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Creating the ethics of synthetic biology

We don't own life, life owns us — and humans' recently acquired ability to alter life itself is a huge responsibility

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In the last 18 months or so, articles about "synthetic biology" have started to appear in scientific journals and been noted in the media. The most recent report is on American biologist Craig Venter's laboratory's efforts to "create" a life form with the minimum number of genes consistent with life.

CREDIT: Christinne Muschi, The Ottawa Citizen

We do not own life, but rather life owns us, McGill ethicist Margaret Somerville writes. It is therefore wrong to patent artificial life forms, declaring their very essence to be human property.

Mr. Venter is stripping down the genome of a living bacterium called Mycoplasma genitalium by removing its genes, one by one, to identify the essential components of its genome, without which it would be dead. He's reduced a 482-gene bacterium by 101 genes and with 381 genes it's still alive and able to replicate.

This kind of science fits within a new area being called "synthetic biology." It is not clearly defined, but involves applying engineering techniques to the elements of life forms to "build a better bug" or, even eventually, a higher animal.

The goals of synthetic biology include modifying or transforming biological systems by building them from the bottom up. Scientists want to make the design of life forms more predictable, like the design of a bridge. One of them put it this way: "We're talking about taking biology and building it for a specific purpose, rather than taking existing biology and adapting it. ... We don't have to rely on what nature's necessarily created."

Synthetic biology can also encompass engineering from the top down, for instance, to identify the genes essential for life as Mr. Venter is doing. (At this stage, we can only guess whether building up to the same 381 genes from scratch would result in the same living bacterium.) As well, some people see putting a gene from one species into another species as a "simple" form of synthetic biology, or even just splicing and recombining DNA.

So, turning to the ethics of synthetic biology, the primary, overriding question is: Should we be doing this at all?

Utilitarian-based ethicists would start their analysis in response to that question by asking whether the benefits outweigh the risks and harms.

As a principle-based ethicist, I would first ask another question: Is undertaking synthetic biology inherently wrong? That leads to yet another question: What does respect for nature, the natural and life require that we not do with synthetic biology, that we could do?

I don't believe using synthetic biology to fiddle around with bacteria, as Mr. Venter is doing, is inherently wrong. (Whether it's ethical requires further analysis.) I'm much less certain of that if scientists were trying to create higher animals, especially ones that could never exist in nature. And I think it would be inherently wrong to use synthetic biology to try to create a "human entity." But what would constitute doing that?

For example, we share 98 per cent of our genes with a chimpanzee. If we engineered those "shared" genes, would we be dealing with chimps or humans? Is that determined by its source, whether chimp or human? Or is a critical factor the nature of the DNA that we use -- for instance, is that which codes for human brain cells different from that which codes for our hair?

Strong ethical objections have been raised with respect to putting DNA that codes for human brain cells into mice, with the resulting possibility the mice could have some form of human consciousness.

Let me be clear, here, that I think it is inherently wrong to design a human. The question I'm addressing here is: What limits does the ethical prohibition of designing humans place on our use of synthetic biology?

Moving on, if what we plan to do using synthetic biology is not inherently wrong, the question for both principle-based and utilitarian-based ethicists becomes the same: Do the benefits and potential benefits outweigh the risks and harms? There is powerful disagreement in this respect, including as to what constitutes harms, risks and benefits.

Apart from the safety concerns raised by synthetic biology in general, including the accidental release of a novel virus or other infectious agent to which animals or humans would have no natural immunity, one of the really big worries is the so-called "dual use" dilemma. Like some other new technoscience, synthetic biology could be used, not only to advance beneficial scientific and medical knowledge, but also to deliberately inflict unprecedented harm. For instance, bioterrorists could use it intentionally to create epidemics.

Synthetic biology has been used already to create a polio virus from scratch and to reconstruct the 1918 influenza virus. An example, often discussed in relation to possibilities for using synthetic biology for bioterrorism, is smallpox. The smallpox virus is now extinct in the world except for two samples held in high security. But it could be constructed through synthetic biology.

And what if that virus were altered in some way to dramatically increase its lethality or contagiousness? Australian scientists working on mouse-pox virus (which is closely related to smallpox) to try to develop a mouse contraceptive, made a change to the virus that, to their surprise, made it lethal to all mice infected with it. They said that creating a vaccine to protect against the altered virus would be very difficult. Whether this research should be published was a matter of extensive debate, because of fear of its being used for bioterrorism.

Such possibilities have added a new lexicon of terms to our language, for instance: biosecurity; biosafety; biodefence; biowarfare; and bioweapons. The latter could include the horrific possibility of organisms that would uniquely target and harm certain racial or ethnic groups, leaving others unaffected. Other

possibilities, such as inserting hyper-aggressivity genes, from an animal source, in human embryos to breed fearless soldiers, have also been discussed.

So, if scientists are going to proceed with synthetic biology, what sort of oversight and regulation are needed? How can we ensure that wisdom and accountability prevail?

Again there is strong disagreement. Scientists and industry want self-regulation and have been proposing codes to safeguard the research and its uses. Environmental and other lobby groups, concerned about potential harmful uses of the new synthetic biology, want external controls and not, as they perceive it, "the foxes guarding the hen houses." This debate continues today.

Finally, what about Mr. Venter's attempt to patent the "products" that result from synthetic biology? Quite apart from the general benefits and harms of patenting, to the extent that synthetic biology becomes a highly profitable, large-scale industry, it will be much more difficult to limit and control. We need only look at the "fertility industry" and its massive growth worldwide in the last five years ($5 billion annually in the United States alone), to see a directly analogous example of that.

Taking Mr. Venter's current research as an example, questions that patenting would present include whether reducing an organism's genes to the minimum necessary for continued life is a patentable invention? Has Mr. Venter created a new life form or is this just a wounded or depleted Mycoplasma genitalium bacterium?

Or what if we were to make an exact copy of existing, natural DNA from the ground up? Did we invent that DNA or just copy the original? Or what if we start from chemical molecules and make DNA that we combine as genes that result in a never-before-seen living entity? That is probably an "invention" -- even a "creation" -- even though we didn't create the inanimate molecules that made up the DNA. But should these entities be patentable? That depends on our philosophy about the nature of life.

I believe that we do not own life; rather, life owns us. That means there are ethical limits on what we may do to change life, in particular human life, and that we must hold life in trust for future generations, which also places limits on what we may do to life. Patenting life forms is inconsistent with the deep philosophical roots on which that view is based.

For instance, patents apply to property and its ownership and control. Life is not property and should not be treated as such by patenting it.

Respect for life requires that it be "hors de commerce." Patenting life commercializes it and therefore breaches the required respect. That said, techniques that can be used to intervene on life may be patented, provided of course that the interventions they make possible are themselves ethically acceptable.

To conclude, synthetic biology faces us with three interrelated, major ethical questions, which will be among the most important we will need to address, not only in relation to synthetic biology but also in general, in the next decade or two:

- How can we develop an ethics of uncertainty? We make many ethical mistakes because we are frightened of uncertainty and try to convert necessary uncertainty to certainty, instead of applying wise ethical restraint in the face of uncertainty. We must learn to face and live more comfortably with uncertainty, if we are to avoid such mistakes. And we need ethics to help us to do that.

- What does an ethics of potentiality require? What are our obligations to future generations to hold life and our world in trust for them? In deciding what we will and will not do with the new technoscience, we must ask ourselves: Can the future trust us?

- And what does an ethics of complexity demand? We are the first humans to have the extraordinary powers science has placed in our collective human hand to change life itself. With great power comes great responsibility. Fulfilling that responsibility will require an ethics of sophistication, depth, insight, creativity, imagination and complexity equal to those same characteristics in the science it addresses.

Together, these three ethical enquiries can help us to build a comprehensive ethics of responsibility.

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