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Inquisitive, problem-solving roots and the new ‘Neurobiology’ of plants

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Plant organogenesis is evidently a two-track process. One track – the constitutive track – involves the expression of stereotypical cell division patterns of stem cell populations and the building up of histological compartments. It is governed by genetic and closely allied internal epigenetic factors. The second track – the facultative track – is perhaps no less rigorous but leads to developmental plasticity. It, too, is governed by genetic factors but, in this case, their expression is influenced by environmental thresholds. Root systems show very good evidence of these two tracks, and much was written on this by Professor Lore Kutschera. It seems that two-track development utilises both intrinsic and determinate elements as well as extrinsic and indeterminate elements. This developmental pattern runs throughout Nature, from the molecular level (ten Hove and Heidstra 2009) to the cosmic level (Barlow et al. 2009); organismal development thus represents the reconciliation of the chaotic and the ordering principles by a living system.

The thresholds that regulate the dynamics of development can be thought of as being analogous to the activation energies of chemical reactions. Plasticity of development involves the crossing of these thresholds, and some investigators (e.g. Trewavas 2005) see these crossings in anthropomorphic terms, referring to them as evidence of a prototypical ‘plant intelligence’ whose expression leads to ‘decisions’ in a general context of ‘problem solving’.

Do the two mentioned tracks of development communicate with each other, and if so, how? Clearly, there must be communication between these two tracks (Barlow 2006) because often the stem cells that feature in the first track have to be initiated and activated at new sites on the plant body. From the classical viewpoint this has to do with ‘correlations’ which were based on particular spatio-temporal patterns of hormonal flow. But in a new way of thinking about development (Baluška et al. 2006), these correlations can be reconsidered in the light of a proposed ‘plant neurobiological’ system. Featured in this scenario (Barlow 2008) are action potentials and variation potentials which serve as informational signals, phloem and xylem elements are the informational channels, and hormones (e.g., auxin) act as facilitators of information flow acting in the manner of neurotransmitter molecules at synapse-like end-walls of cells.

References:

Baluška F, Volkmann D, Menzel D. 2005. Plant synapses: actin-based domains for cell-cell communication. Trends Plant Sci 10:106-111

Baluška F, Volkmann D, Hlavacka A, Mancuso S, Barlow PW. 2006. Neurobiological view of plants and their body plan. In: Baluška F, Mancuso S, Volkmann D (eds), Communication in Plants. Berlin, Springer-Verlag. Pp 19-35

Barlow PW. 2006. Charles Darwin and the plant root apex: Closing a gap in Living Systems Theory as applied to plants. In: Baluška F, Mancuso S, Volkmann D (eds), Communication in Plants. Berlin, Springer-Verlag. Pp 37-51

Barlow P. W. 2008. Reflections on 'plant neurobiology'. BioSystems 92:132–147

Barlow P. W, Střeštík J, Mikulecký M. 2009. Does the Mutual interplay of gravitational, electrical and geomagnetic potentials influence the sap flow in trees? Conference Proceedings: "Man in his Terrestrial and Cosmic Environment", Úpice, Czech Republic, May 19 - 21, 2009

ten Hove CA, Heidstra R. 2008. Who begets whom? Plant cell fate determination by asymmetric cell division. Curr Opin Plant Biol 11:34–41

Trewavas A. 2005. Plant intelligence. Naturwissenschaften 92:401-413