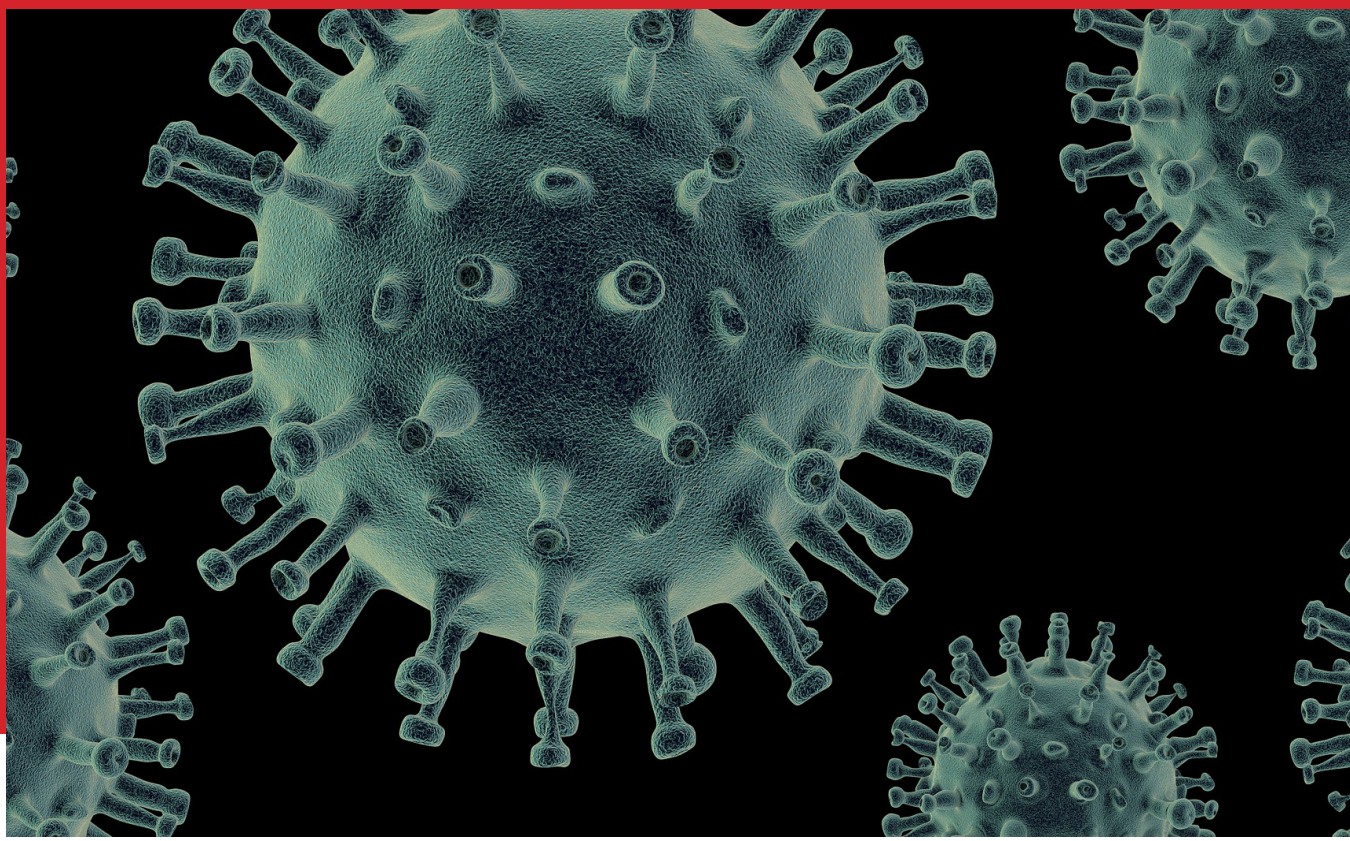
# 2020 Synthetic Biology Update



QUAKERS
Canadian Friends Service Committee

# Differing views on the key issues

"Where silicon and software powered 20th century innovation, the 21st century will bring living technology—a fourth industrial revolution of synthetic biology and genetic editing; the hardware and software of life itself."[1]

"Embracing advanced genetic engineering is required to maintain a healthy world where people can live in harmony and not destroy the planet. The biggest opposition to that is opposition to GMOs."[2]

"By starting with the assumption that our problems are fixable by technology, we end up emphasizing very particular strategies. We improve the metrics that a given technology can improve, but often ignore or leave behind the sorts of problems that the technology can't address."[3]

"If anybody thinks we can understand how to change genomes to improve things, they don't have an appreciation for the lack of knowledge that we have."[4]

# What is synthetic biology and why read on?

It's already happening. Many scientists, biohackers, and corporations are trying to create novel life forms. They want to move from evolution through natural selection into a phase of ever more human designed, life.

Combining life sciences, computer science, and engineering, an entire field sometimes called "synthetic biology" is taking shape. It uses a suite of powerful techniques with names like "CRISPR." As with many new technologies, government regulations have failed to keep pace. The public doesn't provide input into the far-reaching decisions companies make.

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, we are led to respond to synthetic biology. We're particularly interested in the social, ethical, and spiritual implications, which go well beyond the technology itself. See an overview of our hopes and concerns: https://quakerservice.ca/SBIssues

CFSC's specific mandate is listed in the Appendix. It includes sharing easily accessible updates about synthetic biology to raise public awareness. Find out more at: https://quakerservice.ca/SyntheticBiology

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

> [S]omething could be safe and effective and still wrong. Ethics cannot be reduced to the science of safety and efficacy.[5]

The University of Cambridge is warning that synthetic biology may be used to create bioweapons that target individuals in a specific ethnic group based on their DNA.

## COVID-19 and bioweapons

Conspiracy theories have ranged from the truly eyebrow raising—this pandemic is a ploy to make Donald Trump lose the US election, aliens created it (presumably using CRISPR)—to the more plausible-sounding. The *Washington Post* reported that US diplomats had been dismayed at safety problems in a lab in Wuhan, China, where the virus originated. In 2018 they tried to get funding from the US government to improve the lab, highlighting that "the lab's work on bat coronaviruses and their potential human transmission represented a risk of a new SARS-like pandemic."[6] Others have shared research about bioweapons and conjectured that the virus may have been discovered in nature and then edited in the lab, from which it escaped accidentally.[7] A preprint of a scientific paper speculated that the SARS-CoV-2 virus might have been edited in a lab to have genetic code from HIV. But scientists analyzed that data and showed that in fact "these pieces of genetic code are also found in countless other viruses and there's no reason to believe they specifically came from HIV, at all."[8]

So at this point there is no evidence that synthetic biology had any role to play in the spread of COVID-19. But there are those who want it to be the solution. Even before this, some were trying to use synthetic biology to produce vaccines.[9] Others to "program" a viruses' RNA, with the hope of one day editing what viruses do.[10]

CRISPR is now being used for some of the many COVID-19 tests that are available.[11] Labs are studying if CRISPR can be used to attack SARS-CoV-2. This is still in the very early stages of being thought through and is not yet even ready for lab tests. There is no plan as to how to get the synthetic "CRISPR-based system" into the correct human cells that are infected with SARS-CoV-2.[12] We also have no idea what the full impacts on the human body (both intended and unintended) might be, which could depend on all sorts of factors. It also remains entirely unknown if this CRISPR-based system would actually kill off the SARS-CoV-2 or fail to do so. It could conceivably even lead to the virus mutating in unknown ways. In 2016 we reported on that exact thing happening when synthetic biologists tried to cripple HIV. The researchers found that just two weeks later, the virus had mutated and returned. They concluded that, "the very act of editing—involving snipping at the virus's genome—may introduce mutations that help it to resist attack."[13]

CRISPR is also being used to edit viruses in other ways, such as to get them to attack harmful bacteria that don't respond to antibiotics. "What CRISPR is able to do is something that we've not been able to do before. And that is, very selectively modify genes in the viruses to target the bacteria," doctor Michael Priebe asserts.[14]

At the same time that some beleive it will create helpful viruses, the University of Cambridge is warning that synthetic biology may be used to create bioweapons that "target individuals in a specific ethnic group based on their DNA." The academics warned that governments need to start taking the risk of a catastrophic bioengineered pandemic more seriously.[15]

## Editing Humans

We previously reported on Chinese scientist He Jiankui's surprise announcement that he had secretly used CRISPR to edit the DNA of twin girls (see https://quakerservice.ca/SB2019). The specific edit that He attempted was to a gene called CCR5. He claimed the edit would make the girls immune to HIV, although scientists are actually unclear if this would or would not have happened. As it turned out, He's use of CRISPR failed to produce the intended edit. So what, if anything, will happen to the girls due to this genetic edit, remains unknown.

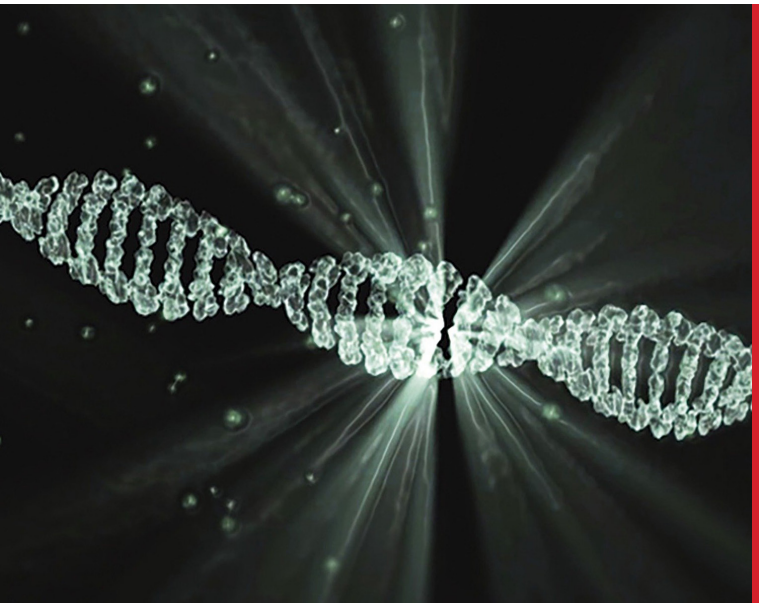
Even if the edit had worked as intended and the twins had indeed become immune to HIV, more recent articles have noted: "a body of research already suggested that CCR5-32 made people more vulnerable to the flu and West Nile virus. A 'good' mutation in the context of HIV can be 'bad' in another context... this process of understanding the full scope of CCR5 has been piecemeal, essentially limited by what scientists think to look for."[16] Even understanding what a change to this one gene could do is a massive undertaking because there are so many potential implications to try to imagine and test for.

But it gets messier still. In a 2019 article in *Nautilus*, author Ken Richardson describes many of the problems with assumptions about genes as the "code" that determines who we are:

> *We've all seen the stark headlines: "Being Rich and Successful Is in Your DNA" (Guardian, July 12); "A New Genetic Test Could Help Determine Children's Success" (Newsweek, July 10); "Our Fortunetelling Genes" make us (Wall Street Journal, Nov. 16); and so on. The problem is, many of these headlines are not discussing real genes at all, but a crude statistical model of them, involving dozens of unlikely assumptions...*
>
> *In a paper in* Physics of Life Reviews *in 2013, James Shapiro describes how cells and organisms are capable of "natural genetic engineering." That is, they frequently alter their own DNA sequences, rewriting their own genomes throughout life. The startling implication is that the gene as popularly conceived—a blueprint on a strand of DNA, determining development and its variations—does not really exist.*
>
> *So it is, in a review in the journal* Genetics *in 2017, that the geneticists Petter Portin and Adam Wilkins question "the utility of the concept of a basic 'unit of inheritance' and the long implicit belief that genes are autonomous agents." They show that "the classic molecular definition [is] obsolete."*
>
> *These radical revisions of the gene concept need to reach the general public soon—before past social policy mistakes are repeated.*[17]

So genes are extremely important, but not as easy to isolate or define as we once thought. And the last point Richardson makes here is particularly noteworthy.

If we misunderstanding what DNA is and is not, that misunderstanding can have very dangerous consequences. One example is "race science" —making supposedly scientific claims about the genetic superiority of certain races to advocate for racist policies.[18]



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# One 2019 experiment boasted 13,200 genetic alterations to a single human cell.

Similarly, if our metaphors about DNA being a predictable blueprint are flawed, those flawed metaphors may embolden us to advocate for flawed policies, including on human gene editing. News media largely seems to be pushing us to accept such metaphors.

A recent study looked at popular media coverage of the synthetic biology technique CRISPR between 2012 and 2017. By far the most discussed topic was using CRISPR to improve human health. The study found that 64.9% of coverage was positive or mostly positive, while *just* 6.1% was mostly negative. 61.4% of coverage did at least mention the existence of possible drawbacks, mostly by touching on uncertainties around editing humans in heritable ways.[19]

Overall then, it seems that the media has been excited about CRISPR and has focused much more on what could go right than on what could go wrong or what we don't know. Articles often fail to mention that many of the far-reaching claims about what may someday be possible in editing humans could equally remain impossible.[20]

Studies continue to find unanticipated mutations and various other unexpected outcomes from CRISPR and other synthetic biology techniques. Scientists continue to debate whether or not these should be of concern.[21]

In the last few months the narrative around CRISPR may have started to shift, with some science media now calling it "clumsy" and "prone to errors" where it was formerly being called "precise."[22] Why the change? Apparently because a newer and supposedly more precise technique—"prime editing"—is now possible.

Whether with CRISPR-Cas9 or other techniques, research races ahead. One 2019 experiment boasted 13,200 genetic alterations to a single human cell.[23]

The World Health Organization is in the process of consulting about and developing guidelines for human genome editing.[24] They have called for the establishment of a registry of all human gene editing research, asking scientific journals and funders of research to ensure that anything they publish or fund is registered.[25]

A group of scientists went further and called for a global moratorium on editing humans in heritable ways (they still support non-heritable edits). Their call was not for a permanent ban. Instead, they argue that a temporary moratorium will give time to develop a framework with internationally agreed steps that may then be taken by any country wishing to permit heritable editing, editing which, they note, will change the future of the human species.[26]

The activist group Stop Designer Babies strongly rejected the call for a moratorium, which it sees as simply a temporary measure. David King, speaking on behalf of the campaign, said, "Only a global treaty banning cloned and genetically modified babies can halt the threat of a new eugenics."[27]

Even before the dust had settled on He Jiankui's announcement of having secretly edited humans, Russian synthetic biologist Denis Rebrikov created a major stir by saying he too planed to make heritable edits to humans. Rebrikov says he wants to try to address a genetic mutation that leads to deafness. He also says, though, that his research will only begin if his government approves it.[28]

Many remain hopeful that gene editing will one day help to cure diseases without causing new and unexpected harms. Medical trials using gene editing in non-heritable ways are increasing.[29]

## Lies and disturbing business ties

A series of stories spotlighted the role that billionaire Jeffrey Epstein (who committed suicide in prison while awaiting trial for alleged sex trafficking) played in a number of scientific fields including synthetic biology. According to these articles, Epstein had radical views including advocating eugenics—calling for humans to be edited to boost traits he considered desirable.[30]

It is unclear to what extent the prominent scientists who met with Epstein took his ideas seriously, and to what extent they just wanted the ego boost and royal treatment he offered them at lavish dinners, and the funding he gave to their projects.

For his part, synthetic biologist George Church was transparent that he met with Epstein, ignoring child sex allegations.[31] Church apologized, but some have criticized his lab for working on projects they say come too close to eugenics, such as a dating app that matches people based on their DNA.[32]

The investigations into Epstein's influence also uncovered how some synthetic biology projects are based on lies. The MIT Media Lab claimed to be growing foods like broccoli in new high tech "personal food computers" that didn't require soil and still grew four times faster than other growing methods. But *Business Insider* interviewed multiple people at MIT who told a very different story. "Ahead of big demonstrations of the devices with MIT Media Lab funders, staff were told to place plants grown elsewhere into the devices," which lacked the features the Lab director claimed they had, and which mostly didn't work at all (when given as a pilot project to a local school, students "would joke that the plants they were growing in plastic cups were growing better than the ones in the personal food computers...").[33]

This story exposes a high pressure culture where techniques like synthetic biology aren't pursued for the sake of knowledge but to get new innovations to market as quickly as possible. We've shared news about over-sold failures before. In each case, some journalists repeat scientists' claims without sufficiently questioning them or highlighting possible risks, uncertainties, unknowns, or social, environmental, or ethical implications. Investors then pour money into the new project, which may never actually deliver on the hype.

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## Gene drives

*Theoretically, we could someday live in a world where creatures couldn't pass diseases on to humans because they'd have certain genetic tendencies edited out of them. Mosquitoes, for example, wouldn't carry malaria. Realistically, however, there are dangers, and one of the major and widely acknowledged problems with instituting gene drives is that humanity can't accurately calculate in advance what will happen when we start tinkering with nature on this scale. And there are plenty of reasons to be wary.*[34]

Gene drives (attempts to force a trait to be inherited by an entire population in the wild) continue to be a well-funded area of research in spite of the massive uncertainties and unknowns. In the last year authors have reflected on what "free, prior, and informed consent" would mean with respect to a gene drive, and the possible need for collective governance, given that gene drives will not respect national borders.[35] Europe has made plans to call for a moratorium "on releases of gene drive organisms into nature, including field trials, in order to prevent these new technologies from being released prematurely and to uphold the precautionary principle..."[36]

A study from Brazil of genetically modified (but not gene drive) mosquitoes found that they behaved very differently from what the company that engineered them anticipated. Rather than crashing local populations of disease carrying mosquitoes, the edited mosquitoes bred successfully with the native populations and continued to spread their modified genetic material beyond the trial area. "The claim was that genes from the release strain would not get into the general population because offspring would die," said researcher Jeffrey Powell. "That obviously was not what happened."[37] This seems to be yet another reminder of how difficult it is to predict what the results of genetic modifications will be outside of the lab.

What's more, a Brazilian biologist involved with regulating the experiment, José Maria Gusman Ferraz, told local news that he warned the regulatory committee that the edited mosquitos might crossbreed with native mosquitoes and establish themselves permanently in the area. He says these concerns were largely ignored. Gusman Ferraz further said that local people were not informed about the risks of the experiment and did not sign a Free and

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## Animals

An experiment done in China recently created "macaque monkeys with extra copies of a human gene suspected of playing a role in shaping human intelligence." The five monkeys that survived outperformed their non-edited peers on memory tests, but the value of this research has been questioned, as has its ethics.[39]

One of the animal stories that has gotten the most positive media attention has been the creation of edited cattle that never grow horns. The animals have been held up as the perfect example of the new precision of gene editing. That is, until the US Food and Drug Administration discovered that at least one of the bulls had foreign bacterial DNA that had accidentally integrated into its genome. These bacteria had a gene for antibiotic resistance, and that gene's "presence in a cow could create unpredictable opportunities for it to spread." This bull had gone on to sire 17 offspring, some of which presumably also had the bacterial DNA.

This revelation came after interviews in which the company boasted, "We have all the scientific data that proves that there are no off-target effects." The company had also been pushing for its animals not to be regulated any differently from regular cows, since, they claimed, the edits made were so precise. It turns out that, in fact, the company never looked for foreign DNA having entered the bull's genome. They simply assumed there would be no need to.[40]

Another recent experiment with cells from African clawed frogs created "tiny robots that move around under their own steam." The creatures, less than one millimeter long, included one with "two stumpy legs that propel it along on its 'chest'. Another has a hole in the middle that researchers turned into a pouch so it could shimmy around with miniature payloads." Researcher Michael Levin said, "These are entirely new lifeforms. They are living, programmable organisms." An artificial intelligence program "starts by generating random 3D configurations of 500 to 1,000 skin and heart cells. Each design is then tested in a virtual environment, to see, for example, how far it moves when the heart cells are set beating. The best performers are used to spawn more designs..." Each being lives for up to 10 days before it dies.[41]

## Synthetic biology to address the impacts of climate change?

There are those who argue that synthetic biology will be necessary to address the harms to ecosystems resulting from climate change. For instance, in Australia researchers are using CRISPR to try to understand how coral responds to heat, in the hope of making it more resilient to rising ocean temperatures.[42] Others write glowingly about all of the imagined possibilities of "synthetic biology for sustainable cities."[43] Still others talk about using synthetic biology to replace farming (yes, *all* farming) with lab-grown food so as to address climate change.[44]

Critics point out that the scale of these proposals is mind-bogglingly vast, and that hey misunderstand the impacts of farming and the massive disruption to livelihoods that switching the world to lab-grown foods would entail (most of the world's food is produced by small scale farmers who operate in sustainable ways).[45]

## Appendix

In 2014 Canadian Yearly Meeting, the national body of Quakers in Canada, asked Canadian Friends Service Committee, the peace and social justice agency of Quakers in Canada, to work on synthetic biology in the following ways:

1. By affirming the seven principles identified in Principles for the Oversight of Synthetic Biology, a document that makes many important recommendations, and supporting attempts 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. By providing Canadian Quakers and the general public with an annual, easily understandable update on synthetic biology;

3. By finding opportunities to link with other faith and community groups, and with Indigenous peoples, to share insights and discernment about synthetic biology; and

4. By engaging with other faith groups and interested parties, including organizations involved in research and/or manufacture in synthetic biology, hold and/or participate in conferences that address ethical, spiritual, social, and economic aspects of synthetic biology.

In 2014 Canadian Yearly Meeting, the national body of Quakers in Canada, asked Canadian Friends Service Committee, the peace and social justice agency of Quakers in Canada, to work on synthetic biology

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