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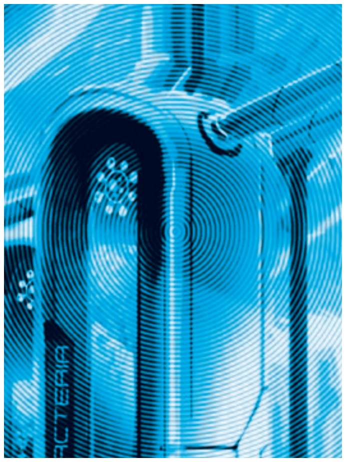
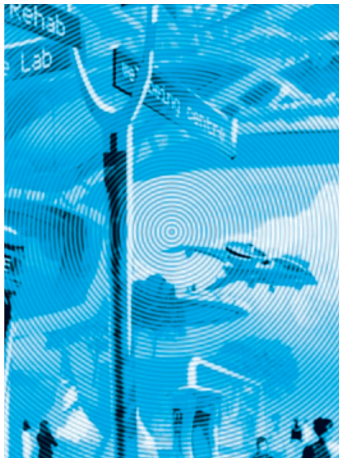
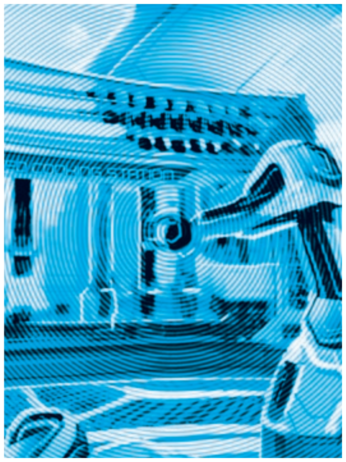
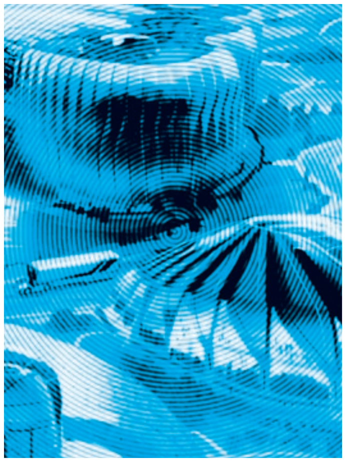
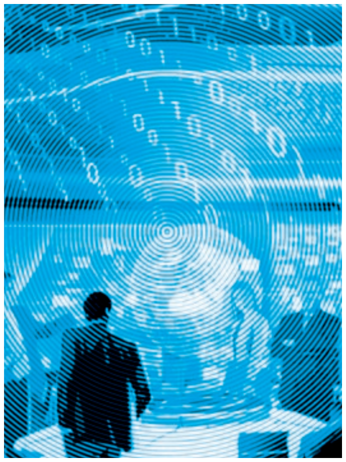


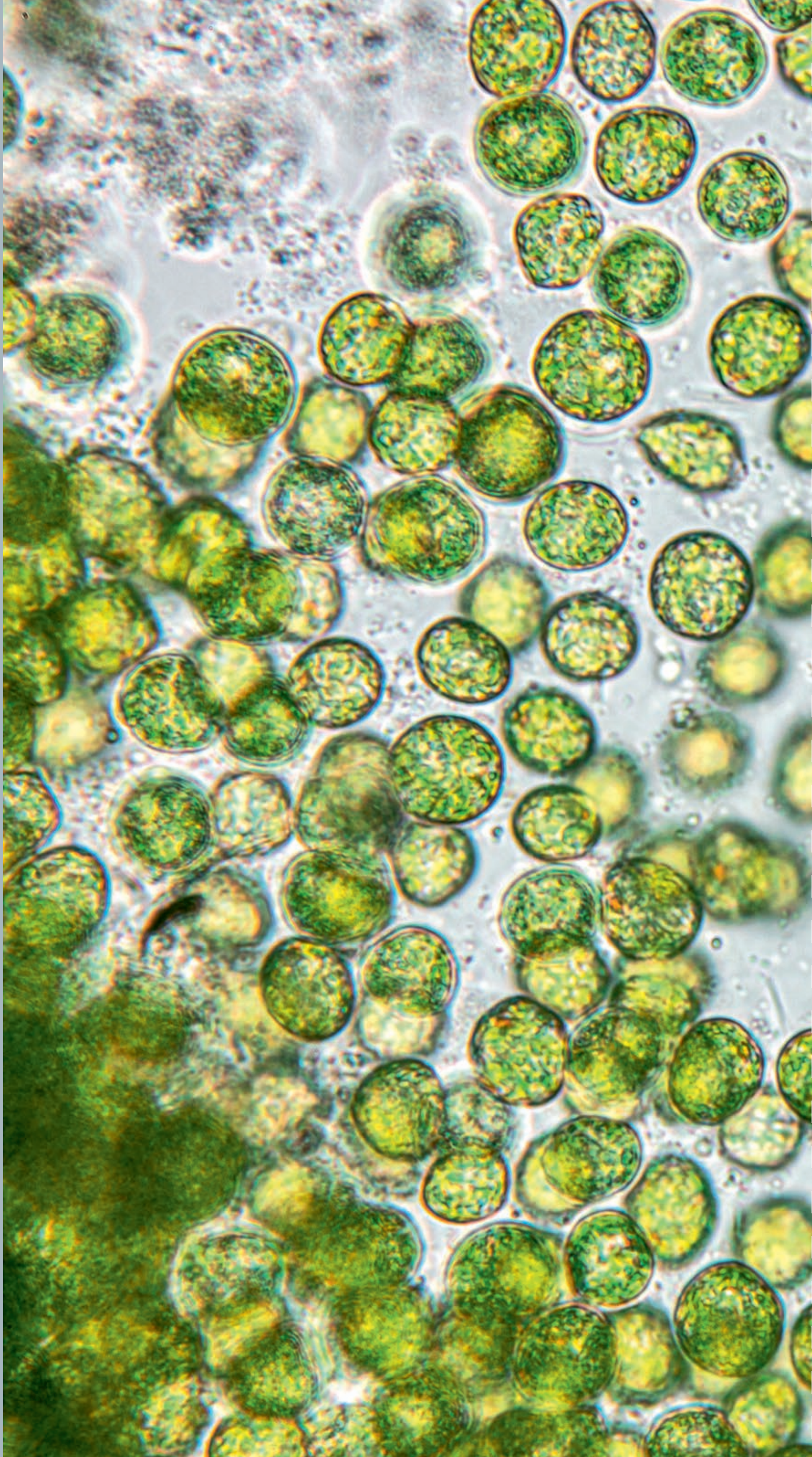


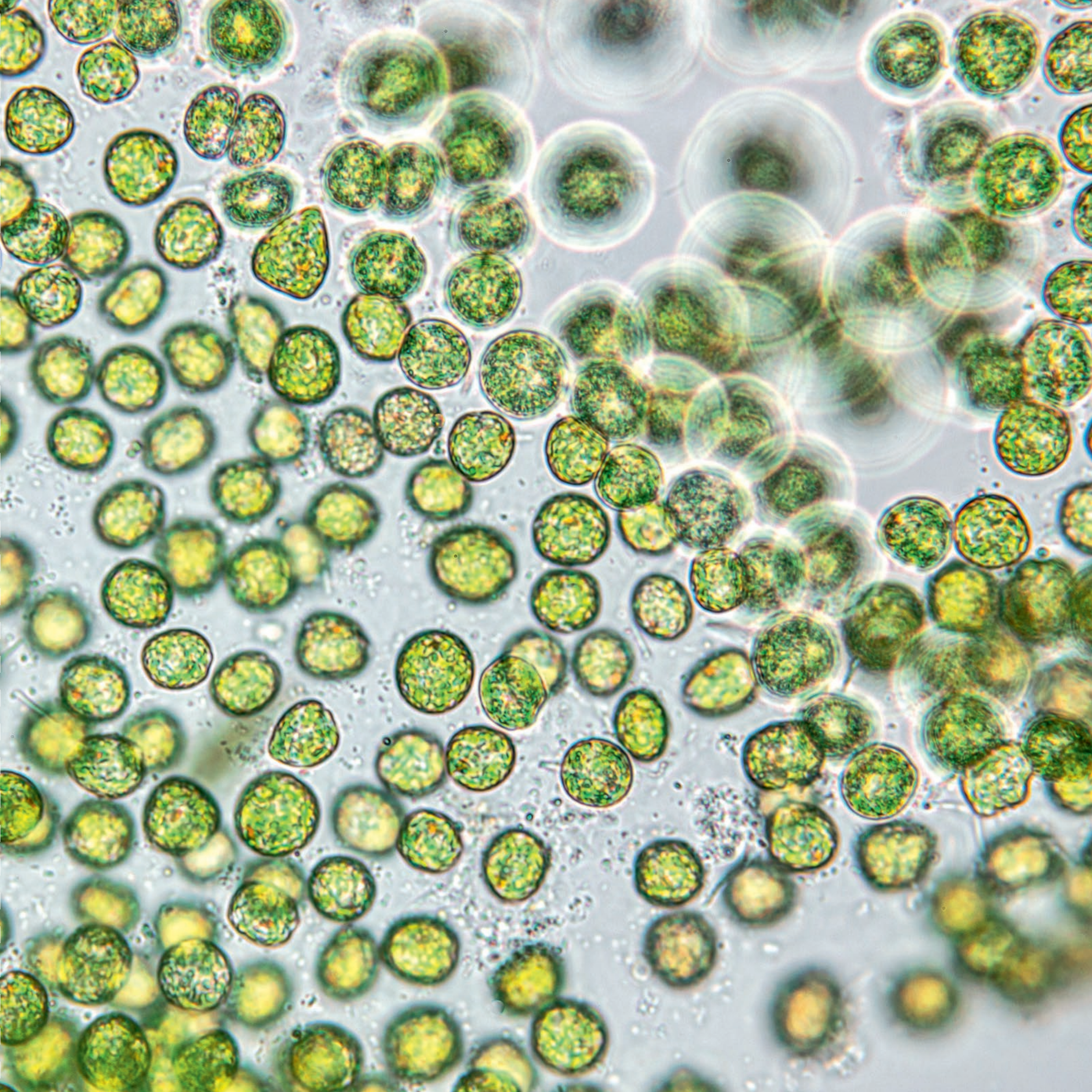


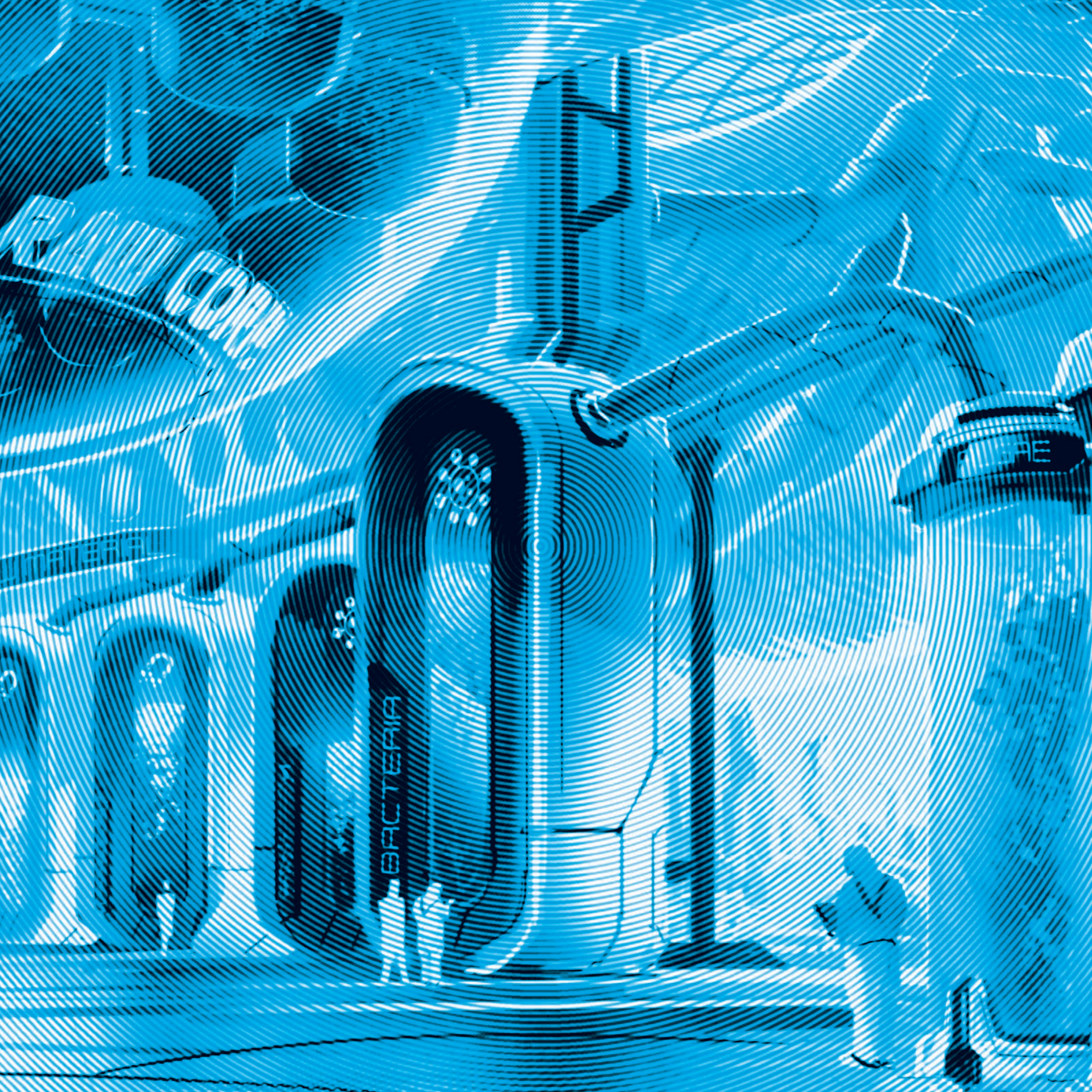




Cell factories






BACTERIA

Operating in a natural cycle

Successfully countering climate change is the guiding principle of our times. Each and every one of us can take on responsibility to this end: we can switch to sustainable products, use renewable energies, do without certain consumer goods and reduce our mobility. However, changing our habits alone will not be enough to effectively address climate change. The global economy must be transformed into a bioeconomy.

Is it possible to live responsibly and to run our economy in a climate-conscious way? Nature teaches us that biology knows no wastage. Over millions of years, evolution has devised “eternal” life cycles – for example the energy, material and water cycles of our Earth. On a smaller scale, we are familiar with the blood circulation in our own bodies. What can we learn for the world of tomorrow from this evolutionary knowledge today? In the natural environment, resources are conserved while maintaining a balanced carbon dioxide turnover, and material flows are embedded in intelligent cycles. On the basis of this model, more and more ideas are now being developed for the practical implementation of a global industrial ecosystem.

In 2050, humans will still be producing the goods they need for everyday life: food, medications, cosmetics, packaging material, fuels and much more. With new production methods, biodegradable products – such as recyclable plastics or compostable sensors – can be manufactured all over the world to cover local needs. Even older materials and long-disused items can be dismantled at molecular level and further processed into pure raw materials. Microorganisms that grow in optimised bioreactors are among the most important protagonists in industry. A key role is played here by the cultivation of algae, since they bind atmospheric carbon dioxide in the production of biomaterials. All the necessary industrial processes will be highly efficient and automated. The technological and organic worlds will merge in the bioeconomy of the future.

BionicCellFactory
Bionics

More nature in technology

How can carbon dioxide, a gas that is harmful to the climate, be withdrawn from the Earth's atmosphere? And how can large quantities of alternative raw materials be made accessible at the same time? In 2023, the specialists from Festo presented a universal model factory that combines these two goals. The BionicCellFactory – a bioreactor system inspired by the accomplishments of nature – unites macrofluidics, microautomation and nanosensors. With its five modules, this holistically designed factory shows how biological transformation can succeed.

Cell factories in the model factory

Living cells are the world's smallest factories. Microalgae, for example, are able to convert sunlight, carbon dioxide and water into oxygen, chemical energy media and valuable organic materials by means of photosynthesis. The natural alga cells are cultivated in the closed cycle of the BionicCellFactory, where the cell growth is constantly monitored and the quality of the resulting alga biomass is analysed. Even the harvesting, processing and refining of the biologically derived material take place automatically in the model factory. This ultimately yields customised biosubstances that can be put to use as required in the chemical, food, cosmetics and pharmaceutical industries.

Minute climate-savers

All products currently produced from the raw material petroleum can be sustainably and resource-efficiently derived from microalgae. Alga cells are climate-savers by nature, since they bind ten times more carbon dioxide than land plants. But in industrial practice they can achieve much more: when automatically cultivated in efficient bioreactors, their natural potential can be increased by a factor of up to a hundred. Used in a targeted way, algae can make a significant contribution to global climate protection.


FESTO

BionicCellFactory
The technology

Binding greenhouse gas

The BionicCellFactory system is divided into five process stages: CO_2 binding, and the analysis, cultivation, harvesting and further processing of the alga biomass. The CO_2 collection module ensures the vital supply of gas to the microalgae – which best grow with a carbon dioxide concentration of around two per cent. This greenhouse gas, filtered from the ambient air, is first blown into a chamber containing CO_2-binding polymer granulate and is concentrated. When the granules are then heated to 90 degrees Celsius, the carbon dioxide is released again and conveyed to the bioreactor via a gassing element.

Monitoring and analysis

The quality of the growing biomass is monitored using a quantum sensor, a digital microscope and state-of-the-art software methods. The microscope constantly supplies images of the alga cells that are immediately evaluated by artificial intelligence. At the same time, a quantum-based particle sensor, into which diluted alga fluid is introduced, analyses the number and size of the individual microalgae in real time and detects any foreign bodies. Thanks to the precision technologies in the analysis module, the cultivation process can be controlled and managed in advance.

Controlled growth

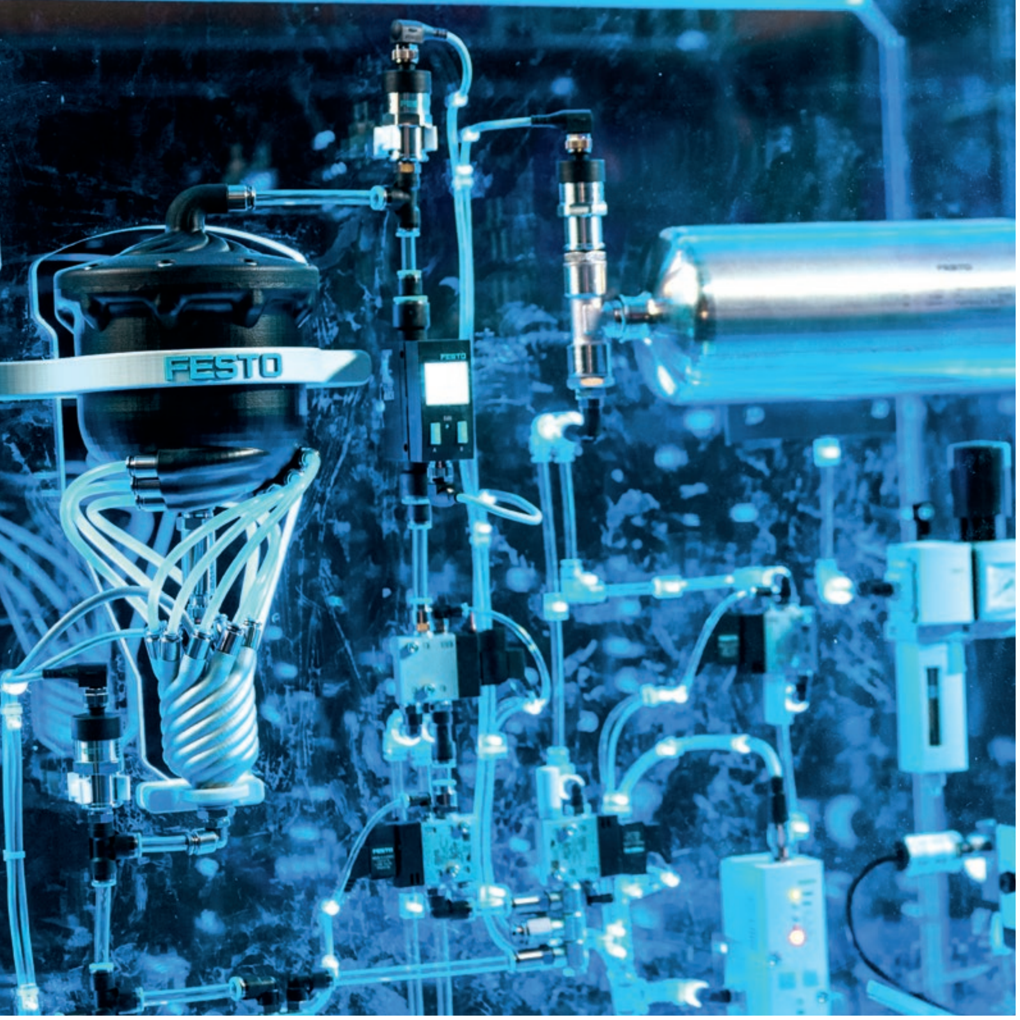
At the heart of the BionicCellFactory is a transparent, 45-metre-long tube system with a capacity of 80 litres, in which the algae carry out their process of photosynthesis. The system is equipped with a large number of sensors that monitor parameters such as oxygen and carbon dioxide concentrations, temperature, conductivity and pH value. This ensures optimal growth conditions for the microalgae. Nutrients such as potassium, phosphorus or nitrogen are supplied to the cells as required.

Harvesting the alga biomass

The harvesting module is the interface between the cultivation and transformation of the biomass. The alga cells are separated from their aqueous environment in a centrifuge at 10,000 revolutions per minute. The harvested algae are conveyed to the next module for further processing, and the water is recycled to the bioreactor to save resources.

Enzymatic processing

The refinement of the algae is carried out step by step in the transformation cubes. Enzymes function as biocatalysts and cut open the cell walls, releasing substances such as starch, proteins, pigments and oil. This eco-friendly transformation process takes place under ambient conditions of 40 degrees Celsius and a pH value of 5; no heavy metals are used.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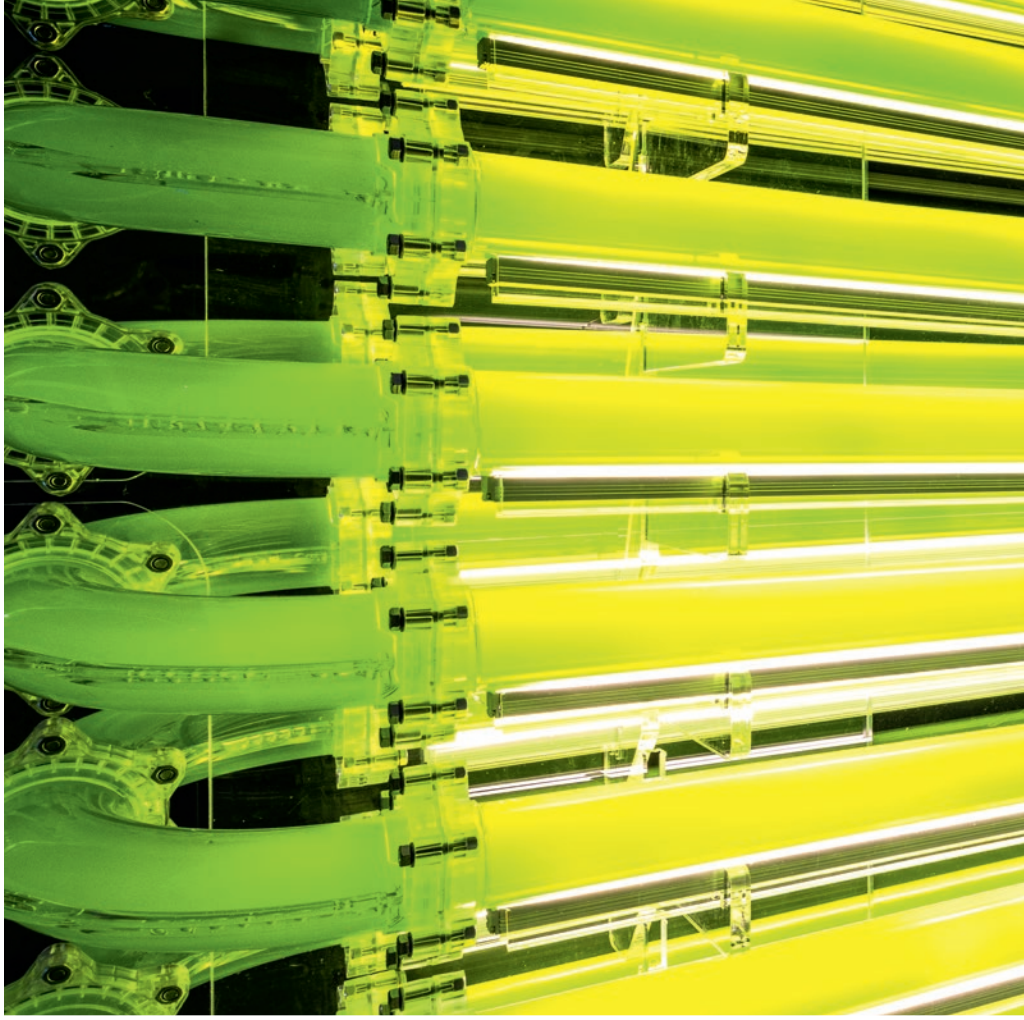

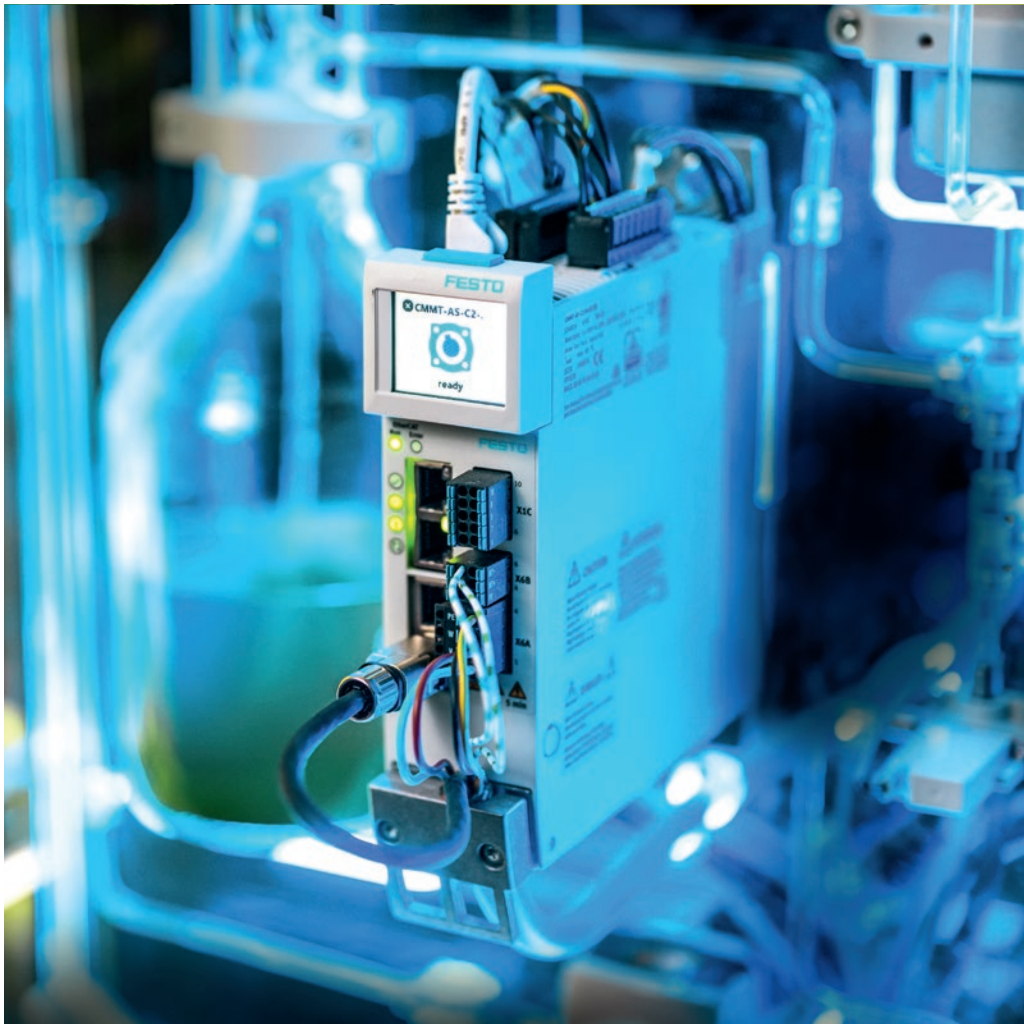
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ready
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BionicCellFactory
The future

Modular and versatile

The modular structure of the BionicCellFactory in five process stages is also reflected in its control architecture. Each module has its own control unit, so that it can be operated and maintained either individually or as part of the overall system. Individual system modules can be quickly and easily replaced, even when the production process is modified. Ease of operation and versatility are essential requirements for the assembly and operation of production systems that combine both the cultivation of biological raw materials and the binding of carbon dioxide.

Production systems of the future

It is a declared aim of the biological transformation to put renewable biological materials to use in future, thereby fulfilling the demand for raw materials in the chemical, food, cosmetics and pharmaceutical industries. For this purpose, upscaled bioreactors with a capacity of several thousand litres will be required on a global scale. To ensure maximum productivity and optimal benefit to the environment, they must incorporate state-of-the-art process automation, including optimised gassing and supply strategies, intelligent control algorithms and various sensor technologies. Innovative concepts will also be required for production systems in the sectors of industry that process the biologically produced raw materials from bioreactors.

New qualifications and vocational fields

With its holistic BionicCellFactory model, Festo has created a means of upholding the principle of a circular economy. Its technical implementation calls for expertise in various specialist areas, an open mind towards interdisciplinary work and, last but not least, extended knowledge of fundamentals on the part of all involved. This combination of biology and physics increases the complexity of automation. The didactic experts are therefore working already today on innovative training vocations, study courses and additional qualifications in the fields of biointelligence, sustainability and biomechatronics.