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ETC GROUP
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SYNTHETIC BIOLOGY: CREATING ARTIFICIAL LIFE FORMS

BRIEFING AND RECOMMENDATIONS FOR CBD DELEGATES TO COP 10

As the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) ponders guidelines for considering new and emerging issues that may have implications for biodiversity – and struggles to adopt a protocol on access and benefit sharing (ABS) – researchers in synthetic biology are developing the capacity to construct synthetic life forms. The repercussions for biological diversity are unknown but could be devastating. Natural organisms, too, may be "tweaked" using synthetic biology to allow for patent monopolies beyond the reach of state sovereignty or of indigenous peoples.

Several decades after the development of recombinant DNA techniques, a new set of genetic technologies is once again changing the way industry manipulates life. Synthetic biology applies digital and engineering approaches to building life forms from scratch using synthetic DNA and other human-made parts. With the genomes of nearly 4000 organisms already sequenced and stored in various databases, synthetic biologists have a lot of raw material to work with.

The CBD has just begun to grapple with the implications of synthetic life forms and is the first multilateral forum to do so. Newly manufactured synthetic organisms raise new risks that are not explicitly covered by existing regulations on genetic engineering. The proposed use of synthetic microbes in the production of the next generation of fuels, medicines and industrial chemicals may massively increase human impact on biodiversity, while accelerating biopiracy and making a mockery of any notion of "benefit sharing." Delegates meeting at COP 10 in Nagoya have the opportunity to address these new challenges to biological diversity.

Copies of two new reports by ETC Group – *Geopiracy: The Case Against Geoengineering* ***and*** *The New Biomassters: Synthetic Biology and the Next Assault on Biodiversity and Livelihoods* ***– will be available in Nagoya at COP 10 and on ETC Group's web site: www.etcgroup.org***

What is Synthetic Biology?

Synthetic biology is a form of extreme genetic engineering that adds manufactured genetic parts (such as synthetic DNA, synthetic ribosomes or synthetic RNA) to a living cell in order to 'hijack' the workings of the cell for industrial uses. Adopting engineering principles, researchers attempt to create modular 'genetic parts' or 'biobricks' that can be easily snapped together to create more complex genetic 'programmes.' Typically, strands of DNA are constructed from scratch out of inert chemicals using a machine called a DNA synthesizer. By specifying the sequence of those chemicals, researchers attempt to 'programme' the 'code' of the DNA in order to change the behavior of the organism.

How do Synthetic Organisms differ from Transgenic Organisms?

Although we are already familiar with genetically modified organisms (GMOs), where DNA is exchanged between species, synthetic organisms are a different type of life form where DNA is not extracted from a living organism – it is built from scratch. This makes it possible to design DNA sequences that have no known analogue in nature. Some researchers are even inventing entirely new types of DNA composed of base pairs that do not occur in nature. There are currently no protocols for evaluating the safety implications of such entirely new sequences. The established way of moving genes between species (known as transgenics) is a comparatively slow process. Building synthetic DNA is faster and cheaper, and could therefore lead to a proliferation of engineered artificial life forms – all with unpredictable impacts on the environment and biodiversity.

What applications of Synthetic Biology are in use or close to market?

Synthetic biology has received billions of dollars of investment and boasts a growing number of start-up companies partnering with multinational energy, chemical, forestry, pharmaceutical and agribusiness corporations. The largest segment of commercial investment is synthetic microbes and enzymes for agrofuel production or production of chemicals and plastics made from biomass. For example, chemical giant DuPont already uses synthetically altered yeast to ferment corn sugars into a bioplastic sold as Sorona, which is not biodegradable and currently consumes corn from tens of thousands of square kilometers of farmland. Companies such as Amyris Biotechnologies, LS9, Solazyme and Synthetic Genomics, Inc. have developed microbes and algae to ferment sugar or cellulose (woody plant material) into next generation agrofuels, chemicals and plastics. Their hope is that synthetic microbes will be able to break down cellulose more efficiently, and convert carbohydrate sugars to hydrocarbon fuels that are more energy-rich than ethanol. Companies such as Amyris Biotechnologies and Genencor are also constructing microbes that secrete high-value compounds such as the anti-malarial drug artemisinin or synthetic rubber. Meanwhile companies such as Agrivida, Chromatin and Syngenta are applying synthetic biology to reengineer crops such as maize to more easily decompose into agrofuel feedstocks.

How does Synthetic Biology threaten biological diversity?

Near term applications of synthetic biology will impact the natural world in at least two ways:

1) The release of synthetic organisms

Currently, deliberate environmental release of synthetic organisms is proposed for bioremediation, soil enhancement or experimentation; the release of fuel-producing algae is also being proposed. But unintentional release could result from human error where microbes escape from biorefineries, production vats and laboratories. Since the behavior of synthetic organisms in nature is unknown and there are no protocols for assessing their biosafety, we can only guess at the potential invasiveness of these artificial life forms in the wild. In cases where a microbe is intentionally engineered to break down cellulose, enhance photosynthesis or secrete toxic compounds, such an escape could be

environmentally disastrous. Photosynthetically-enhanced algae could quickly become invasive, for example. Novel synthetic microbes could also exhibit unexpected pathogenicity with negative consequences for both ecosystems and human health.

2) Increased demand on land, biomass, water and other natural resources

At present most commercial interest in synthetic biology is focused on developing microbes or engineering algae to transform cellulose or other plant sugars to fuels, chemicals and plastics. While first generation agrofuels have already led to massive changes in land use – impacting food and water supplies – so-called "next generation" fuels will transform previously "low-value" forest and agricultural "wastes" such as straw, leaves and branches into valuable feedstocks for chemical and energy companies. This in itself is a problem, as they are not "wastes," but important components of soil, intrinsic to the recycling of nutrients. Returned organic matter improves soils' capacity to sustain biodiversity and crops, absorbing CO_2 and water, preventing erosion and is useful to local, indigenous and peasant communities in other ways. As major industries shift to biomass-derived feedstocks, larger and larger quantities of plant material will be required. This increased demand will inevitably compete with food security, livelihood needs, biodiversity and conservation goals – putting even greater pressure on soils, water resources and ecosystems that are already stretched to their breaking point. There is simply not enough land or plant matter for all the uses that are being contemplated.

How does Synthetic Biology facilitate biopiracy?

While the CBD has been discussing a Protocol on Access and Benefit Sharing over the last decade, developments in synthetic biology are allowing would-be biopirates to more efficiently steal genetic resources. While biopiracy has conventionally meant the physical removal of a material from a community into private hands, synthetic biology enables *digital biopiracy*, where the DNA of an organism is sequenced *in situ*, uploaded to the Internet as information, and than transferred digitally to a DNA synthesizer so that copies can be rebuilt elsewhere. Such digital transfer of DNA 'code' does not even require a Material Transfer Agreement (since no material is transferred). Yet, the technology allows corporations, governments and individuals to take genetic information and use it to create new synthetic organisms, which can then be patented as inventions. While synthetic biologists talk of inventing DNA from scratch, in reality, most genetic parts developed for synthetic biology are derivatives of natural stretches of genetic code that are then 'evolved' through computer models. The implications of this digital biopiracy are far reaching. For example, companies and researchers are already developing organisms that will produce natural compounds such as rubber, artemisinin and liquorice in closed vats. These production facilities could undercut the livelihoods and rights of some of the poorest farmers and plantation workers in the world, by moving raw material production from the field to the fermentation vat. Any financial gains will also move from communities to big commercial interests.

What are other concerns about Synthetic Biology?

A number of social, ethical and technical concerns are raised by synthetic biology technologies:

Bioweapons: Rapid and inexpensive construction of long strands of synthetic DNA also enables rapid and cheap production of pathogens such as smallpox, *Ebolavirus*, etc. In 2005, U.S. military scientists recreated the previously extinct 1918 influenza virus that had killed between 20-50 million people.

Monopoly: While patents on natural DNA sequences are beginning to come under more critical scrutiny from courts and governments, the field of synthetic biology is already seeing broadly worded patents that would give a very small number of companies virtual *de facto* monopoly control over entire economic sectors.

Digital (*in silico*) conservation: *Ex situ* conservation of genetic resources already poses many challenges for the preservation of species far from their own ecosystems. Synthetic biology enables the establishment of digital conservation strategies where species' full genomic information is stored in computers and then recreated at will via DNA synthesis machines. While this may not be feasible for plants or animals for some time, it is a near-term possibility to begin 'backing up' the world's microbial diversity on a computer server rather than through preservation or in bacterial culture collections. Today, 3 billion base pairs (the size of the human genome) can be deciphered in 8 days for $10,000. But, Oxford Nanopore Technologies and Pacific Biosciences claim that within three years they will be able to map the human genome in 15 minutes for $1000, from a single DNA molecule. In other words, by COP 12, it may be possible to store a molecule of all the world's estimated 10 million species embedded on one side of a credit card-sized disk – with the digital map of each species' genome on the other. Such *in silico* collections would be unable to adapt over time to environmental changes and technological access and proficiency would trump natural affiliation or ownership.

Violating Nature: Synthetic biology reconceptualizes life so that organisms are seen as genetically programmable machines to be re-engineered at will. This mindset clashes with the ethos of many indigenous cultures as well as with the understanding of the relationship between humans and nature held by many others. There is no room for the concept of an ecosystem in the *in silico* world.

Decisions on Synthetic Biology at COP 10 in Nagoya

The Parties to the CBD have a number of opportunities to address the governance gaps regarding the impacts on genetic resources, biosafety and biodiversity that have emerged with the rapid development of synthetic biology:

1.- Related to Access and Benefit Sharing

Following a request from the Working Group on ABS, the CBD Secretariat commissioned a review paper on the definition of 'genetic resources' in the context of advances in modern biotechnology including synthetic biology. That paper (*UNEP/CBD/WG-ABS/9/INF/1*) notes "the ABS system may not be able to capture the future potential value of genetic material, not least when it is used in or as a basis for synthetic biology," further noting that if the concept of genetic resources is not expanded to include "informational and digital dimensions," valuable uses of genetic resources will fall outside the ABS framework.

ETC Group Recommendations

- **Parties should close the 'digital loophole' by explicitly extending the definition of genetic resources to include genetic information stored or transmitted in a digital form.**
- **The construction of genetic parts, 'biobricks,' metabolic pathways and synthetic chromosomes for use in synthetic biology should be included under an international ABS regime whether or not those parts are derived from naturally occurring analogues.**
- **Parties should define *Derivative* as a digital sequence, biochemical compound, engineered organism or metabolic pathway resulting from the collection, genetic expression or metabolism of biological or genetic resources, even if they do not contain functional units of heredity.**

2.- Related to Biofuels and Biodiversity

At SBSTTA 14, synthetic biology was discussed under two agenda items: **"Biofuels and Biodiversity"** (Agenda item 6.4) and **"New and Emerging Issues" (**Agenda item 6.9).

The draft Decision on Biofuels and Biodiversity related to synthetic biology to be considered at COP 10 is contained in *document* ***UNEP/CBD/COP/10/1/Add.2/Rev.1*****, p. 163**:

> [14. *Decides* to convene an ad-hoc technical expert group on synthetic biotechnologies and other new technologies that are used or projected to be used in the next generation of biofuels to assess their impact on biodiversity and related livelihoods.]
>
> [16. *Urges* Parties and other Governments, in accordance with the precautionary approach, to ensure that living organisms produced by synthetic biology are not released into the environment until there is an adequate scientific basis on which to justify such activities and due consideration of the associated risks for the environment and biodiversity, and the associated socio-economic risks, are considered.]

Furthermore, synthetic biology is also tackled in **the draft Decision on "New and Emerging Issues,"** contained in *document* ***UNEP/CBD/COP/10/1/Add.2/Rev.1*****, p. 40**:

> *Invites* Parties, other Governments and relevant organizations to submit information on synthetic biology and geo-engineering in accordance with the procedure of decision IX/29, for consideration by the Subsidiary Body on Scientific, Technical and Technological Advice, while applying the precautionary approach on the field release of synthetic life, cell or genome [sic] into the environment.

ETC Group Recommendations

Appropriate oversight and international governance rules need to be put in place to ensure that synthetic biology does not further threaten biodiversity and livelihoods and does not allow the pillage of genetic resources. The CBD is the authoritative body on this matter. While ETC Group is broadly supportive of the three decisions communicated by SBSTTA 14 on synthetic biology, we would further recommend:

- **Decisions taken regarding synthetic biology and the development, handling and use of synthetic organisms or synthetic genetic parts be subject to the strict application of the precautionary principle.**
- **That there should be no environmental release of synthetic living organisms whatsoever.**
- **That commercial use of synthetic organisms should not proceed until the direct and indirect impacts on conservation and sustainable use of biodiversity are better understood and assessed, including the cultural and socioeconomic impacts and the impacts on traditional knowledge as well as the rights of Indigenous Peoples, farmers, fisherfolk, pastoralists. This includes the impacts of procuring feedstocks for biorefineries.**
- **That the Working Group on Article 8(j) should be asked to consider the impact of developments in synthetic biology on Traditional Knowledge, Innovations and practices.**

- **The draft decisions pertaining to synthetic biology put forward by SBSTTA 14 are found on pp. 40 and 163 of UNEP/CBD/COP/10/1/Add.2/Rev.1**
- **"New and Emerging Issues" (agenda item 6.9 in the draft Work Programme) is scheduled for discussion in Nagoya, Tuesday October 19, 10:00 – 13:00 WG 2**
- **"Biofuels and Biodiversity" (agenda item 6.4 in the draft Work Programme) is scheduled for discussion in Nagoya, Thursday October 21, 10:00 – 13:00 WG 1**

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SIDE EVENTS AT COP 10, NAGOYA:

SYNTHETIC BIOLOGY AND NEXT GENERATION BIOFUELS

Monday Oct. 18th, 13:15-14:45, Room 212A - Bldg 2, 1st Floor

GEOENGINEERING: CHALLENGES FACING THE CBD

Tuesday Oct. 19th, 13:15-14:45, Room 234C - Bldg 2 - 3rd Floor

TERMINATOR TECHNOLOGY…THE BAD IDEA THAT WON'T GO AWAY

Monday Oct 25, 16:30 - 18:00, Room 236 - Bldg 2 - 3rd Floor

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ETC Group or Action Group on Erosion, Technology and Concentration

ETC Group is an international civil society organization. We address the global socioeconomic and ecological issues surrounding new technologies with special concern for their impact on indigenous peoples, rural communities and bio-diversity. We investigate ecological erosion (including the erosion of cultures and human rights); the development of new technologies; and we monitor global governance issues including corporate concentration and trade in technologies. We operate at the global political level and have consultative status with several UN agencies and treaties. We work closely with other civil society organizations (CSOs) and social movements, especially in Africa, Asia and Latin America. We have offices in Canada; USA, Mexico and Philippines.