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Modern Plant Breeding: From the Cell to the Plant

Dénes Dudits, Dirk Inzé, Anne Marie Lambert, Horst Lörz

Although biologists can now regenerate complete plants from individual cells, so far they know very little about what happens on a molecular level during the process. The research work financed by the Körber Prize will shed light on these processes and thus open up new possibilities for the breeding and improvement of crop plants by means of cell cultures.

From a single plant cell, many cereal plantlets develop on a special culture medium.
(Photo: Friedrun Reinhold)

Over the last few decades, molecular biology has developed at an almost explosive rate, with researchers illuminating, for example, the structure and mode of action of individual genes down to the last detail. They have even tackled the decoding of the entire human genome. However, in one area the biologists are still largely in the dark: To date, no-one knows which molecular processes are responsible for the growth from one single cell of a complete organism containing billions of cells. Equally little is known about how virgin tissue, from which a new organism is formed, can develop out of mature, differentiated cells which are unable to divide. In plants, however, this phenomenon is not rare; unlike animals, they display an astounding ability to regenerate: from segments, from pieces of tissue, even from a single cell, complete plants can be grown, provided that they are cultivated in a suitable medium.

To date, such cultivation has been based largely on empirical knowledge. "We mix media, we use recipes – sometimes with success, but frequently without," says Professor Dr. Horst Lörz from the Institute of General Botany in Hamburg, explaining the status of cell culture research, "success or failure can only rarely be explained at present; but we want and have to understand the causal relationships." And it is precisely this knowledge gap that the research work stimulated by the 1994 Körber Prize seeks to close, at least to some extent. There are two chief objectives: firstly, the researchers want to know which gene is switched off in a matured (differentiated) cell to make it impossible for the cell to divide. As all the cells of an organism fundamentally contain the same genetic material, the genes that control division must also be present in 'old' cells. The researchers hope to identify them and to ascertain how they can be reactivated. Secondly, the biologists want to discover what happens when a matured cell containing chlorophyll transforms itself into a virgin cell – i.e. capable of division, not specialized – from which a complete plant can grow again. And then they hope to be able to control this process in a targeted manner.

Professor Dr. Dirk Inze and his staff would therefore like to isolate genes which are involved in the process of cell division using the Arabidopsis thaliana, the genetically well-known house plant favored

by botanists. Anne Marie Lambert and her team in Strasbourg want to find out which structural changes are visible in the division of maize and tobacco cells under the light and electron microscope and which molecular-biological processes can be observed. The working group led by Dénes Dudits in Szeged, Hungary, wants to devote itself to the study of cell cultures of the major fodder plant alfalfa, and the research agenda of Horst Lörz and his staff will focus on the investigation of cell cultures of monocotyledonous plants, which include cereals as important crop plants. The cell cultures are particularly important for plant breeding as they make it possible to recognize very quickly whether a required property is present or not. External genes can also be infiltrated into the cells without difficulty – such as those which provide resistance to diseases. The robust plants thus created could then be grown using far less pesticide.

Contact
Körber Foundation
Körber Prize
Kehrwieder 12
D-20457 Hamburg
Phone +49 40 · 80 81 92 -181
E-Mail koerberprize@koerber-stiftung.de