Plant morphogenesis

Oligosaccharide floral messages?

from Keith Roberts

ON page 615 of this issue, Peter Albersheim and colleagues present some initial results that clearly suggest new explanatory hypotheses for the normal growth and development of plants. Their general suggestion is that locked up in the bewildering array of very complex polysaccharides that form the plant cell wall there are short oligosaccharide sequences which, when released, form a set of important signalling molecules that plant cells can use in a variety of ways[1].

There are fundamental differences between the ways that plants and animals develop, most of which rest on the fact that plant cells are immobilized inside a relatively rigid cell wall. Since the wall precludes cell movement, orderly morphogenesis of plants and their organs must depend crucially on a combination of precisely positioned planes of cell division, and controlled and coordinated cell growth[2]. It is a salutory fact that we know very little either about the nature of the spatial controls, or about the molecular mechanisms involved in the determination and control of morphogenetic events. This great area of relative ignorance is all the more surprising when one considers that the plant kingdom offers wonderful experimental systems with unparalleled plasticity of developmental programmes, and that intensive research on plant growth regulators has been going on for over half-a-century.

The whole field is clearly in need of new models that can stimulate fresh approaches to the problem, and the suggestion that oligosaccharides are regulatory molecules provides a good start. The particular experiments reported on page 615, which demonstrate that artificially produced cell wall fragments can switch the experimentally induced pathway of morphogenesis in a model plant system, should be seen in the context of the more general hypothesis.

In the course of chemical work describing the variety of polysaccharides in the primary cell wall, Albersheim and his group found that oligosaccharides released in very low concentrations from the wall of the fungal pathogen *Phytophthora* triggers the expression of plant genes in a response that leads the plant to produce an antibiotic, or phytoalexin[3,4]. (Oligosaccharides that induce plants to produce phytoalexins are called elicitors and their role in stress and pathogenicity has been discussed recently in these columns[5].) It was later found that fragments of the plant cell wall, or endogenous elicitors, might also be involved in the response. This fact, linked with the general realization that signalling molecules in plants are probably small water-soluble molecules that seem not to include the peptide and amino acid derivatives used in animal cell signalling, led to the idea that cell wall oligosaccharides might be used more generally by plants as signalling ligands.

Albersheim coined the term oligosaccharins for regulatory molecules that are derived from plant cell wall polymers. Those that have been described so far are 7-15 sugar residues long and have all been obtained either by chemical or enzymatic degradation of the pectic or hemicellulosic fractions of the cell wall. The range of biological effects that oligosaccharins can elicit is wide and includes the inhibition of auxin-induced growth in peas and the inhibition of flowering in *Lemna*[6].

Scanning electron micrograph of flowers on a tobacco explant, each with an ovary surrounded by stamens. (Courtesy L. Jehanno and K. Tran Thanh Van.)

The new data, which considerably extend the 'oligosaccharin hypothesis' to include a possible regulatory role for oligosaccharins in normal organogenesis, come from a colloboration between Albersheim's group and that of K. Tran Thanh Van. In her elegant system of controlled morphogenesis in thin cell-layer explants of tobacco, controlled combinations of auxin, cytokinin, and *p*H are used to dissect the regeneration of roots, vegetative buds, floral buds or callus on the explants[7]. In the present experiments sets of oligosaccharides, one prepared chemically and the other enzymatically from cell-wall pectin, are shown to switch the expected pathway of morphogenesis at concentrations estimated to be no more than 10^{-8}-10^{-9} M. Thus, with one of the preparations, flower buds can be switched to vegetative buds at *p*H 3.8, but at *p*H 6.0 the switch is in the opposite direction. With the other preparation, flowers give way to vegetative buds at *p*H 3.8, roots are induced instead of only callus at *p*H 5.0, and at *p*H 6.0 calus and vegetative buds become callus and roots.

Although neither the chemical identity of the oligosaccharins involved nor any hints as to their mode of action are yet known, the effects themselves are very dramatic and immediately pose exciting questions about the possible role of the oligosaccharins *in vivo* and in the practical context of plant regeneration. The area of work in plant development opened up by oligosaccharin probes is enormous, and already collaborations are in hand to examine the changes in gene expression induced by them in this particular system.

What these experiments throw into very clear focus is our ignorance of the molecular events involved in cell signalling and recognition mechanisms in plants. As yet, know next to nothing about cell surface receptors or signal transduction. The tobacco explant system, with its interaction of hormones, sugar and *p*H, may be too complex for comfort, but the oligosaccharin hypothesis certainly opens the way to a molecular understanding not only of plant morphogenesis but also of plant cell receptors and signalling mechanisms in general. □

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2. *The Cell Surface in Plant Growth and Development* (ed. Roberts, K. *et al.*) *J. Cell Sci.* suppl. **1** (in the press).
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4. McNeil, M. *et al. Ann Rev. Biochem.* **53**, 625 (1984).
5. Cullis, C. *Nature News and Views* **310**, 366 (1984).
6. Darvill, A.G. *et al.* in *The Cell Surface in Plant Growth and Development* (ed. Roberts, K. *et al.*) *J. Cell Sci.* suppl. **1** (in the press).
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Early Americans

Land bridge of Duvanny Yar

from Paul A. Colinvaux

PRESENT uncertainties about the history of the Bering land bridge and hence of the first peopling of the Americas seem close to resolution. The debate among Siberian geologists is being settled in favour of the modern interpretation, closely associated with Academian N.A. Shilo, who visited Alaska last summer and discussed with a US team what studies would be necessary in Siberia and Alaska to resolve many of the remaining uncertainties.

In the last glaciation, the Bering land bridge fused Siberia to Alaska as an ice-free plain of continental proportions (see figure). Archaeologists who claim that people lived in America more than 20,000 years ago require the land bridge to have been inhabited early in glacial times; those who dismiss all evidence for pre-Clovis peoples in the New World are content for the first inhabitants of the land bridge to have been in place only in the late glacial, shortly before melting glaciers flooded their new homeland. Either way, the inhabitants orig-