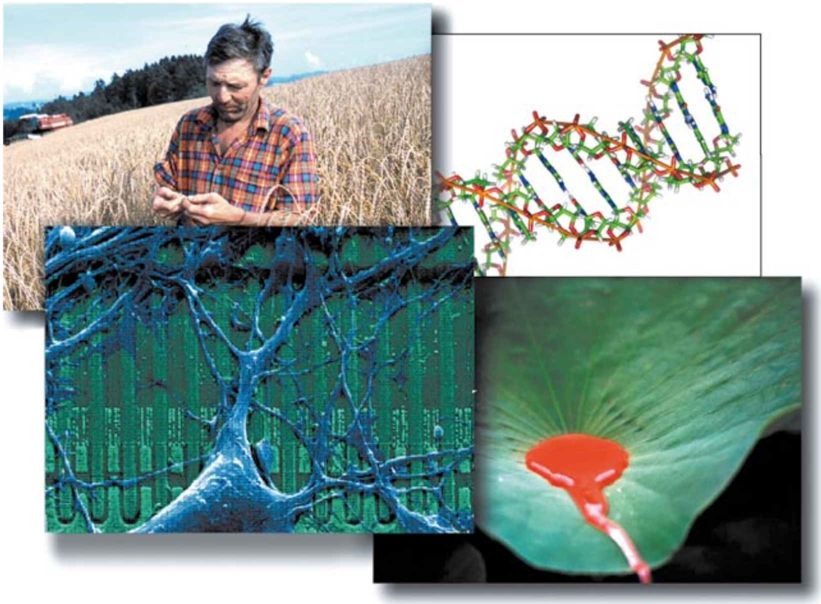
4 LIFE SCIENCES AND BIOTECHNOLOGY



Biotechnology uses findings from biochemistry, microbiology and process technology to produce certain materials. This is done using *biocatalysts*, or so-called enzymes. In the process, catalytically active proteins are employed in a variety of ways:

- As a catalyst to convert substances (e. g. polylactide from starch or the decomposition of toxic contamination in soils)
- Directly as a product from industrial production (e. g. detergent enzymes or food additives)

As biotechnology comprises a very broad spectrum of applications, colour-coding is used to differentiate the various fields of application, these being denoted by red, green, white, grey, blue and yellow.

The past three decades has seen a rebirth of biotechnology, although biotechnical applications have existed for millennia: humans have used them, at times unknowingly, to manufacture foodstuffs or clothing. They were in fact a crucial foundation of human development. But it took the discovery of the structure and function of genetic material, *DNA*, to herald a new era in the life sciences. The sharp growth in the knowledge of how life functions has produced a great number of today's biotechnological applications – in the manufacture of drugs, in new diagnostic and therapeutic concepts, in the production of fine chemicals, or in methods to purify wastewater. No one doubts biotech's potential as an ecologically advantageous and economically promising technology, in many fields.

Biological methods are increasingly complementing the methods used in mechanics and electronics; in the commercial sphere a synergetic effect can be seen between established techniques and biological processes. This observation is exemplified by processes used to synthesise chemical substances, which are increasingly being replaced by processes from industrial biotechnology.

Biotechnology is destined to become more present in our everyday lives than ever before. New cellular therapy methods will be available in the medical field. It will be possible to manufacture drugs inexpensively using plants and animals acting as *bioreactors*. Medicine will be more individualised, and will include new methods in medical diagnostics, where *genechips* will find growing use.

However, some of biotechnology's applications continue to be controversial in society. These include interference with the human genome, especially when germline therapy is involved, where changes can be inheritable. As with *stem cell research*, stringent ethical standards must be put in place. An ethical framework must be set up that irrevocably establishes a connection between what can be done, what must be done and what is permitted. *Genetically-modified food plants* should be part of public debate on this issue. However, there is a demand to secure nourishment for a growing world population, and the products are meanwhile establishing themselves: In 2007, genetically-modified seeds were used for 64 % of the world's soy-bean crop.

► **The topics**. White – or industrial – biotechnology is still relatively young in comparison to red (pharmaceutical) and green (agricultural) biotechnology. It has two fundamental goals:

- Substitution of fossil resources with new renewable raw materials
- Replacement of conventional industrial processes with biological alternatives, which would increase efficiency in the resources employed

red biotechnology
medical and pharmaceutical applications
diagnostics
therapeutics
vaccines

green biotechnology
agricultural applications
transgenic plants
foodstuffs
alternative sources of raw materials

white biotechnology
applications in industrial production
production processes
use of natural substances

grey biotechnology
environmental applications
evidence and decomposition of toxins

blue biotechnology
use of marine organisms
food, cosmetics, medication, new materials

yellow biotechnology
manufacturing of foodstuffs and raw materials

Biotechnological applications are differentiated by colour. The separate technical and scientific disciplines differ among themselves, but they do have something in common: Findings from biochemistry, microbiology and process technology can be used in the handling of microorganisms or their component parts. Source: Fraunhofer

White biotechnology uses nature's tools for industrial production. This explains why the chemical industry, above all, is the current driver of industrial biotechnology. This development has been further accelerated by greater global competition and the resulting increase in energy and commodity prices, as well as by overall efforts to design more sustainable industrial processes.

Applying plant and *agribiotechnology* as a basis for new plant breeds represents an important resource economically for industrialised nations. While non-European industrialised nations have now come to accept the use of transgenic plants and animals, the majority of Europeans still have reservations about cultivating transgenic plants for food and animal feed and using transgenic animals in the foodstuff sector. EU legislation also reflects this attitude. According to the ISAAA (International Service for the Acquisition of Agribiotech Applications), the surface area used for the cultivation of genetically-modified crops grew sharply in 2007, by 12% to 114.3 million hectares. The leaders in the cultivation of genetically-modified crops are the USA, Argentina, Canada, China, Brazil, India and South Africa.

Biotechnological applications within the framework of stem cell technology and gene therapy have a great deal of potential. Stem cells are body cells that can grow into various cell types and tissues.

Over 200 different types of cells originate from the stem cells of an embryo. Research in the field may allow scientists to generate new tissue or organs in the future. In the field of gene therapy, new possibilities are arising to combat hereditary diseases or genetic defects. Gene therapy processes have not yet made their mark on a wide scale, but they could give rise to entirely new markets in the future: predispositions to certain illnesses might be identified, for example, allowing early therapy with customised medication.

Systems biology focuses on a quantitative understanding of dynamic life processes by creating computer-assisted models of them. It tries to understand and represent the complex and dynamic processes of a cell or an organ, for example, as it adapts to the environment, how it ages, or responds immunologically. A large amount of data has been gained from the various levels of the life process regarding individual cell components and functions (genome, proteome, metabolome), and it must all be put into an overall context. These complex processes can only be ascertained with fast computers and then transferred to the appropriate models. This has engendered an entirely new discipline known as bioinformatics. In the final analysis, this should complete the step from qualitatively descriptive biology to quantitative and theory-based biology. Nevertheless, much research effort will be needed before all biological processes within the human being have been completely clarified. There is one last riddle of the human being in particular, the brain, which is still a great mystery.

Bionics focuses on the systematic transfer of solutions from nature to the technical world. Nature's evolutionary processes, which go back millions of years, have produced robust and optimised solutions that can serve as models when seeking to resolve technological issues today. And transferability is not limited to constructions or geometrical forms, but also to new joining methods or special communication techniques (e.g. underwater). ■