Synthetic Biology in the Open:

Pipe dream or the next giant leap for mankind?

A short discourse by the

University of British Columbia iGEM 2011

Prologue

"What does synthetic biology mean to you?"

"You mean, like, Jurassic Park?"

This was one of our favourite responses when we surveyed hundreds of undergraduate students for their definition of "Synthetic Biology". When people think of synthetic biology, do they imagine something unnatural, belonging to a different time, a beautiful and marvellous human achievement but dangerous to the world as we know it? Is synthetic biology a futuristic dinosaur that needs to be isolated on an island?

Synthetic biologists have very grand visions of what their creations can do. We want organisms that can clean up oil spills and non-biodegradable garbage, fix the ozone layer, fertilize barren land and purify contaminated water, synthesize copious amounts of bio-fuels and other compounds at low cost, valiantly beat down untreatable illnesses, and encode yotta-bytes of encrypted data. These organisms must not only perform these functions infallibly, but also adhere strictly to bio-safety and bio-security restrictions. We want them to do what they are supposed to do and stay where they are supposed to stay.

While these expectations may be realizable in laboratory or industrial settings, it becomes exceedingly difficult to design, model and validate synthetic organisms intended for release into open spaces such as nature or the human environment. So our questions are (i) Will synthetic organisms ever be released into the open? (2) What extent of pre-emptive measures is required before this can happen? (3) Does everyone need to agree? Investors, consumers, environmentalists, governments, communities, educators, scientists, churches and the marginalized? The informed and the uninformed?

In this document, we discuss potential steps towards the release of a synthetic organism into the open. Don't worry, we'll keep it within 5 pages and we want YOU to contribute to this dialogue on the CommunityBricks page set up for this:

http://openwetware.org/wiki/IGEM_Outreach:Synthetic_Biology_in_the_Open

Will synthetic organisms ever be released into the open?

The British Columbia iGEM 2011 team chose to create yeast that can produce monoterpenes that confer resistance to pine beetles and the bluestain fungus in order to alleviate the pine beetle epidemic in North American pine forests. However, realistically, our yeast will more likely be utilized in an industrial setting to produce monoterpenes for pharmaceuticals, flavours and fragrances, and bio-fuels. Our synthetic yeast has not been perfected yet, but there are many challenges, many questions and many years between where we are now and the time when we can introduce our organism to beetle-infested regions.

So one question we ask is "Why invest billions of dollars and valuable human resources into synthetic biology aimed at solving real-world problems when we cannot place these synthetic organisms at the heart of the problem?"

Logically speaking, since we cannot bring the oil spill to the bacteria, we must bring the bacteria to the oil spill. But maybe just as a last resort so we do not appear to be flagrantly dispersing synthetic organisms in the open.

Conversely, waiting for the absolute worst case scenario before trying a synthetic biology intervention for the first time seems risky. Perhaps it is better to start small; Test out less dangerous synthetic organisms on a smaller, more controllable scale. Make some mistakes, learn from them and come up with better strategies.

Furthermore, this is not considering the accidental or illegal release of synthetic organisms into the open. As synthetic biology research grows increasingly accessible, the amount of contact with the public grows exponentially. We may not already know it, but synthetic biology is out there.

What extent of pre-emptive measures is required?

iGEM teams create computational models to simulate the function of their synthetic organism. The British Columbia iGEM 2011 team modelled the pine beetle epidemic in North America to predict and optimize the effect of a synthetic biology intervention on the epidemic.

What comes after *in silico* trials?

Is it possible to perform a real-life study? Find or create an isolated system and test out our product there first?

While this may be possible in some cases such as clinically testing if a particular synthetic pro-biotic bacteria is detrimental to health, it becomes difficult when the goal is to release organisms into the larger environment such as the ocean or the forest. How do you stop your organism from leaking into other open spaces? If you cannot stop it, does it mean you should never release it?

A presentation judging panel once asked us *"Is your yeast going to be competitive with yeast in the wild? Otherwise, how will it achieve your goal of subduing the epidemic?"*

The answer is *"Currently, no."*

But do we really want our organisms to be competitive with organisms in the wild? Is it not safer to continually input an extinguishable product into the open, rather than have to implement downstream strategies to eradicate the environment of our organisms after the problem is solved? Does efficiency come in front of safety? We already have many problems today dealing with invasive species. We do not need synthetic invasive species.

Perhaps engineering wimpy synthetic organisms is our best pre-emptive safety bet… compared to unleashing a beast with a built-in suicide system, which will likely be lost in time due to natural selection.

Does everyone need to agree?

When Dr. Joerg Bohlmann described the pine beetle problem to our team, he emphasized that this did not just have consequences for the environment, but also the economies and communities dependent on the forests and lumber industry. So if scientists invent a synthetic organism that could potentially fix this problem, we need to inform and consult with stakeholders in this issue.

The priority is to inform others about our strategy and receive their input. One of the most effective ways is involving the community in our project right from the start rather than waiting until we have the solution in hand. In this way, informed public opinion can guide the development of synthetic biology tools. The public will also be much better prepared when these tools are ready to be implemented.

The human practices pillar of iGEM was established to engage the public through outreach and discussion of synthetic biology safety, security, ethics and ownership. Outstanding human practices projects incorporate public and expert opinion into their projects and produce innovations that are suitable for use by their target audience.

"Human practices has been a hugely important influence in the design of our final product. We contacted a number of experts very early on in the design process to allow us to truly adapt our specifications to meet the requirements of a field testing kit for parasites. This has ensured that our design is as feasible and useful as possible." – Imperial College of London iGEM 2010, Winners of the Best Human Practices Advance

We can only make what people want when we know what people want. And when we make what people want, they are more likely to agree with our project.

So perhaps this section should have been titled "How do we help everyone agree?"