its continuation for many years to come. We would, however, suggest that its value for purposes of immediate reference would be greatly enhanced by its publication being more prompt.

THE additions to the Zoological Society's Gardens during the past week include a Wild Cat (*Felis catus*) from Inverness-shire, presented by Mrs. Ellice; a Solitary Thrush (*Monticola cyanus*) European, presented by Mr. J. Young; a Diana Monkey (*Cercopithecus diana*, var. *ignitus*, ♀) from West Africa, deposited; three Alpine Accentors (*Accentor collaris*), a Bluethroat (*Cyanecula suecica*) European, purchased.

OUR ASTRONOMICAL COLUMN.

A NEW ACHROMATIC OBJECT-GLASS.—It is well known that in consequence of the irrationality of dispersion the nominally achromatic object-glass is really very far from achromatic. There is always a residual colour, frequently called the secondary spectrum, so that the images of bright stars are surrounded by halos of blue and red light. For this reason a refracting telescope designed for visual observations cannot be employed for photography. Many attempts have been made to correct this colour aberration of the achromatic lens, but the plans hitherto suggested have never been practically adopted, owing to difficulties of construction, or to the imperfect durability of the glasses employed. Mr. H. D. Taylor, optical manager to Messrs. T. Cooke and Sons, has recently taken up the question, and he appears to have come very near to a practical solution of the problem. He has aimed at producing an objective which shall be (1) almost perfectly achromatic; (2) equally well corrected for photographic purposes as for visual purposes; (3) capable of practical construction in large sizes; and (4) of ordinary durability.

The new object-glass which is to satisfy these conditions is a combination of two positive lenses and one negative lens, each made of a kind of glass possessing different optical properties. The necessary glasses are manufactured by Messrs. Schott and Gen, of Jena, and there is no reason to believe that there will be any difficulty in the production of large discs. The separate lenses are so constructed that the partial dispersions of two of the lenses combined are as nearly as possible equal to those of the third lens when acting singly. It is calculated that with the kinds of glass actually available the greatest departure from focus in the case of a 12-inch object-glass of 15 feet focus would be about 0·06 inches for the H rays, or only $\frac{1}{14}$ that in an ordinary object-glass of similar dimensions. The curvatures of the lenses are designed to minimise the difficulty of practical construction and testing, and no important loss of light is anticipated from the increased thickness of glass which the new object-glass requires. Indeed, it is probable that there will be a considerable gain of light-gathering power from the convergence of all the luminous rays to a common focus. (Full particulars are given in the Patent Specification, No. 17,994, 1892.)

SOLAR MAGNETIC INFLUENCES ON METEOROLOGY.—Under this title Prof. H. A. Hazen has published a pamphlet dealing with the supposed existence of electric or magnetic fields in the atmosphere, and the possibility of their accounting for weather phenomena. The subject has for some time been under investigation by Prof. F. H. Bigelow, and papers upon it have been published by the United States Weather Bureau, and in several American journals. Prof. Bigelow considers that under certain conditions of the sun there would be generated two distinct magnetic fields—one from the photosphere, and one from the nucleus, the earth being traversed by at least three fields of magnetic force: the lines of permanent magnetism, those from the electro-magnetic or radiant field, and those from the magnetic or coronal field. The radiant field would be favourable to producing warm, dry, high-pressure areas, as seen in the tropical belt, while the magnetic polar field would be favourable to the production of cold, dry, high-pressure areas, such as frequent the storm-belts farther north. It is with the latter influence that we have chiefly to do, in which Prof. Bigelow detected systematic changes recurring in about twenty-seven days. On projecting temperature curves for different parts, according to this magnetic ephemeris, he found *inter alia* that there is a continual lag in the time at which the maximum and minimum points of the curve reach the stations lying to the eastward, *e.g.* a minimum point in the curve in the eastern part of the country corresponds to a maximum point in the west, and *vice versâ*. Prof. Hazen puts these theories to various tests, amongst them the passage of hot and cold waves across the United States, and he concludes that the outcome of these investigations must be a "bitter disappointment" to those who believe in an all-important influence, aside from heat, from the sun upon our weather changes. He admits that there is undoubted evidence that some influence does exist, but at present it appears to be masked by terrestrial conditions, which have yet to be studied and eliminated.

A NEW TELESCOPE FOR GREENWICH.—The *Observatory* announces that Sir Henry Thompson has offered the magnificent sum of £5000 to the nation, through the Astronomer Royal, for the purpose of buying a telescope for Greenwich Observatory. The instrument is to be expressly designed for photographic purposes, and, subject to the acceptance of the offer by the Government, will have an aperture of 26 inches. It will be made from the model of the equatorials used for the photographic chart of the heavens, but with double the dimensions of those telescopes. The guiding telescope will be the 12¾-inch Merz refractor, with a light tube. It is intended to house the new instrument under the Lassell Dome, on the top of the central octagon of the new Physical Observatory, now being built in the south grounds of the Royal Observatory.

OCCULTATION OF SPICA.—On the morning of Good Friday the bright star Spica will be occultated by the moon. At Greenwich the disappearance takes place at 4.5 a.m. at the position angle 123°, and the star will reappear at 5.13 a.m. at position angle 297°, the angles being read from north in the direction north, east, south, west. The occultation will be visible at places between latitudes 79° north and 16° north, which are not too far from the meridian of Greenwich. The moon will be a little past full at the time.

NEW NEBULÆ.—Dr. Max Wolf announces in *Astr. Nach.* 3214, that several new nebulous patches appear upon photographs of the regions round β and δ Cassiopeiæ, taken at the end of last year and the beginning of this, with exposures of about sixteen hours. Three of these spots have the following positions:

	h. m.		
R.A. ...	0 49·0	Decl. ...	60·20
,, ...	0 51·9	,, ...	60·5
,, ...	1 38·0	,, ...	59·5

THE MINUTE STRUCTURE OF THE NERVE CENTRES.

THE Croonian Lecture was delivered by Prof. Ramon y Cajal at the Royal Society on March 8. After giving a short historical survey of his subject and referring to the work of Kölliker, His, Van Gehuchten, Waldeyer, Edinger, Von Lenhossék, A. Sala, P. Ramon, and Retzius, Prof. Cajal proceeded to give an account of his own work, and pointed out in what particulars his results differed from those of Camilo Golgi, the originator of the silver impregnation method. Golgi had shown that the protoplasmic expansions of nerve cells terminate by free extremities in the grey matter, that the prolongations of the nerve cells give off in their course through the grey matter very fine ramifying collateral branches, and that two types of cells may be distinguished—a motor type, distinguished by an unbranched axis cylinder, which becomes continuous with a fibre in the white matter, and a sensory type, distinguished by possessing an axis cylinder which on leaving the cell divides so freely that its individuality is lost as it ramifies in the grey matter. Within the grey substance a network of fibres is formed by the terminal twigs of centripetal nerve fibres, ramifications from the network derived from sensory cells, and collaterals of protoplasmic processes of motor cells.

Passing on to the results of his own work, Prof. Cajal showed that axis cylinders, in addition to the protoplasmic prolongations, end by free terminations in the grey substance. He does not admit that there is any sharp functional difference between the

motor and sensory cells, since morphologically motor cells are found in the olfactory bulb and the retina, and Golgi's sensory cells are sparsely found in the same regions, and, consequently, it is impossible to deduce the function of a cell from its shape and mode of branching.

The connection of the axis cylinder with the sensory cells of the grey matter is not by the mediation of a network, but by free arborisations around cells.

In birds and mammals the cells in the root ganglia have an axis cylinder which extends from the periphery, and the internal branch, entering the cord by the posterior root, bifurcates in the white matter. An ascending branch can be traced for several centimetres along the posterior column, and is found to end by arborisations around cells in the grey matter. The descending branch has a similar distribution. All branches, however, do not bifurcate. Collateral branches, long and short, pass off in bundles at right angles from the main branch and its bifurcations; the destiny of the short collaterals is the grey matter where their varicose arborisations surround the cells in the head of the posterior horn and the cells of Clarke's column. The long collaterals pass in a bundle from the ascending or descending branches and ramify in the substance of the anterior horn, where they come in contact with the bodies or the protoplasmic prolongations of motor cells. From this distribution it is obvious that the extremity of the long collateral is in contact with the body or the protoplasmic processes of the motor cell. For this reason Prof. Cajal speaks of the long collaterals as "*sensitivo-motor*," though Kölliker's term "*reflexo-motor*" enables the physiology of these to be the more easily grasped.

The grey matter of the cord contains at least four types of cells—the *commissural*, where the axis cylinder of the cell is in connection with the opposite antero-lateral column by way of the anterior commissure, cells in connection with the antero-lateral and posterior columns of the same side, motor cells in connection with the anterior root and "*pluricordonal*" cells, where a complex axis cylinder furnishes two, three, or more medullated fibres in connection with the columns of one side or of both.

Cajal holds that, according to the strength of the excitation, impulses entering by the posterior root may pass by the long collateral to the motor cells, and the expression of this is a reflex, or where the excitation is stronger, besides this route, the short collaterals as well as the ascending and descending branches of the bifurcated sensory fibres may conduct, in consequence of which other cells are thrown into activity.

Cajal considers the retina as a nerve ganglion formed of three tiers of neurones, the first of which includes the rods and cones, together with their processes as far as the external granular layer; the second composed of the bipolar cells, and the third of the ganglionic cells.

The internal and external molecular layers are the regions where the connections of the neurones are established. The excitatory process, started in the rods and cones, passes along the bipolar cells, the ganglion cells, the fibres of the optic nerve, into the fusiform and pyramidal cells of the geniculate body and the corpus quadrigeminum.

The optic nerve contains also centrifugal fibres which terminate by varicose arborisations around the spongioblasts of the retina, to which they carry impulses started by nervous excitations of central origin, the significance of which is obscure.

In the cerebellum a transverse section shows three concentric layers of neurones; the first, or molecular layer, consists of small stellate cells, the second of the cells of Purkinje, and the third of the granular layer. All these elements have connections of two kinds—intrinsic, which place the cells of the three layers in connection with each other, and extrinsic between the cerebellar neurones and the neurones of other nervous organs.

The connections of the granules, which are nervous organs, with the cells of Purkinje, are of great interest. The former possess three or four very short protoplasmic processes, each of which breaks up into an arborisation. An axis cylinder of exceeding fineness passes up to the molecular zone, bifurcating at various levels. During their course they come into intimate contact with the protoplasmic processes of the cells of Purkinje. Since each of these parallel fibres traverses the total thickness of the grey matter of a cerebellar convolution and ends by free extremities at the surface, it follows that a single granule is able to act on a multitude of cells of Purkinje. Each of these last is under the influence of a considerable number of granules.

The extrinsic relations (those between the cells of the cerebellum and those of other nervous centres) are very difficult to establish.

As Golgi first showed, the cells of Purkinje give rise to nervous prolongations of the long type of which the termination is unknown, and, on the other hand, there end in the grey matter of the cerebellum axis cylinders coming from other organs, of which the situation is very uncertain. These are the *fibres moussues* and the *fibres grimpantes*. The *fibres moussues* terminate in the molecular layer by collateral processes which are in contact with the protoplasmic expansion of the granules. The ultimate twigs terminate in a varicosity, or in a small ramification. The *fibres grimpantes* traverse the granular layer, coursing along the cells of Purkinje, and surrounding the ascending stem and the proplasmic branches with an elongated terminal arborisation quite comparable with that of a motor fibre in muscle.

It appears therefore that the cells of Purkinje may receive nervous impulses from other centres, either by means of the *fibres moussues*, or by means of the *fibres grimpantes;* whilst the small stellate cells of the molecular layer, as well as the large stellate elements of the granular layer belong to the second type of Golgi's cells, appearing to have no relations with the extrinsic fibres. These last cells are therefore styled "*association corpuscles*," as they appear to have for their exclusive rôle the association of the cells of Purkinje, or the granules, into a dynamic whole of which the significance is unknown.

In the cerebral cortex, for the sake of clearness, three main layers may be distinguished, a molecular layer, a layer of large and small pyramidal cells, and a layer of cells of various shapes. The molecular layer, which is always found in the brains of vertebrates, is formed of a very complicated plexus, the principal factors of which are the peripheral ramifications of the pyramidal cells, the terminal nervous arborisations of certain cells of the pyramidal layer of which the axis cylinders are ascending, and the ramifications of certain cells of fusiform or triangular shape, the greater part of whose expansions become horizontal, and resolve themselves into a large number of twigs. One may compare these elements with the spongioblasts of the retina and with the granules of the olfactory bulbs, as they also are without a differentiation into protoplasmic and nervous expansions.

The layer of pyramidal cells, the thickest layer of the cortex, consists of many elongated cells of pyramidal form, the principal characteristic of which is the possession of a protoplasmic stem, terminating in the molecular layer as a more or less horizontal arborisation of fibres, covered with spiny processes, and giving off many lateral and descending protoplasmic branches, and finally giving rise to a descending axis-cylinder continued to the white substance. The last layer consists of cells of variable form, usually elongated, one of the prolongations very often going towards the surface. The axis cylinder penetrates the white substance, and resembles that of the pyramidal cell.

In their passage through the grey matter all the axis cylinders of the pyramidal cells and the cells of variable shape give off a large number of ramifying collaterals, which terminate freely around the nerve cells. The whole of the ramifying collaterals form in the grey substance, and around the cells, a plexus of extreme complexity, in which are also present ramifying collateral twigs from the white substance and terminal arborisations of fibres of association.

The connections of the pyramidal cells of the cortex may be distinguished as *superficial* (belonging to the molecular layer) and *deep* (belonging to the subjacent layers).

In the molecular layer each protoplasmic "plume" of the pyramidal cells is in contact with an almost infinite number of terminal nervous fibrillæ derived from the terminal arborisations of fibres of association originating in cells in the hemisphere of the same or of the opposite side; from special cells in the subjacent layers; from special cells in the molecular layer itself; from collateral fibres from the white substance, or from the deep layers of the grey substance, and from other situations.

In the molecular layer, then, each pyramidal cell may be influenced not only by the cells of the same region of the cortex, but also by others which lie in other lobes, it may be of the same side or of the opposite side of the brain. It is also probable that the molecular layer receives the ultimate ramifications of

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