the sensory nerves. Thus the peripheral "plume" of the pyramidal cells would be the spot at which the voluntary motor impulse arises, to be communicated to the body of the pyramidal cell, and so to the fibres forming the pyramidal tract.

When an electrical stimulus is applied to the cortex, muscular movements are produced, because the stimulus acts either upon the "plumes" or upon the nervous fibrils whose function it is to carry impulses to the "plumes." Every nerve centre is made up of four constituents: nerve cells with short axis cylinders, terminal nerve fibres coming from other centres or from distant parts of the same centre, nerve cells with long axis cylinders, and collaterals which arise from axis cylinder prolongations of cells, or from nerve fibres of the whole substance. In the retina, olfactory bulb, and molecular layer of the cerebrum, there are in addition cells characterised by the absence of differentiation of nervous and protoplasmic expansions.

In organs where it is well established that excitatory processes arise the cells are polarised, *i.e.*, the nervous impulse always enters by way of the protoplasmic apparatus, or by the body of the cell, and leaves by the axis cylinder, which transmits it to a new protoplasmic apparatus. The differentiation of the protoplasmic apparatus is for the purpose of enabling each cell to be connected with different kinds of nerve fibres, and the more varied the protoplasmic expansion, the greater the number of cells under whose influence it comes. In the same way the more the nervous expansion of a cell is extended, and the more collaterals it possesses, the greater is the number of cells to which its impulses may pass.

In the pyramidal cell of the brain of mammals, the differentiation and extension of the protoplasmic expansion, and the multiplication of the collateral and terminal nervous twigs are carried to their highest point, and on descending the scale both the differentiation and the number of twigs becomes rapidly less; in fish the pyramidal cell is absent.

As regards the education of the brain mental activity is not able to improve the cerebral apparatus by augmenting the number of cells, as the nervous elements lose their power of dividing during the embryonic period, but it is probable that intellectual exercise may produce in certain regions of the brain a large development of the protoplasmic apparatus and of the system of nervous collaterals, so that the associations already existing between certain groups of nerve-cells would be perfected by a further development of terminal twigs, of protoplasmic endings, and of nervous collateral branches, whilst quite new intercellular connections might be established by a new formation of collaterals and protoplasmic expansions.

"Vis à vis de la théorie des réseaux celle des arborisations libres des expansions cellulaires susceptibles de s'accroître apparaît non seulement comme plus probable, mais aussi comme plus encourageante. Un réseau continu pré-établi—sorte de grillage de fils télégraphiques où ne peuvent se créer ni de nouvelles stations ni de nouvelles lignes—est quelque chose de rigide, d'immuable, d'immodifiable, qui heurte le sentiment que nous avons tous que l'organe de la pensée est, dans certaines limites, malléable et susceptible de perfection, surtout durant l'époque de son développement, au moyen d'une gymnastique mentale bien dirigée. Si nous ne craignions pas d'abuser des comparaisons, nous défendrions notre conception en disant que l'écorce cérébrale est pareille à un jardin peuplé d'arbres innombrables, les cellules pyramidales, qui, grâce à une culture intelligente, peuvent multiplier leurs branches, enfoncer plus loin leurs racines, et produire des fleurs et des fruits chaque fois plus variés et exquis.

"Du reste nous sommes très loin de croire que l'hypothèse que nous venons d'esquisser puisse à elle seule expliquer les grandes différences quantitatives et qualitatives que présente le travail cérébral chez les divers animaux et dans la même espèce animale. La morphologie de la cellule pyramidale n'est qu'une des conditions anatomiques de la pensée. Or cette morphologie spéciale ne suffira jamais à nous expliquer les énormes différences qui existent au point de vue fonctionnel entre la cellule pyramidale d'un lapin et celle d'un homme, ainsi qu'entre la cellule pyramidale de l'écorce cérébrale et le corpuscle étoilé de la moelle ou du grande sympathique. Aussi à notre avis est-il très probable qu'en outre de la complexité de leurs rapports les cellules pyramidales possèdent encore une structure intraprotoplasmique toute spéciale, et même perfectionnée dans les intelligences d'élite, structure qui n'existerait pas dans les corpuscles de la moelle ou des ganglions."

ON THE IRRITABILITY OF PLANTS.[1]

SOME years ago I published my observations on the strange and till then undescribed effect produced by various bodies on the sporangiferous hyphæ of *Phycomyces nitens*, well known to every plant-physiologist. To be brief, the phenomenon consisted in the fact that certain bodies attract *Phycomyces*, *i.e.* these bodies cause the hyphæ growing in their vicinity, at a distance of from one to two centimetres, to make curves in their growth, the concavity of which is directed towards the said body. This was particularly the case with iron; zinc and aluminium exhibited the same phenomenon, though in a smaller degree (aluminium only so slightly, that I now feel inclined to count this body among the inactive ones), while other metals showed no effect. In many other bodies the same effect was observed. The sporangiferous hyphæ, on the other hand, have a repellent effect on each other. I formerly designated this phenomenon as dependent on "physiological action at a distance."

At the Edinburgh meeting of the British Association for the Advancement of Science, held in August, 1892, Prof. L. Errera, of Brussels, read a paper on this subject, which was published in the Report of the Society, p. 746, having appeared earlier in the "Annals of Botany" (vol. vi. No. 24, December, 1892). He considered the phenomenon to depend on a kind of hydrotropism.

It is a well known fact that the sporangiferous hyphæ are negatively hydrotropic, *i.e.* that they curve away from a surface which discharges aqueous vapour, and the reciprocal repulsion of the hyphæ was considered by Errera to be a case of negative hydrotropism. From this it was naturally concluded that they are, on the other hand, attracted by a body that absorbs water. The effect of iron, since iron does actually absorb water in a damp atmosphere, is set down by Errera as a confirmation of this supposition. Even in other bodies which absorb water, Errera was able to find the same effect of attraction; indeed, in one case the inflexion of the hyphæ led to the discovery of the hygroscopicity of certain bodies. Thus the phenomenon would be bereft of its mysterious character, and classified among the already known qualities of this plant.

According to my experience, however, the explanation of Errera is not sufficiently well based to be yet admitted.

If iron acts as a hygroscopic (*sit venia verbo*) body, we should expect the phenomenon to be very clearly observable in these bodies, which are known to be particularly hygroscopic; for instance, potash and calcium chloride. But if a stick of caustic potash is fixed in the usual way above the culture of *Phycomyces*, taking care that the fluid dripping from the stick does not fall on the hyphæ or on the substratum, but into a small glass tube closed at the bottom, no attraction will be observed. The stick of potash absorbs much water from the atmosphere, its upper layers actually deliquesce, but, neither in its vicinity nor at a distance, do the hyphæ undergo any regular deviation from their direction of growth. I have made this experiment several times, and always with the same negative result. It is the same with soda. With solid calcium chloride it is difficult to work, because it deliquesces too quickly. I therefore used a solution of calcium chloride (one part of salt to one and a half part of water), with which I soaked a dry cylinder of plaster. This solution slowly absorbed aqueous vapour from the air; the cylinder consequently acted as a hygroscopic body, but no attraction could be observed. In one experiment the increasing weight of the cylinder (length 50 mm., diameter 11 mm., weight 4·904 gr.) was observed during the experiment; it amounted in four hours to 0·262 gr., and even then the body was not yet saturated with aqueous vapour.

Dry plaster also actively absorbs water from the air. I took a slab, measuring 80 × 35 × 10 mm., and dried it at 100°; it weighed 23·077 gr. During an experiment of six hours this slab was without effect on the *Phycomyces*; but in that time it had condensed 1·665 gr. of water. Now we might suppose that in this case the slab, by absorbing so much water, very soon came into a state in which it caused, neither positively nor negatively, hydrotropical curvatures; that in fact it had absorbed too much water to effect attraction, and too little to cause repulsion. But in the following six hours it still increased 0·049 gr. in weight, without exercising even now the least effect on the fungi.

In comparison with this, a plate of iron absorbs very little water. Such a plate, the total surface of which was 4950 mm.,

1 "Öfversigt af Finsk. Vet. Soc. Förhand." Häft xxxvi. 1894

and consequently correspondent to that of the above-mentioned cylinder of plaster, increased in weight, in an atmosphere saturated with aqueous vapour, by only 3·5 mgr. in twenty-four hours.

If we argue that the hygroscopicity is the cause of the curvatures, we might assume that *Phycomyces* is only affected by bodies which absorb very little water, and that the above-mentioned bodies, which are without effect on *Phycomyces*, are too strongly hygroscopic. But then a positive curvature ought to be seen, at a certain distance from the bodies, where the hygroscopic effect is weaker; and this is by no means the case.

With all these facts in view, I cannot agree with Errera's hypothesis that the attracting effect of iron depends on a kind of hydrotropism. According to the statement of Errera, many hygroscopic bodies attract the hyphæ, but it is hardly to be presumed that this is actually owing to hygroscopicity, as other hygroscopic bodies are without effect. It seems to me that this is a case of radiation, depending on the molecular state of the body, and manifesting itself by the physiological effect.

In one point Errera corrects my statements as to the effect of iron. I had found that the condition of the surface (burnished, roughly brightened, or somewhat rusty) did not affect the results. Errera says that the effect of burnished steel is very slight, and this I can confirm as regards very well burnished steel. In this circumstance Errera finds a confirmation of his hypothesis, since a burnished surface gets rusty, *i.e.* absorbs water very slowly. In my opinion this fact only implies that the state of the surface is of a certain importance for the radiation in question, as is known to be the case with regard to the radiation of heat and light.

It is self-evident that my idea of this phenomenon, as dependent on molecular vibration, is a mere hypothesis. It is, however, somewhat confirmed by the fact that similar physiological effects are produced by some phenomena, which we must, from the present stand-point of science, declare to be molecular vibrations; and the statement of this fact is the principal object of this paper.

Platinum belongs to the inactive metals, and well-burnished steel has, as mentioned above, a very slight effect. But if exposed for some time to direct sunlight, these bodies become active, *i.e.* the sunlight creates in them a condition which, though otherwise imperceptible, manifests itself by the fact that the body, clearly and even powerfully, attracts *Phycomyces*. The power of attraction appears on the illuminated as well as on the opposite side of the body. This condition of the body lasts for a few hours, but afterwards ceases.

This phenomenon is somewhat mysterious. It is indeed astonishing to see how the same piece of platinum-foil, which during a series of experiments was without effect on our *Phycomyces*, will attract them after being exposed to the sun, without undergoing any outward change.

But this phenomenon is not entirely without analogy. It is a well-known fact that a number of nonluminous bodies after being exposed to illumination emit light in a manner which has been described as phosphorescence. Some bodies phosphoresce only for fractions of a second, others for more than twenty-four hours. Metals do not belong to the phosphorescing bodies, but in the present case a kind of phosphoresence seems to take place which is not perceptible to our eyes, but, on the other hand, is effective on *Phycomyces*. The phenomenon might be designated as dark phosphorescence.

It is interesting to note that E. Becquerel, who thoroughly studied the phenomena of phosphorescence, had foreseen something of the kind. He says ("La lumière, ses causes et ses effets," 1867, i. p. 259): "Même si les corps ne sont pas lumineux dans le phosphoroscope, on ne peut dire qu'il n'existe aucun effet après l'action du rayonnement; car la lumière pourrait exciter des vibrations d'une autre vitesse que celles qui sont perceptibles à nos yeux (et en général plus lentes), et capables de donner lieu soit à des effets de chaleur, soit à d'autres actions moléculaires encore inconnues."

With regard to the requisite intensity of light, I need only state that in August intense sunlight during seventy minutes was sufficient to cause activity, whereas an exposition of five hours in cloudy weather was without effect. I have not found out the shortest effective period of the insolation; and as to the duration of the state induced by light, I can only say that bodies activated in the afternoon, which, on being tested at once, caused curvatures in three to four hours, were without effect the next morning.

That the effect is due to light, not to heat, is proved by experiments in which the steel and platinum plates were heated for hours to the temperature (40°–45°) indicated by the thermometers during the insolation.

That the ultra-violet rays of the sun have no particular share in the phenomenon, is proved by the fact that the light which has passed through a solution of quinine-sulphate activates the respective bodies.

In experimenting with other metals, and various non-phosphorescing bodies, I could not demonstrate with certainty any such activation by light, which fact, however, does not exclude the possible occurrence of a dark phosphorescence of too short a duration to cause a physiological reaction.

Finally, I have to mention that certain bodies are rendered active by heat. I have found zinc to be one of them. Having heated a stick of zinc (5 mm. in diameter) in a blow-pipe flame until it began to melt, and having then allowed it to cool down to the temperature of my hand, I got, after an experiment of a few hours, the most beautiful curvatures in *Phycomyces* I could wish for. After cooling down for several hours, the stick was no longer active in this manner. Here we can justly speak of positive thermotropism, which is all the more interesting, as Wortmann in his experiments (*Botanische Zeitung*, 1883, p. 462) found only negative thermotropism in *Phycomyces*.

Some other bodies are quite different from zinc. The same plate of platinum that was rendered active by an hour's insolation, remained, after being heated red-hot for five minutes, just as inactive as before. Also in copper, cobalt, nickel, tin, lead, and glass, no effect was to be produced by great heat. There is not the slightest doubt but that plants, in their thermotropic curvatures, are affected by vibrations issuing from the molecules of the body applied, and this is also very likely the case with regard to the effect of light. It therefore does not seem unjustifiable to assume that even molecular vibrations, which are inherent in the bodies themselves, or connected with some change that they undergo, may cause similar physiological effects.

FREDRIK ELFVING.

THE NEW IODINE BASES.

FURTHER details are given in the latest *Berichte*, by Prof. Victor Meyer and Dr. Hartmann, concerning their recently-discovered basic compounds of iodine. It will be remembered that the fundamental base from which these new substituted bases are derived is the hypothetical compound $HO.IH_2$, and that the derivative $HO.I\langle{}^{C_6H_5}_{C_6H_4I}$ had been isolated as a strongly alkaline substance readily soluble in water, and which forms salts with acids with elimination of water, exactly like ammonium hydroxide. For the parent substance, therefore, the name iodonium hydroxide is proposed. At the conclusion of their first paper, Prof. Meyer and Dr. Hartmann announced that they had just succeeded in isolating the simpler di-phenyl derivative $OH.I\ (C_6H_5)_2$, and the present communication describes the strange mode of its genesis, and the character of the free base and its salts. The beautifully crystalline iodide was frequently obtained in small quantities during the whole course of Prof. Meyer's work with iodoso-benzene. It was observed that methyl iodide acts with great energy at the ordinary temperature upon the latter compound, and the product yields in contact with moist silver oxide a liquid from which potassium iodide precipitates crystals of the new iodide, $I.I\ (C_6H_5)_2$. It was subsequently found that when iodoso-benzene itself is triturated with moist silver oxide, the filtered liquid likewise yields similar crystals of diphenyl-iodonium iodide upon the addition of potassium iodide. This discovery led to a systematic study of the conditions of the reaction, and it was eventually elicited that freshly prepared iodoso-benzene is incapable of so acting, but that by a few days' exposure in a thin layer to daylight, or, better still, by heating for some hours to 60°, it is rendered capable of producing the new base when brought in contact with oxide of silver. Moreover, it was ascertained that potash or soda are likewise capable of bringing about the change, although owing to subsidiary decompositions, not so advantageously as moist oxide of silver. It has finally been proved that the reaction depends upon the fact that upon heating to 60° or exposure to sunlight iodoso-benzene, $C_6H_5\ IO$, is partially converted into the more highly oxidised compound $C_6H_5.IO_2$, and by the action of moist silver oxide upon the mixture of the two