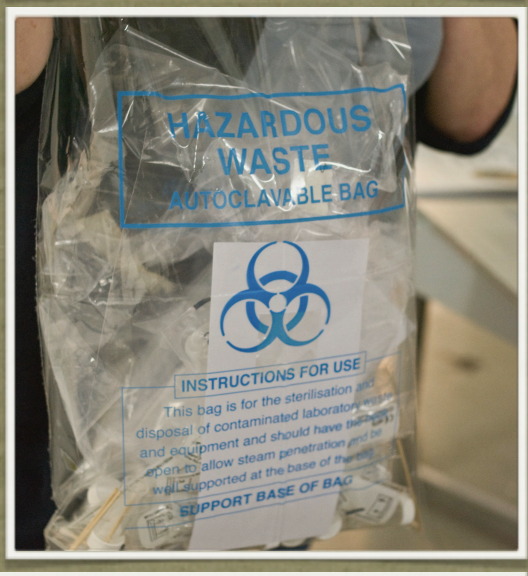

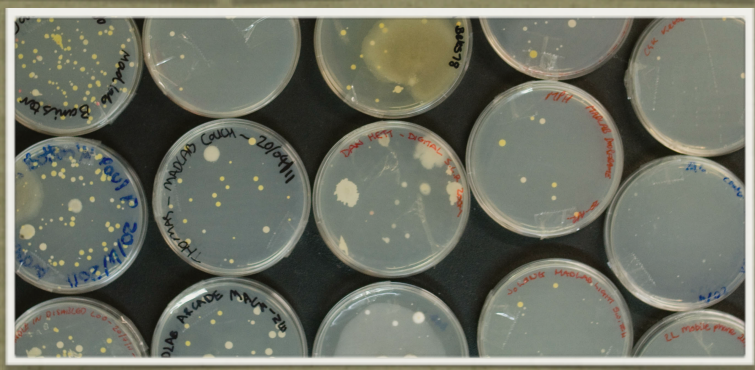

SYNTHETIC BIOLOGY NEWSLETTER

An LIS Consult and Synthetic Biology Project Initiative

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The Synthetic Biology Newsletter is an initiative of LIS Consult and the Synthetic Biology Project of the Woodrow Wilson International Center for Scholars. The newsletter is financially supported by the Commission on Genetic Modification and the Rathenau Institute, both in the Netherlands.

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COMMISSIE COGEM GENETISCHE MODIFICATIE

Synthetic BIOLOGY PROJECT

In this issue

Inside the work of the United States Presidential Bioethics Commission

Eleonore Pauwels, Woodrow Wilson International Center for Scholars

The Presidential Commission for the Study of Bioethical Issues (PCSBI) was created by Executive Order 13521 in November 2009 and replaced the Presidents Council on Bioethics (PCBE). Thirteen members were appointed to PCSBI the following April and held their first meeting in July of 2010. The Commission's 13 members have thus far held four meetings in an attempt to fulfill their complex mission to "identify and examine specific bioethical, legal and social issues related to the potential impacts of advances in biomedical and behavioral research, healthcare delivery, or other areas of science and technology; recommend any legal, regulatory, or policy actions it deems appropriate to address these issues; and [to] critically examine diverse perspectives and explore possibilities for useful international collaboration on these issues." Following J. Craig Venter's May 20 announcement of the development of the 'synthetic cell,' the Commission spent its initial 5 months exploring the potential benefits and concerns of this break-through as well as the benefits and concerns of do-it-yourself biology.

Prudent vigilance

PCSBI concluded its initial deliberations on synthetic biology with its Atlanta meeting in November 2010 and recommendation report delivered to President Obama on December 15th. Among the topics discussed was the importance of finding the right balance between unfettered science and the restrictive precautionary principle, which would require a thorough understanding of all potential risks before proceeding. The report ultimately agreed upon a stance of *prudent vigilance.* It acknowledged that in an emerging field, such as synthetic biology, where much is uncertain and unforeseen, strict regulations can do more harm than good. Therefore, PCSBI recommended regulatory parsimony with the caveat of frequent reevaluation to catch risks as they develop. Moving forward with caution, increased oversight and tools for reflection and reevaluation are the main components of this recommended *prudent vigilance.*

Though the PCSBI report aimed to accommodate the unpredictable nature of an emerging technology, it also sought to address issues already salient in synthetic biology. One issue of concern was the constantly evolving nature of synthetic biology. The recommendation report answered this by suggesting a panel reporting to the White House Office of Science and Technology Policy that would assess and periodically reassess government funding and regulations of research and patent policies.

The public perception of synthetic biology was another salient concern addressed by the Commission. In reporting on Venter's synthetic cell, the media frequently used sensationalist phrases such as "creating life" and "playing God" which ultimately obscured fact, created confusion and heightened unwarranted public concern about Venter's cell. To encourage

honest and accurate discussions about synthetic biology, the panel suggested an independent non-profit institution, not unlike Factcheck.org, to evaluate and clarify synthetic biology claims.

Recommendations

Included in the draft are some specific recommendations. For one, the panel recommends marking new synthetic organisms so they are traceable should they escape from the lab. Another suggested precaution is deliberately engineering weak organisms, which would be unlikely to survive in the wild. One such mechanism would create organisms with atypical nutritional requirements that cannot be met outside the lab.

Other areas of concern, such as the do-it-yourself community of some 2000 people, remain unsettled. One proposition for dealing with the DIY community was to enforce the National Institute of Health's guidelines for studying recombinant DNA across the board, even if NIH funding is not received. Another discussed option was the forced registration of do-it-yourselfers, but concerns were expressed that this might encourage underground operations, resulting in even less oversight.

It has yet to be seen if PCSBI's work will be taken to heart. In addition to a general examination of the ethical and governance issues posed by synthetic biology, the recommendation report includes 18 recommendations believed to promote the ethical principles in synthetic biology, including public beneficence, responsible stewardship, intellectual freedom and responsibility, democratic deliberation and justice and fairness. With several of these recommendations including deliverables scheduled to be made public in mid 2012, time will tell if the actors involved are serious about the prudent vigilance of synthetic biology.

European Group on Ethics

The United States is not alone in its struggle to regulate the emerging field of synthetic biology. The European Union has also initiated dialogues on this topic resulting in the publication of Opinion No 25 by the European Group on Ethics (EGE). The March 2010 document outlines concerns similar to those of the United States, such as how to ensure safety, security, and environmental and social justice as synthetic biology progresses. The report states that governance of such a complex and rapidly changing field requires a multi-pronged approach. Firstly, the EU should adopt much of the policy and regulatory framework already in place for the governance of biotechnology. However, binding legislation alone is not sufficient, and therefore soft law, e.g. code of conduct, guidelines, and best practices, must be used to ensure ethical issues are internalized by the synthetic biology community. Finally, there must be fair and rational discussion, both between the public and synthetic biology stakeholders as well as between countries.

Though PCSBI has completed its report and turned its attention to other issues, the discussion on the ethics of synthetic biology has not ended. This past March, at an event hosted by the Woodrow Wilson Center, PCSBI members Christine Grady and Anita Allen came together with would-be trans-Atlantic partners Hille Haker from EGE and Lino Paula from the European Commission as well as other interested parties to discuss synthetic biology governance strategies. As synthetic biology is a field where innovation and progress happens at the global level, events that bring together policy makers from across the world will be increasingly important. International dialogue and policy convergence will be required

for there to be effective governance of such a globalized field. While the PCSBI and EGE already show convergence in many of their recommendations, e.g. education, public engagement, public funding, open access sharing and the importance of international dialogue, they still differ in opinion in other recommendations. The EGE has taken a stricter stance on risk, recommending prior risk assessment and operating by the precautionary principle. The PCSBI, on the other hand, advocates for periodic risk assessment and prudent vigilance. Bio-security remains a point of difference as well with the EGE calling for an amendment to the convention on biological weapons. Finding a patenting scheme that simultaneously protects intellectual property and promotes fairness and justice remains a problem. Clearly, there is still much work to be done and many discussions to be had. Still, with the publication of their report and participation in international discussions, PCSBI has made progress towards a more ethical synthetic biology that we sincerely hope will continue.

A few words with David Rejeski, Director of the Synthetic Biology Project at the Woodrow Wilson Center…

-How does the work of the Presidential Commission on Bioethics contribute to the debate on the implications of synthetic biology in the US?

"The report calls for periodic assessments of security and safety risks and analyses of potential gaps in oversight and regulatory authority as the science and applications of synthetic biology move forward. The Commission clearly wanted high level engagement and the report places a significant amount of responsibility for implementation in the Executive Office of the President (though largely steers clear of identifying specific offices within the White House)," said Rejeski.

-What kind of (political) follow-up activities can be expected and which actor will take the lead?

"The report says little about accountability. For the Commission's work to have lasting impact, progress towards these recommendations needs to be measured, data made publicly available, and pressure maintained on the implementing parties," said Rejeski.

-Overall, what will be the impact of the PCSBI Report? Does the report bring to light any new strategic concept for the governance of cutting-edge technologies?

"Trying to steer a middle course between oversight approaches that are overly prescriptive, or too 'laissez faire,' the report advocates a principle of prudent vigilance, where the benefits and risks of synthetic biology are assessed both before and after projects are undertaken," said Rejeski.

"The idea of prudent vigilance put forth in the report provides a valuable framework for the oversight of emerging technologies in general," noted David Rejeski. "If properly implemented, it would constitute an anticipatory and adaptive management approach to introducing new technologies into society, one that could potentially reduce the chances for harmful unintended consequences."

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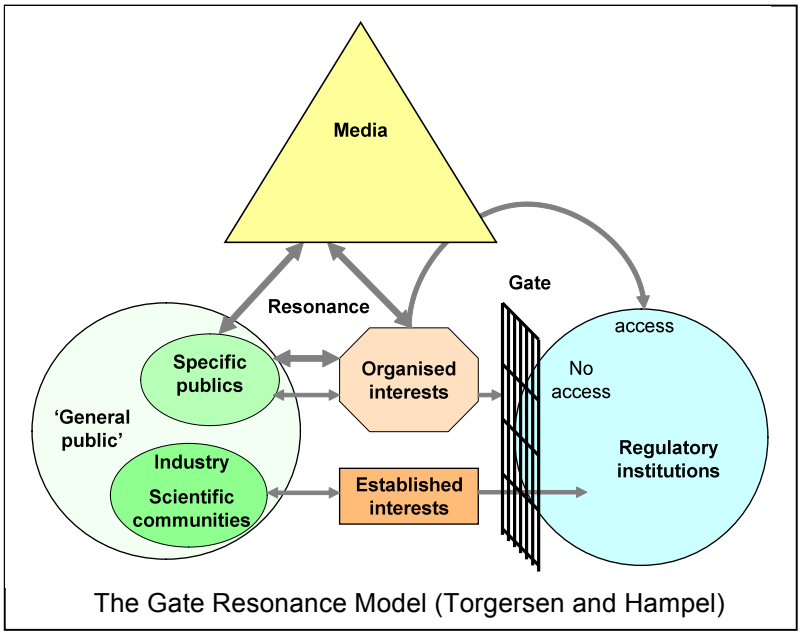
More about dominant frames and discourses in the synthetic biology debate

Huib de Vriend, LIS Consult

Social scientists and communication experts have warned that synthetic biology could elicit controversies similar to those of genetically engineered crops before. Helge Torgersen and Jürgen Hampel used the Gate Resonance Model to assess past controversies about genetically modified crops and potential controversies about synthetic biology. "So far, there are only few indications that a controversy is imminent", Torgersen and Hampel conclude (Torgersen and Hampel 2009). A recent study commissioned by the Rathenau Institute on the present status of the synthetic biology debate in four countries points out an imbalance between different types of discourse. Discourses about risk and innovation are relatively well developed, while an ethics discourse is almost lacking and a political discourse only receives attention from a few Civil Society Organisations (Hanssen et al. 2011).

No imminent controversy

The Gate Resonance Model postulates a) that regulatory institutions have to select issues and restrict the content of the regulatory debate because their processing capacities are limited, and b) that only established interests have direct access to regulatory institutions. The central selecting element is a function called the "Gate." The Gate selects arguments according to formal criteria, strictly adhering to a particular frame, to be processed through formalised routines. The general public and non-established organised interests do not have direct access to the regulatory institutions. Any interest-representing organisation not integrated into the normal mode of policy-making can only have impact by either transforming their views into terms fitting the Gate or trying to modify it, for example via mobilisation strategies. The success or failure of such mobilisation strategies depends on resonance with the media and with the public.



The Gate Resonance Model (Torgersen and Hampel)

A comparison between genetically modified (GM) crops and synthetic biology (SB) in terms of this Gate Resonance model, suggests that there are more differences than similarities between these cases. An important similarity is the experts' emphasis on economic importance and problem solving and the critics' concern about "tinkering with life". A crucial difference is the lack of tangible SB products, especially in relation to food. As a result, SB is

largely unknown among the public and, as conflicts about GM were mainly over food, the potential for mobilisation is low. Moreover, media reports on SB are rather positive, mainly on the science pages, and oriented at new developments rather than societal impacts or risks. Public scapegoats, such as multinationals, are largely absent. All this makes resonance unlikely at present.

As Torgersen and Hampel point out, official policy and regulatory institutions frequently stress the need to consider ethical, legal and social issues (ELSI) that formerly would have been taken up by organised interest groups. Accordingly, these issues are addressed by special ethics committees and taken up in dedicated ELSI research programmes. Such moves make it more difficult for organised interest groups to campaign on these issues and to mobilise their constituency against a field like SB. In contrast, novel societal actors such as student groups promote the field. Technology critics have not yet been able to raise issues of general concern other than those the scientific community already acknowledged to be relevant. Thus, scientists sensitive to societal issues acquired a quasi-detector function which was a typical NGO task in the debate about GM crops.

In terms of the Gate Resonance model the foregoing implies that the regulatory discourse is still open: rather than separating accepted from non-accepted arguments, inclusion of various positions is considered appropriate. The Gate has not yet been set, with one exception: a general consent among established interests holds that technology-specific regulation is currently unnecessary. This will probably not suffice to trigger public mobilisation over regulatory failure (as with GM and BSE). Most scientists and regulators agree that regulatory attention should be directed at single issues such as safety, security, equity (e.g. intellectual property rights) and at future shortcomings of specific forms of regulation. Regulatory activity thus does not systematically neglect certain aspects to uphold an ideology such as “sound science.” Instead, openness to the publics’ fears and the need to “reach out” are often stressed.

Imbalanced debate

A study commissioned by the Rathenau Institute compared the present status of the SB debate in four countries: the United States, Germany, the United Kingdom and the Netherlands. Based on previous studies in the field of SB and converging technologies, four types of discourses were distinguished. The *risk discourse* focuses on biosafety and biosecurity issues. The *innovation discourse* deals with the direction of research and innovation in SB and intellectual property. In the *ethics discourse* the moral and cultural dimensions of artificial biological systems are discussed, including issues of human identity and dignity. The *political discourse* is about socio-economic consequences and about the fairness and legitimacy of decision-making: who will set the priorities for SB and who will be the beneficiaries? In relation to these different discourses, the study further identified a variety of actors that could play a role in the SB debate. Most of these actors have been actively involved in the GM debate. Relatively new is the involvement of ‘creative groups’ including students, Do-It-Yourself biologists, artists, designers and gamers engaging themselves with SB. The study analyses how these various actors are linked to the four different and emerging discourses. The results are presented in the table below.

Table: Actors and discourses in the emerging synthetic biology debate in the United States, the Netherlands, the United Kingdom and Germany

Actors	Risk discourse				Innovation discourse				Ethics discourse				Political discourse			
	US	NL	UK	GE	US	NL	UK	GE	US	NL	UK	GE	US	NL	UK	GE
Goverments	■	■			■	▭	▭		■							
Companies	■				■			▭	▭							
Scientific institutions	■	▭	■	■	■	■	■	■	■	▭	▭	▭				
Civil society organizations	■			▭	■				▭			▭	■			▭
Worried publics																
Creative groups	■				■		▭									
Politicians		▭			▭	▭	▭	▭								
Media	▭				▭	▭	▭	▭	▭	▭	▭	▭				

■ Well developed ▭ Weakly developed □ More or less absent

The pattern that is revealed in this table clearly confirms some of the observations made by Torgersen and Hampel. Whereas ELSI issues have been actively taken up by governmental and scientific institutions, especially in the US, public mobilisation in the SB debate is currently absent. However, in addition to these observations, there is another important aspect to be noted from the pattern in this table. In all the four countries studied, we see a striking imbalance between the different types of discourse in the SB debate. Whereas the risk and innovation discourses are relatively well developed, the ethics and political discourses are clearly lagging behind. Although Torgersen and Hampel concluded that there are few indications that a controversy is imminent, continuation of this imbalance between the different discourses in the SB debate could still elicit controversy in the near future.

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Vaccines: the first commercial application of synthetic biology?

Huib de Vriend, LIS Consult

In July 2010, during the first public meeting of the Presidential Commission for the Study of Bioethical Issues in the US, Commission chair Amy Gutmann asked Craig Venter (J. Craig Venter Institute) whether, by the next flu season, we could "have a one-day production, through synthetic biology, of a flu vaccine?" Venter told the Commission that researchers could produce the seed stock for the vaccine in just 12 hours.

Flu vaccine (wikimedia commons)

Vaccines are hot. In recent years we have seen outbreaks of potential pandemics caused by new strains of influenza virus that do not only require a rapid response in terms of developing new vaccines, but that also triggered a lot of media attention. There was the Mexican or swine flu in 2009, for which the World Health Organization raised its pandemic alert to 5, the second highest level, and the threat of an avian flu pandemic in 2008. Both cases were concerned with a new variation of an existing flu virus. Since influenza evolves rapidly and new strains quickly replace the older ones, a vaccine formulated for one year may be ineffective in the following year.

Vaccine development is therefore an ongoing business. The 26 May edition of Nature contains a special in which vaccination is presented as a promising prevention strategy for several important diseases such as HIV infection, malaria and tuberculosis, which kill more people each year than smallpox did when the global campaign to eradicate it began in 1967. According to scientists affiliated with the Institute of Medical Microbiology, University of Regensburg, Germany, conventional vaccine design strategies, although generally very efficient, are suboptimal or unfeasible for some infectious diseases. In a commentary in the June edition of Human Vaccines they point at new technologies to vaccine development that have evolved over the past few years, often utilizing design principles and construction technologies of synthetic biology. Altogether, they think that synthetic biology can help to develop improved vaccine candidates in considerably less time compared to conventional approaches (Kindsmüller, 2011). The rapid development, production, and distribution of pandemic influenza vaccines could potentially save millions of lives during an influenza pandemic. Synthetic biology might be helpful in speeding up this process. Two approaches recently proposed are the use of libraries of synthetic viral DNA and the construction of universal vaccines.

Advantages of artificial gene synthesis

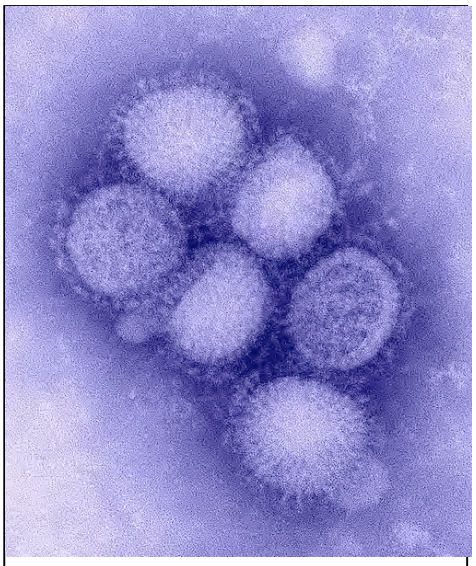
Venter added to his comments before the Presidential Commission that with "rapid DNA sequencing, we can predict, we think, well in advance what the changes will be for next year's flu before the WHO even makes the decision as to the vaccine stocks." Venter also said that it is "very likely ... that the vaccine you get next year will be from synthetic genomic technologies." He added that NIH is funding his team to construct synthetic segments, so

that it will be "easy just to put them together in a very rapid synthesis process to make any seed stock for any change we see for tracking new, emerging infections."

Only a few months later, Synthetic Genomics (SGI) and the J. Craig Venter Institute (JCVI) formed a new company, *Synthetic Genomics Vaccines* (SGVI), to develop next-generation vaccines based on synthetic genome technology. SGVI also announced a three-year alliance with drug company Novartis to develop a bank of synthetic seed viruses as a rapid-response technology for the production of annual or pandemic flu vaccines. SGVI will exploit the JCVI's expertise in genomic sequencing and synthetic genomes, supported by SGI's IP and business know-how. Novartis has been working with JCVI over the last decade to apply the institute's research on viral gene sequencing for vaccine development. Currently Novartis and other vaccines companies rely on the WHO to identify and distribute live reference viruses to create seasonal or pandemic vaccines. Under this collaboration, Novartis and SGVI will work to develop a "bank" of synthetically constructed seed viruses ready to go into production as soon as WHO identifies the flu strains. The technology could reduce the vaccine production time by up to two months, which is particularly critical in the event of a pandemic (Synthetic Genomics, 2010). "It has the potential to safely reduce the time needed to develop new vaccines and improve pre-pandemic preparedness," states Rino Rappuoli, head of research for Novartis Vaccines and Diagnostics (Novartis, 2010). According to SGVI, using the synthetic genomics advances gathered from the construction of the first bacterial cell with a synthetic genome it is conceivable that more universal vaccines could be developed to target a wide range of infectious disease agents in addition to new influenza vaccines.

Towards a universal flu virus

A different approach was followed by scientists at Oxford University who have successfully tested a universal flu vaccine that could work against all known strains of the illness. The vaccine targets two proteins inside the flu virus that are much more similar across strains and less liable to change over time than the usual targets, sitting on the virus' external coat, which are liable to mutate. The problem with the flu is that you've got lots of different strains and they keep changing. Occasionally we are dealing with mutant strains that come out of pigs or birds, such as the swine flu; mutants that we are not immune to. The process of identifying the mutant that causes the disease and developing a (seasonal) vaccine takes at least four months and is expensive. If the flu strain is highly pathogenic the delay means more people get sick and die before the vaccine is ready. The UK government spent an estimated £1.2bn in preparing for the swine flu outbreak of last winter. A universal vaccine would save the time and money now needed to create vaccines to fight whatever particular virus has emerged in any year. Using the same vaccine year in, year out, would be more like a routine vaccination that



H1N1 (wikimedia commons)

would be manufactured and used all the time at a steady level.

The new vaccine has been tested on 11 healthy volunteers who were infected with a strain of the infuenza A virus, along with 11 non-vaccinated volunteers. The volunteers' symptoms were monitored twice a day. The results showed that the vaccine worked as planned. It is believed that the vaccine could provide better protection against flu for people.

A real revolution?

Ron Fouchier is a professor of Molecular Virology at the Erasmus Medical Center in Rotterdam, where he studies respiratory viruses, in particular influenza A viruses. He contests the claim of rapid response to new mutants of the influenza virus. “The synthesis of DNA, which scientists are now capable of doing in a couple of hours, is still many steps away from producing a regular vaccine. This requires optimization of the vaccine seed stock, validation, testing, production, and quality assurance, which are still laborious steps. So what you gain is a couple of days to produce the seed stock DNA construct, on a total of about six months.”

Synthetic genes could also be used as DNA vaccines or recombinant protein vaccines. “This is also a development that has been going on for a number of decades. At present, such vaccines are produced using the conventional molecular biology tools of cloning, transformation, and purification of the vaccine from micro-organisms. What Venter proposes – to use gene synthesis for the first step – gains you 1-2 days. You still have to use the subsequent time consuming steps of validation and production because it is not yet possible to produce sufficient quantities of synthetic DNA for vaccination of large numbers of people. Moreover, DNA vaccines appear to be pretty effective in mice, but their effectiveness to protect humans from influenza is not yet established.”

Fouchier also puts the development of ‘libraries’ in the context of an ongoing development. “Such ‘libraries’ are already available within the existing WHO network of global influenza reference centers. The only difference is that they are not based on fully synthetic constructs.”

Fouchier further doubts the novelty of vaccines based on proteins from the inside of the virus. Already in the early 1990s scientists demonstrated the possibility to induce protective immunity in mice (Sutter, 1994). “Recombinant MVA viruses with insertions from other viruses (such as influenza) have been under investigation for more than 20 years in the conventional way, using recombinant DNA technology. We already knew that these vaccines are effective. The news is that these vaccines have been tested on humans now, where they appear to be effective too.”

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Synthetic biology raises questions about the re-emergence of citizen science …

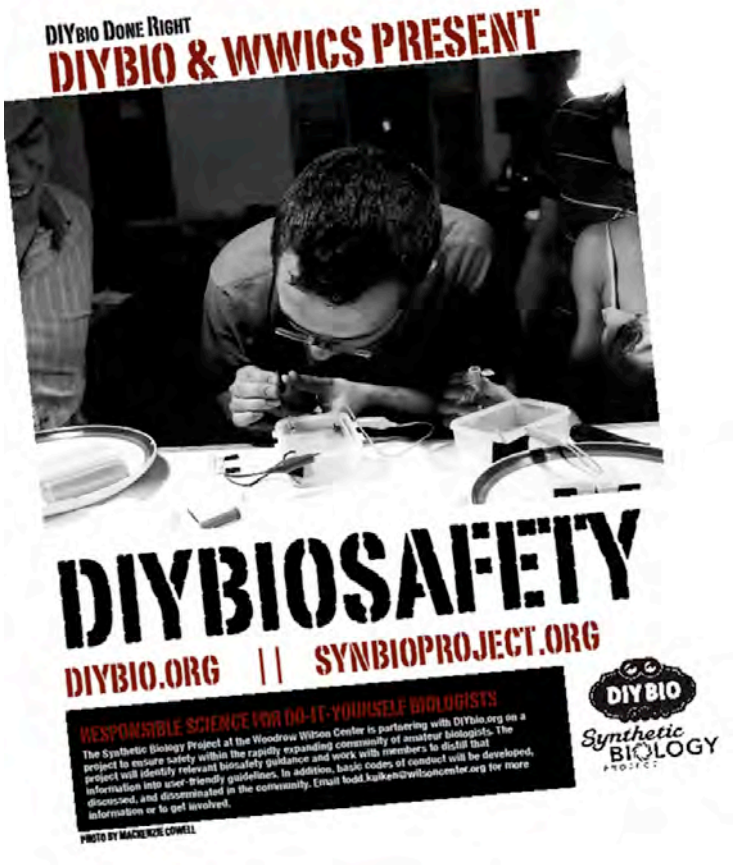
Eleonore Pauwels, Woodrow Wilson International Center for Scholars

Do-It-Yourself biology (DIYbio) is becoming increasingly common in the United States as it becomes easier and less expensive to order genes online and either purchase used equipment or create your own. No longer is a Ph.D. and a university or corporate laboratory required to genetically modify materials when instructions can be found online to create a microscope from a webcam or use an electric screwdiver to create a centrifuge. Meredith Patterson is often described as the quintessential biohacker, a former computer programmer who is conducting experiments in her kitchen on a budget of less than $200. She is attempting to alter yogurt bacteria so that it will signal the presence of the toxic chemical melamine, found in baby milk in China in 2008, using jellyfish DNA that she purchased for less than $100.

Among the firms making this possible is Ginkgo Bioworks, a Massachusetts company that offers off-the-shelf biological components and a third-party service for rapid prototyping. Ginko Bioworks also markets a cloning kit with a set of linkers from the biobrick registry for standardized parts. This makes all kit-generated components compatible with each other. But perhaps the most influential player in the rise of DIYbio is the International Genetically Engineered Machine competition (iGEM). This competition, which began at MIT in 2003, has teams of undergrads from universities all over the world and has inspired many amateur scientists to attempt fairly advanced projects, including a team that developed an arsenic detector using *E.coli*.

Lack of regulation

Opponents of DIYbio argue that the lack of regulation and oversight for biohackers working in garages and kitchens is troubling. Drew Endy of Stanford University agrees that while the lack of oversight is an issue, it does not appear to be a large problem. Jim Thomas from the Canadian nonprofit action group on Erosion, Technology, and Concentration (ETC) is more strongly opposed. He feels that bioengineering research should be done in a more controlled setting due to the lack of understanding of the biosafety of synthetic organisms. We don't know what impact they would have if released into the environment. Jim Collins of Boston University



agrees with Thomas, arguing that synthetic biology is complicated enough that little value will come from biohackers but there is the potential for an accidental outbreak of which the effects would be unknown.

The growing interest in synthetic biology, especially among DIYbiologists, has sparked concern among national intelligence and defense agencies. In December of 2008, the Report of the Commission on the Prevention of Weapons of Mass Destruction stated that "terrorists are more likely to obtain and use a biological weapon than a nuclear weapon," and it predicted that, without preventative measures, terrorists would likely use a biological WMD by 2013. In 2009, Abdallah Fahd al-Nafisi, a recruiter for al-Qaeda, stated that they "have scientists, chemists, and nuclear physicists…There is good reason for American's fears." As early as 2002 US intelligence discovered a lab in an al Qaeda camp along with lab manuals and written orders for *anthracis* and *botulinum* cultures.

A bottom-up approach

The FBI is among the agencies taking a closer look at the DIYbio community with their Biological Sciences Outreach Program. Their current goal is to "collaborate with the science community to secure biology from those who would use it to harm people." While the government has been trying to lock down labs, synthetic biologists have been spreading. The fear is that one day synthetic biology could be simplistic enough and powerful enough that terrorists could reengineer a pathogen, making it deadlier, or engineer a new virus. It is, however, difficult to acquire pathogens, and they are even more difficult to engineer than DNA strands. For example, while it may be possible to purchase the sequence for Spanish flu, it is unlikely that this could be weaponized with current technologies.

Currently the FBI is using a bottom-up approach to regulation, including hosting a table at iGEM, attempting to educate scientists on how they can prevent their innovations from being used by terrorists and those wishing to cause harm. Self-policing is currently the most commonly used approach to ensuring safety, with biohackers and businesses alerting the FBI through local WMD coordinators when they receive orders for pathogenic materials or notice questionable behavior. Additionally, synthesis companies have worked together to standardize screening for certain DNA sequences. Gigi Kwik Gronvall from the University of Pittsburgh Medical Center suggests a wait-and-see approach. She comments that there are many more positives than negatives and that, at the moment, the technology and knowledge is not available to part-timers and biohackers to create and release a new virus. She also notes that federal regulations would probably have little impact due to the international nature of the DIY biocommunity unless there was an international agreement.

A few words with Todd Kuiken, Research Associate within the Synthetic Biology Project at the Woodrow Wilson Center:

-Can DIYbio contribute to scientific progress, for instance in the same way as gamers contributing to further development of algorithms that predict protein folding?

Whether or not DIYbio will contribute to scientific progress in the same way as gamers is yet to be seen and I don't think anyone can really predict that. What DIYbio has already done is enable people to become citizen scientists, to explore and become excited about science again. DIYbio has taken what was once a closed and in some ways elitist enterprise and brought it to the general public.

-Is there a real security threat posed by DIYbio?

There is no more of a security threat posed by DIYbio then there is with anyone who has criminal intent and access to materials that could potentially be used for harm. Keep in mid that the cleaning products under your sink, if combined in the right way could also pose a real security threat. The more pressing issues associated with DIYbio are biosafety. One of the goals of our partnership with DIYbio is develop a code of conduct and safety materials so those participating in this exciting field can do so safely without harming themselves or the environment.

-What, if any, regulations are currently in place to prevent terrorists from purchasing pathogens?

Complete DNA strains of pathogens are highly regulated. It is true though that one could order separate pieces of a strain and theoretically put them together to produce a pathogen. It needs to be stressed though that this is extremely hard to do and a lab along the lines of a DIYbio lab would most likely not have the ability to perform such a fete. In addition if they happened to produce such a strain in a "DIYbio" type lab they most likely would not have the containment mechanisms necessary and would probably succumb to their own strain that they produced.

-Excluding iGEM which usually has Ph.D.s acting as team leaders or guides, what if any breakthroughs or discoveries have been made by biohackers?

I personally don't like the term biohacker as it brings with it a negative image of what the DIYbio movement is really about. There have been many discoveries associated with DIYbio, primarily in the form of kits and tools that have been developed or "hacked" if you will, which enable people to explore biology on their own. Prior to these kits or self-made tools, one would need access to a lab in order to gain access to a centrifuge for instance. Today one can order a dremelfuge for around $50 hook it up to a drill bit and centrifuge at home. (www.shapeways.com)

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Biosecurity at the science-policy nexus: developing a vision for the future

Frans Brom, Keelie Murdoch and Dirk Stemerding, Rathenau Institute

On October 6th 2010, the Rathenau Instituut hosted a select group of Dutch scientists and biosafety and security officers and two internationally renowned biosecurity experts at a workshop in The Hague to discuss matters of biosecurity and its implementation in the Netherlands. The workshop took place against the background of rising concerns about bioterrorism and international calls for national biosecurity and the Dutch Chair of the Seventh Review Conference of the Biological Weapons Convention in 2011. Formulated in response to the perceived challenge of implementing biosecurity across disparate communities and in anticipation of a coordinated biosecurity system in the Netherlands, the agenda sought to reveal the multi-dimensional nature of biosecurity and inspire insightful discussion and forward thinking ideas. This is a summary of the main points that were considered during the workshop, followed by some "sticky points" in conclusion.

Main issues

1. The complementary and synergistic nature of biosecurity and biosafety

In the Netherlands, early reactions to the issue of bioterrorism and associated matters of biosecurity built upon the established field of biosafety and its infrastructures. This is because biosafety and biosecurity both deal with what has been called "hazard risks" and therefore share the general aim of risk reduction. Biosafety is understood as the practices and principles implemented to prevent the *unintentional* release of pathogens and/or toxins ("keeping bad bugs from people"). Biosecurity is understood as the practices and principles implemented to prevent the *intentional* release of pathogens and/or toxins ("keeping bad people from bugs"). While the priorities of each approach may differ slightly, it was agreed that they are indeed complementary and synergistic and efforts must be taken to develop this relationship in a lucid and meaningful manner.

2. Sensitive area of governance

It is important to acknowledge that biosecurity issues are not confined to the misuse by terrorists but also contribute to the weapons of mass destruction (WMD) arms race. Biosecurity refers to a range of programs and practices which includes the development of protective and/or defensive measures and mechanisms (i.e. bio-preparedness) which often operate under a cloak of secrecy as they are classified matters of national security. Biosecurity is thus a sensitive area of governance and must be approached with caution and with due attention to these sensitivities.

3. Governance regimes

Biosecurity is influenced by three established governance regimes and thus embodies aspects of each of them. These regimes are:

a) The security regime (command and control measures)
b) The biosafety regime (containment measures)
c) The scientific regime of self-regulation (codes of conduct/scientific responsibility)

The three governance regimes interact and in some cases clash as biosecurity ideas and infrastructures are developed which introduces complex problems for decision-makers. The values of freedom and openness in science and the accepted modes of scientific

organization and regulation are not easily juxtaposed with the logic of security which aims to isolate, monitor and contain threats to security within a system of security and oversight. Efforts thus must be made to bridge the differences in language and perspective between these regimes and the respective communities.

4. Awareness raising

In the presentations and discussions about biosecurity and recommendations for the way forward, the idea of "awareness raising" played a crucial role. It was broadly accepted that raising awareness about biosecurity was central to its implementation. Awareness raising can include educational modules and training seminars, conferences and symposia and other means of information dissemination and communication.

5. Open-ended policy

The development of new interdisciplinary research fields and emerging and converging technologies seem add odds with a regulative approach based on lists, classifications and strictly defined criteria. Rather, in the wake of synthetic biology, we need to be open to creative interaction and integrated forms of governance. Contemporary technologies require open-ended policy with flexible categories. However, they must also have regulative teeth so that the governance regime is both inclusive and consequential. In the spirit of interdisciplinary, the governance of new technologies should enable the methodical and congruent development of both top-down and bottom-up regulations and policy innovations.

Sticky points

1. Raising awareness

Yet, the idea of "raising awareness" is a black box. It is a concept which is widely discussed but remains ambiguous because its referent has not been thoroughly defined. That is, the meaning of raising-awareness has not been significantly unpacked in the context of biosecurity discussions. It is not just an attitude or a perspective. Rather, it is also a practice which requires further elaboration. The crucial question that can facilitate a stronger sense of understanding and purpose is "what should we be aware of?" For instance, should we be aware of security risks? Safety regulations? Possible dual-use experiments? The people around you such as the people you trust or conversely, the people you don't trust?

2. The biosecurity issue

Policy-makers and biosecurity decision-makers must be aware that the biosecurity problem is not one that should be taken for granted, nor should it be overestimated. Hazard risks are low probability risks, but with high consequences. This suggests that the central purpose of biosecurity should be to minimize the risks. This will require a thorough understanding of the risk factors in the Netherlands. However, it begs the question, is the biosecurity problem merely an international hype or a legitimate concern for the Netherlands? A shared problem definition should thus be developed to frame the problem from a Dutch perspective and to ensure that biosecurity implementations fit the national context. This of course is implicit to the aims to raise awareness and develop a coordinated biosecurity system in the Netherlands.

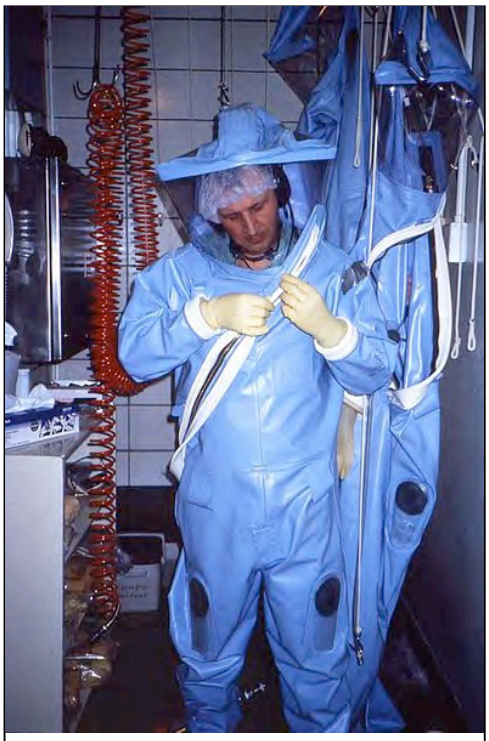
3. *Misuse*

The misuse of biological materials is central to the problem of biosecurity. "Misuse" in this case pertains to activities which employ biological materials, including biological agents and information, in a way that presents harm to individuals and society and is thus counter to the values of science. Some biological research (i.e. experiments in virology or vaccine development) is particularly sensitive to misuse because even legitimate scientific practice

can be harmful if it is accidentally or purposefully applied in a malicious way. From this dual-use perspective, the potential benefits of biological research must be weighed against the risks of misuse. However, there are may unanswered questions concerning how this procedure should be conducted. For instance, is it possible to prevent the misuse of pathogens and toxins without stopping research in these areas altogether? Or conversely, do the potential benefits not clearly outweigh the risks of misuse? If not, who would be responsible weighing the risks and benefits? Is it possible to identify actors who should take responsibility or who would be able to take responsibility for this task? Should this occur on a case-by-case basis or according to established rules and regulations?

4. Codes of conduct

Codes of conduct are considered an essential part of biosecurity by the international community. However, they are drafted and coded at the "top" of the scientific hierarchies (i.e. scientific academies, scientific associations). This suggests that the persons developing the codes of conduct are not necessarily (and not likely) persons from the scientific community that will be expected to eventually implement the rules. Moreover, it runs the risk that the codes of conduct are not operational outside the community of code-drafters. For instance, the language employed may not communicate the desired message and the rules may not be practical or even possible considering local circumstances. Thus, it is important to consider the purpose of a code of conduct. Are the codes operational outside the community of code-drafters? Should they be? Are they meant to be? If so, how could they be? That is, what should codes of conduct aim for on the work-floor and in relation to research management?



Center for Disease Control technician in a protective suit before entering a maximum security lab

(Brian W.J. Mahy, CDC)

5. Converging technologies/synthetic biology

From the perspective of research, these advancements represent incremental changes in technological trajectories. From a systemic perspective, the merging of research fields and the associated new perspectives, create a situation where these new technologies could fall between the cracks of existing regulations or completely outside the spectrum of regulation. As such, synthetic biology is a "sticky issue" because it involves new actors, new activities, new perspectives and new tacit knowledge which is blurring boundaries between disciplines and technologies and fuelling uncertainty and complexity in the area of science policy (e.g. nano-physicists working in a biological context).

6. Emerging fields

Defining an emerging field, from a regulative perspective, is a problem because if new technologies represent converging fields, as does synthetic biology, and are challenging regulation, what should be done? Should policy-makers wait for the development of the field and for the field to define itself (self-definition)? Or should they start a proactive regulative approach which aims to define it? The former seems possible, although waiting may also

include waiting for new difficult controversies to unfold which may prove especially complex without a precedent or an existing basis for making a ruling. The latter however may prevent a range of beneficial developments by killing them before they have the opportunity to exist and evolve into socially valuable products or processes.

Source:

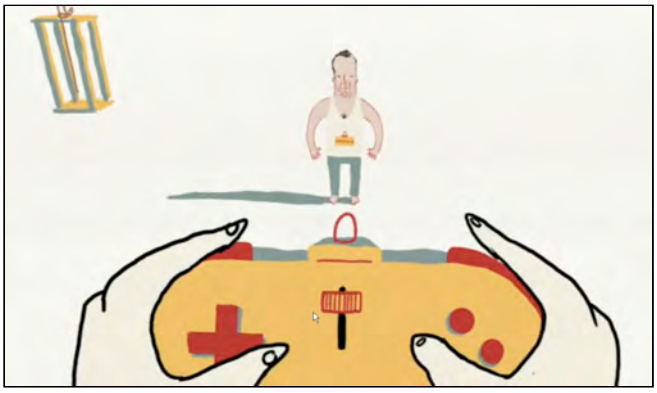
http://www.rathenau.nl/en/themes/project/biosecurity-regulation-and-research-practice.html

BIO:FICTION: where Science and Arts meet

On May 13-14, 2011 the Organisation for International Dialogue and Conflict Management (IDC) and the Austrian Natural History Museum organised Bio:Fiction, the world's first synthetic biology science, art and film festival. From the 130 films submitted a selection of 52 films was judged by an international jury that selected winners in 4 award categories: Fiction, Documentary, Animation and a Special Jury Award. There was an additional Online Audience Award.

Winner of the award for best fiction was "(In)visible" by Sonja Bäumel, an Austrian fashion designer who made a short movie about her idea to use bacteria and plant-based membranes for clothes that adapt to the human body and the environment. "(In)visible" can be watched at the Bio:Fiction website, http://bio-fiction.com/videos/

The award for best documentary went to "E.Chromi" by Daisy Ginsberg and James King. "E. Chromi "visualizes the ideas of the 2009 Cambridge team for the International Genetic Engineering Machine competition, a collaboration between designers and scientists. The team designed E.coli bacteria that change colour depending on the presence of specific compounds. "E.Chromi" can be watched at http://www.echromi.com/



Winner of the award for best animation was "Bruce", The graduation film from Tom Judd of the Royal College of Art, UK. "Bruce" explores how advances in open-source synthetic biology allow a young man to grow his very own action hero. "Bruce" is available at http://vimeo.com/5395365

Several films could be classified as more than one category. The jury agreed that the special jury award should go to the 'mocumentary' "Die Schneider Krankheit," a fascinating and well compiled mix between fiction and documentary by Javier Chillon who used fictional footage dating from the 1950s. "Die Schneider Krankheit" can be watched at http://www.youtube.com/watch?v=7JTuhU4z1jo

The public award, for which visitors of the Bio:Fiction website could vote, went to Christina Agapakis' and Patrick Boyle's "Who Are the Bioengineers of the Future?", a funny impression of Gingko BioWorks, founded by five MIT PhDs in 2008 (http://ginkgobioworks.com/). "Who are the Bioengineers of the future?" Can be watched at http://www.youtube.com/watch?v=q7fpwmQWCkA

Apart from screening movies the festival offered a wide choice of lectures and workshops including general introductions and applications to Do-it-Yourself Biology and Biohackers,

Ethics and Art and Design. On May 14,, the art exhibition 'synth-ethic' opened. The exhibition will continue until June 26, 2011.

Following the Vienna festival Bio:Fiction will go on tour bringing a selection of the best films to people around the world. The Karlsruher Institut für Technologie (KIT) and the Institut für Technikfolgenabschätzung und Systemanalyse (ITAS) will screen a number of films preceding a discussion of the opportunities and risks of synthetic biology at the Zentrum für Kunst und Medientechnologie on June 21. For more information go to http://on1.zkm.de/zkm/stories/storyReader$7561. The second venue will be in Adelaide, Australia, where RiAus OnDemand will complement the *Life 2.0* exhibition with the Vienna highlights on June 22. For more information go to http://bio-fiction.com/en/?page_id=567.

More information about the organisation, the program, the Online Audience Award, the Exhibition and background information can be obtained from http://bio-fiction.com/en/