9h. 47m. p.m., with a northern declination of 8° 46′, and an apparent equatorial diameter of 45½″. On the **30th** he rises at 9h. 19m. p.m., with a northern declination of 8° 49′. He is almost stationary in Leo during the month. Both Saturn and Uranus are, for the observer's purposes, invisible.

Neptune is an evening star, rising on the **1st** at 4h. 24m. p.m., with a northern declination of 21° 34′, and an apparent diameter of 2·7″. On the **30th** he rises at 2h. 27m. p.m. He is in opposition on the **22nd**, and describes a very short direct path in Leo during the month.

December is a fairly favourable month for shooting stars, the chief showers being those of the Geminids on December **9th** to **12th**, the radiant point being in R.A. 7h., and north declination 32°, rising about 4h. 10m. p.m., and setting at 1h. 40m. a.m.; and of the Andromedes, occurring on the evenings of the **26th** and **27th**, the radiant point being in 1h. 40m. R.A. and north declination 43°.

The Moon is new at 5h. 51m. p.m. on the **4th**; enters her first quarter at 0h. 29m. a.m. on the **12th**; is full at 4h. 5m. a.m. on the **20th**; and enters her last quarter at 0h. 9m. p.m. on the **27th**.

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Chess Column.

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

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of November Problems.

(E. Henry.)

No. 1.

1. B to B4, and mates next move.

No. 2.

1. Kt to Kt7, and mates next move.

Correct Solutions of both problems received from G. G. Beazley, H. Le Jeune, Alpha, H. S. Brandreth, J. M'Robert, G. J. Newbegin, W. D. F. Edwards, G. H. Herbert, Miss Attwood, E. C. Willis, G. A. F. (Brentwood), A. E. Whitehouse, J. T. Blakemore, W. H. Stead, W. Clugston, J. E. Simpson, A Norseman, A. S. Coulter, E. W. Brook, L. Pfungst, H. W. Elcum, A. C. Tappenden, H. F. Biggs.

Of No. 1 only from Rev. F. W. Quilter, D.D., A. St. J. C., A. P. Hyatt.

A. P. Hyatt.—See answer to A. St. J. C. below.

Alpha.—The fact that this page has to reach the printer by the middle of the previous month will account for the defect.

Rev. F. W. Quilter.—After 1. B to QKt7, Black may play anything safely except K to Q2. Probably, therefore, you intended Kt to Kt7.

A. St. J. C.—If 1. B × P, B moves, there is no mate.

W. Mason.—By several moves of the Kt at B3; in fact, too many.

W. Clugston.—Thanks for enclosures. Mr. Loyd's idea wants working into a three-mover. Shall be glad to insert your two-mover next month.

A. C. Tappenden.—Yes; we have heard it ascribed to Mr. Loyd. It is very neat.

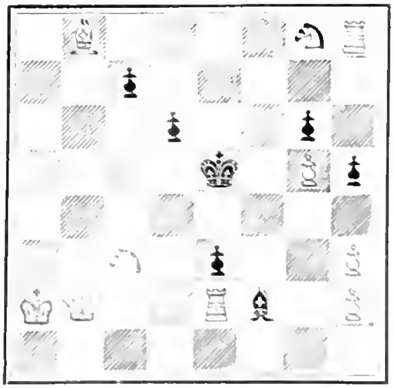
J. T. Blakemore.—Many thanks for the problems, which are very acceptable. One is reserved for next month.

PROBLEMS.

No. 1.

By J. T. Blakemore.

Black (7).



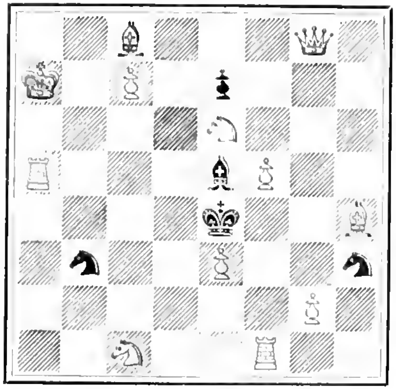
White (10).

White mates in three moves.

No. 2.

By Eugene Henry.

Black (5).



White (12).

White mates in two moves.

CHESS INTELLIGENCE.

An attempt is being made to revive the meetings of the Counties' Chess Association, which came to an end a few years ago, chiefly in consequence of the establishment of the British Chess Association. The latter in its turn came to an untimely end, its place being partly filled by the amateur tournament held at Craigside, Llandudno, twice a year. It is in connection with this place of meeting that the Counties' Association will be resuscitated, and it is proposed to hold a "Counties and Craigside Tournament" early in 1897, under the joint management of Messrs. Firth and Skipworth. It is not very clear from the prospectus whether it is intended that all subsequent meetings will be held at Craigside; but, if this is the case, we fail to see how the Counties' Association will be performing the function suggested by its title. In past years the Association changed its place of meeting from year to year, and thus gave the leading provincial players a chance in their turn of attending the meetings without travelling long distances.

By the death of Mr. W. H. K. Pollock, at the age of thirty-seven, Anglo-Canadian chess loses its leading representative, and the *British Chess Magazine* an able contributor.

Mr. Pollock made his first public appearance as a player in the second class of the Counties' Chess Association about fourteen years ago. On that occasion Mr. Pollock took the first prize, without losing a single game, Mr. Locock (who also made his *début* on this occasion) being second. After this Mr. Pollock rapidly rose to the position of an acknowledged expert, and was a regular attendant at the meetings of the Counties' Association (to which he usually went on foot) and other first-class tournaments, both national and international. Though he never took a very high place in these latter, he was always reckoned a dangerous competitor; witness his brilliant victories over Steinitz and Tarrasch in the Hastings Tournament last year.

Outside the chess world Mr. Pollock was a man of educated tastes, a licentiate of the College of Surgeons, and, like Mr. Blackburne, as fond of cricket as of chess. This latter taste he acquired no doubt at Clifton College, where he was educated for a short time, and afterwards at Somersetshire College, Bath.

The Buda-Pesth International Tournament resulted in a win for M. Tchigorin, after a tie with M. Charousek; this is M. Tchigorin's first absolute victory in an international tournament. The scores were:—Tchigorin and Charousek, 8½; H. N. Pillsbury, 7½; Janowski and Schlechter, 7; Wallbrodt and Winawer, 6½; Dr. Tarrasch, 6; Albin and Maroczy, 5; Marco, 4½; Dr. Noa, 4; Popiel, 2.

M. Charousek more than sustained the reputation achieved by him in the Nuremberg Tournament; Herr Maroczy, on the other hand, showing a lamentable falling off. Janowski's score should have been even better than it was, as he threw away one or two points quite unnecessarily. Winawer started well, but failed to maintain his form. Dr. Tarrasch recovered a little from his disastrous start, but comes out very low for the victor in three successive international contests. The remainder occupy their legitimate places.

The Lasker-Steinitz Match is again in progress, Mr. Lasker being now, apparently, willing to play as often as his old opponent likes. But if the first four games of the present match, all lost by Steinitz, are any augury of the final result, we imagine that these matches will at last come to an end, and that Mr. Lasker will find an opponent more nearly in the zenith of his play.

The bound Volume for 1896, with Index complete, will be ready on the 7th December. The Index for the year will be issued as usual in the January Number, which will also contain an eight-page illustrated literary supplement.

Contents of No. 133.

NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

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