

**Testimony of Arthur L. Caplan to  
the Presidential Commission for the Study  
of Bioethical Issues**

2nd Meeting, Philadelphia, PA

September 13, 2010

## Philosophy Matters

Thank you for allowing me to share some of my thinking about the religious, philosophical and spiritual significance of synthetic biology with the distinguished members of this commission. I know that the President has asked you to report to him about developments in this rapidly evolving field of biology and I hope that this testimony will prove useful to you in carrying out that assignment.

I think much of the ethical commentary concerning synthetic biology has centered on the benefits that synthetic biology may bring, the potential risks involved in pursuing those benefits to human health and well-being as well as questions about the ownership of the key techniques used by synthetic biologists.

These are very legitimate topics for ethical reflection and policy development. I am going to comment on them myself. However I want to persuade you that there are deeper philosophical concerns that, while perhaps harder to pinpoint, underlie some of the disquiet about the field of synthetic biology. I think this commission should attempt to wrestle with some of these issues in its recommendations to the President. As we have seen with many other breakthroughs in the biomedical sciences ranging from cloning to the reproductive technologies to stem cell research, more is involved in evincing public concerns about new directions in science than worries about safety.

### A Short Aside--What do I mean by synthetic biology?

There is no real consensus definition of synthetic biology. I want offer a comment on how I see the field since the commission may find it useful in their analysis.

Synthetic biology is a sub-part of the field of genetic engineering. Synthetic biology tries to create novel sets of genes or entire genomes by building them de novo from genetic elements or 'bio-blocks', or by stripping down existing genomes or by combining existing genomes. The aim of much of the work of synthetic biology is to create novel organisms with specific capabilities permitting the creation of useful products and activities.

To date, most of the public attention given to synthetic biology has focused on efforts to create novel life-forms. But synthetic biology may also involve the transfer of large segments of genetic information between species to produce novel properties or repairs. For example, it may be possible to utilize the transfer of

genomic information from a bacterium to supplement genetic failure in human diseases in the eye or gut. This kind of genomic transfer, synthetic prosthetic genomics, is a part or will be a part, I predict, of synthetic biology as well.

### Is synthetic biology 'opposed' by organized religion?

I became interested in synthetic biology in 1997 when I had the opportunity to give a lecture at the National Academy of Sciences along with J Craig Venter. Venter's talk quickly persuaded me that there were a number of important ethical issues surrounding the nascent attempt to create a new microbial life-form.

I organized a group at our Center for Bioethics at Penn to discuss this emerging field. I was careful to include many representatives from major religious traditions since I felt uncertain as to what sort of reception synthetic biology might receive from communities of faith. This group had a number of meetings at Penn and ultimately produced a paper in *Science*-- "**Ethical Considerations in Synthesizing a Minimal Genome**"-- which was published in December of 1999.

At the time few members of our group had ever heard of synthetic biology. But, as they began to understand what Venter his collaborators and other groups were undertaking I was surprised to learn that the theologians in the group, drawn from traditions including Catholicism, Conservative and liberal Protestantism, Buddhism and conservative Judaism, had no 'in principle' objection to the creation of new life forms. Their concerns were primarily about the impact of synthetic organisms on the environment and with social justice -- ensuring equitable access to the benefits that might flow from synthetic biology.

I think little has changed in the past dozen years with respect to religious attitudes. Among those few theologians around the world who are acquainted with synthetic biology, the creation of novel life forms is not seen as any more threatening to the dignity of humanity than the creation of tangerines, French poodles, or Basmati rice. The notions that humanity holds dominion over the earth, and that man is entitled to manipulate nature to serve human needs are especially strong in Judeo-Christian thought.

Where philosophical and theological concerns, and popular concerns according to recent polls, tend to concentrate is around safety worries for the environment posed by novel life-forms.

Can we be sure that whatever is made will stay where its creators want it to? And, can we be sure that those whose aims are malevolent will not gain access to the techniques for designing novel life that could do enormous harm?

There is very little about the history of human activities involving animals and plants that provides confidence that we can keep novel life forms in their place. We do not have the national or international oversight and regulation requisite to minimize the risk of the creations of synthetic biology causing harm by showing up uninvited due to accident, inadvertence or negligence. People have been inadvertently introducing new life forms for hundreds of years into places where they create huge problems. Rabbits, kudzu, starlings, Japanese beetles, snakehead fish, rabies, fruit-flies, zebra mussels, and long-horned beetles are but a short sample of living things that have caused havoc for humanity simply by winding up in places we do not want them to be. Sometimes those involved in creating new life forms have accidentally lost track of the animals, insects or plants they were working with as happened with the introduction of 'killer bees' into South, Central and North America. In other cases inadequate attention to oversight allowed life forms to escape and wind up in places they were not wanted such as GMO corn's invasion of native strains of Mexican maize.

What standards of control should govern the creation, introduction and release of novel life forms? Should there be specific restrictions on the kind of lifeforms that can be engineered so as to minimize threats to human, animal and plant health? Should synthetic life-forms be engineered when possible to naturally expire after a finite period of time? And if these rules are articulated, which agencies will have clear responsibility and authority for enforcing them? And can enforcement be made uniform and coordinated around the globe?

Not only is there a lack of agreed upon regulations and regulators in place to help manage the products of synthetic biology, few provisions have been made to make sure that the techniques involved or the knowledge generated do not fall into the wrong hands. In an age of terrorism and bio-weapons that is not ethically sound public policy.

With the appearance of the nuclear bomb at the end of World War II, great efforts were made by the United States and other nations to keep the knowledge of the creation of these deadly weapons secret. International organizations sought treaties that would control the proliferation of these weapons and even attempt to place the creation of some forms of weapons off limits. National restrictions were placed on who could work on nuclear weapons and what could be published about them.

None of this has been done for synthetic biology despite the danger posed by the creation of weaponized microbes, germs and viruses that could decimate our food supply, poison our water, or cause pandemic horror in human populations.

Both environmental control and protections against misuse merit more attention than they have received. International coordination is essential if the public is to feel comfortable that safety is being properly managed. Neither poses an insurmountable obstacle to the advancement of synthetic biology. But, a failure to vigorously attend to both could set the field back just as the promise of synthetic biology is poised to begin to deliver much good.

Let me offer four general principles that I think are essential to securing public confidence in the safety of organisms created by synthetic biology.

**First**, since national security and public health must have top ethical priority, it is appropriate to implement controls over the publication of scientific details, the selection of locations of laboratories, and who is permitted to train in them.

**Second**, to ensure the responsible handling of synthetic life, all synthetic organisms should be marked or branded in some way so as to make it easy to distinguish them from natural life-forms. Venter's team inserted several DNA "watermarks" into their recently created novel bacteria, and that precedent ought to be routinized.

**Third**, to ensure the safety of the environment from accidents, every synthetic life form at this point in time ought to have some limit on its lifespan engineered into it.

**Fourth**, a single agency should have clear-cut, responsibility for approving the release of any entity created by synthetic biology outside the controlled environment of a laboratory.

These ideas may help tamp down some of the practical concerns about making new life forms.

All that said, I still believe that there are philosophical, religious, and metaphysical anxieties about creating life or creating prosthetic repairs using genomic transfers that ought to be acknowledged and addressed. While these do not now dominate popular or religious expressions of concern they may come to do so in the future.

How might the emergence of synthetic biology broadly understood, bear upon spiritual matters and religious understanding?

I think there are three ways in which the creation of new life forms and manipulating whole or partial genomes for medical or industrial purposes trigger philosophical anxieties. These are (1) concerns about 'playing god'; (2) the end of the view that life is special or exceptional, and (3) worries about the mixture or placement of large portions of genomes across species.

*Playing god*

There is plenty of room for arguing about what it would take in terms of biological creation to lay claim to the mantle of the scientist who creates the first novel life form. Some argue that viruses should not count because they are parasitical--needing another creature's genome to reproduce. The prize probably will go to the first team to be able to create a creature capable of replicating under the power of its own novel genetic program. Still, however life is defined, there should be no doubt that someone is going to create a new critter in the not too distant future.

The possibility that humans can create life, either from pre-existing organic parts or from inorganic materials, has been the subject of considerable cultural worry and commentary from Mary Shelley's *Frankenstein* to Gene Roddenberry's creation of the android Data in *Star Trek The Next Generation*. While no one will be making living people from scratch anytime soon, the idea that humans can create even primitive life forms seems to some to violate the prohibition that humans should not play god.

The key admonition about not to playing God I think is not about the divinity but about the notion of 'playing.' Playing brings to mind carefree, lighthearted, even irresponsible activity -- not the sort of thing that lends credibility to having confidence in those making new life forms. Cautions about playing god use the notion of play to suggest that scientists are at best cavalier and at worst just screwing around when it comes to making artificial or novel life forms.

That criticism seems unfair. Those involved in the creation of synthetic new life forms do so not as a game but in the hope that they can better understand how life works and, further, perhaps make microbes that can benefit us all. I would maintain that play is not much in evidence in the motivation for or, just as importantly, the funding of synthetic biology.

Well then what about the challenge of being godlike in making new life? Some fear that when the creation of life at human hands happens this will knock down a key theological tenet that only God can create life from non-life. Others worry that in creating new forms of life we will create something that we can neither contain nor control.

It is hard to credit the view that God would give us the abilities to make new life forms and then argue that to do so crosses a line that God does not want crossed. If one takes a more secular view, the fact that human beings can mimic random processes that allowed life to emerge is not especially threatening to faith in a divinity.

What about hubris? Our inability to control what we might make is a problem. It is not clear that we can completely control new life forms. But, surely it is clear that we would be prudent to both create mechanisms for identifying and tracing new life forms and for insuring that they are fragile should they go places they are not wanted. So heeding the warnings against arrogance we should be certain we can control where novel life-forms go but still build in insurance that if they get out they will do no harm anyway.

### *The exceptionalism of 'life'*

Just over one hundred years ago, the French philosopher Henri Bergson claimed that life could never be explained simply by mechanistic explanations. Nor could life be artificially created by synthesizing molecules. There was, he argued, an *élan vital* -- a vital force -- that was the ineffable current of life, which distinguished the living from the inorganic. Life transcended the material world and could only exist by means of a special force or power-- most likely issuing from the divinity.

Bergson was hardly alone in his view that something mystical and special drives life. Vitalism has come in many forms in Western thought from Galen's talk of the 'vital spirit,' to Swann and Pasteur's positing of 'vital action' in their explanations of how life comes to exist to the 20th century biologist Hans Driesch's positing of the mysterious metaphysical 'entelechy' as requisite for life. While materialistic reductionism dominates biological thinking today, there are no exceptionalists in the foxholes of the NIH institutes, many outside the biological sciences still hold the view that life is a mystery beyond human comprehension and that the mystery of life is linked to the will of God.

All of these deeply entrenched metaphysical views are cast into doubt by the demonstration that life can be created from non-living parts. The achievement of the creation of synthetic life will end the argument that life requires a special force or power to exist. Likely more troubling to many, the achievement suggests that neither microbial nor human life are fueled by a transcendent vital force.

The belief in the special, mysterious nature of life, including the long-standing belief that we ourselves are infused with a special, mysterious force that permits us to live, is called into question when life can be created from non-living elements. Learning to live in a world where life has been shown by science to be the product of material forces subject to human control will likely prove for many a challenge to rival worries about safety.

### *Mixing and Purity*

The last deeper metaphysical and spiritual worry about living things or products created by synthetic biology concerns mixing what is seen as foreign, unnatural or alien into our bodies. If it were possible to move a large portion of a genome from a bacterium into the human eye to restore a form of vision many would celebrate but some might balk. Making a microbe that can eat cholesterol from our arteries or immunize us against infectious diseases will leave some cold just as there are worries today about vaccines and drugs in some quarters. Still others may be concerned if genomic transfers could be used to alter our natural abilities or capacities.

These are very real if difficult to engage concerns. The future of synthetic biology depends in part on recognizing these worries and finding ways to engage and debate them.

### Conclusion

I know this group understands the importance of coming to grips with concerns over the safety of the creations of synthetic biology. I believe it is equally important to begin the process of coming to terms with deeper metaphysical and spiritual concerns that are stirred by the demonstration that humans can create novel life-forms.