THEME 01

Biology as a technology

BIOLOGY TECHNOLOGY CIRCULARITY

Recently, we have seen a trend in scientific developments at the intersections of biology and technology in fields like biotechnology, bioinformatics and synthetic biology. This, in turn, has led to the introduction of a uniquely biological perspective in newly developed technologies in fields as varied as design, architecture, material science, health care and agriculture. As a result, the line that has historically separated nature and technology is becoming blurred.

Our observations

- Global problems like climate change, resource depletion and waste demand sustainable, circular and adaptive solutions. A close inspection of organisms like bacteria reveals that they can be viewed as highly adaptive, tiny factories producing basic elements (like lipids and proteins) and complex chemicals in an efficient way with minimal waste. Gaining insights into biological principles is increasingly possible with the advances in fields like biotechnology, bioinformatics and synthetic biology. We are still only beginning to decode nature's data. For example, we have only yet to discern the functions of roughly 500 out of 30,000 known plant genes.
- According to the WEF, the Fourth Industrial Revolution will bring about the combination of computational design (so that complex forms will be built with simple code), additive manufacturing (3D printing), materials engineering and synthetic biology. This will lead to a convergence between the digital and the biological spheres.
- Scientific domains where digital and biological data are combined are experiencing rapid progress. For example, the data generated by the completion of projects like the Human Genome Project in 2001 gave a boost to the field of bioinformatics. This hybrid science links biological data with computer science, mathematics and statistics. Mining these data leads to new insights and discoveries in the biological sphere, for example, scientists are able to predict the structures of amino acid sequences.
- Synthetic biology is another such example of a hybrid field. Specifically, it applies engineering principles to biology in order to (re)design and fabricate biological components and systems. This area is rapidly growing and has proven to have surprising applications, like the usage of DNA for digital data storage.
- Across many fields, technology seems to be becoming more biological. For example, in material sciences, new materials show the capacity to merge digital and biological qualities. Smart, programmable or shapeshifting material, and self-healing concrete are examples of materials that have adaptive characteristics. Designs of soft robotics and biodegradable, dissolvable chips to blend in with nature are on the rise. Furthermore, architects are designing building environment with biology in mind, for example, by using bio-receptive concrete.
- On the other hand, biology seems to be becoming more technological. Our bodies are enhanced with monitoring and interfering technologies, like wearables and microchips.

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Connecting the dots

The foundations of modern science, introduced to us by thinkers like Rene Descartes, taught us to place the human outside the natural sphere. We made a separation between the cultural, or man-made, and the natural. Scientific and technological progress alienated us from our natural environment. The supposedly rational, modern man disengaged from the natural environment and tried to dominate and manipulate it with his own tools for his own needs. In the Industrial Revolution, new inventions were assembled from parts, rather than grown as in nature. Later, we came to appreciate how this modern relationship to nature came at a high price: pollution, waste and a greater distance from nature. We can understand this paradox by considering the modern invention of plastic. Plastic's attractiveness is its durability and the fact that it does not perish like an organic material. However, it was this same un-natural characteristic that created problems of toxicity. We are now faced with issues like the Great Pacific garbage patch and dangerously high concentrations of particulate microplastic polluting drinking water. Plastic exemplifies how we have designed our world in a way that it is creating negative externalities for our environment while excluding positive design principles of biology like adaptivity and circularity. Neri Oxman, professor at the MIT Media Lab, says that we are currently finding ourselves stuck between two representations of the world: a binary representation of the digital world (0 and 1) and the quadruple representation of the biological world (the four base pairs of DNA). However, as Oxman elaborates, designers today are increasingly combining these two representations to create products, buildings and cities that are not ecologically indifferent or ecologically agnostic but that explicitly include ecological principles like resilience, adaptivity, and circularity. She coined the term material ecology to describe this emerging field. Indeed, in the coming Fourth Industrial Revolution, we can expect the digital and biological spheres to become less distinct. The intersection between biology and technology has come to the forefront as one of the most important domains where innovation is accelerating. These advances drive engineers, designers and architects to combine the digital code of computational design and the biological code of nature in order to pioneer a symbiosis between organisms, our bodies, our products and even our buildings. Rather than creating inventions assembled from parts, Oxman believes that these fields create continuities. For example, while plastic causes discontinuities in our environment, plastic bags created from the substance chitin using biopolymer printing are biodegradable in water. Thus, the ecological principle of circularity is introduced into design. Another example is applying microorganisms to control erosion in order to enhance soil resilience. Material ecology sees the material world as a part of biological world, without a separation between product and the natural environment. As the Third Industrial Revolution has led to waste, non-degradable plastics and pollution, the Fourth Industrial Revolution has the potential to lead us to smarter inventions by learning from ecological principles.

Implications

- The FAO defines the bioeconomy as a knowledge-based production and utilization of biological resources, biological processes and principles to sustainably provide goods and services across all economic sectors. The EU is well-situated in this economy.
- The biotechnology industry is rapidly evolving and has become an economic engine over the last years, specifically in the Boston area in the U.S. and in China, the world's second largest pharmaceutical market after the U.S.
- Biodesign has a wide range of new applications including solar powered glass, natural insulation (zero carbon housing) and bioluminescent lighting, among others.

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