formation. Sir John Evans called attention to the fact that in one section in Belgium, where the Palæozoic strata were extremely folded, Coal Measures had been met with beneath a wedge of Old Red Sandstone. Mr. E. Wethered suggested that the Coal Measures showed a tendency to become less and less productive when traced eastward from the South Wales basin; and Prof. Louis asked how the supposed horizontality of the Dover Coal Measures could be explained, while in their supposed prolongation in Belgium they were so greatly disturbed. Mr. Etheridge, in concluding the discussion, thought there could be no doubt that the bottom rock at Brabourne was Old Red Sandstone, and remarked on the evidence now forthcoming for the continuous underground extension of this formation from Bristol across the south of England, under London and parts of Kent, into Belgium.

The next paper was that of Dr. Marsden Manson, of Sacramento, Cal., on "The laws of climatic evolution"—a highly speculative attempt to explain the Glacial Period as a critical and unique stage in the evolution of this and other planets when the climate passed from "internal" to "external" control. According to Dr. Manson, the climatal conditions of all times preceding the Glacial Period were determined by planetary heat, and were independent of latitude; but the dissipation of the continuous cloud-envelope, through the loss of the planetary heat by which it had been sustained, brought about a new set of conditions. After a Glacial Period, due to the more rapid cooling of the land than the sea, a gradual rise of temperature along with a zonal distribution of climate would occur, through the trapping of solar heat by the lower layers of the atmosphere. This latest of the many ingenious attempts which have been made, on both sides of the Atlantic, to explain the Glacial Period was admirably presented by the author to a large audience, but was subjected to severe criticism in the discussion, the general feeling being that such speculations scarcely fell within the scope of Section C.

Prof. E. Hull brought before the meeting a wide subject of more tangible character, in a paper on "The sub-oceanic physical features of the North Atlantic." By tracing out the depth-contours of the Admiralty Charts, Prof. Hull showed that the British and continental submarine platform breaks off abruptly in a "Grand Escarpment" at depths varying from 100 to 250 fathoms. This escarpment, from 6000 to 7000 feet high, is, according to Prof. Hull, indented by deep bays and old river-channels, the latter, almost cañon-like in places, often prolongations of the river valleys of the existing land. These and other submarine features lead him to agree with Spencer and Upham that the whole area of the North Atlantic to a depth of 10,000 feet was a land surface at a very recent period, and that the conditions of the Glacial Epoch may be thus explained. This paper was followed by another on the same subject by the President of the Section, in which it was shown that the exaggeration of the vertical scale made Prof. Hull's diagrams misleading as to the slopes of the supposed escarpments and submerged river-valleys; and evidence was adduced to prove that extensive earth-movements were frequently in progress on the edge of the continental platform. Hence, it was urged, the features to which Prof. Hull had called attention might possibly be due to subterranean causes, a view which was shared by several speakers in the subsequent debate.

On the subject of earth-movement, Prof. J. Milne presented the report of the Committee for Seismological Investigation; and Mr. R. D. Oldham, of the Geological Survey of India, gave a lucid description, illustrated by lantern slides, of the Great Indian Earthquake of 1897. The surface indications of faulting and overthrusting which characterised this earthquake were very clearly demonstrated.

At the opening of Tuesday's meeting the President, in exhibiting a portrait of the late E. Wilson, referred feelingly to the loss which geological science had sustained by Mr. Wilson's untimely death, and other speakers bore testimony to his painstaking and self-denying services to the Bristol Museum.

On behalf of Prof. H. F. Osborn, who had expected to attend the meeting but was at the last moment prevented, an exhibit was made of some beautiful water-colour drawings of restorations of *Brontosaurus*, *Phenacodus*, and other extinct vertebrates, executed by Mr. C. Knight for the Museum of Natural History of New York. A brisk discussion sprang up, in which Prof. H. G. Seeley, Prof. O. C. Marsh, Sir John Evans, Prof. W. Boyd Dawkins, Prof. W. J. Sollas, and others took part, as to the advisableness of giving reins to the imagination in the production of these restorations, upon which point widely diverse opinions were expressed.

There was scarcely sufficient time at this meeting to do justice to the carefully prepared paper by Mr. W. H. Wheeler on "The action of waves and tides on the movement of material on the Sea-coast." It was shown by Mr. Wheeler that the travel of shingle is not usually coincident with the prevailing winds, but is in the direction of the flood-tide, and is mainly due to wavelets set up by tidal action, whose total kinetic energy is very large.

Among the other papers brought before the Section were the following on cave exploration: by Mr. H. Bolton and the late E. Wilson, on the exploration of two caves at Uphill, Weston-super-Mare; by Rev. G. C. H. Pollen, on further exploration of the the Ty Newydd Caves; by Mr. T. Plunkett, on further exploration of the Fermanagh Caves; and the Report of the Committee on the fauna of caves near Singapore. Mr. P. M. C. Kermode, in the Report of the Committee for investigating the mode of occurrence of the Irish Elk in the Isle of Man, announced the discovery of a large and nearly complete skeleton of that animal near Peel. Mr. J. Lomas brought forward evidence in favour of the occurrence of worked flints in the Glacial deposits of Cheshire and the Isle of Man, but it was felt that further research was necessary before the author could be considered to have established his case. Mr. C. W. Andrews gave an account of the discovery of a portion of the skeleton of a huge Dinosaur in the Oxford Clay of Northampton. Papers were also contributed by Mr. J. R. Dakyns on the probable source of the upper Felsitic lava of Snowdon; by Mr. H. B. Woodward on arborescent Carboniferous Limestone from near Bristol; and by Mr. W. L. Addison and Mr. L. J. Spencer on crystallographic and mineralogical subjects. Several of the Reports of Committees possessed matter of much interest, especially that presented by Prof. A. P. Coleman on the Interglacial deposits near Toronto (where fresh facts of importance have been gained by excavations), and that of Prof. P. F. Kendall on Erratic Blocks; while the Committee for collecting Geological Photographs, that on Fossil Phyllopoda, and that on Life-zones in British Carboniferous rocks were all able to report steady progress in their investigations. New committees were formed and grants obtained to investigate the caves at Uphill and at Ty Newydd, and as already mentioned to preserve photographic and other records of the Moel Tryfaen section; and most of the old committees connected with this Section were re-appointed.

PHOSPHORESCENCE.[1]

IT is not possible in one lecture on phosphorescence to give any historical sketch which shall do justice to the work of those who have made a study of the phenomena. In a list of the names of the many who have enriched the subject with facts and with theories, those of Becquerel, of Stokes, and of Crookes stand out most prominently. Any attempt to make a sketch of our knowledge of phosphorescence and fluorescence must be to a very large extent an adaptation of the work and of the views of these masters.

The phenomena themselves may be divided into two main classes—those in which the evolution of light is associated with chemical change, and those in which there is no evidence of such direct alteration. In the first class the commonest instances are connected with the process of oxidation. Examples of this kind are numerous. It is hardly possible to take any very easily oxidisable substance and to fail to get some evolution of light. Phosphorus, sodium and potassium, ether, many aldehydes, and a host of organic compounds may be cited as instances. The experimental illustrations of these are not, however, suited to an audience of more than a very few. The same may be said of the examples of animal and vegetable phosphorescence. It is proposed, therefore, to deal more especially with the second class, and to limit the experiments to the cases where the light given out is visible and not of such a character as to necessitate the use of a photographic plate. This evolution of light may occur in varying conditions. In instances such as solutions of quinine and fluorescein and many solids, of which thallene is a good example, the duration of the phosphorescence is so short that it may be said to last only while

[1] A discourse delivered before the British Association on September 12, by Mr. Herbert Jackson.

light is acting. Balmain's luminous paint is an illustration of the persistence of the phosphorescent light. With many minerals, notably some fluorspars and felspars, light is given out when they are slightly heated, or in some cases only crushed.

The most brilliant phenomena are those which can be studied when many bodies are excited with electric discharges inside a Crookes' vacuum tube, while outside of a slight modification of his focus tube fairly brilliant phosphorescence can be obtained by the action of Röntgen rays upon several substances, notably upon some of the platinocyanides.

In dealing with the whole subject of phosphorescence with the view of attempting to connect all the various phenomena together, it is convenient to divide it into—the nature of the substance giving out the light, the nature of the light given out, and the nature of the exciting causes.

With regard to the nature of the substance, either very much or little might be said ; very much from the details of numerous experiments with a great number of compounds, but little from the point of view of general principle. The most important question in this respect is probably the question of the relation of phosphorescence to the purity of the substance giving out the light. Experiments with carefully prepared compounds of many metals make it clear that not a few substances can be made to exhibit phosphorescence when they are so free from impurities that none can be detected by any analytical methods. In some cases, however, there is either no light given out under any of the conditions for exciting phosphorescence, or the light is so feeble that it is necessary to add impurities so as to obtain a suitable molecular condition for rendering a substance responsive to excitement. That the light given out is not to be ascribed to the impurity has been determined by many experiments with varying impurities and careful examination with the spectroscope. The further consideration of these physical and chemical conditions is better left until the other two aspects of the subject have been dealt with.

If a large number of observations be made of the phosphorescent lights given out by compounds of such metals, for example, as sodium, potassium, calcium, strontium and barium, magnesium and aluminium, it is hardly possible to avoid coming to the conclusion that the colours of these lights have a close resemblance to the colours of the lines and bands seen in the various spectra of the different metals and some of their compounds. Examination by the spectroscope confirms this conclusion in several instances. It is not suggested that the lines of the metals and the bands of their compounds are reproduced in the spectra of the phosphorescent lights. What is noticeable is that the maxima of light are grouped about these bands and lines, fading away from them and extending to other parts, so that a more or less continuous spectrum is seen with positions of greatest brilliancy. In the case of some specimens of lime these positions are well defined, and in some kinds of fluorspar the green and some red bands are well seen, either when the fluorspar is heated or when it is excited by discharge in vacuo. The questions of exact coincidence and of the shifting of the positions of the maxima of brightness seen with different compounds of the same metal need not be considered here. The intention is only to emphasise the similarity between the phosphorescent spectra of several metallic compounds and the spectra of these compounds, or of the metals in them, obtained in other ways.

In experimenting with phosphorescent compounds it is frequently noticed that specimens of the same substance in apparently the same state of purity give different colours. Confining attention for the present to lime, as a very infusible substance easily obtained in a state of purity, what follows will be made clearer by a brief consideration of the spectrum of the coloured flame produced by holding some compound of calcium, *e.g.* calcium chloride, in the flame of a bunsen burner.

The spectroscope breaks this red flame up into red, orange and green bands and a blue line. For the moment the suggestion may be taken that these differently coloured bands are indications of the existence in the flame of groups of particles of calcium compounds of varying degrees of complexity—the red being related to more complex groups, the orange to less, and so on. It seemed not unlikely that it might be possible by preparing lime from a great many calcium salts to obtain separate specimens which might preserve in the solid state some relation in their own molecular complexity to that of the salts from which they were obtained, or the conditions of decomposition of the different calcium salts might impress upon the residual limes different characters of molecular structure. The preparation of about 350 specimens of lime showed that it was quite possible to get specimens some of which phosphoresced red, some orange-red, some orange, others green, and some blue. Examination of their phosphorescent lights with the spectroscope showed, as referred to before, that the maxima of brilliancy in their spectra were grouped about the bands and lines of the usual spectrum of calcium oxide. The details of the preparation of these specimens of lime are too elaborate to enter into here, nor is it possible to do more than just to refer to their varying densities and different rates of hydration. Out of the number of specimens tried the most satisfactory were analysed to make sure that it was really lime and only lime which was being dealt with in each case. In general terms it may be said that the most complicated organic salts of calcium yielded the best attempts at lime giving blue phosphorescence, simpler bodies gave green, while the best orange was obtained from Iceland spar, and the red from specially prepared calcium carbonate. That lime yielding a blue colour was obtained from highly complicated organic salts does not contradict the former suggestion that perhaps it is really of simpler molecular structure than the others. Chemists are familiar with the conception that the complexity in structure arising from the massing of many molecules together in groups is probably often greater in bodies of apparently simple chemical composition than in those of a much more highly complicated nature.

The colours seen in the specimens of lime shown are not pure. In each one the other colours are present ; thus the orange contains also the red, green and blue, only these are masked by the greater proportion of the one colour. Compare for example the light obtained from a vacuum tube containing the gas helium. In this case the colour is yellow, although the spectrum contains beautiful red, green and blue lines. If the different colours are related to varying molecular complexity in the substances, then it might be said that the lime showing a green light contains a large proportion of groupings of such a nature as to be capable of oscillating in a way to give rise to green light, and in like manner for the red, orange and blue specimens. Whether it will be possible or is in the nature of things to separate out the different kinds in a state of purity can only be decided by further experiment.

The examples of different forms of lime have been so far exhibited only under the conditions obtaining in a high vacuum with an electric discharge. Before trying to show the points in common between these phenomena and the phenomena of phosphorescence in other conditions, it may be as well to consider briefly the character of the action in a high vacuum. The suggestion which follows is not intended to be anything but an imperfect attempt to bring all the phenomena of phosphorescence into line with one another.

When a discharge passes through a vacuum there can be little doubt that the transferring medium is the residuum of gas in that partial vacuum. If the particles of this gas behave as visible masses are seen to do, they are probably attracted or are driven to the electrode, which is at high potential. Receiving the same kind of charge as this electrode, they fly off from it in that charged condition.

But if these particles consist of more than one unit, each unit, after the group has travelled a certain distance from the electrode, must repel each other unit in the same way as the whole little group was repelled from the electrode. If, however, the units making up the group are held together by that something which is called chemical attraction, a condition of strain is set up in which the electrical repulsion is striving to overcome the chemical attraction. Travelling unimpeded through the high vacuum this condition of strain would be maintained until the charged group met with something capable of discharging it. At that moment of discharge the chemical attraction would assert itself; there would be a rushing together of the units composing the group, and an over-rushing, whereby oscillations would be set up. These oscillations, considered as blows or pulses, either directly or ethereally transferred to a substance, would set it in turn oscillating in a manner fitted to its own molecular structure, and its oscillations would in their turn give rise to the undulations which appeal to our eyes as the phosphorescent light. If instead of the discharge taking place on a substance capable of responding to and absorbing most of the energy of the consequent oscillations, it were to occur on glass, platinum, or any of the materials which have been employed, it is conceivable that the oscillations would appear as short ethereal waves or, in other words, Röntgen rays. In the case of a low vacuum, or of no vacuum at all, the charged particles would discharge themselves against the intervening gas, which would in its turn respond to the rapid oscillation and give out its own particular coloured light. The expression "short ethereal waves" is used intentionally, for if there should be forthcoming experimental evidence of the complex molecular structure of a gas, it is reasonable to suppose that in a high vacuum, with consequently a high potential at the electrode, the internal electrical repulsion in a group would tend to a dissociation resulting finally in the simplest form of system capable of separate existence in those conditions. It might be expected that the oscillation frequency of so simple a system would be very high.

Here it may be stated that this comes to practically the same thing as Sir William Crookes' original conception of radiant matter.

Leaving the method of electrical excitation in vacuo for obtaining phosphorescence we may now turn to light as a source of oscillations. For the sake of simplicity it will be best to continue the experiments with the same substance, viz. lime. If this body be exposed to the light of the sun, of the electric arc, of a hydrogen flame, and of a great many other substances in a state of vigorous combustion, a phosphorescent effect is obtained, feeble in comparison with the results in vacuo, but apparently similar in kind. The best light for inducing the phosphorescence is the spark from a fairly powerful coil with a Leyden jar in circuit. Many specimens of lime go on giving out light for a considerable time after exposure. A cylinder of lime such as is used in the production of the lime-light glows quite visibly when it is rotated before a jar-spark.

The light from the sun is not so active in inducing this glow; but with suitable arrangements a fairly visible result can be obtained. The colour of the glow from most lime made from limestones is an orange-red becoming a golden orange when the lime is heated. The introduction of glass, mica or Iceland spar between the spark and the lime, cuts off the glow at once; since these bodies are opaque to the undulations to which lime of this kind responds. Quartz, rock salt, and selenite are quite transparent.

It is found that the different forms of lime which have already been exhibited in vacuum tubes yield when exposed to the jar-spark their specially coloured phosphorescent glows. But these are difficult to see; they are very faint when pure specimens of lime are used. However, there is a way out of the difficulty. The faint light scarcely visible at the ordinary temperature may be increased very considerably by raising the temperature. As an extreme instance of this a specimen of calcium sulphide may be taken. After exposure to almost any source of white light this glows with a bluish phosphorescence which becomes quite brilliant when the sulphide is heated. A similar change is noticeable in the case of the different limes. The orange, green and blue varieties exposed to a series of jar-sparks, and subsequently dusted over hot plates, give with easy visibility the colours which they exhibited in the vacuum tubes and which may, for the present, be considered as sensible indications of their molecular constitutions.

Two important considerations have to be dealt with at this point. In the first place the question arises how far one and the same light, *i.e.* one and the same oscillation frequency, will excite the different specimens of lime. Without entering into dry numerical details, it is not possible to give a complete answer to this question. In a general sense, however, it is apparently true that, although the range of frequency is large, the red and orange varieties of lime respond to oscillations less rapid than those which readily affect the varieties giving a green or blue phosphorescence. It is possible to obtain a form of lime which illustrates this experimentally. It is not easy to make. It is prepared from calcium urate by heating this for many hours to a dull red heat, and afterwards raising the temperature of the blackened mass sufficiently to burn off all the organic matter and leave only lime. The residue on analysis was shown to be really lime. Such a specimen exposed freely to jar-sparks, and afterwards heated, shows mainly an orange phosphorescence; but if glass or mica or Iceland spar be placed between the lime and the source of light, then the effect of heat is to intensify greatly a phosphorescence of a blue colour. It must be clearly understood that this blue was there before, only masked by the superior brilliancy of the orange colour; the undulations which would otherwise have affected the molecular groupings capable of giving out the orange light being cut off by the glass or mica. It would be tedious to give all the reasons for assuming that the oscillations exciting the blue phosphorescence are probably the more rapid. To some extent the transparency of glass and mica to X-rays may be taken as confirmatory; but to follow the argument out from spectroscopic evidence and measurements would involve a discussion unsuited to a lecture dealing with general questions. Referring, however, to the suggested explanation of the action taking place in a vacuum tube, it is not inappropriate to mention now that it is possible to make a specimen of lime give an orange glow in a moderate vacuum while a portion of the same specimen is exhibiting a blue glow in a high vacuum. The readiness with which this blue glow appears, and the time which it takes to develop, must be taken into account in dealing with its supposed origin, and with its relevancy with the question of the relation of the rapidity of the exciting undulation to the wave-length, *i.e.* to the colour, of the phosphorescent light. Perhaps it is advisable to leave this point for the moment, and to turn to the second consideration. This deals with the question of the duration of the phosphorescence.

At the beginning it was shown that some bodies glow only while light is acting upon them, or while they are under the direct influence of an electric discharge. In others there was a marked after-glow; while still others required the application of heat before any phosphorescence was visible, or, as in the case of the limes, before the phosphorescence was easily visible. With Balmain's luminous paint, or with any body which gives a marked phosphorescence that lasts for some time after withdrawal from the exciting influence, it can be readily shown that lowering the temperature reduces the brilliancy of the glow, but lengthens the time during which it lasts. The effect of heat has already been mentioned as vastly increasing the brilliancy; but it greatly diminishes the duration of the light. On the other hand, Prof. Dewar has shown that great reduction of the temperature will cause the phosphorescence to linger for a considerable time in many substances which had hitherto been considered as practically non-phosphorescent. The different behaviours of substances in this respect can, perhaps, be best brought under one explanation by applying the idea of a statical charge or a condition of strain to the phosphorescent substances themselves. Duration of phosphorescence would then be a measure of rapidity of discharge. If it be supposed that, the strain having been set up in the particles of a substance, these discharge themselves against one another, or rather against uncharged particles, then a substance with great freedom of transference of movement among its particles would fail to show any sign of phosphorescence; since the strain would be released or conducted away by rapid transference before a condition could be set up, out of which oscillations of sufficient amplitude could arise. With rather less freedom of movement among the particles the non-conducting state might be reached by restricting the extent of that movement by cold, as in Prof. Dewar's experiment. Still less freedom of interchange may be considered to obtain in Balmain's luminous paint, and even less in the limes, which require heating to show up their phosphorescence; while, in the case of the chlorophane and many other minerals, the condition of strain, however set up, can apparently be retained indefinitely. Specimens of lime after exposure to the jar-spark have been found to give out light when heated after being four years in the dark. It seems not altogether improbable that the influence of impurities in promoting phosphorescence may often be attributed to their interfering with the freedom of movement, and so permitting the groupings of the substance to be sufficiently highly charged. The effect of heat in rendering a substance a better conductor can be well studied with pure substances in vacuo under the electric discharge.

Under the vigorous bombardment of radiant matter the temperature of the substance rises. In some substances this leads to an increase in the brilliancy of the glow maintained often even when the heating is very considerable; in others the hotter portions are marked out by a complete absence of phosphorescence. Observation seems to favour the conjecture that this absence is in many cases to be explained on the hypothesis that the heat endows the molecules with such freedom as to practically render them uninsulated. To pursue this part of the subject any further would lead to a discussion of a question that can only be referred to. It is the consideration of how far the change of glow in some specimens of lime from a red or orange colour in a low vacuum to a green or blue glow in a high vacuum is to be attributed to shorter oscillations in the exciting cause, and how far the change is connected with a dissociation of complex groupings into simpler ones; a dissociation which may be considered to be brought about by the rapid oscillations breaking up the lime groups into two or more smaller groups. Connected with this is also the question dealing with the possibility of phosphorescence being coincident with the recombination of the separated smaller grouping; but this part of the subject can only be illustrated by experiments of too minute a character to be suitable to a lecture, and involves besides the study of too many details. One other thing which must be taken into account in drawing any deductions from the change in the colour of the glow as the temperature rises is that in some cases the effect of heat is to discharge some colours in a complicated substance, and so leave visible others which were before masked.

The whole question of the inter-relations of the molecular weights of the phosphorescent substances, of the wave-lengths of the exciting undulations, and of the wave-lengths of the resulting glows is an important and interesting one; but it must be left alone in the present lecture with the statement, somewhat unsatisfactory it is feared, that, while there is no doubt that special undulations of measurable wave-length are most efficient in exciting phosphorescence in some substances, the same effects can be produced, though to a less degree, by vibrations which can perhaps be best described as undifferentiated and irregular pulses.

Returning to the sources of oscillations, there is one other source which has yet to be considered, and that is chemical combination. The fact that many substances will phosphoresce during and after exposure to the flame of hydrogen has already been alluded to. The flame of coal-gas burnt in a Bunsen burner will excite phosphorescence in many specimens of lime; but the effect is not strong enough to be shown to an audience.

Naturally this effect would be stronger the nearer the lime was placed to the source of light. Inside the flame itself would be the nearest attainable position, but then the heating effect practically masks or destroys all others. In phenomena such as the glow of phosphorus the temperature does not rise to any very marked extent. It is possible to obtain chemical combination in the presence of many bodies of a porous nature without, during the early stages of the action, getting very marked heating effects. The action of spongy platinum in inducing the oxidation of coal-gas or alcohol vapour may be taken as a familiar illustration of the use of a porous material for this purpose.

In the case of a conducting metal it could not be expected that the oscillations arising from the chemical combination would cause phosphorescence even in the early stages, when the temperature has not risen to any extent; but if such a body as lime could be obtained in a very porous condition it might, while acting as an inducer of chemical combination, itself respond to the oscillations arising out of that combination.

This is found to be the case. A jet of unlighted coal-gas allowed to play over warm porous lime produces a slight phosphorescence, very faint, but quite visible in a dark room.

By dusting easily volatile substances, such as finely powdered resin, over slightly heated lime, the oxidisable vapour is brought more closely into contact with the lime, and the phenomenon of phosphorescence is made more visible. So far, however, it has not been obtained with sufficient brilliancy to be shown to more than a few people at a time. When the different limes that have already been experimented with are subjected to oscillations from this chemical source, they yield their respective colours in the same way as before. The lime, which showed a green glow in the vacuum tube, or when dusted on to a hot plate after exposure to the jar-spark, gives a green glow with the powdered resin. So also in the cases of the orange and blue yielding limes. The possibility of the phosphorescence being due to the resin vapour itself is excluded by control experiments with other porous bodies which do not phosphoresce, but yet are equally active in bringing about oxidation.

This phosphorescence was often well seen when some of the limes were being prepared in a furnace. (It has been already mentioned that many substances retain the power of phosphorescing at a high temperature, especially if they are in a very fine state of division or not quite pure.) Most of the limes were made from organic salts of calcium, and as the organic matter burnt away, a thin and scarcely visible flame played over the surface of the lime at the top of the crucible in which the calcination was carried out. It was frequently quite possible to predict by watching the glow which was developed in the lime what colour would be given when the phosphorescence was brought about by oscillations from the other sources, such as the jar-spark or the discharge in vacuo.

No one who has spent much time in experimenting with various substitutes for lime in lantern work can have failed to be struck by the very different appearances of the light on the screen given by such bodies as magnesia and zirconia in comparison with lime; but, perhaps, the best examples are the two mantles in use at the present day for incandescent gas lights. One of them, the Welsbach mantle, gives a light of almost a white colour. The other, or Sunlight mantle, shows a much pinker colour to the eye.

Experiments with many substances used in a similar way to the mantles seem to indicate that, in addition to the ordinary heating effect of the gas flame, there is another and a phosphorescent effect which probably, so far as observation can tell, precedes the ordinary hot stage. It is not usual to find any pure substances capable of showing this phenomenon to any marked extent unless, as mentioned just now, they are in an extremely fine state of division; a condition which, like the presence of impurities, may be considered to be unfavourable to the too rapid discharge of the strained particles; thus giving them the opportunity of becoming fully enough charged to make their oscillations, when they are discharged, of sufficient vigour to be sensibly visible.

If either of the mantles mentioned be introduced into a tube and treated with an electric discharge in a high vacuum, the phosphorescent glow can be studied either with or without the heating effect. The glow of the Welsbach mantle is a greenish white, but not very marked. The Sunlight mantle gives a fine red glow. It is interesting to note that the glow shows great persistence even when the temperature of the substance has been raised very considerably by the vigour of the bombardment.

Having now dealt with the last source of oscillation which it was proposed to consider, it may be as well to summarise the conclusions which for the present seem to be the least open to objection so far as experimental evidence goes. The attempt has been made to connect together all the phenomena of phosphorescence with a view of showing between them a likeness in kind. Any theoretical suggestions should be taken only as hypotheses for assisting this attempt and for pointing the direction of further experiments. It is believed, then, that the following typical examples of the various phenomena which are described as phosphorescent phenomena are similar in kind and can be related to one another by the application of slight modifications of the same general principle—the glow of phosphorus, the fluorescence of quinine, the sparkling of heated chlorophane, the luminosity of Balmain's paint, the light from lime in a vacuum tube, and the glowing of barium platinocyanide under the influence of X-rays. To these it is proposed to add coloured flames and the spectral light of glowing gases. It is suggested that all these phenomena may be looked upon as outward evidences of response on the part of the substances to rapid oscillations, whether these oscillations have their origin in chemical combination in what is commonly spoken of as light, or in electrical discharge. The nature of that response may in some cases be of a direct character; but, when account is taken of the many degrees of persistence of phosphorescence and of potential phosphorescence, it seems in many cases first to assume the form of something which, to avoid circumlocution, may be called a statical charge. The release of this condition of strain is accompanied by oscillations which give rise to the visible undulations of the phosphorescent light.

One final suggestion may perhaps be made, though it is mentioned with diffidence, as many may consider it outside of the subject.

If it be accepted that the light of the sun has its immediate origin mainly in the masses of luminous clouds floating in the photosphere, and if these clouds be considered as condensations into material of greater molecular complexity than that from which they were condensed, then it may be not altogether out of place in the present lecture to speculate on the relation between the actual light from the glowing clouds and possible oscillations of the particles of the medium in which they exist. There is no need to emphasise the idea that the oscillations of very simple molecular systems give rise to undulations which can only be perceived when, by their action upon something more complex than themselves, they cause either a distinct chemical change or set up undulations within the range of the visible spectrum.

May it be that there are similar oscillations in the sun, that the simpler materials out of which the photospheric clouds are condensed vibrate too quickly to give out visible light, but that their oscillations are rendered visible when they are absorbed and responded to by the more complex groupings of the condensed masses? A sun-spot, looked upon as a partial absence of clouds, would mean that the conditions which serve to screen us to a great extent from the rapid undulations have been somewhat modified.

Is it too much to suppose, in view of the close resemblances between many of the actions of light and electricity, and of the well-known electrical effects of ultra-violet light and of X-rays, that the breaking down of a dielectric which they can accomplish may, on a vastly larger scale, accompany an unusual exposure of the earth to similarly rapid undulations? Should there be anything in this suggestion, it may help to remove a part of the difficulty in relating the presence of sun-spots to those casual electrical disturbances with which they undoubtedly coincide in point of time.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

A NEW technical institute was opened at Wellingborough on Thursday last, by Sir Philip Magnus. The building has been erected by the Urban District Council at a cost of 3000*l.*, exclusive of the site, and it will be maintained out of the free library rate.

THE following donations are announced in *Science*:—Colonel Oliver W. Payne has given 1,500,000 dollars to the Cornell University Medical College; the late Mr. Rowland Hazard has bequeathed 100,000 dollars to Brown University; Mr. George A. Gardner has given 20,000 dollars to the Massachusetts Institute of Technology, to be added to the general endowment fund; Dr. D. K. Pearsons, of Chicago, has offered 50,000 dollars to Fairmount College, Wichita, Kans., on condition that 150,000 dollars can be raised; in connection with the Maryland Agricultural Experiment Station, the State Legislature has granted 14,000 dollars for the erection of a science hall, to be used jointly by the college and station. 10,000 dollars have also been granted for inaugurating State work in entomology and vegetable pathology, and an annual grant of 8000 dollars for maintenance has been made.

THE new Technical Institute and Public Library, erected by the West Ham Corporation, will be opened to-day by Mr. J. Passmore Edwards. The foundation-stone of a natural history museum, which will be built close by, will also be laid. The Technical Institute, the principal of which is Mr. A. E. Briscoe, will be wholly under the control of the municipality, and will be financed from municipal sources. Every department is well equipped, special attention being paid to the chemical laboratories and the engineering workshops. The buildings have cost 450,000*l.*, and a further 15,000*l.* has been spent on equipment and fittings. The money for the working has been created by the accumulation of the Excise duties grants, but the corporation have secured sanction to raise 35,000*l.*, and have power to levy a 1*d.* rate (which will produce about 3800*l.*) for technical instruction purposes. The new central library is wholly on the ground floor, and is fitted with all the modern appliances of such institutions. Towards the cost of the natural history museum Mr. Passmore Edwards has contributed 2500*l.* The Essex Field Club, who will have the scientific control of the museum, will house their large collection here.

IN the course of an address upon "Science and Education," delivered at Mason College on Tuesday, Sir Archibald Geikie remarked that there is no more pernicious doctrine than that which measures the commercial value of science by its immediate practical usefulness, and restricts its place in education to those only of its subdivisions which are of service to the industries of the present time. By all means let artisans know as much as could be taught them regarding the nature and laws of the scientific processes in which they are engaged. But it is not by mere technical instruction that the industrial and commercial greatness of the country will be maintained and extended. If we are not only to hold our own, but to widen the boundaries of applied science, to perfect our manufactures, and to bring new departments of nature into the service of man, it is by broad, thorough, untrammelled scientific research that the success must be achieved. The continued development of the faculty of prompt and accurate observation is a task on which students cannot bestow too much attention. Amongst the mental habits which education in science helps to foster are a few which specially deserve attention as worthy of most sedulous care all through life. In the first place should be put accuracy; in the next thoroughness, which is closely akin to accuracy; then breadth; then the habit of wide reading in scientific literature; and then patience. It is by failures as well as by successes that the true ideal of the man of science is reached.

THE following entrance and other scholarships have been awarded at London Medical Schools:—London Hospital Medical College: Price Scholarship, value 120*l.*, Mr. F. W. Jones; Epsom Scholarship, value 126*l.*, Mr. Colmer; Price University Scholarship, value 60*l.*, Mr. Bousfield; Science Scholarship, value 60*l.*, Mr. J. W. Fox; Science Scholarship, value 30*l.*, Mr. Rainforth.—Charing-cross Hospital Medical School: Livingstone Scholarship (100 guineas) to Mr. G. E. Bellamy; Huxley Scholarship (55 guineas) to Mr. B. R. Bickford; Universities Scholarships (each 60 guineas) to Mr. H. G. Gabb and Mr. B. G. Fiddian. Entrance scholarships have also been awarded to Mr. R. H. Cooper (60 guineas), Mr. D. M. Davies (40 guineas), and Mr. T. Law (30 guineas); and exhibitions of 30 guineas each to Mr. A. C. Ingram, Mr. G. O. Lambert, and Mr. B. R. Lloyd.—Guy's Hospital Medical School: Scholarships for University students: H. S. French, Christ Church, Oxford, 50*l.*; Open Science Scholarship, E. H. B. Milsom, Guy's Hospital Medical School, 150*l.*; F. Rogerson, Guy's Hospital Medical School, and N. J. Spriggs, private study (equal), 30*l.* each.—St. Thomas's Hospital Medical School: Entrance Scholarships in Natural Sciences: 150*l.*, Chas. Michael Roberts; 60*l.*, Harry Mellor Woodcock; 20*l.*, Charles Hugh Latham.—University College, London, Medical Entrance Scholarships: 131 guineas, Mr. H. A. Haig; 55 guineas, Mr. M. Stewart Smith; 55 guineas, Mr. W. M. Sadler.—The first and second entrance scholarships of the Middlesex Hospital Medical School have been awarded to Mr. W. Cameron Macaulay and Mr. William Gordon Taylor, respectively.

THE Secondary Education Bill introduced into the House of Commons by Colonel Lockwood, proposes to separate technical from secondary education. For this and other reasons the Council of the Association of Technical Institutions has entered a protest against the Bill. It is pointed out that the proposed separation of technical and secondary education is an entire reversal of previous educational policy, and if it were carried into effect it would be detrimental to the education of this country. The power which Colonel Lockwood's Bill gives for the creation of a new local authority to deal specially with secondary education is also objected to, the multiplication of local authorities for the purposes of education beyond the elementary stage being regarded as a retrograde step. Other defects which the Bill possesses are: (1) The proposal to provide for the financial needs of secondary education by taking away from technical education part of the money assigned for instruction in science and art, and of the money available under the Local Taxation Act. (2) The proposal that the limits of secondary and technical education shall be settled on the basis of the opinions expressed by an advisory Council on which secondary schools and teachers shall be very largely represented, but which shall not contain a single representative of technical institutions. (3) No provision is made for the registration of teachers in technical institutions. (4) The proposal that a local secondary education authority shall not provide or have the management of any secondary school. The Council desires that steps should speedily be taken to organise secondary education in this country, and is willing to aid any statesmanlike attempt to accomplish this, but Colonel Lockwood's Bill would, it is pointed out, do mischief by creating a distinction between technical and secondary education, and setting up a purely artificial barrier between the two. It is not expected that the Bill will pass, but as the manner in which it is received may influence the Government to incorporate the proposals contained in it in the Secondary Education Bill to be produced next session, it behoves those interested in technical education to show unmistakably that such provisions as those in Colonel Lockwood's Bill are not generally acceptable.