ARPA-E: Not as green as it's cracked up to be

Synthetic Biology

ARPA-E, Advanced Research Project Agency – Energy, is a Department of Energy (DOE) program that has been highlighted in the 2010 and 2011 Green Scissors reports as an environmentally harmful government subsidy. Both reports note that the program funds some environmentally beneficial projects, and therefore does not include the ARPA-E budget in the total list of cuts. This issue brief, which explains ARPA-E's support of synthetic biology research (for applications such as biofuels), is the first of a series describing the environmentally harmful or risky aspects of ARPA-E.

About synthetic biology

Scientists have been manipulating the genetic code since the early 1970s when they began genetically engineering bacteria, plants, and animals. This "old" form of genetic engineering involves taking a short segment of DNA from one organism and inserting it into another organism. Synthetic biology, on the other hand, is a "new" extreme form of genetic engineering that looks to reengineer entire genes and genomes. Scientists are now able to manipulate genetic material like never before due to advances in genetic engineering, DNA sequencing, nanotechnology, and robotics. Synthetic biology has been defined as "the design and construction of new biological parts, devices and systems that do not exist in the natural world and also the redesign of existing biological systems to perform specific tasks."[1] In other words, synthetic biologists hope to create novel genes, novel genomes, and even novel organisms. Each of these novel organisms bring novel risks to the environment, worker safety, and public health that have yet to be properly addressed.

Synthetic biology may help us to better understand biological processes, but it is an inherently risky technology. Synthetic biologists are attempting to create novel genes and organisms that have never existed before in nature. It is impossible to predict how these new organisms, which have not faced any natural evolutionary pressures that normally keep populations in check, will behave once they get out in the environment.

The line between "old" genetic engineering and synthetic biology is often blurry since the latter is an extension of genetic engineering technologies and still utilizes similar techniques. For this reason, genetic engineering and synthetic biology research are grouped together in this analysis since they both carry similar types of risk to varying degrees. Additionally, much of the work currently called synthetic biology is not much different than genetic engineering, but as the technology advances it will be able to create increasingly novel organisms which will only increase the riskiness of this research.

Most of this work is on redesigning some of the most common organisms on the planet such as algae (which is responsible for up to 40% of our planet's oxygen), E. coli, and yeast. These organisms are easily able to swap genes with their wild-type counterparts, and if being used at a commercial scale they will undoubtedly escape confinement. Even if these bugs die out in the wild, their transgenic or synthetic DNA does not just disappear – it can easily be picked up by their natural relatives and pass on indefinitely. Unlike other types of pollution, genetic contamination cannot be cleaned up. As far as we can tell, neither the DOE nor any federal agencies funding this type of work have conducted proper risk assessments on this technology.

1 *Extreme Genetic Engineering: An Introduction to Synthetic Biology. Ottawa, ON.. ETC Group, 2007.*

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In fact, a report found that between 2006 and 2010 the DOE had spent more than $700 million on synthetic biology research -- much more than any other agency. Of this, only $15 million, or roughly 2% of total funding, had been dedicated to the study of the ethical, legal, and social implications of the research. According to publically-available data, none of this funding was dedicated to environmental risk assessment.[2]

The environmental risks of synthetic biology research is unknown since it has not been studied, but past experience with invasive species can be instructive: for example, scientists are re-engineering algae to produce more lipids for fuel, and therefore de-optimizing oxygen production. If these algae get out and start producing these oils in open waters, these algae could pollute local ecosystems and their high oil-producing genes could be passed on to wild-type algae. Most types of algae reproduce on a daily basis which means that not only is actual biomass increasing rapidly, but the rate at which algae are able to mutate is quite rapid as well. Also, algae swap genes frequently; this occurs both through horizontal gene transfer (one algae to another) but also vertical gene transfer (algae to other organisms).[3]

Algae is also a natural aerosol and can blow in the slightest breeze or be easily carried out of a lab on a worker's clothes. These algae could get into the lungs of workers and even float into the air of local communities. It's possible that the algae could just die and not cause harm. But it is also possible they could survive, find a niche, and take over an ecosystem. This is a hypothetical but not unrealistic assumption: using today's technologies, algae that is cultivated at a commercial scale (i.e. at a level where a company would make a profit) would probably be produced in open ponds. They would likely be engineered to be more fit than the wild local algaes so their engineered genes would not be lost, and so their survival in the environment is quite possible.

Without proper precautionary assessment, society won't know the risk of harm that synthetically engineered algae or other organisms would cause.

ARPA-E and synthetic biology

ARPA-E first started funding synthetic biology research in 2010 with $55 million (about 32% of total DOE funding on synthetic biology that year). All of the 13 electrofuels projects that ARPA-E is funding employ genetic engineering or synthetic biology. None of the ARPA-E research seeks to compare the production levels of naturally-occurring organisms (which would not carry risks of biological or genetic pollution with synthetic genes) with those of these genetically engineered and synthetic bugs.

To make matters worse, DOE is currently in the process of trying to get an exemption from the National Environmental Policy Act (NEPA) for *all* their research projects – including genetic engineering and synthetic biology. NEPA normally requires proper environmental assessments of any major federal action, and major funding initiatives normally fall under this requirement. Friends of the Earth strongly opposes conducting research of this type that could have catatstrophic environmental consequences without even a review of what the potential impacts are, or what alternatives are available. DOE should not be able to fund risky research without performing due diligence to ensure these projects do not harm the environment, workers, or the public.

2 *Trends in Synthetic Biology Research Funding in the United States and Europe. Rep. Woodrow Wilson International Center for Scholars' Synthetic Biology Project, June 2010.* <http://www.synbioproject.org/process/assets/files/6420/final_synbio_funding_web2.pdf?>.

3 *For example, the algae-eating Elysia chlorotica slug has picked up algae photosynthesis genes, and can now perform photosynthesis.*

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Friends of the Earth believes that it is important to develop innovative new solutions to climate change. Unfortunately, ARPA-E is funding many programs that pose real concerns for the environment. We have called for a moratorium on the release and commercial use of synthetic organisms until a precautionary regulatory framework is in place to determine whether and for which purposes a synthetic organism or its products can be safely and justly used. Additionally, appropriate oversight and security mechanisms must be in place before the research and development of synthetic biology continues.

For more information on synthetic biology, including a report on the dangers of synthetic biology for biofuels production, see http://www.foe.org/healthy-people/synthetic-biology.

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