Canadian Friends Service Committee (Quakers)

SYNTHETIC BIOLOGY: 2017 UPDATE #1

Combining life sciences, computer science, and engineering, techniques called “synthetic biology” are taking off. Their proponents are hoping to create increasingly novel life forms. Canadian Friends Service Committee (CFSC) is the peace and social justice agency of Quakers in Canada. Grounded in our values of peace, integrity, equality, simplicity, and respect for all creation, we are led to respond to the rapidly advancing field of synthetic biology.

CFSC's specific mandate is listed in the Appendix. It includes sharing easily accessible updates about synthetic biology to raise public awareness. The following is the first update of 2017. Previous updates are at http://quakerservice.ca/SyntheticBiology

Please share any thoughts or feedback (however brief or detailed): matt@quakerservice.ca

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As with previous updates we will start with two quotes that highlight very different points of view:

"There is published evidence that overly stringent excessively precautionary regulation stalls science and innovation."[1]

"In place of a process that trusts technology and mistrusts humanity, we must learn and live out a process that builds trust between people and their institutions…"[2]

Gene drives continue to be the biggest and most controversial story in synthetic biology. Gene drives aim to overcome evolution by forcing a trait through an entire population (or even an entire species). The intention is to pass on a trait, or its absence, to all offspring. For a few years the Pentagon has expressed deep concerns that gene drives may soon have the ability to "alter evolution in ways scientists can't imagine."[3] Mathematical models suggest that resistance to gene drives will develop quickly, making them at least for the time being highly improbable to succeed at a population level.[4]

CFSC joined hundreds of other agencies from around the world in calling for a moratorium on research into gene drives until robust risk assessment and governance frameworks are put into place.[5] Currently there are no laws about the use of gene drives, and many uncertainties remain. The impacts of accidental or intentional release of a gene drive could be anywhere from minor to catastrophic. The Convention on Biological Diversity, at its meetings in December 2016, did not agree to a moratorium on gene drives. However gene drives were discussed, and a call for caution and better risk assessment was issued, in spite of four countries, including Canada, doing their best to keep this conversation from happening.[6, 7]

At the 2016 International Genetically Engineered Machines (iGEM) competition, a group of undergraduate students came close enough to engineering a working gene drive that it created a stir. In response iGEM developed guidelines for how students can work with gene drives at future competitions. "We were very surprised at the interest in our project," said Kathryn Almquist, a member of the team that attempted to develop a gene drive. "We didn't realize how big of a deal this was."

Reporters asked several do-it-yourself synthetic biology labs about gene drives and one board member said that if someone there wanted to start working with gene drives then "we would have to have a long conversation with them," but did not say that do-it-yourself gene drives are off the table.[8]

iGEM prizes. Photo CC-BY iGEM Foundation and Justin Knight

A dragonfly cyborg using computer chips and synthetic biology is in the works. You can see a 30 second video of the "DragonflEye" at https://vimeo.com/219709402. The dragon fly is made to wear tiny solar panels and electronic parts with the goal of sending signals to take over the insect's neurons and force it to fly as controlled by humans. The dragonfly's nerve cord was edited using genes naturally found in the eyes to make its "steering" neurons light sensitive. The electronic parts on the insect's back may eventually be able to force it in different directions through emitting pulses of light. The DragonflEye may be used as a living drone for surveillance.[9]

Synthetic biology weapons could take any number of forms, one presumably being spreading diseases to crops to cause people to starve or economies to collapse. The US Department of Defence (DARPA) is now taking an interest in using synthetic biology to edit already-mature plants. It claims to be examining the use of synthetic biology and insects to protect plants. "Viruses, pests, fungi, herbicides, drought, pollution, salinity, flooding, and frost—the plants that we depend on for food, clean air, and materials are challenged by myriad threats, natural and man-made." DARPA claims they will use synthetic biology to "transform certain insect pests into 'Insect Allies,'" having them transmit complex "protective traits" via viruses they carry between plants.

DARPA's press release says that changes that currently take 15 years to propagate in a plant population will be pushed through in a single season but assures that trials will be done in "closed laboratories, greenhouses, or other secured facilities."[10]

Transforming mature plants in the way DARPA describes has never been done and may not be possible. To date there are still major technical challenges to the use of synthetic biology in agriculture.[11]

However, in addition to synthetic biology ingredients that end up in food (e.g. stevia, vanillin), synthetic biology is increasingly being applied to the more complicated task of editing whole plants. A piece in *The*

Atlantic describes this trend as "cool," quoting a company CEO on how synthetic biology techniques will allow innovations to meet consumer desires for currently impossible foods.[12]

Some are critical of these new trends though. Arctic apples that don't turn brown, even when rotten, are now available in grocery stores. Dana Perls, in a piece in Stat News, notes, "Yet there's a reason an apple turns brown — it's a signal it has been cut or bruised. If a little oxidizing is worrisome, we can use lemon juice, a proven, natural method to prevent it."

Perls notes that this apple and other foods made via synthetic biology can be marketed as non-genetically engineered organisms (GMOs) because existing definitions are out of date with technological capabilities. "So far, no safety assessments specific to these new techniques are required, and no regulatory oversight is in place for this swiftly moving set of new technologies."[13]

Synthetic biology is being used to market crops to farmers as well as consumers. Monsanto has reportedly started work on crops edited via synthetic biology in addition to its older GE crops. It's unclear what exactly Monsanto will seek to do via synthetic biology, but so far its focus has been on improving crop yields. Its press release states, it will use synthetic biology to "enhance beneficial or remove undesired plant characteristics."[14]

There is good reason to be skeptical about the actual effects synthetic biology may have on crops. For decades there has been heated controversy over GMOs. Many feel that claims about the health risks of GMOs have been advanced in an unscientific and biased way.[15] At the same time, there may be a misrepresentation of a consensus among scientists about the safety of GMOs for human health, where no such strong consensus exists, and instead significant scientific uncertainty remains.[16]

While the debate about the health impacts of consuming GMOs rages on, this is far from the only dimension worth considering as synthetic biology foods proceed to market.

For years, multiple studies have found that GE crops do not have higher yields than non-GE crops. Additionally, they have been correlated with *increased* herbicide use.[17] Given that improved yields and reduced herbicide use have been put forward as the main arguments for the use of GE crops,[18] the question arises: *Even if there are no risks to human health from consuming GMOs, are the alleged benefits (which may not exist at all) significant enough to warrant the use of such crops?*

Scientist Michael Hansen offers his assessment of the use of synthetic biology in food by touching on bigger questions:

> "There is global agreement in the World Agriculture Report that industrial agriculture and genetic engineering are not the answer for the future of food. The answer is ecologically rational farming systems.

> "Biotechnology by its very nature is focusing on one or a few genes or specific traits whereas truly ecological agriculture is focused on whole systems. That's the direction consumers want and where we need to go for health and sustainability."[19]

In a particularly poor example of reporting on synthetic biology, a full article about US government regulations of the use of techniques like CRISPR does not make one mention of *what* those regulations actually are, or *why* they have been enacted (i.e. what safety or uncertainty issues they are responding to)! Amazingly, the *MIT Technology Review* instead focuses entirely on how those wishing to use synthetic biology in animals are disappointed and may engage in "civil disobedience" - simply going ahead with making the edits they are prohibited by regulators from making.[20]

In a somewhat more balanced piece, the *Wall Street Journal* discusses a few of the obvious issues with the do-it-yourself approach to synthetic biology: "While [the low cost and ease of use of CRISPR] raises the prospect of people with nefarious intent gaining access, the greater concern with amateur enthusiasts is that someone might make a seemingly innocuous gene edit in a fungus, insect or plant that turns out to wreak havoc on the environment."

The article notes that lesson plans to teach about these issues in high schools have been developed. "The lesson doesn't involve doing an experiment. Rather, it covers the history of Crispr and gene editing, some of the key findings, and the moral questions Crispr raises."[21]

The Nuffield Council on Bioethics has been studying moral questions and released a detailed initial review.[22] It's commendable for having been produced by a group with varied expertise (science, law, philosophy, sociology, and industry), and for being based on a public call for evidence to consider.[23]

Among many things, the review notes that both the speed and amount of research being done using synthetic biology is increasing, because costs are now lower and techniques are easier for researchers to apply.[24] The review notes "speculative interest" that synthetic biology "may have a role to play in the selecting or enhancing of military personnel in relation to genetic susceptibility to disease or improved physical fitness"[25] i.e. creating "super soldiers."

A team of undergraduate students claim to have developed a synthetic biology bacteria capable of breaking down plastics in the ocean. So as not to leave the resulting acids floating in the ocean once the

plastic has been broken down, another edited bacteria is supposed to turn these acids into voltage for a microbial fuel cell.[26]

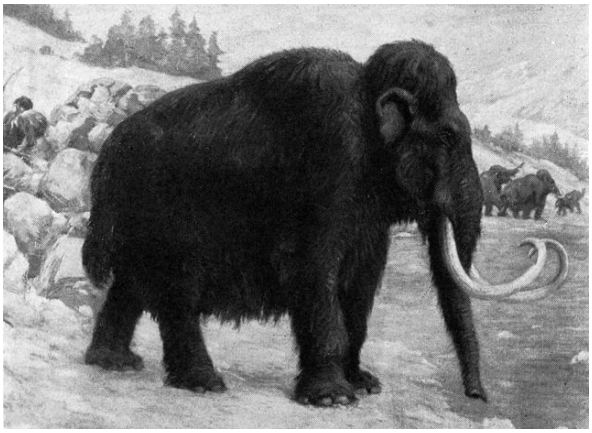
Synthetic biology is being used to work on soil that will supposedly keep the ground under buildings sturdier. The claim is that a cement-like material would be created by "custom-built soil microbes... in response to the changing pressures in soil to help shore up the ground under foundations."[27] The article makes no mention of unknowns like the impacts on ecology, unwanted expansion of the organism into new areas, unpredicted behaviours or evolutionary changes of the synthetic biology edited microbes, etc.

A thorough scientific analysis based on available data, which the authors admit is limited, describes 94 core ecological processes and shows that climate change is already having a significant disruptive impact on at least 82 of them. From decreasing crop yields to shifting migration patterns, the paper acknowledges many major impacts of climate change. The authors offer the solution of "human-assisted evolution" through techniques like synthetic biology. In a review of the paper one author notes, "[the] situation is all the more fraught if the only feasible way to redress the damage of one uncontrolled global experiment is to pick up the pace on another."[28]

Synthetic biology is being used with the hope of editing plants to convert carbon dioxide "20 times faster" and with less energy used. Says scientist Tobias Erb, "Although nature is apparently very good at tinkering new solutions together, she is not necessarily a great engineer. All of these naturally existing solutions are the product of an evolutionary process, and not rational design. This means that natural pathways all come with certain flaws and disadvantages. So we started to ask if we could create options that would be more efficient than the naturally evolved ones. For instance, plants convert CO^2 relatively slowly."[29]

The most complex fully synthetic virus to date has been developed at Auburn University. Confusingly, the researchers assert they will use this expensive and complicated 3D-printed virus for the purpose of treating bone cancer in dogs.[30]

The woolly mammoth is extinct. Yet public relations efforts by synthetic biologist George Church and others have made headlines once again, claiming "de-extinction" of the woolly mammoth is "two years" away. When reading further, one learns that the plans are actually to create an Asian elephant with some mammoth traits, thanks to synthetic biology.[31] Even still, at least one analyst has said that these stories cross the line from sensationalized to "fake news." John Hawkins' article describes the amount of actual work done to date by Church's lab, after many years of work on de-extincting the woolly mammoth, as two orders of magnitude away from what would be needed. He asks, "Who would click on a story with an accurate headline? 'Forty-five mammoth genes in elephant cells, more than 4,000 to go!'"



He also notes that Church hasn't published anything in any peer-reviewed journals about this research and suggests, "[W]hen reporting on any ongoing unpublished work, competent journalists should be asking some questions: Can we see the data? What more needs to be done before experts will accept your results? If you are waiting for a big result to publish later, why is this newsworthy now?"[32] We would add that all journalists should be asking about risks, uncertainties, unknowns, who might be harmed, what the ecological implications are, and other ethical dimensions! For example, even if it were scientifically possible, why invest money in this? Researchers have suggested that reintroducing extinct species to New Zealand would cost "three to eight-times more respectively than conserving threatened species."[33]

The woolly mammoth is not the only target for de-extinction. Even extinct plants may be sources of profit. Synthetic biology company Ginko Bioworks claims it will soon have perfumes with the scents of extinct flowers. Others explain that only a few molecules, terpenes, which have particular sharp scents, are likely to be used to produce the extinct flower perfumes. This means that what Ginko produces will not have the full fragrance of extinct plants, merely something like an aspect of that fragrance.[34] Like the synthetic biology "milk" we've written about previously, which only contains 11 proteins and ignores everything else that makes up milk,[35] Ginko's perfume appears to be another example of rounding off complexity (the richness of the scent of a flower) by picking only a few key molecules and ignoring everything else.

Thanks to synthetic biology, for $160 (US plus tax and shipping) you can add jellyfish protein to beer and have a drink that faintly glows green when placed under black light. This is the promise of The Odin. Whether or not The Odin requires safety assessments from the US Food and Drug Administration has yet to be determined, and the beer kit's manufacturer is reported as saying he will "continue to sell the kits until the government says otherwise."[36]

At Scripps Research Institute in California synthetic biologists created a novel form of E Coli bacteria through adding to the normal DNA letters (G, T, C, and A) "two new molecules they call X and Y." These are unlike natural DNA. Previous attempts at expanding the DNA alphabet have been made, but the organisms did not survive and pass on their edited traits the way the present synthetic biology E Coli has.[37]

APPENDIX:

Canadian Yearly Meeting of the Religious Society of Friends (Quakers) recommends that Friends work on this concern in the following ways:

1. That CYM affirm the seven principles identified in Principles for the Oversight of Synthetic Biology, a document that makes many important recommendations, and continue to work with the Biotechnology Reference Group of the Canadian Council of Churches (BRG) on discerning ways to implement the seven principles:
    i. Employ the Precautionary Principle;
    ii. Require mandatory synthetic biology-specific regulations;
    iii. Protect public health and worker safety;
    iv. Protect the environment;
    v. Guarantee the right-to-know and democratic participation;
    vi. Require corporate accountability and manufacturer liability; and
    vii. Protect economic and environmental justice.
2. That CYM request that Canadian Friends Service Committee (CFSC), with the help of concerned groups such as the ETC Group and the BRG, provide Canadian Quakers with an annual, easily understandable update on synthetic biology;
3. That CYM request CFSC, and encourage Monthly Meetings, to find opportunities to link with other faith and community groups, and with Indigenous peoples, to share insights and discernment about synthetic biology; and
4. That CYM encourage CFSC and Quaker Meetings in Canada to engage with other faith groups and interested parties, including organizations involved in research and/or manufacture in synthetic biology, to hold and/or participate in conferences that address ethical, spiritual, social, and economic aspects of synthetic biology.

Find out more about synthetic biology, including background of how this concern of Friends has developed and what Meetings from across Canada have said:
http://www.quakerservice.ca/syntheticbiology

Questions? Comments? Contact us
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