At a glance

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Synthetic biology and biodiversity

Synthetic biology is a new dimension of modern biotechnology with the potential to design and manufacture living organisms, components and products. It will be on the agenda of the 13th meeting of the Conference of the Parties (COP) of the United Nations Convention on Biological Diversity (CBD), to be held from 4 to 17 December 2016, in Cancún, Mexico. Synthetic biology could provide novel solutions for environmental and biodiversity-related issues, but could also have an adverse impact on the natural environment. The European Union is party to the CBD and the protocols relevant in the context of synthetic biology.

Background

Synthetic biology builds on the techniques of classical genetic engineering, which implies the insertion of foreign genes into an organism, but goes beyond it as it involves the design and construction of new biological parts and the redesign of existing natural biological systems. Synthetic biology comprises major genetic changes and the creation of entirely new sequences of DNA, allowing the development of organisms with novel functions. In 2014 the first entire living organism with artificial DNA was produced, when a team engineered *E. coli* bacteria able to replicate a genetic code containing two unnatural bases (the DNA building blocks).

Opportunities for species and habitats

Synthetic biology has the potential to be used for the protection of habitats and biodiversity. One important application in this context is **bioremediation**, a process aimed at cleaning the environment of waste products and pollutants with the help of living organisms. Synthetic biology might for instance be applied to develop organisms with the ability to process waste or purify water by removing contaminants such as heavy metals and pesticides. *E. coli* bacteria for example have been developed to degrade the environmental toxicant methylmercury formed in water. In addition to naturally occurring bacteria, which can break petroleum down into less toxic by-products, synthetically engineered microbes could be used to degrade more persistent chemicals such as dioxins or certain pesticides. Engineered microorganisms (such as *E. coli* bacteria, baker's yeast and microalgae) able to synthesise wanted products could meanwhile help to relieve pressure on **plant and animal species** currently hunted or harvested for the extraction of certain substances (such as morphine).

A positive impact for biodiversity could be achieved in a more indirect way by breeding plants with a reduced need of insecticide protection, but also producing higher yields. A lesser environmental impact and the preservation of wildlife habitats could therefore be possible consequences. Endangered species could be made resistant against presumed risks, such as pesticides in the case of bees or fungal diseases in the case of bats. The new technologies could in addition be used to eradicate invasive species, which are a major threat to biodiversity. Moreover the possibility of using synthetic biology to restore extinct species is also being explored.

Possible threats

The development of synthetic genetic material and its potential impact on biodiversity is also associated with scientific uncertainties however. Organisms bearing genetic material which does not occur naturally could pose a risk to biodiversity if they are intentionally or accidentally released into the environment. Possible scenarios include the transfer of genetic material to naturally occurring species, resulting in hybrids (combining natural and synthetic genetic material) and changing biodiversity. These novel organisms could become invasive, outcompeting or displacing existing species. As well as the accidental transfer of genes to wild populations, there is the possibility of targeted quick spreading of genetic alterations through populations

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Author: Anne Altmayer, **Members' Research Service**
PE 593.572
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using gene drive systems. These systems increase the prevalence of a particular gene, for instance one that reduces fertility. This method makes it possible to control populations of disease vectors, such as mosquitos.

The extinction of a whole species might however have consequences for food chains (for instance spiders and birds living on insects) and thus on entire ecosystems. Another unwanted effect could arise from the fact that a large number of synthetic biology applications are based on the conversion of biomass into desired products by engineered organisms. If developed on a massive scale, this could increase demand for biomass and in turn step up the conversion of natural habitats into agricultural land, potentially accompanied by a loss of biodiversity on account of a greater use of fertilisers. In addition to these immediate effects on biodiversity, the possibility of creating and restoring species could bring about a change in public perception, trivialising biodiversity loss.

Regulatory aspects at EU level

According to the opinion of the EU's Scientific Committees on synthetic biology, the new technologies are currently encompassed within 'genetic modification' as defined in Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms (GMOs) and Directive 2009/41/EC on the contained use of genetically modified micro-organisms. The committees recognise however the difficulty in defining the relationship between genetic modification and synthetic biology. There is also an ongoing discussion as to whether it is the products or the processes that are the determining factor for a technique to fall within the scope of GMOs. Moreover, questions are raised regarding the source of genetic material and the use of methods that do not necessarily fall under the current definition of genetic engineering. Problems also arise from the definition of GMOs used in EU legislation, which has remained unchanged since 1990, making the classification of new techniques difficult.

Operational definition of synthetic biology, to be discussed at COP 13

'Synthetic biology is a further development and new dimension of modern biotechnology that combines science, technology and engineering to facilitate and accelerate the understanding, design, redesign, manufacture and/or modification of genetic materials, living organisms and biological systems.'

Synthetic biology and the Convention on Biological Diversity (CBD)

The Convention on Biological Diversity is an international agreement that entered into force in 1993. It is committed to three main goals: the conservation of biological diversity, the sustainable use of the components of biological diversity and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources. The convention is supplemented by two protocols, which both are relevant in the context of synthetic biology.

The Cartagena Protocol on Biosafety, which entered into force in 2003, aims to ensure the safe handling and use of living modified organisms (LMO) resulting from modern biotechnology that may have adverse effects on biological diversity. In the context of synthetic biology some questions still remain unclear however: The protocol applies for instance to living organisms, whereas non-living components (such as DNA molecules) and products (such as produced chemical substances) are not regulated by this protocol. There may also be cases in which there is no consensus on the distinction between living and non-living (e.g. in the case of protocells). The provisions of the Cartagena Protocol on Biosafety are implemented by EU legislation on GMOs.

The Nagoya Protocol, which entered into force in 2014, provides a framework for the fair and equitable sharing of the benefits arising from the utilisation of genetic resources. In this context it remains for example to be clarified to what extent the protocol would cover new aspects such as the use of digitally stored genetic information. The Nagoya Protocol is transposed into EU law by Regulation (EU) 511/2014 on Access to Genetic Resources and Fair and Equitable Sharing of Benefits Arising from their Utilisation in the Union. The 2015 CBD Conference of the Parties recommended a precautionary approach when making use of synthetic biology techniques.