The Hope for a Self-Healing Brain

We do not look back on the folk aspects of the history of medicine with any sense of nostalgia. Leeches, trephination, and bloodletting are not therapies we miss. Before we understood the germ theory of disease or had developed anaesthesia, medicine was much less successful and intensely more painful. But within a decade or so, we will perhaps envisage today’s medicine with the same kind of horror we now feel when we view ancient remedies. Regenerative medicine is the new frontier, unlocking the secrets of how the body generates itself. The promise of regenerative medicine is still more profound. When we know, in effect, what our cells know, health care will be revolutionized, giving birth to regenerative medicine, ultimately including the prolongation of life by regenerating our ageing bodies with younger cells. The new therapies may begin to emerge over the coming decade.

Techniques are now developing that transform one type of cell from the body into another type without using cloning or embryonic stem cells. Scientists have made human skin cells in a test tube behave as if they were immune system cells, by bathing the skin cells in extracts of the immune cells. In more preliminary work, they have been able to get skin cells to behave as if they were nerve cells. The unexpected plasticity of differentiation displayed by stem cells from adult tissues has upset the dogma that tissue-specific cells are committed to a developmental fate. Until recently, a stem cell was by definition not differentiated, displayed a capacity for self-renewal throughout the lifetime of an organism, and had the potential to give rise to a large number of differentiated progeny. However, over recent times the potential of somatic stem cells for therapeutic applications has come to be viewed as almost infinite, limited only by the ingenuity of investigators in the manipulation of their genomes and culture conditions. Stem cell populations from some tissues may not be restricted to generating progeny identical to their origin, but instead have a plasticity that can be harnessed to generate cells of all germ layers. Allied to the enormous proliferation capacity of both embryonic and adult stem cells, this offers a wealth of opportunities for treatment and prevention of disease.

Around 300 laboratories in Europe handle both embryonic and adult stem cells, though even within countries no uniform way of handling cells and evaluating therapy has been established. There is now an urgent need to do so. This is not only because early results in leukaemia patients undergoing cancer therapy indicate improving prospects for patients. It is also because the list of new diseases, including neurodegenerative diseases, that could benefit from this approach is growing.

Still there remain significant lacunae in our understanding of the molecular mechanisms regulating adult stem cell development and differentiation. The sequencing of genomes from humans and experimental organisms followed by the advent of gene array and proteomic technologies has provided tremendous resources for stem cell research in the post-genomic era. New technological approaches make it possible to identify genes and proteins expressed in perhaps even individual cells. Characterisation of gene expression profiles in discrete stem cell subpopulations will facilitate our ability to identify the molecular mechanisms that regulate the self-renewal and differentiation of adult stem cell development. Furthermore, expression profiling of adult stem cell populations from different tissues will provide important insights into the spectrum of genes which specify the identity and phenotype of a prototype stem cell. Such expression profiling will provide an essential tool in elucidating hierarchical relationships between stem cells and defining the molecular mechanisms that regulate stem cell plasticity. Armed with that knowledge, we might then be in a position to exploit the circuits controlling the biological processes for therapeutic purposes.

The Editors