that the concussion will raise a cloud of finely divided solid matter from the bottom of the tube along which the flame will be propagated and be driven out at the other end. *A* (see figure) is a wooden box 12 inches long, 8 broad, and 6 deep, closed on all sides, with the exception of a rectangular hole ($3\frac{1}{4} \times 2\frac{3}{4}$ inches), into which can be inserted a long narrow rectangular tube (B), also of wood, which may be 20 feet or more in length; the upper side (*cc*) of this tube is hinged, and along the bottom is strewed a thin layer of finely-divided dry coal-dust, or, what is better in the lecture-room, lycopodium powder. Into the wooden box, which in my apparatus has a cubic content of more than a gallon (5 litres) is placed about $1\frac{3}{4}$ pints (say 1 litre) of coal-gas; this can be most readily effected by pouring this amount of water into the box and displacing it over the water-trough by a current of the coal-gas. The opening is then closed by a sliding lid, and the gaseous contents are mixed by violently shaking the box for a minute or so. The end of the long tube (along which the powder or dust has been strewn, and the lid *c c* pushed down) is then inserted into the box, and the gaseous mixture is fired by thrusting a lighted taper through a small hole (*d*) at the end just where the tube enters the box. The mixture of coal-gas and air explodes, and the flame rushes along the whole length of the tube with astonishing velocity, and is driven, often to a distance of six or seven feet, out at the other end, and is followed by a cloud of smoke.

The experiment is unaccompanied by danger, and is so simple that it may be readily performed in a lecture-room. I showed it some time since to a number of colliers and others engaged in coal-mining, and it seemed to bring home to them far more forcibly than possibly any amount of mere description would have done, the real character of the phenomenon. T. E. THORPE

THE PHOTOGRAPHIC SPECTRUM OF THE GREAT NEBULA IN ORION[1]

LAST evening (March 7) I succeeded in obtaining a photograph of the spectrum of the great nebula in Orion, extending from a little below F to beyond M in the ultra-violet.

The same spectroscope and special arrangements, attached to the 18-inch Cassegrain telescope with metallic speculum belonging to the Royal Society, were employed which have been described in my paper on "The Photographic Spectra of Stars" (*Phil. Trans.*, 1880, p. 672).

The exposure was limited by the coming up of clouds to forty-five minutes. The opening of the slit was made wider than during my work on the stars.

The photographic plate shows a spectrum of bright lines, and also a narrower continuous spectrum which I think must be due to stellar light. The bright stars forming the trapezium in the "fish's mouth" of the nebula were kept close to the side of the slit, so that the light from the adjacent brightest part of the nebula might enter the slit.

Outside this stronger continuous spectrum I suspect an exceedingly faint trace of a continuous spectrum. In the diagram which accompanies this paper the spectrum of bright lines only is shown, which is certainly due to the light of the nebula.

In my papers on the visible spectrum of the nebula in Orion, and other nebulæ (*Phil. Trans.*, 1864, p. 437, and 1868, p. 540; also *Proc.* Roy. Soc., 1865, p. 39, and 1872, p. 380), I found four bright lines. The brightest line, wave-length 5005, is coincident with the less refrangible component of the double line which is strongest in the spectrum of nitrogen. The second line has a wave-length of 4957 on Ångström's scale. The other two lines are coincident with two lines of hydrogen, Hβ or F, and Hγ near G.

In the photograph, these lines which had been observed in the visible spectrum are faint, but can be satisfactorily recognised and measured. In addition to these known lines, the photograph shows a relatively strong line in the ultra-violet, which has a wave-length 3730, or nearly so. The wide slit does not permit of quite the same accuracy of determination of position as was possible in the case of the spectra of stars. For the same reason, I cannot be certain whether this new line is really single, or is double or multiple. In the diagram the line is represented broad, to indicate its relative great intensity.

This line appears to correspond to ζ of the typical spectrum of white stars (*Phil. Trans.*, 1880, p. 677). In these stars the line is less strong than the hydrogen line near G; but in the nebula, it is much more intense than

Hγ. In the nebula, the hydrogen lines F and Hγ are thin and defined, while in the white stars they are broad, and winged at the edges. The typical spectrum has been added, for the sake of comparison, to the diagram.

I cannot say positively, that the lines of hydrogen between Hγ and the line at 3730 are absent. If they exist in the spectrum of the nebula, they must be relatively very feeble. I suspect, indeed, some very faint lines at this part of the spectrum, and possibly beyond λ 3730, but I am not certain of their presence. I hope, by longer exposures and with more sensitive plates, to obtain information on this and other points. It is, perhaps, not too much to hope, that the further knowledge of the spectrum of the nebulæ afforded us by photography, may lead, by the help of terrestrial experiments, to more definite information as to the state of things existing in those bodies.

[1] Paper read at the Royal Society, March 16, by William Huggins, D.C.L., LL.D., F.R.S.

THE ACTION OF CARBONATE OF AMMONIA ON THE ROOTS OF CERTAIN PLANTS, AND ON CHLOROPHYLL BODIES[1]

1. *Roots.*

THE observations which led to the first of these papers were originally made many years ago on *Euphorbia peplus*, and have now been extended to other genera. A plant of *E. peplus* having been dug up and carefully washed, the smaller rootlets may be placed under the microscope without further preparation, the thicker roots may be examined by means of sections. If such roots are left, before being examined, in a solution of carbonate of ammonia (1 to 7 per 1000) for a short time (varying from a few minutes to several hours), they present a wonderfully changed appearance. The most striking alteration is that the surface of the root assumes a *longitudinally striped appearance*, due to longitudinal rows of darker brown cells, alternating with lighter coloured rows. The darker colour is seen under a high power to be due to the presence of innumerable rounded granules of a brown tint, which the lighter-coloured cells are without. Similar brown granules are deposited in cells scattered throughout the parenchyma, and markedly in the elongated endoderm cells surrounding the vascular bundle.

The granules are apparently neither resinous nor fatty, for they are not removed by alcohol or ether; they are,

[1] Abstract by Mr. Francis Darwin of two papers by Mr. Charles Darwin read before the Linnean Society on March 16.

however, slowly acted on by caustic potash, and seem to be of the nature of protein.

It will be observed that the most remarkable part of the phenomenon is that the granules are only formed in some of the external cells, and that these cells are, before the treatment with ammonia, indistinguishable in shape or by their contents from their fellows, which are unaffected by the solution.

There is, however, a curious functional difference between the two classes of cells, namely, that the granular cells do not produce root-hairs, which arise exclusively from the cells of the light-coloured rows. With this fact may be compared an observation of Pfeffer's, that the root-hairs of the gemmæ of Marchantia grow only from certain definite cells. He describes a similar state of things in Hydrocharis, but with these exceptions it seems not to have been hitherto suspected that root-hairs arose from cells in any way specialised.

In connection with this fact, the theory suggests itself that the light-coloured cells have been emptied in consequence of the granules having been used up in the development of the root-hairs. But this view is not compatible with the fact that light-coloured cells may often be found which have not produced root-hairs. Again, in the case of Cyclamen, root-hairs are produced from granular cells. Effects similar to those now described were observed in some other Euphorbiacious plants, *e.g. Phyllanthus compressus*, though not in all the genera of this family which were observed. Among genera belonging to other families may be mentioned Drosophyllum and Cyclamen, as showing the phenomenon especially well. Altogether 49 genera were observed; of these 15 were conspicuously acted on, and 11 in a slight degree, making together 26 genera, while the roots of the remaining 23 genera were not acted on in any plain manner.

Before attempting to draw any conclusions, a few more details must be taken into account. The root must be alive, otherwise no precipitation will take place; the process is therefore a vital one, and seems in some measure to resemble "aggregation," as it occurs in the tentacles of Drosera. In both cases carbonate of ammonia is the most efficient re-agent, but other salts, such as nitrate of ammonia, produce a similar effect. What the nature of the process may be, must remain doubtful. The view here suggested is that the granular matter is of the natuae of an excretion; the arrangement of the dark-coloured cells in rows agrees with what we know of the disposition of certain cells whose function is admittedly to contain excretions. The granules are, moreover, deposited in the loose exfoliating cells of the root-cap where they cannot take part in the life of the root; and this fact points in the same direction.

2. *On the Action of Carbonate of Ammonia on Chlorophyll Bodies.*—The effects of solutions of carbonate of ammonia and of other fluids on the tentacles of Drosera, &c., was described in "Insectivorous Plants," under the name of "*aggregation.*" This process consists essentially in the appearance of curiously-shaped masses, of an albuminoid nature, which undergo striking changes of form. The masses were believed to be protoplasmic, but this conclusion has not been generally accepted, and has been called in question by such authorities as Cohn and Pfeffer. The present paper is intended to show that carbonate of ammonia causes a kind of aggregation in chlorophyll bodies; and as these are undoubtedly protoplasmic, the belief in the protoplasmic nature of the aggregated masses in Drosera, and other carnivorous plants, is supported.

The changes which occur in the chlorophyll bodies may be well observed in the case of Dionæa. If a young leaf is immersed for twenty-four hours in a solution of carbonate of ammonia (7 to 1000), and is then examined by making thin sections, the contrast with a normal leaf will be found strikingly great. In most of the cells, not a single chlorophyll-grain can be seen, but in their place are found masses of translucent yellowish-green matter of diversified shapes, resembling in a general way the aggregated masses in the tentacles of Drosera. The matter is not exclusively derived from the chlorophyll-grains, but consists, in part, of matter deposited from the cell-sap, which is often the first to be formed, and is afterwards surrounded by the green matter derived from the chlorophyll-grains.

The same process may be observed in Drosera, and here it is not necessary to make sections, as the chlorophyll-grains may be well seen at the bases of the tentacles. Many observations were made in this way, and also by means of sections. In the case of Drosera it was possible to show that the chlorophyll-grains may recover from the effects of the carbonate—and this is a fact of some importance. After placing drops of various solutions on the discs of leaves still attached to their plants, green spheres or green zones surrounding a central purple mass were to be found in the tentacles. In this case it will be seen that the chlorophyll grains join with the purple cell-contents in forming aggregated masses. These masses were observed to be in constant slow movement. The leaves were then syringed with water and left to themselves for some days. When again examined, the green spheres had in large part disappeared, and instead of them normal chlorophyll-grains were found.

Other observations were made on Drosophyllum, Sarracenia, *Primula sinensis*, Dipsacus, Pelargonium, Cyclamen, and many other genera, with various results. In some cases the chlorophyll-grains disappeared, and the green masses were formed, in other cases hardly any effect was produced; in others again the chlorophyll-grains became confluent and formed curious horse-shoe like masses in the bottoms of the cells.

In the case of Spirogyra the effects of the carbonate were well marked, the spiral chlorophyll body breaking up into variously formed rounded and pear-shaped masses, which slowly changed their outline. Here also plainly-marked deposition of fine granular matter from the cell-sap was caused by the ammonia solution.

Finally, it may be pointed out that whether or not the argument from the facts here given in favour of the protoplasmic nature of the aggregates in Drosera be considered valid, the observations themselves possess some independent interest.

NOTES

In the New Code it is satisfactory to find that science is placed on a fair footing. While in elementary schools, the substratum of instruction, in the form of "obligatory subjects," is reading, writing, and arithmetic, still the grants for optional subjects are such as to encourage teachers to make them a regular part of education. In the class-subjects for older scholars, for example, we find geography and elementary science, and these it is recommended, should be illustrated as far as possible, by maps, diagrams, specimens, and simple experiments. In geography the subjects for the different standards are carefully graduated; in Standard V., for example, such subjects as latitude and longitude, day and night, and the seasons, are set down; under Standard VI., among other subjects, are the "circumstances which determine climate;" and under Standard VII., "the ocean, currents, and tides, general arrangement of the planetary system, the phases of the moon." Under Elementary Science, again, the object of the instruction is stated to be the cultivation of "habits of exact observation, statement, and reasoning." For the first standards, lessons in "common objects, such as familiar animals, plants, and substances employed in ordinary life," are to be given. For Standard IV, there is required "a more advanced knowledge of special groups of common objects, such as (*a*) animals or plants, with particu-