What if nature taught us how to adapt to climate change?

Over the past 3.8 billion years, nature has been engineering itself to survive. It has also developed efficient and sustainable adaptation mechanisms against changing environmental conditions. To further the EU's political ambitions, could we employ biomimicry to mitigate climate change and achieve climate neutrality?

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Since the dawn of the industrial revolution, societies have gone from a set of metabolisms – using energy from water, wind and living beings – to a techno-industrial metabolism in which the economic and productive systems rely on carbon-based energy and excessive non-sustainable exploitation of natural resources. This new relationship between human beings and their environment has led to ecosystemic challenges such as climate change and diminishing biodiversity. Thus, over the past 200 years, the planet has been experiencing further biophysical transformations than what would otherwise have occurred naturally. While techno-industrial societies rely on fossil fuels, high temperatures and pressure to transform materials or create movement, natural ecosystems rely on molecular chemistry or physics, giving us clues on how we can use energy with maximum efficiency and adapt to changing environments.

Biomimicry comes from the Greek words *bios* (life) and *mimikos* (one who imitates). It is not a new practice; the most famous example of biomimicry is Leonardo Da Vinci's flying machine inspired by birds. Biomimicry is a multidisciplinary approach that seeks to learn from nature's biological mechanisms and imitate them to solve system problems. It is linked to biomimetics – the 'interdisciplinary cooperation of biology and technology or other fields of innovation with the goal of solving practical problems through the function analysis of biological systems, their abstraction into models, and the transfer into and application of these models to the solution'.

There are three levels of practice in biomimicry. The organism level involves copying the form, shape or structure of a specific organism. The behaviour level involves imitating natural processes, such as the interaction between an ecosystem and its surroundings. The ecosystem level is about imitating the working principles of ecosystems, i.e. how different parts of an organism interact on a large scale.

Potential impacts and developments

At the organism level, most biomimicked structures fulfil an aesthetic purpose. Over the centuries, trees and plants have served as a source of inspiration for structures such as the ornamental structural columns in Greek and Roman classical architecture. In some rare cases, bio-inspired structures can interact with the environment. One such example is the Taichung Metropolitan Opera House in Taiwan, which can collect rainwater that is then filtered and reused.

At the behaviour level, biomimicry can make a greater contribution to fighting climate change and its impacts. A well-known example is the Harare Eastgate Centre, designed to resemble the shape and functioning of a termite mound. Termite mounds have a climate control function. Similarly, the way the

Authors: Nera Kuljanic with Michael Sicaud-Clyet, Scientific Foresight Unit (STOA)

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centre extends upwards, the different wind velocities at its top and bottom, the fresh air that is drawn by means of a Venturi effect, as well as the heat emitted by the people and machinery on its premises give the building an impressively stable interior temperature, achieved without resorting to costly and energy-hungry air-conditioning. The building thus both mitigates climate change, by reducing energy consumption, and adapts to extreme heat events.

It is at the ecosystem level that biomimicry could have the biggest mitigating effect on climate change. An example includes the natural carbon removal process. Decomposition of organic matter 'includes physical, chemical and biological mechanisms that transform organic matter into increasingly stable forms'. In boreal ecosystems, plant litter serves as a carbon source for micro-organisms that can degrade cellulose, hemicellulose and lignin. Bacteria provide trees with a number of substances (nitrogen, phosphorus, phytohormones and natural antibiotics) that improve their growth and protect them from disease. Fungi provide the forest ecosystem with nutrients, water and minerals. They also completely digest the lignin and produce humus, an organo-mineral complex that consists of about 60 % carbon, 6 % nitrogen, and smaller amounts of phosphorus and sulphur. The formation of this humic substance contributes to soil fertility and carbon storage. Fungi secrete glomalin (a glycoprotein made of glucose), which is estimated to contain a third of the carbon sequestered in the Earth's soils. Finally, earthworms help to store carbon by mixing humus and clay provided by trees. Through all the above processes, decomposition plays an important role in the global carbon cycle by fixing nearly as much carbon as photosynthesis does. In 2019, natural land sinks, such as forests, grasslands and wetlands, fixed around 11.5 Gigatons of CO_2, which is about 28 % of human-caused emissions. Thus, a whole ecosystem composed of trees, litter and micro-organisms produces an efficient process of carbon capture and storage.

There is currently no technology mimicking decomposition as a way to mitigate climate change. An ongoing ERC-funded project, CO2LIFE, 'intends to develop a biomimetic chemical process that converts CO_2 into valuable molecules using membrane technology'. CO2LIFE's starting point is acknowledging nature's effective mechanism to concentrate CO_2 and fixate it into organic material, especially glucose, by means of enzymatic action. The findings of this project could make an important contribution towards developing a technology that imitates nature's biological processes to mitigate climate change.

Anticipatory policy-making

An important issue regarding the further development of biomimetic solutions is the overall lack of financial investment in nature-based solutions and biodiversity restoration. Indeed, the development of biomimetic solutions could benefit from more substantial policy support, as is the case in the United States, where the government has provided funding for biomimicry research. In the EU, Germany hosts more than 100 public research institutions conducting biomimicry-related research and development, and a pioneering research centre in biomimicry was established in France in 2014. The EU has been funding work such as the Horizon 2020 AIRCOAT project and the Horizon Europe Nature4Nature project.

The role of education policy is important to further the understanding of the complexities of natural ecosystems. There are a number of higher education programmes in biomimicry in the EU – for instance, in the Netherlands, Spain and France – aimed at understanding nature's capacity for solving system problems.

Finally, carbon-farming methods, where CO_2 is removed from the atmosphere and stored in plant materials or soils, might need to be certified as part of the recently proposed regulation establishing a Union certification framework for carbon removals. Similar schemes could apply to future biomimetic technologies replicating chemical and biological processes from nature, to store and convert carbon.