Canadian Friends Service Committee
(QUAKERS)

SECOND UPDATE FOR 2015:

SYNTHETIC BIOLOGY

By combining biology, computer science, and engineering, synthetic biologists are creating novel life forms. Canadian Friends Service Committee 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, Quakers remain one of the few faith communities actively following developments in synthetic biology (SB).

CFSC's specific mandate related to SB is listed in the Appendix. Part of this mandate is to provide easily accessible updates on the field to be shared with Friends and the general public. The following is a second update for 2015, read the first at:
http://quakerservice.ca/SBUpdate2015

As you read each piece of news we invite you to consider three queries:

1. How can we address the ecological dimension of synthetic biology? e.g. impacts on biodiversity, synthetic organisms being untested by evolution and ecosystems;

2. How can we address the social dimension of synthetic biology? e.g. equitable distribution of benefits, needs of the vulnerable; and

3. How can we address the spiritual dimension of synthetic biology? e.g. the sacred in living beings and in nature as regards SB; the valuing of technology as compared to human wisdom and inner truth.

Please give us any thoughts or feedback however brief or detailed.
Contact matt@quakerservice.ca or call 416-920-5213.

Let's start with a quote from a synthetic biologist at the University of Southern Denmark contrasted with one from the Kabarak Call, issued by Friends from around the world at a gathering in Kenya in 2012.

"Encouraging the emergence of life from lifeless liquid chemicals manufactured artificially in a laboratory could provide us the building blocks to create a new man-made nature." - Martin Hanczyc[1]

"In past times God's Creation restored itself. Now humanity dominates, our growing population consuming more resources than nature can replace. We must change, we must become careful stewards of all life. [...] We are called to work for the peaceable Kingdom of God on the whole earth, in right sharing with all peoples. However few our numbers, we are called to be the salt that flavours and preserves, to be a light in the darkness of greed and destruction." - *Kabarak Call for Peace and Ecojustice*[2]

La Jolla synthetic biology labs. Photo credit: Steve Jurvetson/Flickr, CC-BY

In April, researchers in China published the results of a study in which the DNA of 'nonviable' human embryos were edited using synthetic biology techniques. The scientists sought to remove a specific gene responsible for an inherited disease. The findings included that the wrong DNA was often affected, and that many of the embryos did not survive. Synthetic

[1] http://inventorspot.com/articles/running-shoes-printed-synthetic-biological-material-have-life-th
[2] http://www.saltandlight2012.org/call.pdf

biologists responded with a mixture of excitement about the possibilities and recognition that the particular SB technique in question (CRISPR/Cas9) still requires further refinement. Multiple journals refused to publish the study and ethicists stated opposition to such research.[3] A group including scientists who worked to develop CRISPR and other SB tools, wrote in *Science*, "At present, the potential safety and efficacy issues arising from the use of this technology must be thoroughly investigated and understood before any attempts at human engineering are sanctioned, if ever, for clinical testing."[4]

Researchers say they have produced a biologically-active particle targeted to the specific, harmful, bacterial cells inside an infected host (animal or human), which will kill bacteria without bursting them and suddenly releasing their toxic contents into the host. Synthetic biologists hope this innovation will eventually provide an alternative to antibiotics as, "unlike traditional broad-spectrum antibiotics, these viruses target specific bacteria without harming the body's normal microflora."[5]

Community labs continue to grow in popularity, serving as spaces for learning about SB:

> Community labs like Genspace in Brooklyn, NY, and BioCurious in Sunnyvale, CA, provide courses and hands-on experience in the fields of biotechnology and synthetic biology. There, communities of students, parents, educators, artists, and many others engage in projects that look at biotechnology, robotics, neuroscience, barcoding, bioprinting, bioluminescence, and constantly more new initiatives.[6]

In 2014, the International Genetically Engineered Machines competition began expanding to include entries from community labs (with no academic affiliation) and a new category for those using SB to create art.[7]

The founder of one of Canada's first SB community labs, Biospace in Victoria, BC, describing its popularity told reporters that if people understand that biological "parts" as merely electric parts, "they get this amazing sense of empowerment: 'How would I create my world out of the parts of life?'"[8]

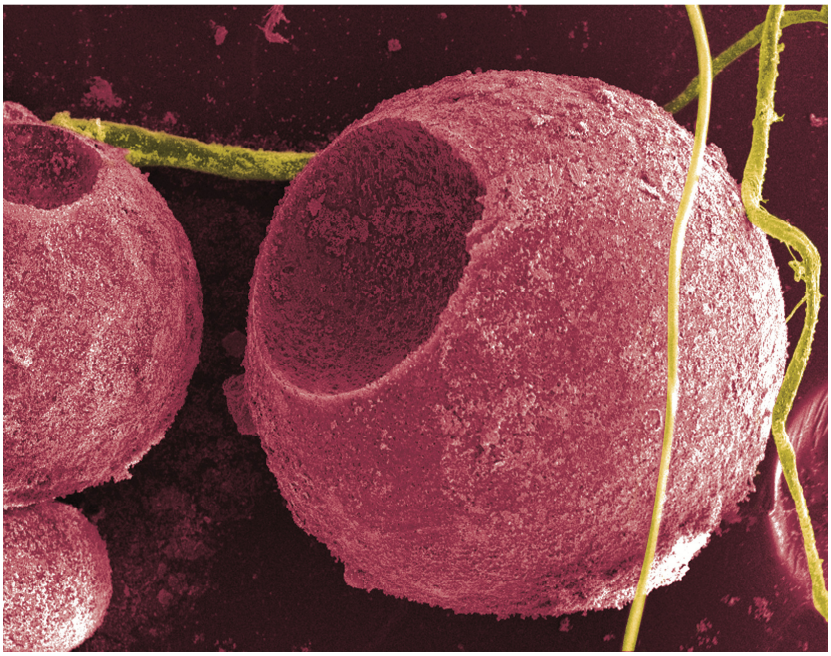
---

[3] https://www.vox.com/2015/5/4/8547797/what-is-crispr
[4] http://www.sciencemag.org/content/348/6230/36.full
[5] https://newsoffice.mit.edu/2015/engineered-particles-kill-harmful-bacteria-0625
[6] http://blogs.plos.org/citizensci/2014/11/24/synthetic-biology-diy-bio/
[7] N. Twilley, "Synthetic Life After G.M.O.s," New Yorker, December 5, 2014
[8] http://www.cbc.ca/news/technology/biohacking-diy-bio-1.3252735

Scientists at the University of Washington have developed a game with the goal of engaging members of the general public in SB design without requiring them to have any scientific background. In the game, "players organize coloured puzzle pieces to react in specific ways" which mimic the ways in which DNA functions. As players learn more they can solve increasingly complex "challenges".[9] Some consider this a positive way to engage the general public, while others call the game a further clouding of the reality that SB creates actual living organisms.

Along similar lines, a British company is working on "a high-level programming language for biology designed to make simple, reproducible and scalable workflows by stacking smart and reusable elements. The aim is to standardise biology and to make it more reproducible."[10]

Through SB, using the light responsive properties of flowers, scientists at Duke University claim to have found a way of activating or deactivating genes. "This technology should allow a scientist to pick any gene on any chromosome and turn it on or off with light, which has the potential to transform what can be done with genetic engineering," says Lauren Polstein, a Duke PhD student and lead author on the work.[11]



Pacific Northwest National Labrotory/Flickr, CC-BY

[9] http://blogs.plos.org/citizensci/2015/02/22/nanocrafter-playing-game-synthetic-biology/
[10] http://www.huffingtonpost.com/daniela-quaglia/synthetic-biology-the-daw_b_7990020.html
[11] http://www.bioopticsworld.com/articles/2015/02/blue-light-turns-genes-on-and-off-boosting-study-of-gene-function.html

Synthetic biologists at Harvard and Yale drew a good deal of attention when they said they'd created highly genetically modified E. Coli bacteria which would be "safer" than other SB organisms because they can only survive if provided designer amino acids "not found in nature".[12]

Christopher Voigt of MIT said of the story, "You can imagine creating an organism that is designed to do only what it's engineered to do, in the time period that it's engineered to survive for. Where this is all going is completely rethinking organisms from the ground up."[13]

Despite the optimistic pronouncement of complete safety outside of the lab (supposedly because the SB bacteria would quickly die without its synthetic amino acids) it remains uncertain whether mutations that would allow the bacteria to modify other compounds in place of the designer amino acids are truly impossible. Uncertainty about how much control synthetic biologists have over the evolution of the organisms they create makes a SB-based solution to biosafety highly controversial.

In mid-2015 Intrexon Corp purchased another genetic engineering (GE) company specializing in fruit.[14] The move gives Intrexon, a company working on SB as well as more "traditional" GE, near total control of GE mammals, fish, and now apples. The company also entered into new partnerships in 2015 with tree pulp producers to "increase biomass"[15] in tree species such as eucalyptus and poplar via SB. Other GE trees (not produced through SB) received approval from government regulators in the US to be released into the wild in 2015 over protests from some scientists and environmental groups about the inadequacy of evidence of the trees' safety.[16]

In another example of release outside of the lab, a company used the website Indiegogo to crowdfund a SB flower which changes colours under a special solution. The SB flower's seeds were sent to those who contributed to the campaign.[17]

Indiegogo and other sites also make home SB kits available for between $130 and $3,000, some allowing tinkering with powerful SB techniques such as CRISPR/Cas-9 (mentioned above, it was used by the Chinese team to edit nonviable human embryos). The home kits are described by

---

[12] http://www.nytimes.com/2015/01/22/science/scientists-genetically-modified-organisms-bioengineering.html?_r=0
[13] http://www.theguardian.com/science/2015/jan/21/genetically-recoded-organisms-artificial-compounds
[14] http://www.capitalpress.com/Orchards/20150302/us-firm-buys-canadian-gm-apple-company
[15] http://www.nassaunewslive.com/driving-sustainable-agriculture-through-improved-qualities-in-eucalyptus-and-poplar-trees/644920
[16] http://www.nationofchange.org/2015/02/05/usda-secretly-approves-gm-trees-despite-10000-1-opposition/
[17] https://www.indiegogo.com/projects/color-changing-flowers

one seller as something, "everyone will be able to use"... "even if you have had zero experience" with SB.[18]

Community labs and online retailers often bill their offerings as grassroots efforts to "democratize" biotechnology. One example is a small group seeking to produce a SB yeast that will excrete a substance which could eventually be made into "cheese". "The essential amino acid makeup of the synthetic milk is going to be identical to real milk," Jimenez-Flores the founder of Counter Culture Labs says. "If it has the right caloric content, it's going to be nutritionally indistinguishable from cow's milk."[19] There is an assumption here, as in many applications of SB, that the very complex, like natural milk with fats, proteins, sugars, and so on, can be reduced to a few simple parts. The SB yeast is being designed to produce just 11 proteins. This approach appears to assume that most of the natural content is just "noise" (i.e. unnecessary, imperfect, and expendable).

Outdoor clothing brand The North Face is working with a Japanese synthetic biology company to release a winter jacket made from synthetic material modeled on spider webs.[20]

As a response to climate change, researchers are investigating SB's uses in terraforming (i.e. "deliberately altering the environment in a way that cools the planet, perhaps by absorbing carbon dioxide or reflecting sunlight"). This line of inquiry is driven by the question of scale, "Instead of creating global engineering projects, why not create life forms that do a similar job?" Proponents believe that humans may destroy the planet to the point where SB terraforming will become a "necessity" in the near future.[21]

SB is being used by researchers in the US and Canada to create yeasts that produce opiates.[22] Their hope is to develop pain killers which are less addictive than morphine.

A new shoe is being designed which will be 3D printed to exactly fit the wearer's skin and will use SB "proto-cells" which react to the wearer's movement by puffing up and providing extra support. The shoe's designer claims, "When the shoes are removed, the proto-cell material can

---

[18] https://www.indiegogo.com/projects/amino-desktop-bioengineering-for-everyone#/, https://www.indiegogo.com/projects/diy-crispr-kits-learn-modern-science-by-doing#/
[19] http://www.wired.com/2015/04/diy-biotech-vegan-cheese/
[20] http://ecowatch.com/2015/11/11/north-face-moon-parka-spider-silk/
[21] http://www.technologyreview.com/view/536211/how-synthetic-organisms-could-terraform-the-earth/
[22] http://www.pbs.org/newshour/updates/brewers-yeast-morphine-sugar/

become dormant until it is needed again and then re-animated by dipping it into proto-cell soup to let them heel [sic] any damaged areas."[23]

Student presentation at iGEM 2012. CC-BY iGEM Foundation

In one of the first examples of combining the fields of robotics and SB that we're aware of, scientists at Virginia Tech are in the early stages of engineering SB bacteria colonies which can "control" the movement of a robot. "The robot in the simulation was equipped with sensors and a miniature microscope to measure the color of bacteria telling it where and how fast to go depending upon the pigment and intensity of color. The scientists observed complex behaviour, at times similar to predatory behaviour..."[24]

The World Economic Forum noted in its Global Risks 2015 report that, "The establishment of new fundamental capabilities, as is happening for example with synthetic biology and artificial intelligence, is especially associated with risks that cannot be fully assessed in the laboratory. Once the genie is out of the bottle, the possibility exists of undesirable applications or effects that could not be anticipated at the time of invention. Some of these risks could be existential – that is, endangering the future of human life."[25]

---

[23] http://inventorspot.com/articles/running-shoes-printed-synthetic-biological-material-have-life-th
[24] https://hacked.com/coming-soon-robots-bacteria-controlled-brains/
[25] http://reports.weforum.org/global-risks-2015/part-2-risks-in-focus/2-4-engineering-the-future-how-can-the-risks-and-rewards-of-emerging-technologies-be-balanced/#box2.6

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 CFSC Program Coordinator Matthew Legge:
416-920-5213 or matt@quakerservice.ca