PLANT BIONICS

by Mick Geerits

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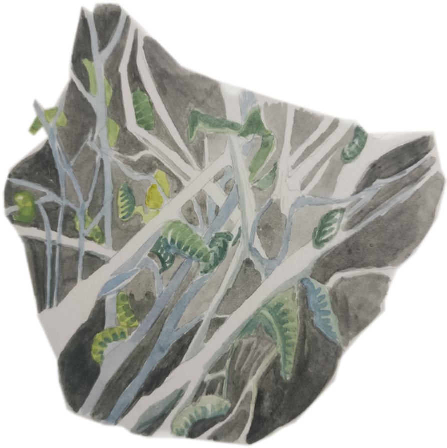
MYCELIUM NETWORK

"We focus on four themes in the recent literature: (1) the physical, physiological and molecular evidence for the existence of mycorrhizal networks, as well as the genetic characteristics and topology of networks in natural ecosystems; (2) the types, amounts and mechanisms of interplant material transfer (including carbon, nutrients, water, defence signals and allelochemicals) in autotrophic, mycoheterotrophic or partial mycoheterotrophic plants, with particular focus on carbon transfer; (3) the influence of mycorrhizal networks on plant establishment, survival and growth, and the implications for community diversity or stability in response to environmental stress; and (4) insights into emerging methods for modelling the spatial configuration and temporal dynamics of mycorrhizal networks, including the inclusion of mycorrhizal networks in conceptual models of complex adaptive systems. We suggest that mycorrhizal networks are fundamental agents of complex adaptive systems (ecosystems) because they provide avenues for feedbacks and cross-scale interactions that lead to self-organization and emergent properties in ecosystems."

"Mycorrhizal networks: Mechanisms, ecology and modelling", Suzanne W. Simard, Kevin J. Beiler, Marcus A. Bingham, Julie R. Deslippe, Leanne J. Philip and François P. Teste, Fungal Biology Reviews, Volume 26, Issue 1, April 2012, Pages 39–60



SCAFFOLDING FOR PLANT CELLS

"We have developed a method of 3D cell culture for plants, which mimics the plant tissue environment, using biocompatible scaffolds similar to those used in mammalian tissue engineering. The scaffolds provide both developmental cues and structural stability to isolated callus-derived cells grown in liquid culture. The protocol is rapid, compared to the growth and preparation of whole plants for microscopy, and provides detailed subcellular information on cells interacting with their local environment."

"A 3-dimensional fibre scaffold as an investigative tool for studying the morphogenesis of isolated plant cells" CJ Luo, Raymond Wightman, Elliot Meyerowitz and Stoyan K. Smoukov, BMC Plant Biology, 15:211, December 2015

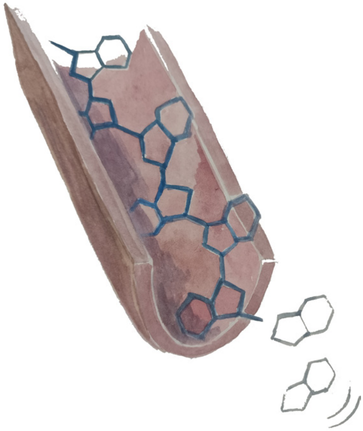
DIELECTRIC PLANT PROPERTIES

"The accumulation of spontaneous APs at specific times during daily light-dark spans were recorded, giving specific electrophysiograms, representative for flower-inducing and vegetative conditions. It is anticipated that hydraulic changes at the apex leading to flower initiation are mediated by a specific hydro-electrochemical communication between leaves, the shoot apex and the root system. These results have been used to substitute a flower-inducing photoperiod by specific timing of electric stimulation via surface electrodes."

"Hydro-Electrochemical Integration of the Higher Plant — Basis for Electrogenic Flower Induction.", Wagner, Edgar, Lehner, Lars, Normann, Johannes, Veit, Justyna and Albrechtová, Jolana, 2006, Communication in Plants, 2006, Pages 369-389

"The dielectric constant of banana fruit decreased as a result of the ripening
treatment. Experiments indicated that the best frequency of sine wave that can predict the level of ripeness was 100 kHz. The coefficient of determination (R2) of ripeness level prediction was obtained 0.94 at this frequency. This method can confidently predict the ripeness level of banana fruit"

"Evaluating banana ripening status from measuring dielectric properties",M. Soltani, R. Alimardani and M. Omid, Journal of Food Engineering 105, March 2011, pages 625–631



ELECTRONICAL-LY CONTROLLING PLANT PHYSIOLOGY

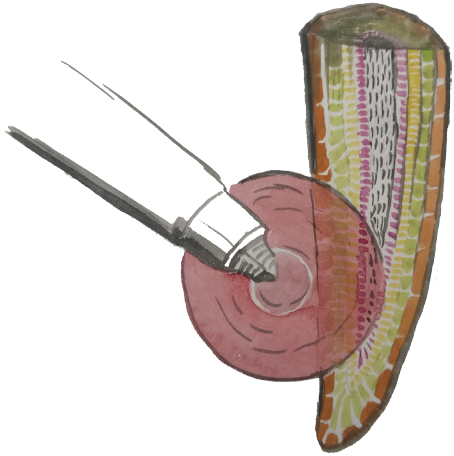
“Here, we report the employment of OEIPs for the delivery of the plant hormone auxin to induce differential concentration gradients and modulate plant physiology. We fabricated OEIP devices based on a synthesized dendritic polyelectrolyte that enables electrophoretic transport of aromatic substances. Delivery of auxin to transgenic Arabidopsis thaliana seedlings in vivo was monitored in real time via dynamic fluorescent auxin-response reporters and induced physiological responses in roots. Our results provide a starting point for technologies enabling direct, rapid, and dynamic electronic interaction with the biochemical regulation systems of plants.”

“Regulating plant physiology with organic electronics”, David J. Poxson, Michal Karady, Roger Gabrielsson, Aziz Y. Alkattan, Anna Gustavsson, Siamsa M. Doyle, Stéphanie Robert, Karin Ljung, Markus Grebe,, Daniel T. Simon, and Magnus Berggren, PNAS, vol. 114, no. 18, March 2017, pages 4597–4602

CONDUCTIVE POLYMER NETWORK

“Recently we have demonstrated plants with augmented electronic functionality. Using the vascular system and organs of a plant, we manufactured organic electronic devices and circuits in vivo, leveraging the internal structure and physiology of the plant as the template, and an integral part of the devices. However, this electronic functionality was only achieved in localized regions, whereas new electronic materials that could be distributed to every part of the plant would provide versatility in device and circuit fabrication and create possibilities for new device concepts”

“In vivo polymerization and manufacturing of wires and supercapacitors in plants”, Eleni Stavrinidou, Roger Gabrielsson, K. Peter R. Nilsson, Sandeep Kumar Singh, Juan Felipe Franco-Gonzalez, Anton V. Volkov, Magnus P. Jonsson, Andrea Grimoldi, Mathias Elgland, Igor V. Zozoulenko, Daniel T. Simon and Magnus Berggren, PNAS, vol. 114, no. 11, March 2017, pages 2807–2812



FUTURUM PLANTAE

With a connected network of plants established nutrients become like a currency, allowing plants to take on specialised and social roles. These are four of these specialised plants.

BIONICA PLANTENNA

A signal repeating and distributing plant that uses its satellite dish like appendages (I) to extend the broadcasting range of plants in the area. Its roots (II) are highly connected to the underground mycelium network allowing it to pick up local communication and broadcast it rapidly to the whole eco-system. Its leaves contain logic compnents and noise cancelling circuitries (III).

Idle appendages are closed to conserve energy (IV).

BIONICA FRUCTUS

Fructus is optimised for fruit production. Through sensing, with its logic centre (I), when each of its fruits (II) is ripe and releasing it into the collecting leaf (III) it consistently produces consumable fruits. The fruits have the ideal balance of nutrients for the organisms that the ecosystem intends to attract (IV).

BIONICA MACHINOR

Machinor is the system engineer of the ecosystem. Its roots tend to the underground mycelium networks that form the backbone of the nutrient distribution network. It also provides structure and cavities ideal for the mycelium to bloom (I) in. It has multiple entry points (II) to the surrounding soil allowing it to tend to a relatively large patch of mycelium (III). The leaves on mechinor are dark (IV) as they absorb all frequencies of light allowing it to make optimal use of the limited light that reaches it.

BIONICA SYMBIOSA

Symbiosa is optimised for nutrient production from bioluminescent light frequencies. It has gill like organs (I) at the end of its appendages (II) that filter the air. The dark coloured lung like organs (III) contain bioluminescent bacteria that transform the filtered chemicals into light. This light is then used by the Symbiosa plant to perform photosynthesis.

The top of the plant stores water as well as the dissolved chemicals it filtered from the air (IV).

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