Submission of information on Synthetic Biology, Ref: SCBD/BS/CG/MPM/DA/8427

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This comment is relevant to iii (adequacy of existing national, regional and/or international instruments to regulate) and vii (the degree to which existing arrangements constitute comprehensive framework):

++We should learn from prior mistakes. Experience with "traditional" GMOs so far has resulted in many unanticipated and far reaching direct and indirect consequences for biodiversity.

It is essential to cast a wide net and "connect the dots" in order to fully grasp the ever widening scope of consequences from GMOs and thus to learn from those lessons as we approach synthetic biology, since we have every reason to assume that similar and likely even more dramatic consequences can be expected.

Indirect impacts are often more difficult to assess, and are also more serious and of greater magnitude even than direct impacts. They can occur at all levels. For example, manipulation of one part of an organisms genome can have unanticipated effects on the activity and expression of other non-target genes. That, in turn may alter the role of those organisms within the population, and ultimately be reflected ongoing as some alteration to the ecosystem (for example if traits confer invasiveness for example). Narrow assessments cannot begin to capture the full range of risks. Nor can assessments based purely upon biochemical and genetic analyses in isolation from social and political contexts.

Many examples of consequences of GMOs are available in previously referred: **http://natureinstitute.org/nontarget/report_class.htm**.

However, I highlight just a few of the more indirect ones:

While debates and research on safety of GMOs have focused primarily on effects of consuming GMO crops, what may be a greater concern is the increased use of herbicides, especially glyphosate used on "roundup ready" GMO soya and maize. The WHO recently declared glyphosate to be a human carcinogen. Hence some cancers should now be considered an unanticipated and indirect impact of GMO crops.

Meanwhile, some targeted weeds developed resistance to glyphosate herbicides as a consequence of its rampant use. In response, industry has developed, and agencies have recently permitted the sale of 2,4-D resistant varieties and the associated new formulations of herbicides ("Enlist"). Spraying agent orange on crops can hardly be considered likely to benefit biodiversity (or human health). Damages that are likely to be inflicted from this escalating GMO "warfare" against increasingly resistant weeds and pests constitute part of an evolving and expanding history and scope of unanticipated and indirect consequences of GMOs.

Farmer suicides resulting from indebtedness incurred by farmers who purchased proprietary GMO seeds and experience crop failures should be considered an unanticipated indirect impact of GMOs.

Is it not logical to assume synthetic biology will dramatically expand upon the litany of such impacts? Many of those will likely have far reaching negative consequences on biodiversity and on human welfare (which in turn feeds back to negatively impact on biodiversity).

Understanding the full extent and reach of potential impacts requires that we acknowledge and identify that market forces are driving research and development in synthetic biology (and some with interests in those markets are playing a role in establishing policy). The fundamental aim of marketing is not protection of biodiversity, but profitability. The CBD should not assume itself to operate outside of the social and political sphere. This should be openly recognized and incorporated into an holistic consideration of the impacts of synthetic biology, and the CBD's role in determining policy.

Again, we can learn from experience with GMOs: an ongoing "battle" for public approval of GMOs continues to rage, with industry backed interests promoting a message that GMOs are "proven safe" for consumers. Scientists on the other hand have clearly articulated "there is no consensus on GMO safety", with analyses from peer reviewed literature clearly demonstrating that the scientific debate over GMO safety has hardly been resolved, even in spite of many commercially grown GMO crops on the market, and even with (lax) regulatory processes and assessments in place.

We should aspire to avoid replication of this scenario, where regulatory oversight has failed to prevent harms. Especially given the ever more risky and dramatic manipulations of life that synthetic biology makes possible.

While the CBD has debated whether or not synthetic biology is a new and emerging threat, out in the "real world" research and development of synthetic biology is speeding rapidly ahead with numerous products already available on commercial markets - from cosmetics and flavorings to drilling lubricants for fossil fuel extraction (Encapso). Furthermore there is a strong DIY "movement" that entirely lacks any oversight or regulation even as there exist troubling potentials for the development of pathogens and bioweaponry using synthetic biology techniques.

This should be cause for alarm and requires a strong, rapid response based very soundly on the principles of precaution and with rigorous enforceability.

Risks to biodiversity include harms resulting from industries that synthetic biology applications seek to enable.

A large sector of synthetic biology research is aimed at development of microbes capable of breaking down plant cellulose feedstocks that can then be used to produce fuels and chemicals. These synthetic "biorefinery" approaches, like other forms of bioenergy, rely upon assumed access to staggering quantities of plant biomass.

The impacts of huge new demands for biomass crops, wood and the water, nutrients and soils required for their production have already had serious negative impacts on biodiversity and those will increase many fold if technologies for conversion of cellulose are further advanced by synthetic biology.

Even at current scales, demand for biomass for bioenergy is having serious consequences on biodiversity - resulting in increasing scope and intensity of forest harvests, conversion of forests to tree monocultures, expanding demand for biomass crops resulting in displacement of food production and other land uses, etc. Some examples:

++In the southeastern USA, wood pellet production has grown very rapidly with demand from European energy companies subsidized for producing "renewable energy". According to the FAO pellet exports from North America to Europe doubled in one year, between 2012 and 2013, and globally expanded by 12%. The southeast has already suffered massive losses of biodiversity due including fromexpanding monoculture pine plantations in service of the pulp industry. The National Academy of Sciences reported the region was experiencing a rate of deforestation four times faster than Brazil between 200 and 2012. Now pellet manufacturing is contributing to further logging and conversion of land.

An investigation revealed that pellet manufacturers were in fact clearcutting remaining pockets of endangered Mid-Atlantic Coastal wetland forests.
http://www.nrdc.org/energy/forestnotfuel/files/enviva-wood-pellets-FS.pdf

++ Climate change perhaps now represents the biggest threat to biodiversity, as recognized by CBD. Land use change, especially conversion of natural ecosystems, forests, grasslands etc. is a major source of GHG emissions, as acknowledged in CBD reporting (Tech report 65) on biofuels and biodiversity Hence when demand for biomass results in land conversion, it contributes to climate change, hence to biodiversity loss. This includes not only the foregone sequestration resulting from harvesting of trees or other biomass, but also impacts from harvest and transport machinery and soil disturbance. Recent studies of forest soils for example indicate ongoing emissions of carbon from that can continue ongoing for decades after trees are cut and removed.
http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12221/abstract

++A modelling study of the consequences of an aggressive cellulosic biofuel program revealed that by 2050 up to 103 billion tonnes of carbon would be released and under a more conservative scenario would see the loss of 3.4 million km^2 of grasslands currently used for grazing, 38% of the natural forest cover and 38% of wooded savannah in sub-Saharan Africa based on 2000 figures. In Latin America, the same scenario would be associated with the loss of 20% of natural forests and savannah. http://www.calepa.ca.gov/cepc/2010/AsltonBird/AppAEx13.pdf
Unintended Environmental Consequences of a Global Biofuels Program, Jerry M. Melillo et al, MIT Joint Program on the Science and Policy of Global Change, Report No. 168, January 2009

++ Bioenergy crops result in a domino effect on land use involving displacement of food production and livestock grazing into biodiverse ecosystems. A study modeled the projected impacts of planned expansion of Brazilian biofuels (cane ethanol and soya biodiesel), showing the interaction between crop expansion into existing rangelands, and resulting displacement of cattle ranching into forested areas. "*Sugarcane ethanol and soybean biodiesel each contribute to nearly half of the projected indirect deforestation of 121,970 km2 by 2020, creating a carbon debt that would take about 250 years to be repaid using these biofuels instead of fossil fuels*."
http://www.pnas.org/content/107/8/3388.full
Lapola, D. et al. 2010. Indirect land use changes can overcome carbon savings from biofuels in Brazil. *PNAS.* 107, no. 8.

++ Researchers found that 530,000 hectares of diverse native grasslands in the western U.S. cornbelt had been converted to corn and soya monocultures between 2006 and 2011, with associated loss of bird and other species. This was largely as a result of biofuel mandates increasing demand. http://www.pnas.org/content/110/10/4134.abstract
Wright, C. and Wimberley, M.C. 2012. Recent land use change in the Western corn belt threatens grasslands and wetlands. PNAS vol 110, no. 10.

The above examples represent just a very small sampling of studies that point to the very serious impacts on biodiversity resulting from ever expanding demands for biomass. The development of synthetic microbes to facilitate further conversion of biomass into fuels and chemicals etc. only contributes further towards locking us onto this dangerously misguided pathway that assumes we can simply substitute living biomass (and biodiversity) as an alternative to fossil energy sources.

Re: risks and risk assessment

It is critical that risk assessments take into account the full breadth of what is not known or is unknowable. In doing so it may only make sense to assume assessments are not feasible and precaution is advised.

Predicting outcomes for synthetic organisms is impossible hence risks simply cannot be accurately assessed. Predicting the full range of outcomes from development of synthetic organisms is not possible with current levels of understanding. It is especially impossible at this stage to predict how a synthetic organism will behave in nature, or how it may change or evolve over time in the event of environmental release.

The focus of synthetic biology has been on microbes and microalgae, which present some very unique concerns:

1) **They cannot be contained**: Most synthetic biology applications involve use of microbes such as ecoli and yeast, as well as various species of microalgae. These are so small, generally invisible to the naked eye, difficult to detect, and easily become air or waterborne. Some are capable of surviving under otherwise harsh circumstances, are highly adaptable, have prolific and rapid reproductive cycles and frequently engage in horizontal gene transfer with other organisms. Microbes and single celled organisms should be considered essentially impossible to "contain" and environmental release should, honestly, be considered inevitable.

In the context of research and development using GMO and synthetic microalgae for biofuel production, researchers have repeatedly raised concerns about the potential for environmental release, and they assume escape into the environment to be simply unavoidable. See for example: http://www.sciencedirect.com/science/article/pii/S2211926412000549

2) **Engineered traits often overlap quite precisely with those that are associated with invasiveness.** The characteristics that are desireable for fuel and chemical production from microalgae for example, include tolerance to conditions of mass cultivation, hardiness, resistance to predators and pests, fast growth and ability to outcompete for nutrients etc.

3) **Microbes play key fundamental roles in maintaining crucial processes hence disruption of their biology could have far reaching consequences**: We are only just beginning to understand the key role of microbes in regulating and maintaining life: producing oxygen, assisting in digestion, fermentation, decomposition, nutrient uptake and many other processes. Hence any negative impacts from synthetic biology, and especially if/when environmental release occurs as

appears likely, could potentially have broad, far-reaching and most likely irreversible consequences.

A recent review, for example, concludes "Growing evidence points to belowground biota (microbial) as a significant contributor to aboveground diversity and functioning as well as impacting eco-evolutionary responses to environmental change."
http://www.nature.com/nature/journal/v515/n7528/full/nature13855.html

Towards a fuller comprehension of the very key and fundamental role of microbes, consider that researchers recently pulled together observations from the geological record around the time of the End Permian extinction to conclude that "Collectively, these results are consistent with the instigation of Earth's greatest mass extinction by a specific microbial innovation." The innovation they refer to was one that enabled very efficient microbial metabolism of organic carbon to methane. The evolution of that metabolic pathway resulted from a horizontal gene transfer event.
http://www.pnas.org/content/111/15/5462.full

Manipulation of microbial metabolic pathways is now common fare for synthetic biology laboratories.