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Jim Thomas: Synthetic Biology/Designing New Life Forms

IFG Teach-In: Techno-Utopianism & The Fate of the Earth

Great Hall of the Cooper Union, New York City

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Jim Thomas has been actively campaigning on technology issues since 1994 when he co-founded the 'New Luddites' in the UK – an ad hoc network of activists and academics questioning corporate agendas in science and technology. Subsequently a co-founder of GEN (the UK's network of groups against genetically engineered crops) as well as a campaigner for Greenpeace International on GMO and food issues, Jim played a key role in the grassroots, direct action and consumer campaigns that halted GM foods and crops in the UK at the end of the 90's. He subsequently worked with grassroots movements on several continents to help advise and establish GMO campaigns elsewhere.

In 2002 Jim began working with ETC Group and as Program Director of that organisation has spent the last decade pioneering critiques of emerging technologies particularly Nanotechnology, Synthetic Biology and Geoengineering [see also: GeoengineeringMonitor.org]. He has helped develop international campaigns addressing these technologies as well as common civil society initiatives for technology oversight and assessment.

Jim was the organizer of the first ever international conference on the societal impacts of nanotechnology (held in the European Parliament in 2003 - see "From Genomes to Atoms - The Big Down; Atomtech: Technologies Converging at the Nano-scale"). He was lead author on several ETC publications about emerging technologies and is a regular participant at international negotiations relevant to new technologies including the UN Convention on Biological Diversity where civil society action has resulted in moratoria on geoengineering technologies and terminator seeds as well as work on Synthetic Biology.

Currently Jim is tracking developments in Synthetic Biology and geoengineeirng and in the new flexible manufacturing technologies of robotics, drones and 3D printing. He is a co-founder of the Synbiowatch.org initiative and of the International Civil Society Working Group on Synthetic Biology. He has written for several publications including *The Guardian*, *The Times*, *BBC online*, *Grist* and wrote a regular technology column in *The Ecologist*.

I'd just like to add to the chorus of thanks for the organization of this event. It's been a real feast of thinkers on technology, so thank you very much, Jerry. And I have to say, as somebody who enjoys reading books about the politics of technology I feel like my bookshelf is coming to life in front of me, minus some of the dead guys, of course.

It's also very good to follow after Debbie, talking about the real world effects of genetic engineered crops because the next box that I'm going to open, this Pandora's box, if you like, of synthetic biology is often considered as the next stage of genetic engineering. It's often called extreme genetic engineering because it uses the new tools and techniques which the genetic engineers are now using to manipulate life forms.

In fact there's a graph that often comes to my mind from about 2008 from the Department of Commerce which has two curves. One curve is the development of genetically modified organisms from about 1974 through to 2020 or something and it goes something like this [sweeping out a line slowly increasing in slope]. And the other is the development of synthetic biology products and processes from about 2008 and it goes like this [sweeping almost vertically straight up] – exponentially.

And at the point where those 2 curves cross, that's the point at which synthetic biology becomes the way in which we do genetic engineering which is roughly speaking about now. It's sort of the equivalent of how, in the middle of the 1990s, digital production of photography became the way in which we do photography.

Now digital production of life forms is becoming the way in which we do genetic engineering. All of that said, for the rest of this talk I'd like you to stop thinking about genetic engineering. Because sometimes it's not useful to look at a new technological platform through the lens of the previous technology. It's like trying to think about the importance of the computer through considering typewriters.

A more useful lens to talk about synthetic biology might in fact be, manufacturing and production. And another useful lens actually is Star Trek.

As a kid I used to watch Star Trek occasionally, talk about techno-utopianism. One of the things that used to interest me a lot were the technologies. They had these little flip communicator machines that are now cell phones. But particularly there was a technology called a matter compiler. Do people know about matter compilers?

A matter compiler was a sort of digital make-anything machine. Captain Jean-Luc Picard would walk up to the matter compiler and he would say, "Computer, tea, Earl Grey, hot" and, zoop! There would be a cup of tea. And as a child, I imagined, 'Wow,' you could go up to it and you could say, 'Computer, ice cream.' Or 'Computer, plastic star wars figures.' And it would just give it to you. And that sounded like a very cool thing.

Today, you grow up, and we realize that those flip-phone communicators come with a whole host of problems in fact, as Doug Tompkins was talking about earlier, and we'll hear more about. And so it is with a matter compiler. I think today, I would strongly, strongly resist the creation of a matter compiler – a make-anything machine in this society.

That if we had a machine that could just, zup! – make anything, it would up-end all sorts of economies. It would destroy meaningful ways of living. It would increase inequality and it would probably harm the environment. Certainly it would be owned by some god-awful mega-corporation or the military, probably both.

The reason I feel all of this is from watching the field of synthetic biology for the past few years. Which is the closest we've come, to date, to a matter compiler, a machine that can make anything.

Just as an aside, we have machines that can make anything on the 2-D world. We have machines that can create any image or sound or audio or video that we want; something like a digital printer or an mp3 player. What those do is they take actual sound waves and light waves and images and they turn it into digital information that can then be re-constituted once again as real, actual images and sound.

And that's incredible. It means that I can take one of these matter-compiler things [and] I can take a photo of this audience and within a few minutes I can have 200,000 T-shirts with this photo printed out in China, or put on the side of a building in Times Square. But that's not a cup of tea or a vanilla ice cream.

However that process of digitization, which started with sound and text and image, is now moving on to digitization of matter. And the most obvious part of this – of atoms, of real stuff – the most obvious part part of this is 3-D printers. So I can get a 3-D sensing wand that I can put it over this audience and then print you all out in glorious ABS thermo-plastic.

But that be a make-anything machine. It would just be a model of you. To actually make a real copy of you I would have to have a kind of print head that would print out all the skin and the bones and the blood in exactly the right place – that would be able to print out exactly the right different molecules and compounds where you want them.

And that is what brings us to synthetic biology. Because the synthetic biologists, and the industries that are supporting synthetic biology, believe that they have little tiny machines, such as bacteria and yeast and so forth, that can print out compounds at will, kind of 3-D printers for chemicals.

You might have noticed I just did an unusual thing just there. I talked about living organisms – yeast [and] bacteria – as machines. This is pretty central to the way the synthetic biologists think. Next week we have something called the International Genetically Engineered Machines Competition that's about to happen in Boston. Not organisms – machines.

Because synthetic biologists would say, 'We already have a very efficient kind of matter compiler that's able to produce many hundreds of thousands of compounds out of pretty basic inputs, and that's nature, it's biology.' Biology can take carbon and oxygen and nitrogen and arrange it into anything from the iridescence of mother of pearl to the hardness of a coconut shell to the pungent compounds that are the smell of garlic. And it does all that through these little machines whether they're coconut trees or bacteria or so forth.

When a synthetic biologist looks at a forest they don't see just a beautiful ecosystem, they see a large-scale production system for compounds. And they want to know how they can interface with that and begin to control which compounds are produced where.

In order to do that, in order to decide what a living organism or a living machine prints out you would need to have an interface, you would need to have a kind of language. Synthetic biologists believe that they have that. That in fact, living machines actually have sorts of instructions – they have a code – it's DNA.

We heard earlier from David Ehrenfield, the limits, of the idea of DNA as a code. But that's how they think. That if you could just take this, it's like software for the machine. You don't have to have it printed out in ones and zeros on a long punch card, but it's printed out in the letters G, T, A, and C on a long piece of protein.

If you could re-write that code then you could instruct the forest to give you a cup of tea or a vanilla ice or something. I think I'm probably losing a lot of people here. I want to get a bit more concrete about how you would do this.

The first thing is you need to find what is the code that would give you, let's say, vanilla. Vanilla is the second most important spice in the world by terms of value. And [for] vanilla, the compound in question is vanillin.

So we've been reading genomes – DNA – for about 30 or 40 years. We have a lot of data. And we can crunch through that and we can work out, roughly speaking, which parts of the DNA code, lead to an organism producing vanillin.

So you can come up with a DNA sequence that looks like it will probably produce vanillin: G-T-T-C-C-A-G. That's a list of digital letters.

The second step is you need to turn that into actual DNA and that's not very tricky. You have machines called a DNA Synthesizer, there're about the size of a photocopier and they make DNA for you, synthetic DNA.

You can type into them that you want a piece of DNA that goes, G-T-T-C-C-A-T-G, and it will print it out for you. In fact you don't really need a machine because there are companies on the internet that will do this for you. DNA 2.0, for example, where you go to their website, give them your credit card details, and for 30 cents per letter you can order G-C-C-T-T-A-C-C and they will send it by FedEx to your house.

So now you have this little so-called genetic program, this piece of DNA. You then have to put that into an actual living machine that will print out the vanilla for you. So synthetic biologists are most interested, actually, in yeast. Yeast they see as a machine that takes sugar and turns it into beer. But if they could re-program it it could take sugar and turn it into vanilla. So that's what they do. They engineer it into the yeast and the yeast spits out vanillin.

A real synthetic biology company will produce many different versions made of that code to find the best one. Then they'll have their little machine, their little factory, that produces vanillin.

Because this is tiny, you want to have millions of those, you replicate them – because they're living organisms – and put them all into a big vat. And now you have a vat, that when you put sugar in it, will produce vanillin. Does that make sense?

What you've done is you've gone from digital code over here, G-T-T-C-C-C-A, to vanillin which you can actually put in a milkshake, or something.

And if I change the code over here, G-A-C-C-T-T, it could produce patchoulol over here which is patchouli scent. Or I could do it, T-T-T-C, change it over here as well and what comes out over here could be cow's milk.

These aren't random, hypothetical examples. These are real. There's a company called Evolva, a synbio company, that produces the vanillin through synthetic biology and yeast that's now sold and put in products.

The patchoulol is produced by Amaris and its sold through Firmenich, one of the biggest flavor and fragrance companies. And the milk proteins are being developed by a company called Moo Free, as in free of moo. It's a silicon valley company and they've developed yeast that will produce cow milk protein so you can make vegan cheese. That's going to hit the market, they say (who knows?), in 2017.

So you could take that milk, you could mix it with the vanilla, and in a way I've then got a machine that will give me that ice cream that I wanted as a child.

And it's not just those three things. There's now a whole basket of compounds that are being printed out through synthetic organisms in these production systems. Everything from saffron and coconut oil, vetiver, stevia, and so forth, that are hitting the market place right now.

What does this mean? It means a lot. The first thing is I've taken vanillin and I've been able to make it in a vat. That vat is now a competitor to the 200,000 vanilla farmers in places like Madagascar, Comarus, Reuni (sp?), and Uganda, Mexico.

And the patchouli that I've produced, that's now a competitor for the patchouli farmers in places like Indonesia or Madagascar. And so through all of those. I mentioned coconut oil. Coconut is produced by about 25 million people in the Phillippines [who] depend on coconut production. It's one-in-five people in the Phillippines. Coco is another one. And so forth and so on.

There's a company called Allylix in San Diego who produce vetiver oil. Vetiver is a musky fragrance oil and they produce it in synthetic organisms. Up until recently vetiver oil was mostly produced by farmers in Haiti. It's probably the most important agricultural export crop for 60,000 farmers in Haiti. That's the poorest country in the western world and it's about to lose it's most important agricultural export because of synthetic biology. And so on and so on.

Evolva, the company I mentioned that are working on vanillin, have about a couple of dozen different projects they're working on with things like turmeric and ginger and ginseng and even human breast milk. The U.S. Department of Defense has a project to produce a thousand compounds of interest to the defense industry – interesting to know what they are – through printing them out in synthetic biology.

And there are 200,000 plant-derived compounds. Synthetic biologists say that they can produce any compound that you could find in a plant, they can now produce in a microbe. And that's what they're trying to do. It's a massive change in production.

And not just in microbes. Probably one of the leading synthetic biology projects is to produce artemisinin, it's an antimalarial compound. It's previously grown by 100,000 farmers in East Africa and Southeast Asia. But as of last year about a third of global supply came from one big tank of synthetic organisms in Italy by Sanofi-Aventis. And almost overnight the planted area of artemisinin dropped by two-thirds. That's something on the order of 70,000 farmers looking for something else to plant.

It's not only terrible for those farmers and the agricultural economies around them, there's now actually, work being done in Israel by a team to take those same genetic sequences and build them into tobacco. So that in fact rather than it being produced on the fields in East Africa or even in a vat in Italy, it will be produced on the fields that are controlled by Phillip Morris and so forth here in the U.S. So that important commodity that supported 100,000 poor farmers has moved to the control of large monoculture agriculture. And so on and so forth.

And there's many more issues besides. I haven't talked about biosafety. The fact that you're producing very extreme organisms that really are very much more novel than the sort of genetic engineering that we've seen so far. I haven't talked about the fact that it's quite easy now to print out ebloa or smallpox or something like that. And that certainly has the world's militaries both worried and excited, as you can imagine.

But really, I think, where this is significant is, in the longer term, is this isn't just the only digital production technology that's coming down the line. I've already mentioned 3-D printing. In fact, there's a lot of work on flexible production through flexible robotics. Also work on drones in agriculture.

And I'd echo what Pat [Mooney] said earlier: that we can't think of these technologies one at a time and look at their economic impacts one at a time. We have to look at the new arrangements that these technologies together are creating. I think we're moving into a world where a set of new, digital production technologies of stuff – whether that's digital production of compounds through synthetic biology, digital production through 3-D printing, or digital production through flexible robotics in large robotic factories – means that anything can be produced anywhere without very many people involved in the process, all the way from the field where we're removing the farmers who grow vanillin or grow vanilla or stevia, all the way through to the production that used to be workers and craftsman.

That's I think a discussion that nobody's yet had. That we need to urgently have because that production system is changing.

I want to end with two, maybe, glimmers of hope. Earlier this year, a so-called natural soap company called Ecover let it be known that they were going to move over their soap production to using an oil from a synthetic biology algae in place of using coconut oil or palm oil. When that became known tens of thousands of consumers reacted against that, signed petitions, wrote letters, wrote on their facebook page and so forth and they had to back off a little bit and they're now caught up amidst stakeholder processes trying to work out what they do with that very strong reaction that there was to use of synthetic biology.

Just over a week ago, the hundred and ninety four nations of the United Nations Convention on Biological Diversity agreed to a set of decisions that are the first global decisions on governance of synthetic biology. They agreed that every country should set up regulations on synthetic biology, those regulations should be based on precaution, and there should be all sorts of assessment including socioeconomic assessment.

Many of the countries that were at those negotiations – which had been going on for four years – wanted a complete moratorium. In fact it was countries of the south – it was countries like Malaysia, the Phillippines, Bolivia, and African countries who did not want this technology to move into commercial use and pushed very, very hard for that position.

I think, what this shows, is that there is a sort of native awareness and appetite to slow down and maybe stop and reverse this new production paradigm in its tracks. And I think we need to build on that.

Thank you.