in this series was growing, apparently because its nodules had been invaded by the fine endophyte *Rhizophagus tenuis*. This has occurred spontaneously in open pot cultures of *Griselinia littoralis*[4], but has not been reported previously in podocarps.)

Similar results were obtained with *Agathis australis*, of which six seedlings had been inoculated with whole and seven with crushed spores. Four which had received a whole inoculum and one which had received a crushed inoculum developed a typical vesicular–arbuscular infection and resumed growth; in the rest the buds remained unbroken and the roots uninfected. Initial differences in size were too large for a significant difference in weight to develop between these mycorrhizal and non-mycorrhizal plants in a single season, so an earlier experiment in which this was obtained ($P < 0.05$) should be recorded. On this occasion newly germinated seedlings were grown for 5 months in soil from beneath *Griselinia littoralis* and then transferred for 21 months into a mixture of steamed, crushed rock and steamed humus (2 : 1 by volume). Three seedlings developed mycorrhizas and a mean dry weight of 3·04 g. The other six plants ceased to grow and averaged only 1·37 g.

Honey coloured sessile spores were recovered from root washings of all mycorrhizal plants except those infected by means of Griselinia soil or by *Rh. tenuis*. Many had the pale colour of newly formed spores and the characteristic formative structure was often seen.

It is interesting that Endogone mycorrhizas have stimulated growth in an inorganic soil because the soil organic matter seems to influence natural infections[5], and because a nitrogen fixing system is sometimes associated with podocarp nodules[6]. Growth was less than in the soils with organic matter, and it may prove to be brief.

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[1] Mosse, B., and Bowen, G. D., *Trans. Brit. Mycol. Soc.*, **51**, 469 (1968).
[2] Nicolson, T. H., and Gerdemann, J. W., *Mycologia*, **60**, 313 (1968).
[3] Kahn, A. G., *Nature*, **215**, 1170 (1967).
[4] Greenall, J. M., *NZ J. Bot.*, **1**, 389 (1963).
[5] Nicolson, T. H., *Sci. Prog. Oxf.*, **55**, 561 (1967).
[6] Bond, G., *Ann. Rev. Plant Pathol.*, **18**, 107 (1967).

Amino-acid Receptor in Larvae of *Pieris brassicae* (Lepidoptera)

Behavioural studies have indicated that some invertebrates can detect amino-acids, but physiological information is limited to amino-acid receptors in some Crustacea[1] and in two Ixodid ticks[2]. I report here a receptor in an insect which is sensitive to all twelve amino-acids tested.

The maxillae of lepidopterous larvae bear two sensilla styloconica, both with a gustatory function but differing in physiological characteristics. In larvae of *Pieris brassicae* L, one of the four chemoreceptor cells present in the lateral sensillum is sensitive to mustard oil glucosides[3], compounds which typically occur in the Cruciferae, their natural food. A second cell is stimulated by sucrose[3], and a third cell seems to be sensitive to amino-acids.

The amino-acids to be tested were dissolved in 0·5 M NaCl, and the sensilla were stimulated with a capillary which at the same time served as the recording electrode[3]. Tests with control solutions (0·5 M NaCl) revealed some, presumably spontaneous, action potentials in one or two cells. Addition of 0·1 M L-proline, L-cysteine or DL-methionine resulted in a strong stimulation of one of the chemoreceptor cells with, for example, an average frequency of fifty impulses during the second second of stimulation for L-proline. The amino-acids L-serine, L-leucine, *S*-methylcysteine and γ-aminobutyric acid (concentration

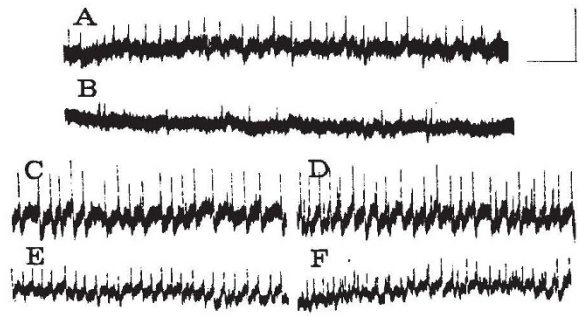

Fig. 1. Chemoreceptor responses of the lateral maxillary sensillum styloconicum when stimulated by various chemicals. All solutions contain 0·5 M NaCl. *A*, 0·1 M L-cysteine; *B*, control, 0·5 M NaCl; *C*, 0·001 M sinigrin; *D*, 0·001 M sinigrin + 0·1 M L-cysteine; *E*, 0·1 M sucrose; *F*, 0·1 M sucrose + 0·1 M L-proline. All records start 1 s after the onset of stimulation. Calibration, 50 μV and 0·1 s.

0·1 M) also stimulated, but to a somewhat lower degree. The least stimulating compounds were *S*-methyl cysteine sulphoxide[4], DL-alanine, L-glutamic acid and glycine. A concentration of 0·1 M, however, still produced a distinct reaction with average frequencies of between twenty and thirty impulses, whereas the control produced only eleven impulses/s on average.

When the various compounds were tested at lower concentrations, the reactions decreased accordingly. From such experiments it was inferred that the threshold values for L-proline, DL-methionine, L-cysteine and L-cystine are probably about 10^{-3} M or possibly even lower.

I wished to test whether the concentrations of free amino-acids in plant tissues are high enough to stimulate this cell in natural conditions—that is, during feeding. Unfortunately no detailed quantitative information was available about free amino-acids in cabbage leaves, but a mixture of amino-acids in concentrations corresponding to those in potato leaves[5] provoked reactions of considerable intensity. In four insects an average of twenty-eight impulses was measured during the second second of stimulation, as compared with eleven impulses in the controls. This observation strongly suggests that free amino-acids are natural stimuli to this chemoreceptor.

The high activity of some amino-acids containing sulphur is interesting in view of their fairly high concentrations in cabbage.

To test the possibility that the amino-acids stimulated either the mustard oil glucoside receptor or the sugar receptor, an amino-acid was added to a solution of sinigrin (Fig. 1*C–D*) or sucrose (Fig. 1*E–F*). These mixtures elicited activity in two cells, whereas when tested individually the compounds predominantly stimulated only one cell. I therefore conclude that the lateral sensillum styloconicum contains a separate receptor cell which is sensitive to amino-acids.

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[1] Hodgson, E. S., *Symp. Zool. Soc. Lond.*, **23**, 269 (1968).
[2] Elizarov, Yu. A., *Zool. Z.*, **44**, 1461 (1965).
[3] Schoonhoven, L. M., *Koninkl. Ned. Akad. Wet., Proc. Ser. C*, **70**, 556 (1967).
[4] Synge, R. L. M., and Wood, J. C., *Biochem. J.*, **64**, 252 (1956).
[5] Kaspers, H., *Biol. Zbl.*, **78**, 461 (1959).

Inhibition of Hypostome Formation and Polarity Reversal in Hydra

Regeneration of *Hydra littoralis* is usually strictly polarized in the sense that distal structures such as hypostome and tentacles always form at the distal cut