The Relation of Growth Substances to Horticultural Practice*

By Dr. M. A. H. Tincker, Royal Horticultural Society, Wisley

MUCH of our recent knowledge of plant hormones we owe to the Utrecht botanists, whose investigations led to the recognition of the nature and function of these substances. Earlier experiments carried out with seedling oats showed that the shoot apex produced substances capable of regulating growth. When cut off and placed on gelatin, quantities exuded from the tips of the active substances proportional to the number of seedlings used for a fixed period of exudation. These substances could be transferred to other seedlings. A wide search was made for a ready source of these compounds, found to be present in small quantity in grain, pollen and leaves. Higher concentrations are available in urine.

At the Leicester meeting of the British Association Prof. F. Kogl described the isolation and chemical recognition of auxin *a* and *b*. Their structure is complicated ; but with these two compounds a third active compound, hetero-auxin, was found. It is a simpler chemical, β-indolyl acetic acid, previously well known to chemists.

Small quantities (5 mgm.) of indolyl acetic acid when applied in lanolin, a convenient solvent, to the young stems of tomato plants growing vigorously, cause within 24 hours twisting and bending of the petioles and stems, as unequal growth takes place on the two sides. This is a quick ready means of testing closely related and other chemicals. In a few days, roots appear from the stem, root initials also develop inside, clearly seen by cutting the stem longitudinally. Similarly, the production of roots may be induced in severed portions of plants, and this is the practical point, for vegetative reproduction is thus facilitated.

The paste method has been largely superseded by dilute solutions. Herbaceous or woody cuttings are taken with expanded leaves, their basal ends placed in the solution to a depth of an inch ; owing to the loss of water in transpiration from the leaves, sufficient solution is taken up to induce subsequent root production when the cuttings are placed, after washing in water, in sand in propagating frames.

The list of active chemicals includes the related indolyl butyric and indolyl propionic acids. The organic salts or esters of these acids are active, so are some of their metallic salts such as sodium indolyl-acetate. Scatole has recently been proved active. Alpha and beta naphthalene acetic acid are very highly active, phenyl acetic and anthracene acetic acid are less active.

Although fairly closely related, iso-indolinone is inactive. The substitution of sulphur for the nitrogen and hydrogen group in indolyl acetic acid very greatly reduces the activity. Although closely related to indolyl propionic acid, tryptophan is inactive ; it may be a stage in the formation of the growth substance in Nature.

The treatment causes : (*a*) more cuttings to form roots ; (*b*) more roots to be formed on each cutting ; (*c*) the active process (including *a* and *b*) to be accelerated.

Amongst herbaceous plants, cuttings of lupins, delphiniums, pelargoniums, violas and alpine phlox have shown accelerated rooting by treatment with pastes in lanolin and with very weak solutions. There is a tendency to damage delicate tissue by the use of solutions of too high a concentration ; 1 part in 30,000 or 40,000 parts of water is recommended for such cuttings.

With holly, taken at the end of June and treated with indolyl acetic acid, 1 part in 10,000 of water for 24 hours, half the cuttings rooted in 6 weeks whilst none of the controls, placed in water for 24 hours, rooted in this time. With *Viburnum Carlesii*, cuttings taken at the end of July and treated with alpha naphthalene acetic and others with indolyl acetic, 1 part in 10,000 of water for 24 hours, rooting took place rapidly. In ten days, the active growth taking place inside the stem split the outer layers. Cuttings of *Ceanothus dentatus* taken in late November produced roots in January, and *Myrtus communis* cuttings taken in January rooted in a month. Stimulation may occur at a season of normal quiescence.

Species and varieties of heather (*Erica*) responded quickly to alpha naphthalene acetic acid, *Pieris formosa* taken in late August and *Gaultheria procumbens* have given favourable results. With *Rhododendron rubiginosum*, 85 per cent of the cuttings treated in alpha naphthalene acetic acid and indolyl acetic acid, 1 in 20,000 for 48 hours, rooted in three months, whilst only 5 per cent of the controls form roots. Other plants tested include species of *Buddleia*, *Camellia*, *Deutzia*, *Escallonia*, *Hydrangea*, *Pernettya*, all of which showed favourable results by these methods. Even with the more recalcitrant genera and species some encouraging results have already been obtained. Further results are reported in tests made by horticultural and chemical firms, and at other research stations and laboratories. These greatly extend the list of species in which root formation has been accelerated. Certain species may yet prove quite unresponsive but the indications are to the contrary, provided the time of year and concentration of solution can be correctly selected.

The concentrations are surprisingly low, for frequently 1 in 40,000 of water is effective. It appears from certain *ad hoc* tests that there is a critical concentration below which little or no activity is induced. Twice the length of time for uptake from a solution half as concentrated may not be so effective as a stronger solution used for the given time.

Pouring solution on to the sand before inserting cuttings is not recommended, as bacteria interfere. Freshly made solutions should be used as moulds and bacteria may contaminate them if kept. Since the solutions are not stable in light, storage in coloured and opaque vessels at higher concentration is recommended.

The success obtained has been quickly appreciated

* Substance of a lecture to Section K (Botany) of the British Association, delivered at Nottingham on September 3.

by chemical manufacturers and by horticulturalists. There are now a number of solutions readily available on the market in many countries.

Thus it is seen that investigations, primarily of botanical interest, dealing with fundamental problems of plant development, have quickly led to results of much interest and value to the practical man; showing once more the relationship of science and its discoveries to everyday life, to industry and to recreational pursuits.

The Teaching of Geology in Schools

JUST over two years ago, at the Norwich meeting of the British Association, Section C (Geology) appointed a committee to report on questions affecting the teaching of geology in schools. A short report was presented at the 1936 meeting of the Association, and, at the suggestion of members of Section L (Education), an extended report giving detailed proposals was prepared for the Nottingham meeting. These reports were discussed in a joint meeting of Sections C and L, at which Mr. H. G. Wells presided, on September 7.

The views of the geologists were explained by Prof. A. E. Trueman, who opened the discussion, Prof. G. Hickling, Prof. W. W. Watts, Prof. L. J. Wills, Sir Lewis Fermor and Prof. P. G. H. Boswell. It was pointed out that, while geology has never figured very prominently in school curricula, many pupils were formerly introduced to it, for example, on field excursions, by teachers who had received some training in the subject, but that few intending teachers at present are encouraged to include it in their university or college courses. While appreciating something of the difficulties of the overcrowded curriculum, it was felt that geology should be more widely included in school courses. The Committee did not press its claims in competition with any other subject; in general, while it wished to secure the inclusion of some outlines of geological knowledge in all science courses in secondary schools (for example, as a part of schemes of 'general science'), it only asked, in addition, that geology should be included as an optional subject at more advanced stages. The inclusion of some geology in the scheme of informative education outlined by Mr. Wells in his address to the Education Section was noted with keen satisfaction.

Both the cultural and utilitarian aspects of geology were emphasized. It is one of the richest of cultures, stimulating a broader interest in the outside world and increasing the appreciation of scenery. On the other hand, it is an eminently useful science with numerous and obvious applications in mining, engineering and agriculture. It was suggested that geology should form an essential part of the school curriculum in mining and industrial areas, partly on account of its economic importance, partly for the wider interest it would give to later life.

The syllabuses proposed by the Committee are intended only as suggestions, and great elasticity of treatment appears to be desirable in the case of geology even more than in other sciences, the bias and the arrangement of the various topics depending largely on the location of the school.

In the senior elementary schools there is more opportunity for variety of treatment, and a rather practical bias is suggested. Dr. W. K. Spencer described some of the work carried out in such schools.

The lack of any courses in geology in most schools was held responsible for the present dearth of trained geologists; Prof. Hickling and Prof. Watts pointed out that while the supply is thus restricted the demand for geologists is increasing. It was emphasized that there are attractive careers in this field for a number of men of ability and good physique.

Two teachers who took part in the discussion expressed rather different points of view. First, Mr. James Davies, one of the few teachers who are actually teaching geology in secondary schools, indicated the nature of his courses. In pleading for a wider adoption of geology he spoke of the attractiveness of the subject and said that there is nothing more inspiring than leading a party of young people over hill and dale (his school is in South Wales). As an example of the chance of a beginner in geology making new discoveries, he mentioned the first recognition of a marine band in the Coal Measures by one of his pupils. In his school, both geology and geography appear in the curriculum. On the other hand, Mr. V. C. Spary, speaking as a teacher of geography, expressed fears that the introduction of geology into the time-table could only mean the displacement of geography. He agreed, however, that a well-balanced course of geography must include many lessons of a geological nature, for "geography teachers must borrow a great deal", and he thought it a great advantage for teachers of that subject to have some geological training.

Mr. Wells agreed with Mr. Spary that the teaching of geology as a specific subject is not highly desirable until an advanced stage in education is reached, but thought that reference would nevertheless be made at earlier stages to the geological record when teaching biology, and to physiography in teaching geography. He went on to inquire what constitutes geological training when the biological and physiographical sides are taken away. In reply to these questions it was insisted that palæontology and physiography are branches of geology, and while it may be convenient to treat them in relation to other subjects in the curriculum, it is desirable that the pupils should know that they are then learning geology. Anxious as they are to see their subject taught in schools, geologists would much prefer to have it taught under its own name.

In the course of the discussion, there was no real criticism of the view that geology should be taught in schools; there was, however, this difference of opinion as to whether it should appear as a separate subject except at more advanced stages (for example, at the Higher School Certificate stage). The inclusion of the subject as a part of a course in 'general science' would possibly be the most satisfactory solution in many schools, up to the stage of the School Certificate, as the Committee had recommended.

In connexion with the discussion, Prof. H. H. Swinnerton arranged an interesting exhibit to show a course of simple experimental work in geology suitable for schools.