the luminosity begins there is such a rapid increase in the ionisation that the current through the gas and the rate of doing work increase in an exceedingly short time through a wide range of values, and thus a gradual increase in the rate of work is exceedingly difficult to obtain. On several occasions, however, I was convinced that on gradually increasing the rate of work the mercury lines were the first to appear, and were the last to disappear when the rate of work was reduced from a high value, at which both the nitrogen and mercury spectra were bright, down to a point where the discharge ceased to be luminous.

The preceding considerations have also an important application to the difference between the arc and spark spectra. In the continuous arc discharge, although the average rate of work is much higher than in the spark, the maximum rate is very much less; in the spark discharge we have an exceedingly intense current density lasting for a very short time, and while the spark is passing we have a very much greater rate of work than in the arc. Hence the state of things in the spark will be analogous to that represented in Fig. 5, and the lines corresponding to systems of the type B will be enhanced relatively to those of type A; we conclude, then, that the arc lines correspond to systems of the type A, the spark lines to those of type B.

The work done in the discharge tube is probably ultimately converted for the most part into heat, so that the rate at which work is being done at any part of the tube is approximately proportional to the rate at which heat is being produced in the tube. I do not, however, regard temperature, *i.e.* the energy due to the translation of the atoms as a whole, as having any direct connection with the production of spectra. The work done by the electric field on the corpuscles is, since the corpuscles can easily penetrate the atoms of the gas, first converted into internal atomic energy; this energy may ultimately be for the most part transformed into the energy of translation of the molecules of the gas, and so appear as temperature, but it by no means follows that if we heat the molecules of the gas by non-electrical means to the temperature to which even a few of its molecules are raised by the electric discharge we shall get a luminous spectrum. The production of the spectrum depends upon the internal energy of the atom; when we use the electric discharge all the work done by the corpuscles goes at first into the form of internal atomic energy, while if we supply the same amount of energy to the gas by thermal, as distinguished from electrical, means, the energy will go first into increasing the energy of translation of the atom, and very little of it will ever get inside the atom. It is probable, however, that some of the energy of translation will get converted into internal energy, and that temperature is one way of giving internal energy to the atom, and so producing luminosity; from our point of view, however, it is a very extravagant method, as the fraction of the energy spent in heating the gas which goes to produce luminosity is small.

The coefficient of absorption α of the systems will depend upon the way in which the internal energy is given to the atom as well as upon the rate at which the electric field is doing work in the neighbourhood of the atom. Thus, for example, if the internal work is given by means of rapidly moving corpuscles, the coefficient of absorption will depend upon the velocity of the corpuscle, for we can easily show that when a corpuscle passes at a fixed distance from a system of corpuscles having a definite period of vibration there is one velocity of the corpuscle, depending on this period, fast if the period is short, slow if it is long, for which the energy given by the corpuscle to the system is a maximum. Thus the relation between the amounts of energy absorbed by two systems from the corpuscles depends upon the velocity of the corpuscles. The velocity of the corpuscles in a discharge tube depends upon the pressure of the gas, so that even though the rate at which the electrical forces are doing work may be the same at two different pressures, the relative intensities of the lines of two systems A and B may be different.

Again, we might expect that the coefficient of the rate of absorption of energy would be different according as the energy is given to the atom by means of the large systems which form the positive ions or by means of small corpuscles, and that the relative brightness of lines might be different in the two cases. In the Kanal-strahlen we have positive ions moving through a gas and producing luminosity, and the spectrum of this luminosity possesses interesting peculiarities differentiating it from the spectrum of other parts of the tube. Perhaps the most striking difference, however, is when the positive ions strike against a salt like lithium chloride; they make the red lithium line appear with great brilliancy, while if corpuscles strike against the chloride the red line is not visible. It is remarkable that the spectrum of the metal is produced much more readily by the positive ions when they strike against a salt of the metal than when they strike against the metal itself; this is shown in a striking way if we take the liquid alloy of sodium and potassium and direct a stream of Kanal-strahlen upon it; the clean parts of the alloy appear quite dark, but the specks of oxide scattered over its surface shine with a bright yellow light, giving the sodium spectrum.

When the internal energy of the atom is increased by means of light, as in Prof. Wood's beautiful experiments on the fluorescence of sodium vapour, the coefficient of absorption of a system will depend upon the relations between the periods of that system and the period of the incident light vibrations; thus, as Prof. Wood found to be the case, the numerous lines in the spectrum given out by the vapour alter greatly in character and wave-length when the period of the incident light is changed.

The same principles which explain the variation in the intensities of the spectra given out by two different systems in the same atom can be applied to explain the variations in the intensities of the spectra of two gases, A and B, when these are mixed together. We know that under some conditions the lines of only one constituent of the mixture appear, while under others we get the lines of both the gases. Let us suppose that the lines of A appear with a lower rate of work of the electric forces than those of B, and that we send a constant current through the discharge tube, we can calculate what the electric force must be to produce from the molecules of A alone the number of ions required to carry this current; having found the electric force on this supposition, we can, knowing the current, find the rate at which the electric forces would be doing work in the tube; if this rate of work is less than that required to make B luminous, the current will be carried by the ions of A alone, and the spectrum of B will not be developed; if the rate of work on this supposition is greater than that required to make B luminous, the spectrum of B will appear, and it must take a share in carrying the current. Let us suppose that we have so much of A present that the rate of work is not sufficient to develop the spectrum of B, and consider what will happen as the proportion of A is diminished. In order to supply the number of ions required to carry the given current from the smaller number of molecules of A, the electric force, and therefore the rate of work in the tube, must, on the supposition that the current is wholly carried by A, increase, and if we continually diminish the amount of A present the rate of work will at last reach a value sufficient to make B luminous with the given current. This stage will give the smallest quantity of A which can for the given current wholly swamp the spectrum of B. The rate of work done in the tube will depend on the current going through it and also on the pressure of the gases, so that both these quantities will influence the proportion of the gas B required to make its spectrum visible.

MICROSCOPIC AQUATIC PLANTS AND THEIR PLACE IN NATURE.[1]

EVERY piece of water, besides containing large plants and animals which are readily visible to the naked eye, harbours a more or less considerable number of minute forms, which pervade all the layers of the water in varying amount, and collectively constitute the plankton or pelagic life. The most important difference between the

[1] Abstract of a lecture on "The Microscopic Plants of our Waters," delivered before the London Institution on February 1 by Dr. F. E. Fritsch.

plankton and the remaining flora and fauna of our waters lies in the fact that all the organisms which compose it are free-floating during the greater part of their life. Practically all the pelagic plants belong to the group of the algæ, and their minute size, of course, suits them well to a floating existence. A certain number of them are motile (*e.g.* Volvox, Gonium, Pandorina, &c.), and these are able actively to maintain themselves in their position in the water; but the large majority are non-motile, and all these forms are slightly heavier than water, and consequently tend to sink; they develop diverse mechanisms, by means of which their power of flotation is increased. The most important of these are:—assumption of a flat plate-like shape (Pediastrum, Merismopedia, many Desmids); development of numerous delicate processes from the body of the plant (Stephanodiscus, Richteriella); arrangement of the individuals of a colony in a more or less stellate manner (Asterionella, some Tabellarias); assumption of a delicate acicular shape (Synedra); formation of fat in the cell (many Diatoms and Cyanophyceæ), and so on.

In spite of these adaptations, however, most of the non-motile organisms of the plankton sink to the bottom of the containing vessel in the space of a few minutes after they have been collected. How is it that this does not happen in nature? It has been suggested that the continuous currents in the water, due to the wind and other causes, help to buoy up the organisms of the plankton; but it is of course also possible that in collecting such delicate forms they are damaged in some way or other so as to deprive them of that power of floating which suits them so well to their natural habitat. An interesting point connected with the development of the diverse floating mechanisms is that in some plants they have been found to be far more strongly developed in the summer than in the winter forms; this is, undoubtedly, in some way connected with the lower specific gravity of the water in summer, although the exact relation is not yet quite evident.

If the plankton of any piece of water is examined from week to week or month to month, we find not only astonishing variations in the quantity of organisms present, but also very marked differences in the specific constitution of the pelagic life. The quantity of the plankton is generally very much less in the winter than in the summer months, and the organisms composing it are quite different in the two seasons. Thus in the Thames there are four well marked annual phases, each characterised by its own peculiar plankton. This periodicity exhibited by the pelagic life stands in close relation to the external seasonal changes; some of the forms prefer cold, others warm water, and consequently they flourish in those seasons which are most to their liking. Some plants are particularly sensitive, and consequently only put in an appearance for a very short space of time each year. During their period of absence from the plankton these organisms persist as resting spores in the mud at the bottom of the piece of water; when favourable conditions return the spores germinate, giving rise to a new generation of pelagic organisms, which by their prolific division are able to dominate completely a piece of water in a few days' time.

The pelagic plants form the food of the animal plankton; these, again, are devoured by their larger brethren, which are the main source of nutrition for the smaller fishes. The larger fish are mostly carnivorous, feeding on smaller individuals of their kind. The organic matter of the pelagic plants thus gradually travels from one organism to another until it comes to form part of the body of the large aquatic animals; it passes through a series of incarnations before being returned to the water in the form of excrements or products of decay of dead animal and vegetable bodies. This organic matter is built up by the pelagic plants from simple inorganic salts and from carbon dioxide dissolved in the water, and these latter substances are thus changed into a form which makes them available to the aquatic fauna. All the organisms of the latter, as, indeed, all the animals of the world, are ultimately herbivorous. Without some kind of plant growth a piece of water must remain a lifeless, dead mass, unpopulated, and a thing apart from the living world around it. The presence of vegetation immediately transforms it into a throbbing universe, full of energetic life, exhibiting complex inter-relationships, and connects it with the remaining parts of our universe. The most important element of the vegetation from this point of view, however, is the phytoplankton, and a piece of water with plenty of pelagic plants is sure to form a good breeding-place for fish and other aquatic animals.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The report of the committee of the school of geography for 1905 shows that the school now holds a strong position in the University, and is doing valuable work in encouraging the study of geography and surveying, and in providing special courses of geographical lectures suited to the requirements of the different final honour schools. Both the lectures and practical instruction were well attended throughout the year, although there were only a few candidates for the diploma. This year, in addition to the ordinary work during term, a special course lasting three weeks, specially suited to those who are engaged in teaching, is being arranged for August. The instruction will be both practical and theoretical, and there ought to be no lack of support for so useful an innovation.

CAMBRIDGE.—The forestry committee having been commissioned to submit a scheme of study and examination for the diploma in forestry, recommends that the Senate approve the following:—Candidates, before receiving the diploma in forestry, shall be required to produce evidence that they have (1) passed (or obtained exemption from) the Previous examination, together with the additional subjects; (2) satisfied the examiners in physics, chemistry, geology, and botany, either in part i. of the examination for the diploma in agriculture, or in that examination in combination with the Natural Sciences Tripos, part i., or in some other examination or examinations approved by the committee; (3) diligently attended courses of instruction in forest botany, in entomology, in forestry, in forest mensuration, surveying, and engineering, and such other courses in related subjects as may from time to time be approved by the committee; (4) attended for a time equivalent to one academical year courses of instruction in practical forestry approved by the committee; (5) obtained a certificate of proficiency in practical forestry approved by the committee; (6) passed the examination for the diploma; (7) been admitted to a degree in the University.

The general board of studies has approved for the degree of Doctor in Science Mr. G. H. F. Nuttall, Christ's College.

The general board of studies also recommends that it be authorised to appoint, subject to confirmation by the special board for medicine, Mr. G. H. F. Nuttall to be reader in hygiene in connection with the special board for medicine; that the university lectureship in bacteriology and preventive medicine terminate on his appointment as reader; and that the readership terminate with the tenure of office of Mr. Nuttall.

DR. W. A. THORNTON has been appointed to the newly-created professorship of electrical engineering at Armstrong College, Newcastle.

ACCORDING to a message from Wolfville, Nova Scotia, Mr. Carnegie has promised to the Acadia University 6000*l.* for a new science building as soon as 20,000*l.* has been raised for a forward movement now in progress. Of this sum nearly half is already in hand, and the rest is definitely promised.

THE council and principal of the Bedford College for Women will hold the usual reception at the college on Commemoration Day, May 9, after the presentations for degrees at the University of London. The Pfeiffer entrance scholarship in science, tenable for three years, and of the annual value of 48*l.*, will be offered for competition in June next.

AT the annual dinner of the students of the Camborne Mining School, held in Camborne on March 10, the prin-