In considering the spheres of usefulness of such lamps as are at present available, we recall first of all the considerable number of industries in which "grading" and estimations of quality of products by visual appearance are of the greatest importance. Tea, leather, tobacco, seeds, flour, and many other materials are all judged by colour, and until the modern daylight lamps were available a very great deal of time was lost owing to the lack of good daylight often experienced during the winter in industrial towns. So far as can be judged, however, artificial daylight has proved entirely satisfactory for purposes of this kind when sufficient care is employed in choosing a lamp suitable for the work in hand. A jeweller requires a strong light concentrated in a small area, and for this work one of the lamps with a focussing reflector would be best. On the other hand, for warehouse lighting a lamp giving good diffusion, such as the Sheringham Daylight, may prove the more suitable. The fully corrected lamps have been adapted for studio lighting by artists, and for counter illumination in drapers' shops and elsewhere. Fig. 2 shows a "Lamplough" transmission unit in use for grading pigments at Messrs. Winsor and Newton's.

Persons with experience of work with the artificial daylight units learn to adapt their estimations to the relatively constant light of these lamps, and less difficulty is often experienced than in working with highly variable daylight.

The "higher efficiency," and less fully corrected, lamps are applied with success for the lighting of shop windows by drapers and florists. A great improvement in colour values is secured without undue expense. The main factor militating against the employment of artificial daylight for general lighting seems to be a

purely psychological one. Objection is taken to the "cold" appearance of the light when contrasted with that from ordinary lamps, but after all the matter is scarcely of importance if the corrected light is readily available when required.

It may be recalled that the difficulty of obtaining a reasonably constant standard of white light is one of the greatest difficulties in the application of colorimetry for modern industrial purposes. Stanford (*Biochemical Journal*, xvii. No. 6, 1923) has recently pointed out the usefulness of an artificial daylight lamp (the Sheringham lamp was actually used) for purposes of colorimetry with limited range colorimeters,¹ and for many chemical estimations, such as comparisons in Nessler cylinders. Artificial light corrected thus, or by a suitable filter of daylight glass, or by one of the laboratory methods described above, is of the greatest service in the more general problem of colour measurement which is being investigated with much energy in Germany and America at the present time, although the subject seems to attract little attention in Great Britain.

In conclusion, one might comment perhaps on the lack of interest shown by commercial firms in the subject of artificial daylight, and the improvement of lighting generally. In 1920 there were 15,000 fully corrected artificial daylight lamps in use in America, and the demand was then rapidly growing. In Great Britain it is doubtful whether a tenth of the American demand has been reached. The saving of time effected by the employment of such lamps in bad weather is so great that this indifference seems extraordinary, and the sooner this state of affairs is remedied the better for those industries to which this subject is of importance.

¹ See "Colour and Methods of Colour Reproduction" (Blackie), p. 114.

The Plant Commonwealth and its Mode of Government.¹

By Sir FREDERICK KEEBLE, C.B.E., F.R.S.

TO describe in any detail the different kinds of receptor, or receiving apparatus, whereby an external stimulus of light, gravity, etc., is registered by the plant, lies beyond the purpose of this discourse. It is, however, essential to that purpose to point out that the region of reception of the stimulus is often separated by some distance from the region of reaction. Cut or burn the root of a sensitive plant, and presently the leaves begin to move. First, those nearest to the base of the stem bend down hingewise on the leaf cushion (pulvinus) and their leaflets fold together; then in succession those higher up the stem undergo a like series of changes, until all have soon reacted to the shock. Place a root on its side and its growing region an inch or so behind the tip, elongating more on the upper than on the lower side, initiates a curvature which continues until the tip points again vertically downward. But if, as Darwin showed, the tip be cut off before the root is placed in a horizontal position, no curvature occurs until a new root-tip has been regenerated. In the intervening days the root continues to grow horizontally. Cover or cut off the tip of the first leaf of a grass seedling and the actively elongating

region fails to respond by curvature to one-sided illumination.

It is therefore evident that there is often a definite separation of receptor and effector region, and one of the most interesting problems in plant physiology is to discover how that gap is bridged. In animals nerves serve to connect the receptor organs—the receivers of specific stimuli—and the effector organs—the structures which respond by movement or other definite changes. But though many have sought for and some have thought to find them, those specialised conductors of excitation which are called nerves appear to be absent altogether from plants. Some have believed that the intercellular protoplasmic fibres serve like nerves to conduct impulses. It may be so, but facts are not very favourable to this interpretation of their function. It would, indeed, seem more probable that the protoplasmic intercellular strands serve to transmit not nervous impulses but materials from cell to cell.

There is, however, no need to carry these speculations further, since recent discoveries have thrown a new light and put a different complexion on the mode of transmission of excitation in plants. If a little mica plate be inserted into a cut made half way across the

¹ Continued from p. 15.

tissue of the first leaf of an oat seedling at a short distance behind the receptive tip, excitation resulting from unilateral illumination is transmitted as in intact plants. But if a second plate of mica be inserted in a second cut made on the opposite side at a slight distance from the first no curvature results; the plant remains unresponsive to unilateral illumination. Similarly, as might be supposed, if the tip be cut off completely and replaced so that it rests on a plate of mica introduced between it and the rest of the leaf, curvature does not occur. But if the tip be cut off and glued on again with gelatin, unilateral illumination induces the same curvature as it does in the intact oat leaf. The receptor apparatus in the tip suffers no damage from the operation, and undergoes the same excitation as in the normal plant. This excitation passes through the gelatin to the intact effector region and brings about in that region redistribution and changes in rate of growth which are made manifest by curvature.

There would, therefore, appear to be no escape from the conclusion that that which passes from receptor to effector regions is a stimulatory substance—a hormone. The message transmitted by the receptive tip to the reacting region is a chemical message. As a letter in the post-bag may pass many doors and cause no stir until it is delivered at the right address, so the hormone which evokes heliotropic response passes through or by many cells without, so far as is known, producing any effect upon them. It is not for their address. Only when it reaches the cells beyond the growing point which have ceased to divide and begun to grow in length and breadth does the message which the hormone bears become significant. Similar beheading and reheading experiments have been made by Mr. G. R. S. Snow in my laboratory. Although it might seem unduly sanguine to expect anything to happen after a root tip has been cut off and stuck on again, the experiment, which has now been repeated many times, demonstrates that the receptive tip, after the operation, responds to the stimulus of gravity stimulation, and that the message which provokes curvature in the growing region is transmitted across a gelatin junction. For if after replacement of the cut off tip the root is laid in a horizontal position, instead of remaining in that position as a tipless root does, it curves until the tip points once again vertically downward.

No less remarkable are the discoveries which have recently been made by the Italian physiologist, Ricca, on the much investigated subject of the movements of the Sensitive plant, *Mimosa pudica*, and allied sensitive species. The movements of this plant have often been described and always excite wonder. In tropical countries, where the Sensitive plant grows close to the ground and covers large tracts, any one who walks over it may see the leaves bending down and folding up as his foot approaches, as though the plants were shrinking from impending danger.

Many explanations have been offered of the significance of these movements; but none seems satisfactory. Extreme sensitiveness to contact is not peculiar to the species of *Mimosa*. It is manifested also by other genera of plants, by *Neptunia*, which, like *Mimosa*, belongs to the Legume family, and by

Biophytum, e.g. *Biophytum sensitivum*, a member of the Geranium family. A recital of all the interesting experiments which have been made on *Mimosa pudica* from the time of Claude Bernard to the present day is beyond my powers or your patience. Nor is the recital necessary for my present purpose, for the new classical experiments of Ricca, and the as yet unpublished experiments made recently by Mr. Snow, throw new light on the nature of the message which passes to the leaves when the plant is stimulated as it may be by tapping, shaking, cutting, or burning a part of it. Working with strong-growing woody species in the congenial climate of Italy, Ricca has shown that the excitation set up by stimulating a part of the stem travels in the wood. Even after all the other tissues of the stem are removed the excitation continues to pass upward and to bring about progressively the characteristic movements of the leaves. If a length of stem above the point to be stimulated is killed, as, for example, by subjecting it to high temperature, the message still passes and is delivered to the living leaves above the killed region of the stem.

That the excitation is of a chemical nature is shown by cutting the stem, interposing a short tube containing water between the severed ends, and then stimulating the lower part of the stem. Even under these untoward conditions the message is delivered. The hormone, rising with the water current up the vessels, diffuses through the column of water in the glass tube and, passing into the vessels above the cut, travels along them, and at each level at which a leaf is borne, the hormone passes into the motile pulvinus and excites its tissues, so that the turgid cells of the under side of the pulvinus lose water and resilience and, becoming flaccid, no longer bear up the leaf stalk, which therefore falls like a flag at half-mast. As in old times, a knock-up went round the town leaving his noisy message at the appointed doors, so the hormone, albeit more discreetly, travels through the watery highways of the plant delivering its chemical message as it goes.

Research, however, whilst unveiling old mysteries discovers new ones, and Mr. Snow, who has just come back from studying the behaviour of Sensitive plants in the West Indies, informs me that whilst he has confirmed Ricca's remarkable results, and has shown that the hormone which travels through the wood may be made to diffuse across a film of collodion without losing its potency, has also discovered that this is not the whole of the story. Transmission of excitation in the Sensitive plant is apparently of two kinds. There is the relatively slow transmission of a specific hormone by way of the wood vessels of the stem; but there is also a high-speed transmission, far more rapid and much less far-reaching. When this high-speed transmission of excitation is employed by the stem, the track which it follows is not that of the wood vessels, nor does it lead to movement of more than two leaves above the point of stimulation.

Mr. Snow has demonstrated the existence of these two modes of transmission by the simple device of making very gradually an oblique cut in the stem. As the knife penetrates into the deeper tissues below the cortex—which tissues are known as the phloem or bast—a drop of fluid exudes from the cut. It used to be supposed that this exudation, which escapes from

certain long tubular cells, is the sign of some hydrostatic disturbance in these cells, and that this disturbance leads to the setting up of a pressure wave which evokes the movement of the leaves. But if the knife be stayed at this point, though the water drop gushes out, nothing else happens. Let it, however, be pressed a little so that it penetrates deeper into the bast and reaches to, or almost to, the cambium, which lies between bast and wood, and suddenly the high-speed transmission takes place; in a flash, the nearest two leaves fall. If the knife be withdrawn no further excitation takes place, but if it be pushed home into the wood, the second more leisurely mode of transmission comes into play. The chemical messenger which travels into the water current in the wood vessels is released and, slowly but surely, as the transpiration current rises through the stem, leaf after leaf falls until all have shown by their position that they have received and responded to the message.

These observations come opportunely. Without them I should have been tempted to round off my discourse with a confident generalisation. The varied happenings in the plant commonwealth which I have described—the revival of powers of cell-division in wounded tissues, the heliotropic curvatures of roots and stems, the ordinary response of the Sensitive plant to shock—all are brought about by specific chemical messengers or hormones. Many other phenomena of plant response to stimulation are undoubtedly also due to hormones. May it not therefore be that the mode of government of the plant commonwealth is not duplex, like that of animals, but simplex? Whereas

the integration of the animal body into an individual is the outcome of messages of two kinds, the integration of the plant body is effected by messages of one kind only. In the animal body, the two kinds are those messages transmitted at high speed along the nerves and those material messages or hormones, which are distributed by means of the blood stream. In the plant body, messages of the latter kind only are at present and with certainty known to pass to and fro between the members of the commonwealth.

Until, however, the nature of the high-speed transmission of excitation in *Mimosa* is explored, it would be rash to predict confidently that the fundamental difference between plant and animal will be found to lie in this, that the plant commonwealth has not and never had the means of rapid message-sending which in the animal world takes place by means of the nervous system, and that the passionless perfection of plants has been achieved solely by developing the system of special messengers. Or adopting Bayliss's metaphor: If the integration of the animal is to be regarded as due to the simultaneous employment of a telegraph system and a postal service—one for quick messages which may be of a physical kind, the other for less rapid messages of a material kind—then it may be that the integration of the plant commonwealth has been and is effected solely by the employment of the postal system. One—the animal world—partakes rather of the nature of an empire, and the other—the plant world—partakes of the nature of a commonwealth, and if so the title of my discourse needs no further justification.

Obituary.

PROF. J. G. LONGBOTTOM.

THE death has been announced, at the early age of fifty-four, of Prof. John Gordon Longbottom, of the Royal Technical College, Glasgow, which occurred on June 6 after a serious operation. Prof. Longbottom was a native of Keighley, Yorkshire, and served his apprenticeship in engineering in the works of Messrs. F. and J. Butterfield. His technical education was received at the Bradford Technical College, and a Whitworth Scholarship enabled him to proceed to the Royal College of Science and University College, London, where he became an assistant to Prof. Karl Pearson. About twenty-eight years ago he joined the staff of the Royal Technical College, Glasgow, and became professor of mechanics on the retirement of the late Prof. Rowden.

Prof. Longbottom was very retiring, and consequently his abilities were not widely known outside the College. His mathematical knowledge and his power of applying it to practical problems were of great advantage to his students, who will remember him not only for the soundness of his work, but also for the kindness of his disposition. His appointment was made prior to the erection of the new buildings of the College, and he was therefore responsible for the equipment of the Materials Laboratory—an installation which is worthy of the College. He was a member of the Institution of Mechanical Engineers and of the Institution of Engineers and Shipbuilders in Scotland; he contributed to the latter Institution a paper on the stresses on the rim and arms of a flywheel.

PROF. IAN DEYL.

PROF. IAN DEYL, who died on February 4 in Prague, was born in 1855 in Vysoké Veselí nad lidlinon, and prepared himself for the duties of an all-round practical surgeon. But at last he became an ophthalmologist. I cannot dwell here on his numerous original investigations so far as they refer to medicine, of which the most interesting ones treat of the relations of eye diseases to the diseases of the body. He solved in fishes and birds the most complicated problem of the embryology of the mechanism of the eye, namely, the way in which the crossing of the eye-nerves on the lower part of the skull takes place.

Deyl was a member of the Bohemian Academy of Sciences, of the Royal Society of Bohemia, of the Ophthalmological Society, etc. He was of noble character and a great benefactor of the blind, and an institution for the blind bears his name.

BOHUSLAV BRAUNER.

We regret to announce the following deaths:

Dr. C. E. Moyse, emeritus vice-principal of McGill University, Montreal, aged seventy-two.

Sir Jethro Teall, F.R.S., lately Director of the Geological Survey of Great Britain and of the Museum of Practical Geology, London, on July 2, aged seventy-five.

Sir Harry Veitch, formerly vice-president of the Royal Horticultural Society, on July 6, aged eighty-four.