

Next generation biofuels and synthetic biology¹

Biofuels: Not a silver bullet

For some, biofuels hold out the promise of a win-win-win solution. They claim that biofuels will reduce greenhouse gas emissions, promote energy independence, and encourage rural development. This enthusiasm translates into significant government support. Annual global subsidies for biofuel production were \$11 billion in 2006 and could rise to \$50 billion by 2020.² Many governments have enacted new pro-biofuel policies in recent years.³ Developed country governments like the UK and EU have set consumption targets for biofuels.

But analysis is revealing a harsher reality. First generation biofuels – bioethanol from cereal crops and biodiesel from oilseeds – may instead increase greenhouse gas emissions. This is primarily because of land use change, such as deforestation to create palm oil plantations. The fertiliser-intensive agriculture these biofuels require also drives soil erosion and the eutrophication of aquatic ecosystems.⁴ Biofuels compete for agricultural land, putting pressure on food availability. Ensuring that the poor retain access to land and receive a fair share of the benefits from biofuels is fraught with challenges.⁵

The biofuel industry therefore increasingly claims that next generation biofuels can reduce these negative impacts. The first to arrive will be lignocellulosic biofuels made from the lignin and cellulose in the cell walls of plants. The feedstocks for these biofuels – trees, grasses, or leftover plant materials – have several potential advantages. They require less intensive agriculture and may be grown on “marginal” land, reducing competition for resources. Lignocellulosic biofuels could be made from agricultural or forestry residues such as rice husks and corn stover.⁶ A 2007 UN report estimated that these biofuels would be commercialised by 2015 and become competitive with petroleum-based fuels in the next 10-15 years.⁷

¹ By David Wei, FIELD.

² Simon Upton, ‘Subsidies to biofuels: A time to take stock’ (*Global Subsidies Initiative*, 30 May 2008) <<http://www.globalsubsidies.org/en/subsidy-watch/commentary/subsidies-biofuels-a-time-take-stock>> accessed 5 August 2011.

³ UN-Energy, ‘Sustainable Bioenergy: A Framework for Decision Makers’ (April 2007) 3 <<http://www.fao.org/docrep/010/a1094e/a1094e00.htm>> accessed 5 August 2011. Countries that have enacted new pro-biofuel policies in recent years include Argentina, Australia, Canada, China, Colombia, Ecuador, India, Indonesia, Malawi, Malaysia, Mexico, Mozambique, Philippines, Senegal, South Africa, Thailand, and Zambia.

⁴ Conference of the Parties to the Convention on Biological Diversity, ‘The Potential Impacts of Biofuels on Biodiversity’ (24 April 2008) UNEP/CBD/COP/9/26, 6.

⁵ See e.g. Lorenzo Cotula, Nat Dyer and Sonja Vermeulen, ‘Fuelling exclusion? The biofuels boom and poor people’s access to land’ (May 2008) <<http://pubs.iied.org/pdfs/12551IIED.pdf>> accessed 5 August 2011.

⁶ UN-Energy (n 3) 44.

⁷ UN-Energy (n 3) 13. See also Nuffield Council on Bioethics, ‘Biofuels: ethical issues’ (April 2011) 55 <<http://www.nuffieldbioethics.org/biofuels-0>> accessed 5 August 2011.

Further down the pipeline are biofuels produced from photosynthetic algae. This involves growing, harvesting, and then heating or chemically treating algae to recover the oil inside their cells. Algae that continuously secrete oil through their cell walls are in development.⁸

The new science of synthetic biology

The science behind these new biofuels is synthetic biology. Synthetic biology has rapidly grown out of genetic engineering into a new science with new risks. Genetic engineers merely modify existing organisms by splicing a few genes from one organism into another. Synthetic biologists have far greater ambitions. They aim to design entirely new life forms with pre-selected functions, like the microbes which will digest trees and grasses and ferment them into biofuels, or the algae which will harvest solar energy to produce oil.

[T]he synthetic biologist seeks to build a bespoke system (such as an organism) by re-designing an existing system or constructing one from scratch using parts taken from nature or specially designed. This approach can lead to organisms...with properties not found in nature (such as bacteria that produce spider silk or cells that change colour when they divide).⁹

The Royal Society (UK)

Synthetic biologists have developed several approaches to designing life.¹⁰ Some are designing a biological shell which will express synthetic DNA as flexibly as a computer runs programmes. The shell is created by disabling the genes of an existing organism one at a time and removing those that can be removed without killing the organism.¹¹

Others seek to catalogue and assemble biological parts like Lego bricks. BioBricks, a leading effort of this type, is a registry of DNA sequences that each reliably perform a specific function. Each “brick” is designed to be compatible with the others.¹²

Still others aim to construct synthetic life forms entirely from scratch using DNA synthesisers, “the biological equivalent of word processors”.¹³ The world’s first self-replicating synthetic genome, announced by the J. Craig Venter Institute on 20 May 2010, was constructed in this way.¹⁴ Venter described it as “the first self-replicating species we’ve had on the planet whose parent is a computer.”¹⁵

⁸ Presidential Commission for the Study of Bioethical Issues, ‘New Directions: The Ethics of Synthetic Biology and Emerging Technologies’ (December 2010) 60
<<http://bioethics.gov/cms/sites/default/files/PCSBi-Synthetic-Biology-Report-12.16.10.pdf>> accessed 5 August 2011.

⁹ The Royal Society, ‘Synthetic Biology: scientific discussion meeting summary’ (2 and 3 June 2008) 2
<<http://royalsociety.org/WorkArea/DownloadAsset.aspx?id=5486>> accessed 5 August 2011.

¹⁰ See The European Group on Ethics in Science and New Technologies to the European Commission, ‘Ethics of Synthetic Biology’ (Opinion No. 25, 17 November 2009) 13-14
<http://ec.europa.eu/bepa/european-group-ethics/docs/opinion25_en.pdf> accessed 5 August 2011, which similarly considers these three approaches.

¹¹ ETC Group, ‘Extreme Genetic Engineering: An Introduction to Synthetic Biology’ (January 2007) 11-13 <<http://www.etcgroup.org/en/node/602>> accessed 5 August 2011.

¹² *ibid* 16.

¹³ *ibid* 3.

¹⁴ Presidential Commission for the Study of Bioethical Issues (n 8) 41.

¹⁵ Nicholas Wade, ‘Researchers Say They Created a “Synthetic Cell”’ *The New York Times* (New York, 20 May 2010) <<http://www.nytimes.com/2010/05/21/science/21cell.html>> accessed 5 August 2011.

Unknown risks and harms

It is extremely difficult to anticipate the risks and harms of a new science like synthetic biology, and therefore of next generation biofuels. Traditionally, the risks of new genetically engineered organisms are assessed by comparison with their known relatives. Containment rules and risk mitigation strategies are then set based on the rules for the known relative.¹⁶ But synthetic biologists are capable of designing organisms with no relatives in nature.

Many of the potential risks and harms of next generation biofuels are environmental. For example, a report by the UN Convention on Biological Diversity (CBD) Secretariat noted that several candidate species for future biofuel production show the traits of invasive species.¹⁷ Building “terminator genes” into synthetic organisms or making them dependent on artificial substances may decrease the likelihood of uncontrolled proliferation. But uncontrolled proliferation may occur despite best efforts at containment. Synthetic microorganisms released into the environment, accidentally or intentionally, could share genes with other microorganisms through horizontal gene transfer or evolve beyond their functionality.

*One hypothetical, worst-case scenario is a newly engineered type of high-yielding blue-green algae cultivated for biofuel production unintentionally leaking from outdoor ponds and out-competing native algal growth. A durable synthetic biology-derived organism might then spread to natural waterways, where it may thrive, displace other species, and rob the ecosystem of vital nutrients, with negative consequences for the environment.*¹⁸

(US) Presidential Commission for the Study of Bioethical Issues

Other risks and harms are social and economic. The “marginal” lands where new feedstocks are to be grown often enable the livelihoods of small-scale farmers, women, and indigenous peoples. Just like first generation biofuels, next generation biofuels could weaken access to land and the distribution of benefits to the poor instead of improving them.

Synthetic biology also presents new biosecurity threats. DNA sequences and design software are available online and synthesised DNA is available by mail order.¹⁹ In 2002, a team of researchers at the State University of New York demonstrated the potential threat by recreating the polio virus from sequences of DNA ordered by mail.²⁰

Legal and policy analysis: A gaping hole

As the science of synthetic biology strides forward, we increasingly risk these harms and others which are currently unknown. But there is little clarity on how synthetic biology is currently regulated under domestic and international law, and no clarity on how regulation should proceed.

Governments and civil society are just beginning to engage with synthetic biology. Legal and policy analysis is significantly underfunded. Of public funds spent on synthetic biology

¹⁶ Presidential Commission for the Study of Bioethical Issues (n 8) 131.

¹⁷ Conference of the Parties to the Convention on Biological Diversity (n 4) 6.

¹⁸ Presidential Commission for the Study of Bioethical Issues (n 8) 63.

¹⁹ European Group on Ethics in Science and New Technologies to the European Commission (n 10)

44.

²⁰ ETC Group (n 11) 23.

research since 2005, only 4% from the US and 2% from the EU have been used to examine the ethical, legal and social implications of synthetic biology.²¹

A few NGOs such as ETC group and Friends of the Earth are raising public awareness of synthetic biology and campaigning for a strong regulatory framework. The US Presidential Commission for the Study of Bioethical Issues, and the European Group of Ethics in Science and New Technologies to the European Commission, have begun policy analysis at the domestic and EU levels.

Among international regulatory institutions, only the CBD is specifically considering synthetic biology. The CBD Secretariat is currently receiving submissions on “synthetic biology... [and] applying the precautionary approach to the field release of synthetic life, cell or genome into the environment.”²² These submissions will be considered by the CBD’s Subsidiary Body on Scientific, Technical and Technological Advice in May 2012.

In a decision at the 2010 CBD conference in Nagoya, Parties shied away from a moratorium on the field release of synthetic life, and merely acknowledged the entitlement of Parties to establish moratoria through domestic legislation.²³ When constructing this compromise, developed countries and biofeedstock producers such as Brazil, Argentina and the EU opposed convening an expert group on synthetic biology and opposed requesting that Parties avoid release of synthetic life into the environment.²⁴ In contrast, developing countries such as The Philippines, Cameroon, the Dominican Republic and Bolivia recommended ensuring that synthetic life is not released into the environment.²⁵

A cross-cutting patchwork of international law and regulation applies to next generation biofuels developed with synthetic biology. This patchwork includes the following parts.

- Several principles of international environmental law are applicable. For example, the precautionary principle provides guidance when dealing with risks. The no-harm rule requires that states prevent and minimise the risk of transboundary harm.
- Multilateral environmental agreements such as the CBD and its Cartagena Protocol on Biosafety will apply to next generation biofuels. Guidelines developed under these agreements on the sustainable use of biodiversity, environmental impact assessment and invasive alien species may also apply.
- Certain World Trade Organisation agreements will be relevant. Intellectual property related to synthetic biology will be covered by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). The Agreement on the Application of Sanitary and Phytosanitary Measures (SPS) permits states to take measures to

²¹ Synthetic Biology Project, ‘Trends in Synthetic Biology Research Funding in the United States and Europe’ (June 2010) 2 <<http://www.synbioproject.org/library/publications/archive/researchfunding/>> accessed 5 August 2011.

²² Convention on Biological Diversity Notification, ‘Invitation to provide information on new and emerging issues relating to the conservation and sustainable use of biodiversity and the fair and equitable sharing of benefits arising from the use of genetic resources’ (19 January 2011) Ref: SCBD/STTM/JM/RH/VA74761 <<http://www.cbd.int/doc/notifications/2011/ntf-2011-013-emergingissues-en.pdf>> accessed 5 August 2011.

²³ Conference of the Parties to the Convention on Biological Diversity, Decision X/37, ‘Biofuels and biodiversity’ (2010) para. 16 <<http://www.cbd.int/decision/cop/?id=12303>> accessed 5 August 2011.

²⁴ International Institute for Sustainable Development, ‘Summary of the Tenth Conference of the Parties to the Convention on Biological Diversity’ (18-29 October 2010) 9(544) Earth Negotiations Bulletin 22 <<http://www.iisd.ca/download/pdf/enb09544e.pdf>> accessed 5 August 2011.

²⁵ *ibid.*

protect human, animal, or plant life or health. A related issue is how trade agreements and environmental agreements will fit together.

- Human rights instruments like the Universal Declaration of Human Rights and the International Covenant on Economic, Social and Cultural Rights protect land tenure and the right to food, two of the many rights affected by biofuels.

Other parts of international law apply to other uses of synthetic biology. For example:

- Instruments such as the Biological and Toxin Weapons Convention and World Health Organisation biosafety standards aim to protect us from both accidental release and the malicious use of pathogenic microbes.
- Some human rights instruments relate to the medical applications of synthetic biology. These include the Universal Declaration on the Human Genome and Human Rights, the International Declaration on Human Genetic Data, and the Universal Declaration on Bioethics and Human Rights. These aim to protect human dignity as new medical biotechnology is developed.

Given the potential risks and harms, the effective international regulation of synthetic biology and second generation biofuels is crucial. This will require applying many areas of international law and plugging up gaps in the existing patchwork. In short, new biofuels will demand new thinking on our part.

Contact:

David Wei
Staff Lawyer

david.wei@field.org.uk
T: +44 (0)20 7842 8524

Foundation for International Environmental Law and Development (FIELD)
Suite D, 1st Floor, The Merchant Centre
1 New Street Square, London EC4A 3BF, United Kingdom

www.field.org.uk