The Engine of Progress

Innovation, according to scientists from the WZB Berlin Social Research Center, is the buzzword of the decade. But what does the word actually mean? In his book *The Theory of Economic Development*, first published in 1911, Austrian economist Joseph Schumpeter came up with a pragmatic definition and spoke of the "carrying out of new combinations," which doesn't lead steadily and in small steps to the improvement of what we already have, but improves it by leaps and bounds. Innovations are new and different means to combine the "things and forces" within our reach. But how do we arrive at these "new and different combinations"?

Every genuine innovation involves the "paradox of searching." New York sociologist David Stark describes it thus: "When you don't know what you're looking for, but you recognize it when you find it." Consequently, genuine innovators don't know what objective it is they're looking for, so the only thing that helps is to take action with a view to finding it. In science, this kind of searching is called "research."

The fact that a search process of this kind takes place on a long timeline and not uncommonly leads to the crucial solutions being uncovered on the back of insights from seemingly distant disciplines is well illustrated by the following example: Back in the 1960s, scientists were working with a particular form of microorganisms known as archaea. They are real survivors and have evolved extraordinary strategies to be able to exist under the most extreme conditions – including high temperatures and salt concentrations.

Archaea are real survivors

In 1971, Dieter Oesterhelt and Walther Stoeckenius discovered a pigment protein in the cell membrane of one such species of archaea, *Halobacterium salinarum*. They called it bacteriorhodopsin. Powered by light, it pumps protons out of the cell, enabling a simple form of photosynthesis. This was a scientific sensation that even the renowned German magazine SPIEGEL reported on in its March 22, 1976 issue.

Protein pumps protons out of the cell

Bacteriorhodopsin went on to become a model object in bioenergetics, membrane and structural biology. Dieter Oesterhelt's team at the Max Planck Institute of Biochemistry in Martinsried led the way with the research work. From the mid-1970s onward, more than a hundred publications a year appeared on the subject, and related proteins were described, such as halorhodopsin, a chloride pump, which is also light activated.

Thirty years after the discovery of bacteriorhodopsin, Max Planck scientists Peter Hegemann, Georg Nagel and Ernst Bamberg hit upon a light-activated ion channel through which calcium ions flow into the cell interior in the single-celled green alga called *Chlamydomonas reinhardtii*. A few years later, American scientist Karl Deisseroth from Stanford University succeeded in introducing these channels, known as channelrhodopsin, into the cells of other organisms – including

Photo: Axel Griesch

mammals – through genetic manipulation, and in activating them with light there.

The ability to implant light-activated pigment proteins like halorhodopsin and channelrhodopsin means that scientists can now intervene undisturbed in the communication between nerve cells, and the research of the relationships between the activity of specific neural networks and discrete cognitive processes is now, for the first time ever, realistically within reach. Light-activated ion channels and pumps form the foundation of the new, already multi-award-winning field of optogenetics. However, they also open the door to medical applications.

Based on these methods, many new findings have already come to light on diseases like Parkinson's, autism, schizophrenia, drug dependency and depression. In cooperation with Fovea Pharmaceuticals, a subsidiary of Sanofi, scientists at the Max Planck Institute of Biophysics in Frankfurt are working to develop channelrhodopsin to such a stage that it can be used to transform nerve cells in the retina of the human eye into light-sensitive cells in a bid to give almost blind or completely blind individuals back their sight.

Transformation in the retina

This is still a long way off, but it does serve as a striking contemporary example of how unconventional ideas come about by taking a detour around existing theories and thinking outside of the box. However, developing an idea to the point at which it can be turned to account requires a social environment – scientists from other institutions and dynamic industry partners alike.

Innovation is never the work of a single genius alone. Even though it often takes years, if not decades, for the application potential of an idea to be tapped, the underlying "search process" – in other words, the basic research – is indispensable. After all, companies can't establish explicit opportunities for differentiation and build up competitive edge out of basic technologies. Groundbreaking new technologies, in contrast – those that set the path for technological progress – hold the prospect of considerable (potential) competitive advantages for the commercial enterprises involved.

Basic research pays off

The economic effects of basic research are enormous; it's just that they can't be economically quantified or allocated in the usual manner. Those who increasingly seek to make the direct economic value added of basic research into a criterion for funding decisions would do well to remember this. Basic research isn't a machine into which we can insert one taxpayer-financed euro in one end so that two euros in revenue come out at the other end. Nevertheless, it remains the real engine of creative innovation.

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