



First Self-Replicating Synthetic Bacterial Cell

J. CRAIG VENTER INSTITUTE

Fact Sheet: Ethical and Societal Implications/Policy Discussions about Synthetic Genomics Research at JCVI

Background ►

Dr. Venter and his team at the J. Craig Venter Institute (JCVI) consider the ethical and societal implications of their work to be as important as the scientific research. To this point he and the team posed the ethical questions before beginning any actual experiments or research into constructing a minimal genome or the work to construct the first synthetic cell. Here is an outline of the important work that JCVI has undertaken since 1995.

1995-1999: *Mycoplasma genitalium* and the minimal genome project

Research on the minimal genome started in 1995 after the publication of the *Mycoplasma genitalium* genome at the legacy JCVI organization, TIGR. This organism has the smallest genome of a self-replicating organism, prompting Dr. Venter and his team to wonder if *M. genitalium* could be a platform to determine the minimal set of genes that could still sustain cellular life. This notion and the research plan to test it underwent a thorough ethical review by a panel of experts at the University of Pennsylvania (Cho *et al.*, *Science* December 1999:Vol. 286, no. 5447, pp. 2087 – 2090). The panel's independent deliberations, published in *Science* along with the scientific minimal genome research, concluded that there were no strong ethical reasons that should prevent the team from continuing research in this field as long as they continued to engage in public discussions.

JCVI Work on PhiX174 Synthesis: The first synthesis of a non-pathogenic virus

In 2003, before publishing their results in PNAS on Generating a *Synthetic Genome by Whole Genome Assembly: phi X174 Bacteriophage from Synthetic Oligonucleotides*, a team of scientists from JCVI contacted several Government agencies, including the US Department of Energy (DOE), the White House Office of Science and Technology Policy (OSTP), and the

National Institutes of Health, to discuss any potential repercussions of their findings. After a series of meetings (which also included Department of Homeland Security representatives) discussing the method presented in the paper, the findings were released at a press conference hosted by DOE in conjunction with the Secretary of Energy, Spencer Abraham.

JCVI Policy Team

Shortly after, in 2004, the JCVI's Policy team, along with the Center for Strategic & International Studies (CSIS) and the Massachusetts Institute of Technology (MIT) were funded by the Alfred P. Sloan Foundation to conduct a series of workshops and an invitational public session over a 20-month period to discuss the ethical and societal implications of synthetic genomics. Over the course of the study, the group explored the risks and benefits of the emerging technology, as well as possible safeguards to prevent abuse, such as bioterrorism. In October of 2007 the group published their findings in a report, outlining options for the field and its researchers.

Most recently in December of 2008, JCVI received funding from the Alfred P. Sloan Foundation to examine ethical and societal concerns that are associated with the developing science of synthetic genomics. The ongoing research is intended to inform the scientific community as well as educate our policymakers and journalists so that they may engage in informed discussions on the topic.

Ongoing Activities: Lectures, Media, Congressional Education

Dr. Venter and the JCVI team routinely give public lectures and presentations around the globe to both scientific and lay audiences, members of congress, schools, and other organizations. Realizing that most people get their information from the media, Dr. Venter and the team also conduct many interviews with global media (online, print, video, radio, etc.) about their work and the implications and applications.

Specifically over the last three years the team has made several trips to Capitol Hill to brief more than 50 members of Congress. The most recent work published on the first synthetic bacterial cell published in *Science* has been reviewed by OSTP, Department of Homeland Security, the NSABB, etc. The team supports and has asked for continued review and discussion about their research.

Overview of Selected Studies ►

Selected Studies of the Societal, Ethical, and Policy Considerations Associated with Synthetic Genomics and Synthetic Biology by both JCVI and other National and International Groups and Governments

Completed studies and reports from the United States

- Cho MK, Magnus D, Caplan AL, McGee D, and the Ethics of Genomics Group. 1999. **Ethical Considerations in Synthesizing a Minimal Genome**. *Science* 286: 2087-2090. <http://www.sciencemag.org/cgi/content/short/286/5447/2087>

This was the earliest study of the societal and ethical implications of synthetic genomics. Funded by an unrestricted grant from The Institute for Genomic Research Foundation (TIGR), a legacy organization of today's JCVI. The study was performed in parallel with research to define a minimal bacterial genome.

- United States Department of Energy, Office of Science, Biological and Environmental Research Advisory Committee, 2004. **Synthetic Genomes: Technologies and Impact**. <http://www.science.doe.gov/ober/berac/synbio.pdf>

Report of a DOE advisory group on the potential benefits and concerns associated with synthetic genomic technologies.

- National Science Advisory Board for Biosecurity (NSABB) 2006. **Addressing Biosecurity Concerns Related to the Synthesis of Select Agents**. http://oba.od.nih.gov/biosecurity/pdf/Final_NSABB_Report_on_Synthetic_Genomics.pdf

The Subcommittee on Synthetic Genomics of the NSABB prepared this report on security issues related to the construction of select agents using synthetic genomics technologies.

- Garfinkel MS, Endy D, Epstein GL, and Friedman RM, **Synthetic Genomics: Options for Governance**, 2007. <http://www.jcvi.org/cms/fileadmin/site/research/projects/synthetic-genomics-report/synthetic-genomics-report.pdf>

Report focuses on the biosecurity and biosafety concerns associated with synthetic genomics and presents and evaluates 17 policy options for consideration by policymakers. The two-year study, funded by the Alfred P. Sloan Foundation, was prepared by Michele Garfinkel and Robert Friedman, JCVI; Drew Endy, MIT; and Gerald Epstein, Center for Strategic & International Studies.

- National Academies/OECD/Royal Society, 2009. **Opportunities and Challenges in the Emerging Field of Synthetic Biology: A Symposium** http://sites.nationalacademies.org/PGA/stl/PGA_050738

This two-day symposium, funded by the Sloan Foundation, NSF, and BIO brought together biologists, social scientists, and policy experts to educate each other and to explore possibilities for trans-Atlantic collaborations.

Ongoing US-based studies

- **Synthetic Genomics: Scientists' Understanding of Society's Concerns, Society's Understanding of the Science and Scientists** http://www.sloan.org/assets/files/press/alfred_p_sloan_foundation_funds_new_synthetic_biology_initiative_to_examine_societal_issues.pdf

JCVI's current study on the societal implications of synthetic genomics, funded by the Alfred P. Sloan Foundation (2009-2010). Garfinkel and Friedman from JCVI, in conjunction with Lori P. Knowles, University of Alberta, Health Law Institute and Paul B. Thompson, Michigan State University, Department of Philosophy, are examining the sometimes differing views of society and scientists with respect to synthetic genomics. Also examines regulatory issues in the US and the EU.

- **Synthetic Biology Project: Ensuring Benefits are realized through Responsible Development** <http://www.synbioproject.org/>

The Woodrow Wilson International Center for Scholars established this project as an initiative of the Foresight and Governance Program with a grant from the Alfred P. Sloan Foundation. The project aims to identify gaps in knowledge about risks, to understand public perceptions about the field, and to explore governance options to promote innovation while ensuring safety.

- **Ethical Issues in Synthetic Biology: Non-Physical Moral Harms and Public Policy** <http://www.thehastingscenter.org/Research/Detail.aspx?id=1548>

Funded by the Alfred P. Sloan Foundation, this project aims to identify non-physical concerns about and potential consequences of synthetic biology, including how to incorporate these concerns into public policy discussions.

- **Synthetic Biology Engineering Research Center (SynBERC)** <http://www.synberc.org/content/articles/human-practices>

SynBERC is a multi-institutional research group funded by National Science Foundation to explore a number of engineering issues in synthetic biology.

US Government actions

- 2009. Federal Register Notice: Department of Health and Human Services, National Institutes of Health, Office of Biotechnology Activities. **Recombinant DNA Research: Proposed Actions Under the NIH Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines)**. <http://oba.od.nih.gov/oba/rac/ProposeRevisionsNIHGuidelines-March-4-2009.pdf>

Considers whether synthetic DNA is identical to recombinant DNA with respect to NIH Guidelines and thus whether language in the Guidelines needs to be changed. Public comments are currently under review.

- 2009. Federal Register Notice: Department of Health and Human Services, Office of the Secretary. **Screening Framework Guidance for Synthetic Double-Stranded DNA Providers**. <http://www.gpo.gov/fdsys/pkg/FR-2009-11-27/pdf/E9-28328.pdf>

Provides guidance to firms that supply synthetic DNA with respect to screening orders and customers for malicious intent. Public comments are currently under review.

Completed studies and reports from the United Kingdom and Europe

- De Vriend H, for the Rathenau Institute. 2006. **Constructing Life: Early social reflections on the emerging field of synthetic biology**. http://www.cisynbio.com/pdf/Constructing_Life_2006.pdf

Early and rigorous description of the constellation of societal issues that may be raised by synthetic biology.

- International Association Synthetic Biology Code, 2009. **The IASB Code of Conduct for Best Practices in Gene Synthesis**. http://www.ia-sb.eu/tasks/sites/synthetic-biology/assets/File/pdf/iasb_code_of_conduct_final.pdf

A suggested code of conduct for DNA synthesis firms, drafted by members of the IASB consortium. IASB is European-based; the process to draft this Code of Conduct included US firms.

- **Synbiosafe (European Commission 6th Framework Program, Project on Synthetic Biology Safety and Ethical Aspects)**. <http://www.synbiosafe.eu/>

Three major products, all edited/directed by M. Schmidt, Synbiosafe manager: a book (**Synthetic Biology: The Technoscience and Its Societal Consequences**), a documentary film (**SYNBIOSAFE: Safety and Ethical Aspects of Synthetic Biology**), and a special issue of *Systems and Synthetic Biology* (**Societal Aspects of Synthetic Biology**)

- UK Parliamentary Office of Science and Technology, 2008. **POSTnote** <http://www.parliament.uk/documents/upload/postpn298.pdf>

This document discusses possible applications and risks of new synthetic biology, including policy options for governance and development of the field.

Ongoing studies in Europe, 7th Framework program

- **SYBHEL (Synthetic Biology for Human Health: Ethical and Legal Issues)** <http://sybhel.org/>

This is one of just a few ethics and policy projects worldwide to focus solely on the impacts of synthetic biology technologies with respect to human health.

- **Synth-Ethics (Ethical and Regulatory Issues Raised by Synthetic Biology)** <http://www.synthethics.eu/>

This is a general project focused on safety, security, and notions of life, looking both at Europe generally and within specific countries.

Synthetic Biology Periodic Meetings: SB 1.0, 2.0, 3.0, 4.0, x.0....

The synthetic biology community holds recurring international meetings that include ethicists and social scientists with general interests in the research. Each meeting has dedicated time to presentations on societal impacts and issues.

- SB 1.0, 2005. Several talks on ethics and security. http://syntheticbiology.org/Synthetic_Biology_1.0.html
- SB 2.0, 2006. All ethics/policy talks on last day of the meeting. http://webcast.berkeley.edu/event_details.php?webcastid=15766
- SB 3.0, 2007. All ethics/policy talks were on one day, in the middle of the meeting. <http://www.syntheticbiology3.ethz.ch/monday.htm>
- SB 4.0, 2008. Societal impacts talks were scattered throughout the meeting. http://sb4.biobricks.org/agenda/sb4_agenda.pdf