



waag society

institute for art, science and technology



**BioHack Academy
History of Biohacking**



Definitions

Google

bi·o·hack·ing

/bīōhakīNG/

noun

the activity of exploiting genetic material experimentally without regard to accepted ethical standards, or for criminal purposes.

biohacking

n. The manipulation of DNA or other aspects of genetics either for fun, or maliciously

More at Wordnik | from Wiktionary, Creative Commons Attribution/Share-Alike License

TOP DEFINITION

>

biohacking

refers to managing one's own biology using a combination of medical, nutritional and electronic techniques.

I'm going to do some biohacking on my hangover by getting some IV hydration with essential nutrients.

#bio hack #biohacker #bullet proof #biopunk #cybernetic

Wiktionary

Urban
Dictionary



Definitions

biohacking noun

bio·hack·ing | \bī-ō-ha-kin \

Definition of *biohacking*

: biological experimentation (as by gene editing or the use of drugs or implants) done to improve the qualities or capabilities of living organisms especially by individuals and groups working outside a traditional medical or scientific research environment

// Every November, college kids from Michigan to Munich descend on MIT, eager to show off their *biohacking* skills. In the International Genetically Engineered Machine (iGEM) competition, teams battle one another to build the coolest synthetically altered organisms.

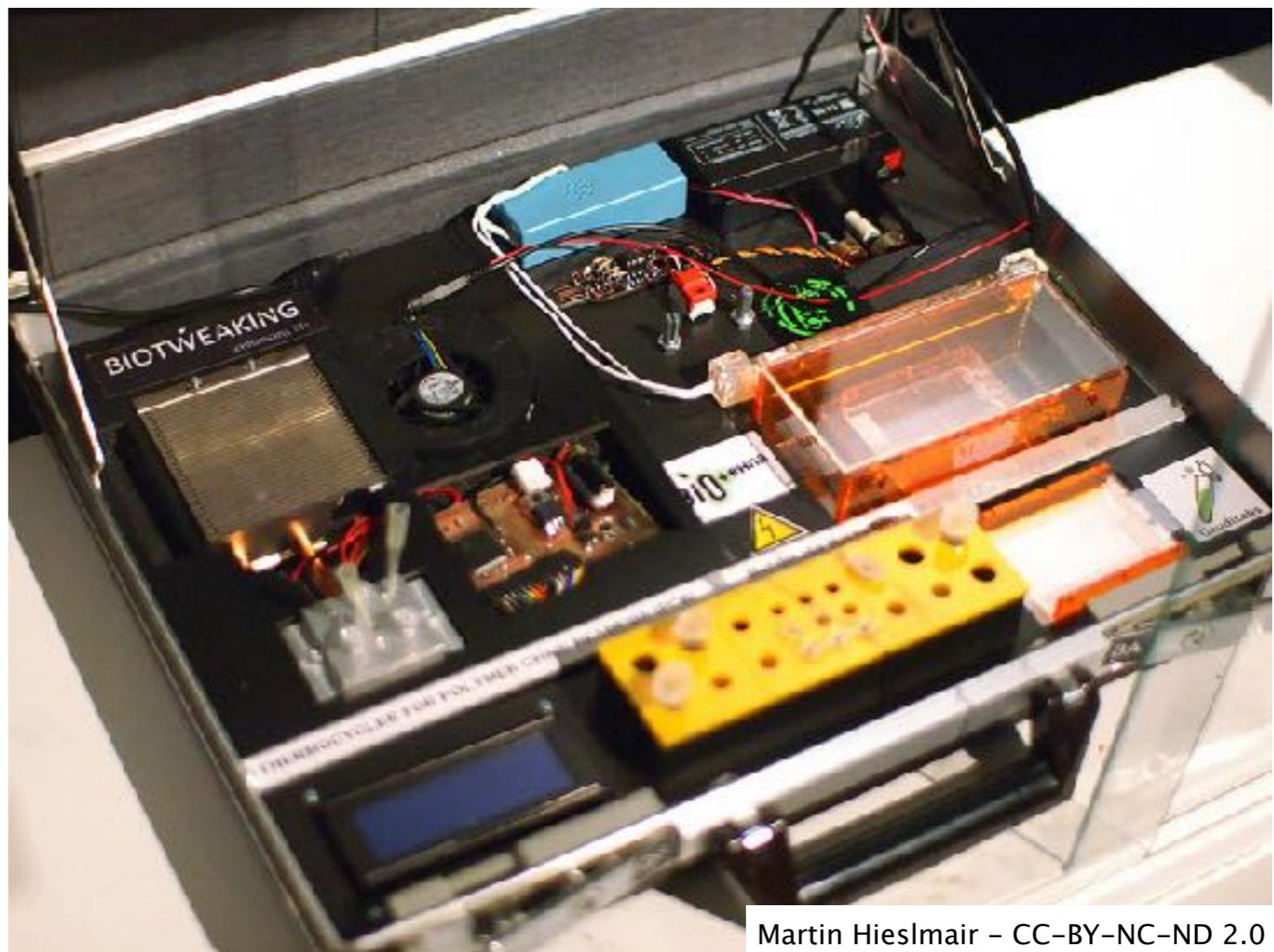
— Alexandra Witze

Merrian-
Webster



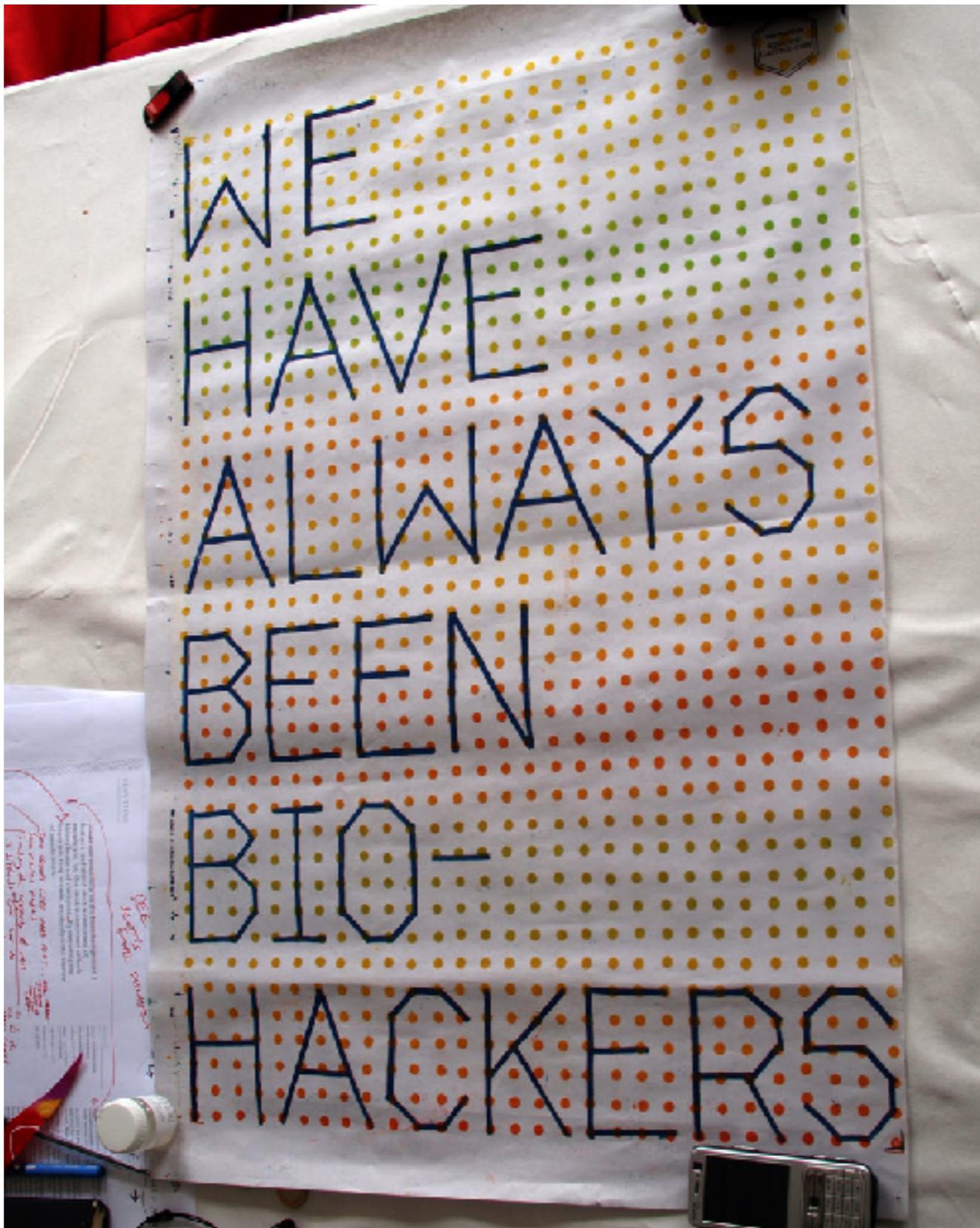
What it means to be a hacker

- Create & Share
- Freedom of inquiry
- Hostility to secrecy
- Sharing as ideology and strategy
- The right to fork
- Emphasis on rationality
- Distaste of authority
- Playful cleverness



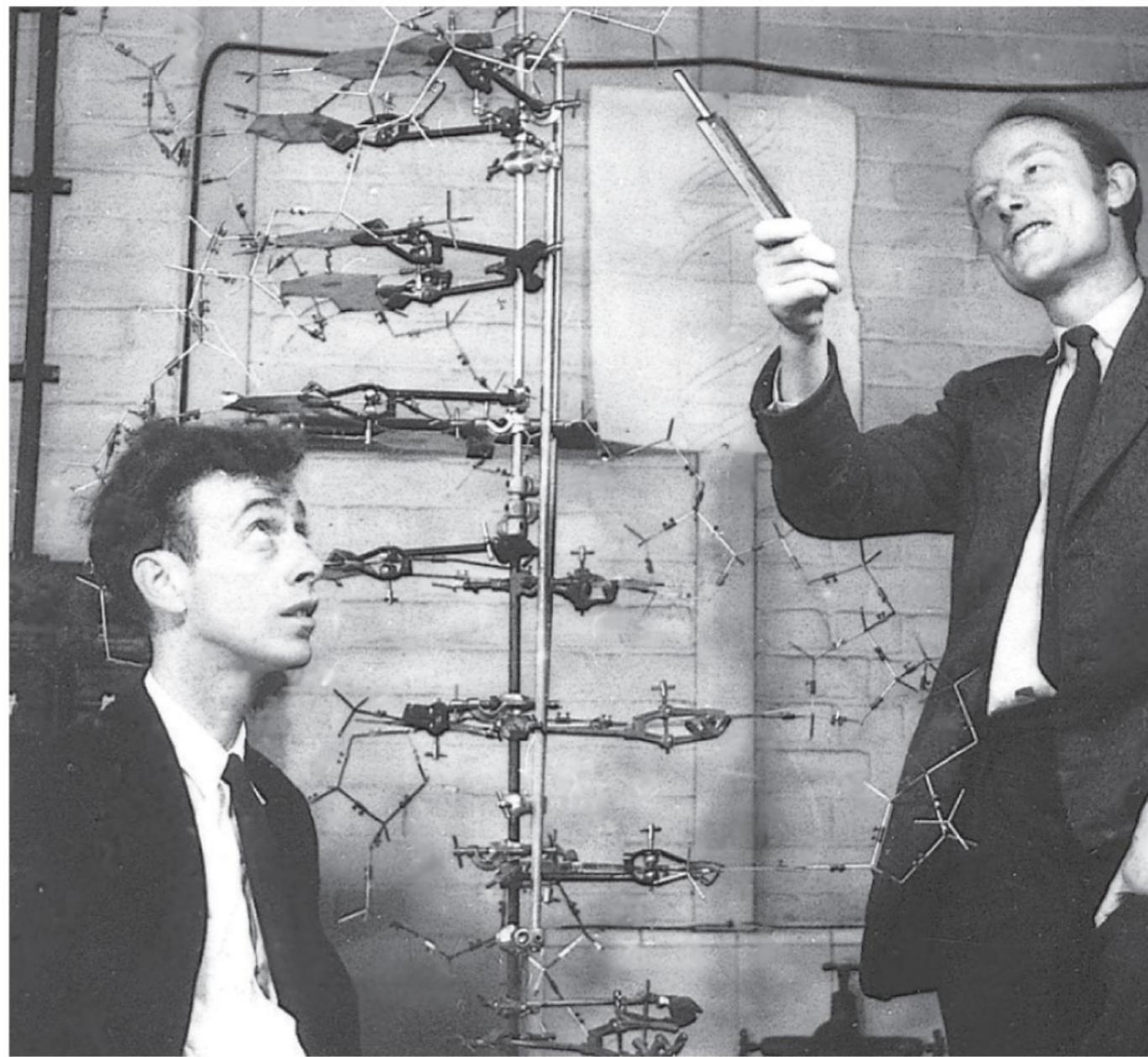
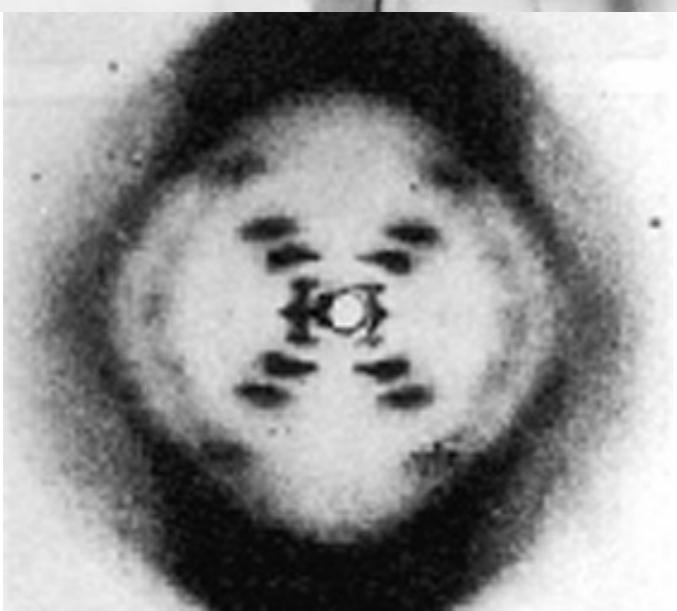


We have always been biohackers





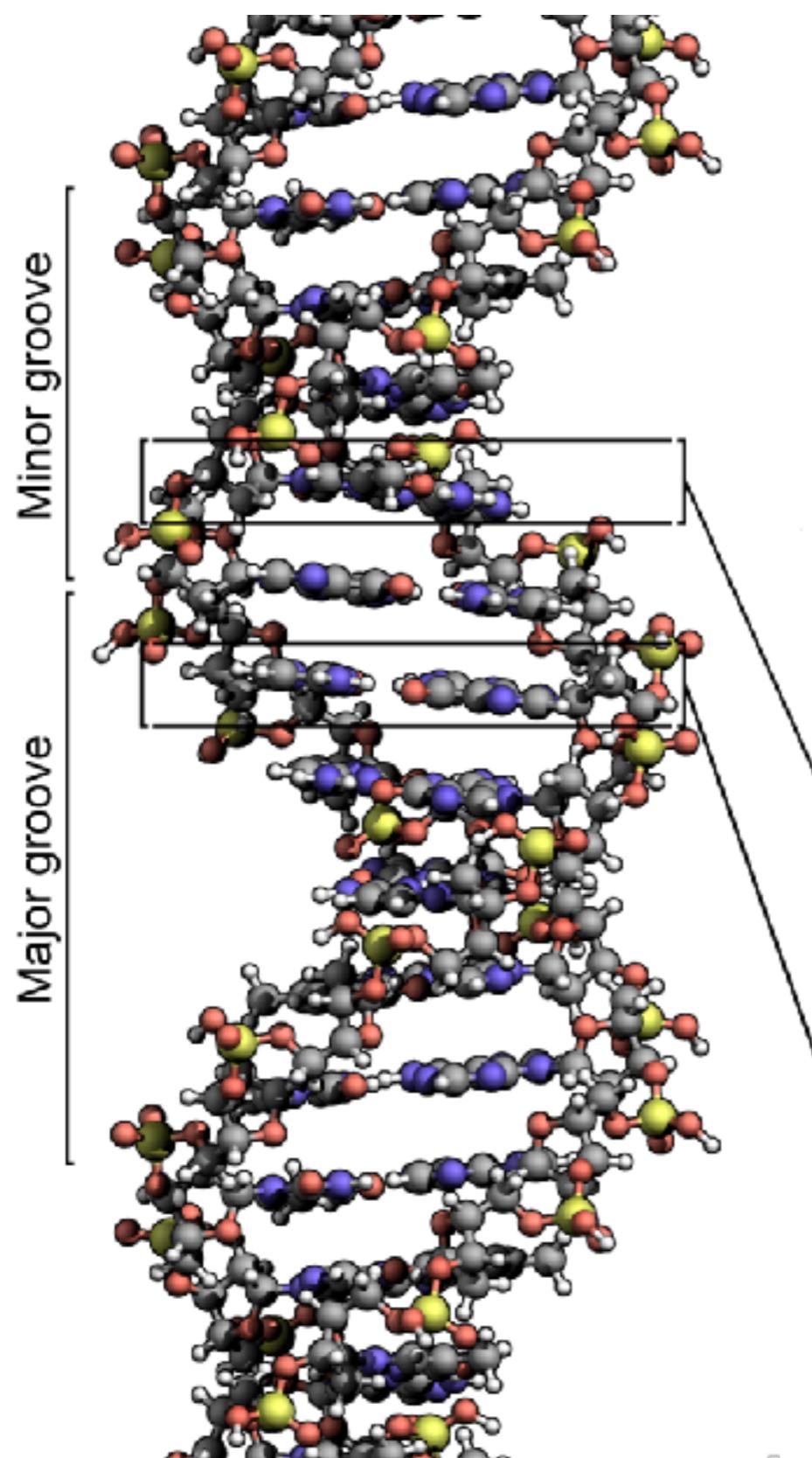
Discovery of Double Helix 1953



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DNA Molecule



Living code:

AACATGACCTGACGA

Digital code:

100101001110101010101010
01010101001010101001010110
1101111001

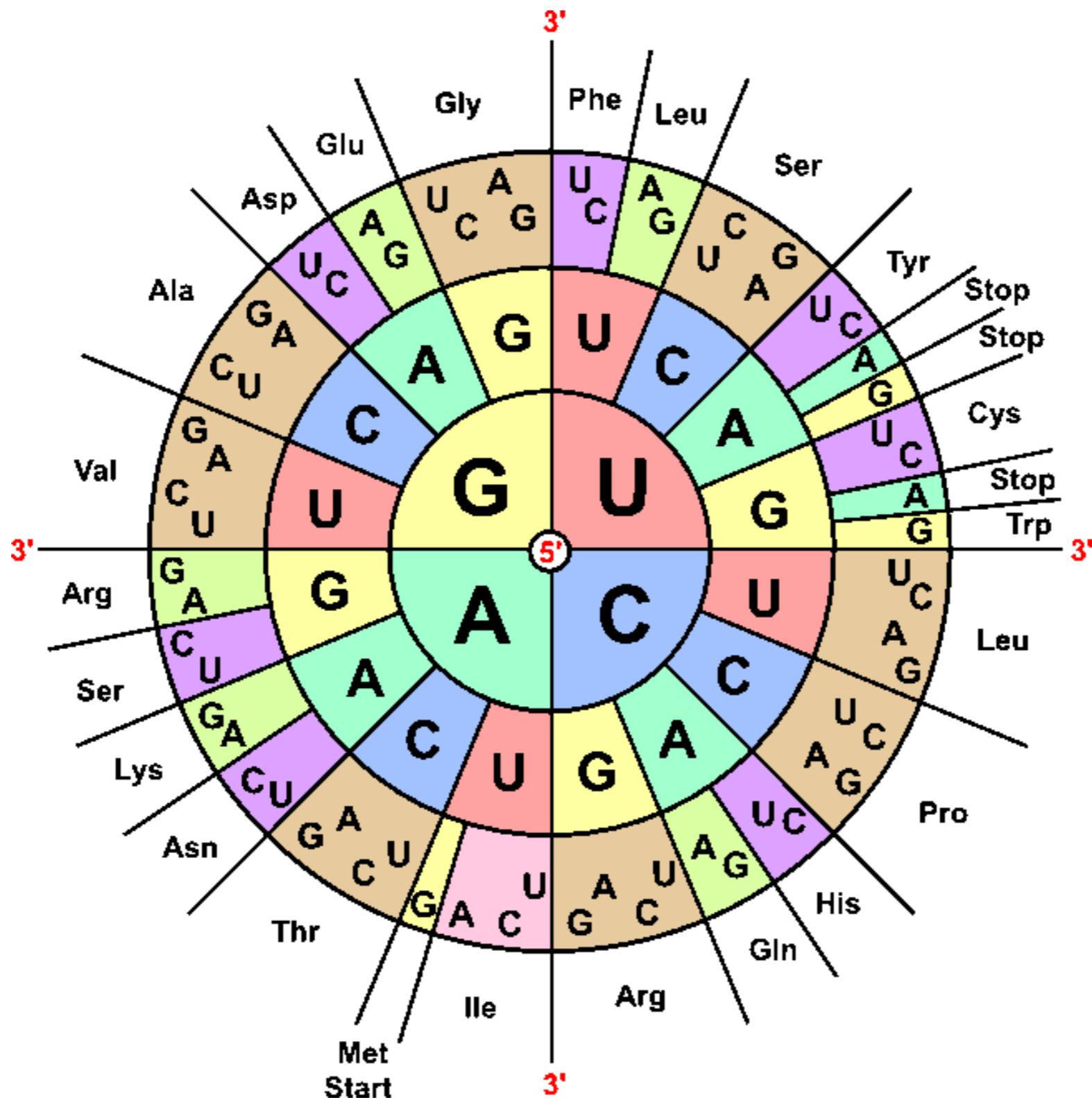


Robert W. Holley, Marshall Nirenberg, Har Gobind Khorana 1968



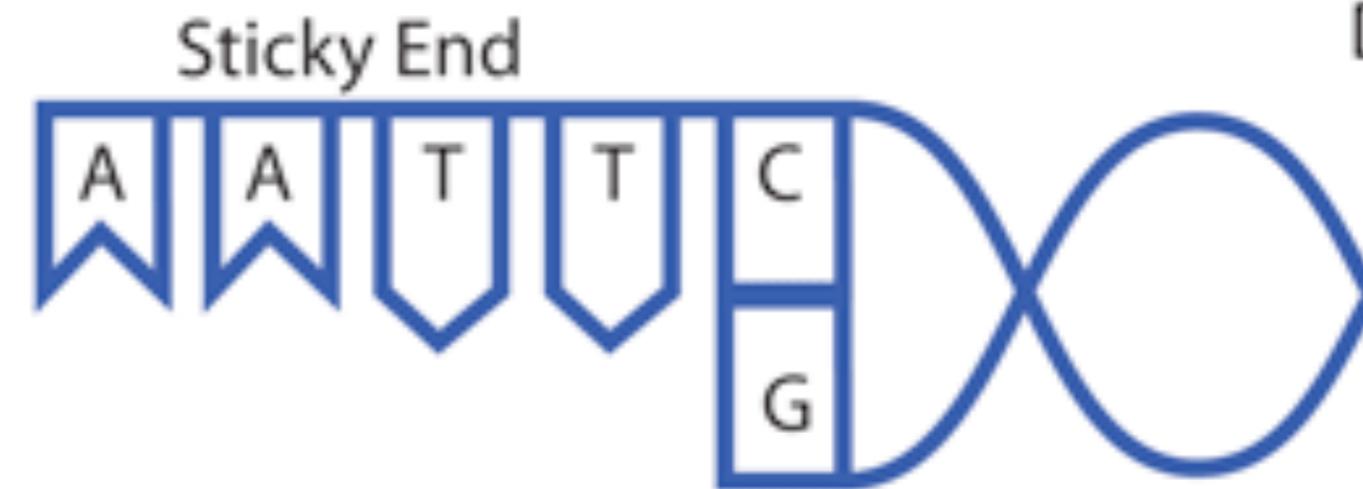


Amino acid rosetta stone



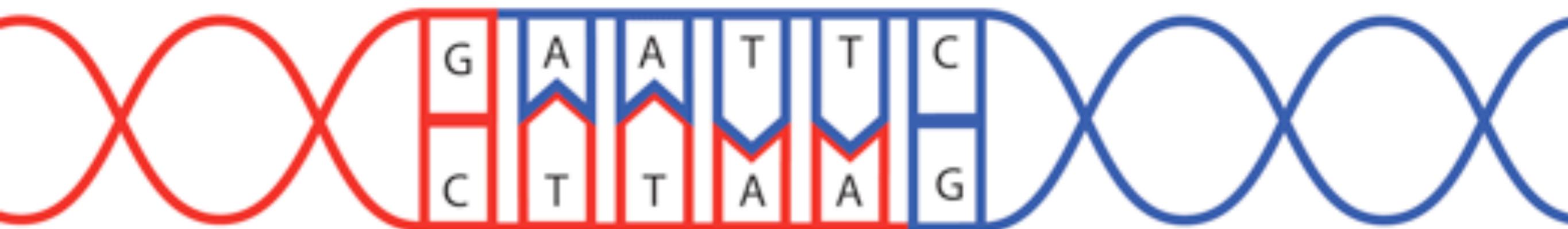


DNA ligase, 1967



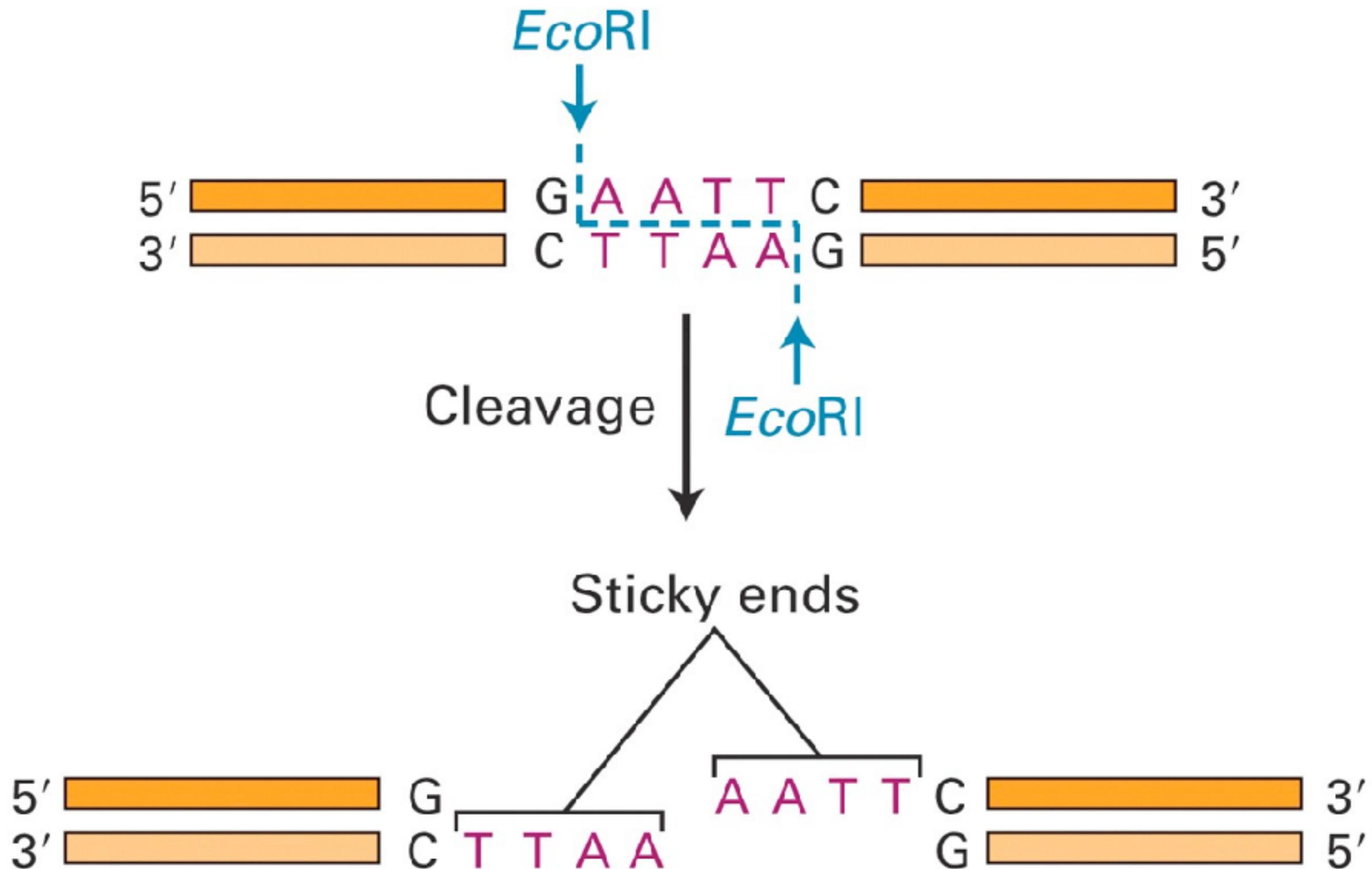
↓ Ligation

Recombinant DNA





Restriction Enzyme 1970





Reading DNA 1977



Courtesy of Dr. F. Sanger, MRC, Cambridge.
Noncommercial, educational use only.

Different-length strands can be lined up by size to determine DNA sequence.

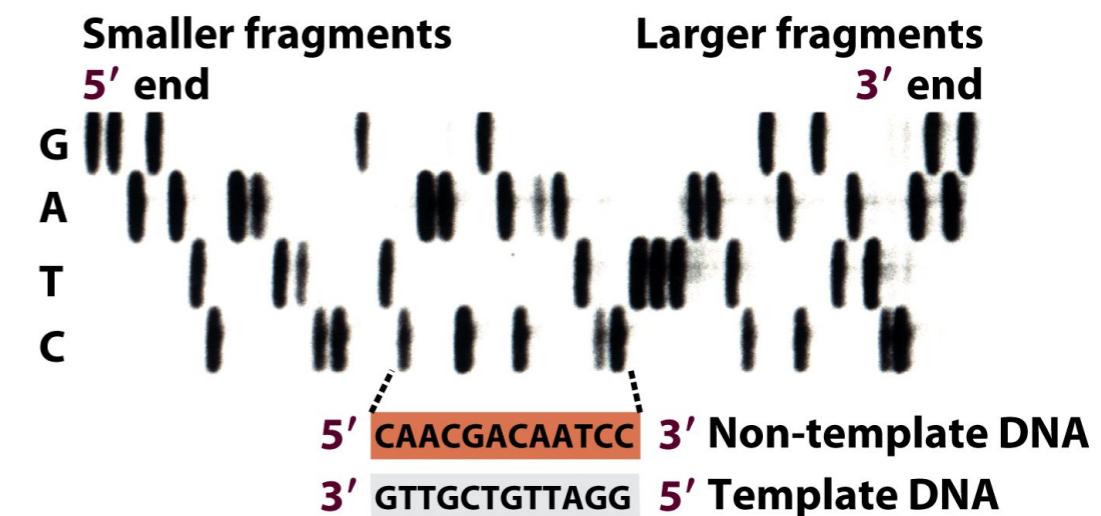
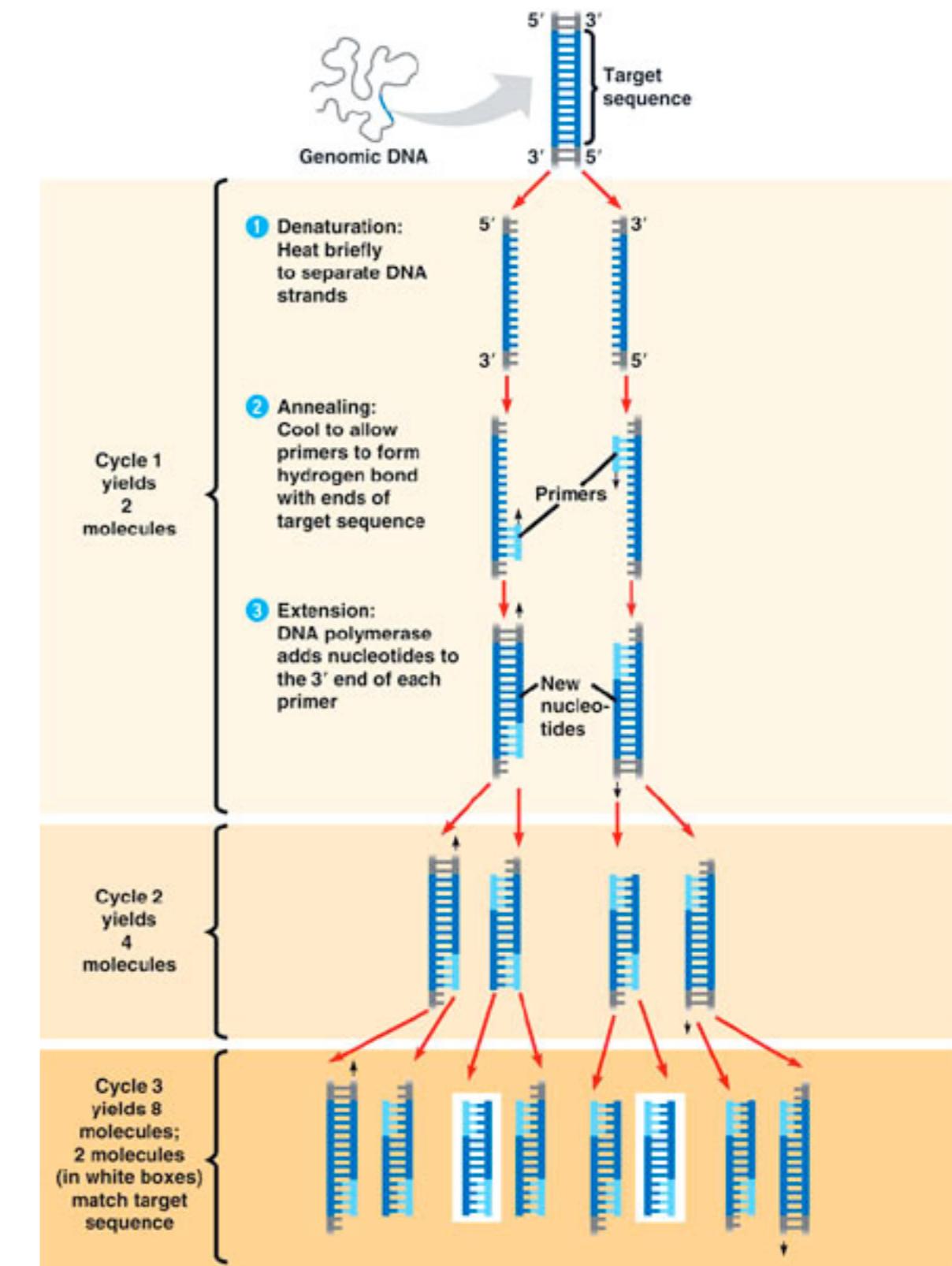


Figure 19-6c Biological Science, 2/e

© 2005 Pearson Prentice Hall, Inc.



Polymerase Chain Reaction, 1983





Reading DNA



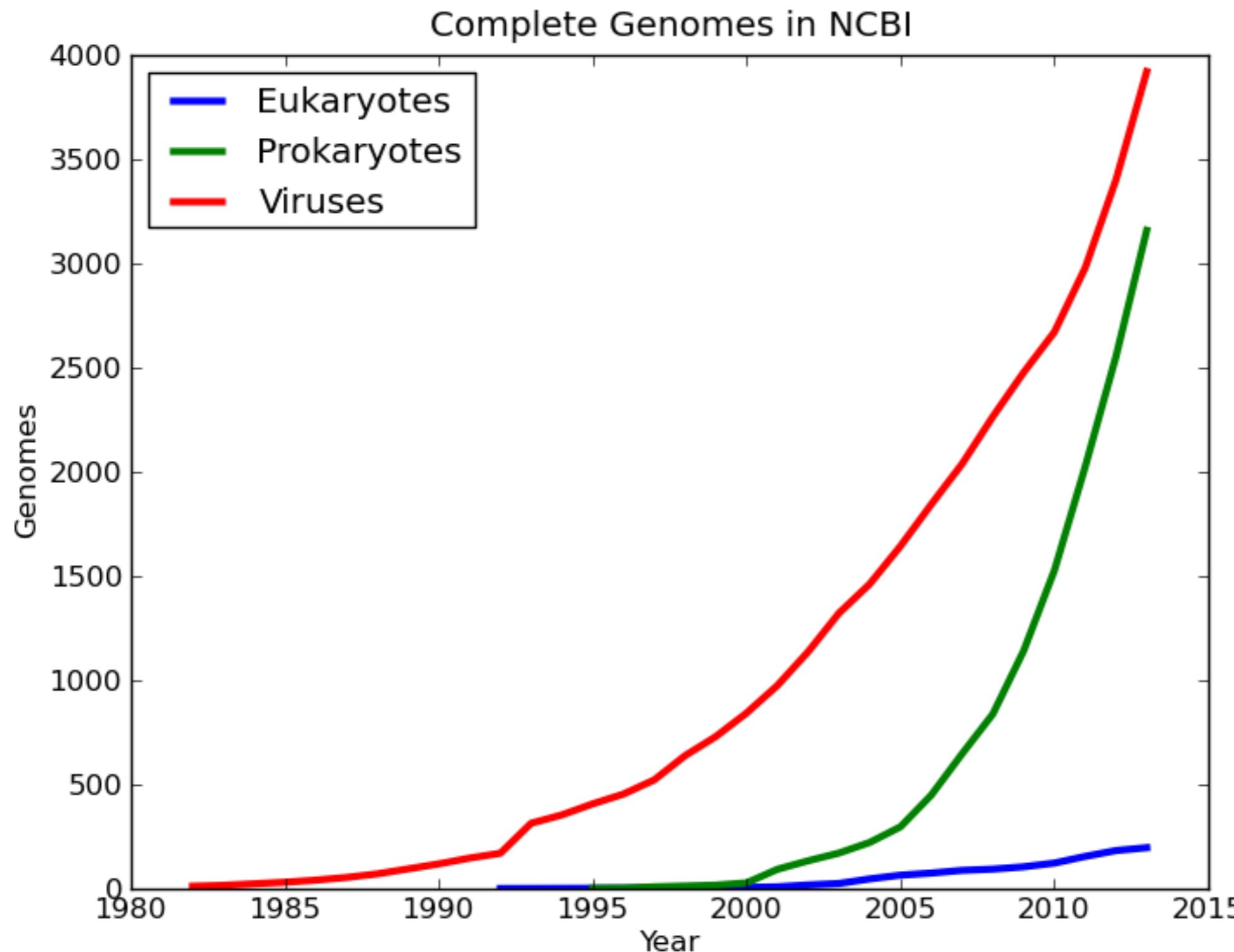


Beijing Genomics Institute





Growth of Genbank

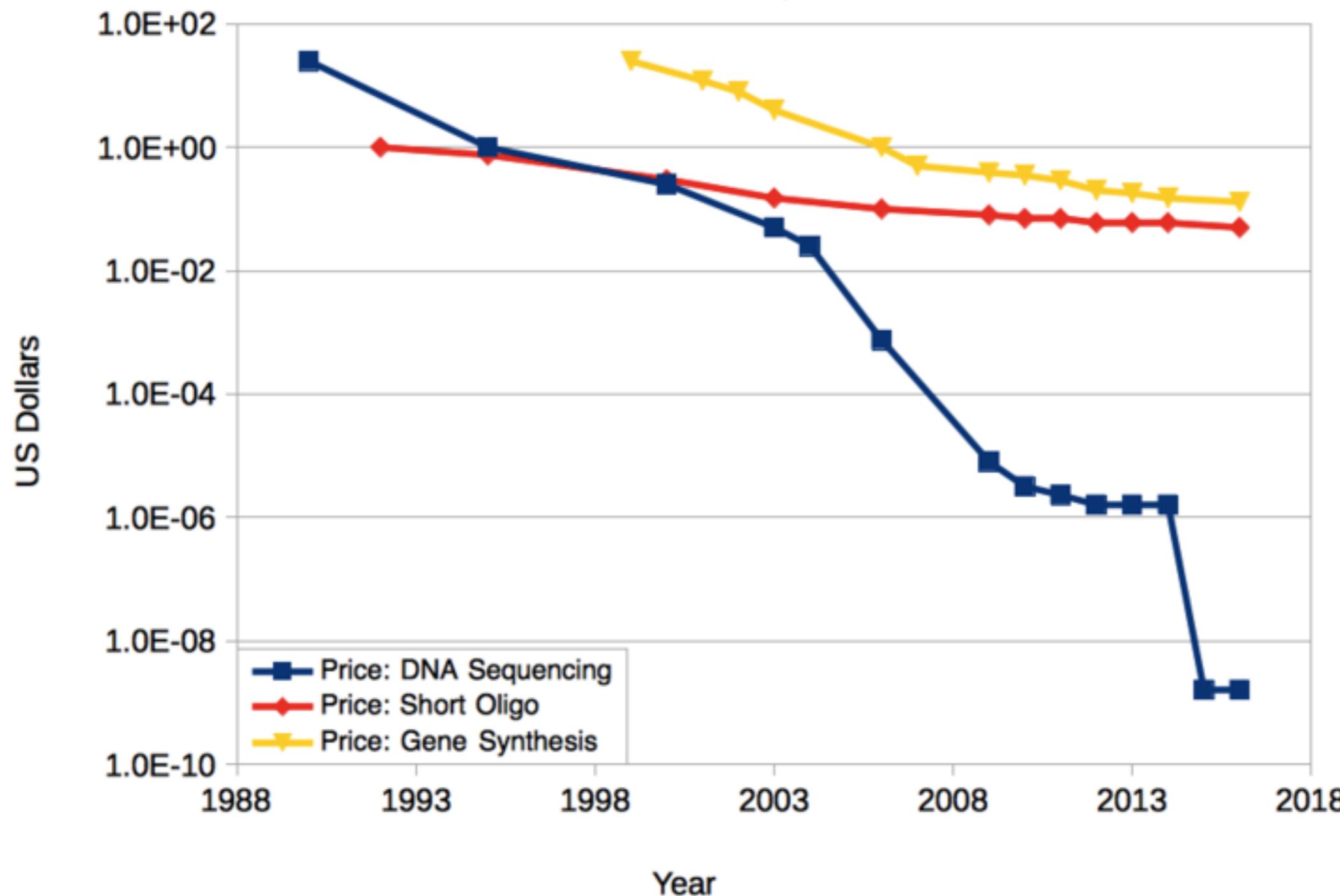




Cost of DNA

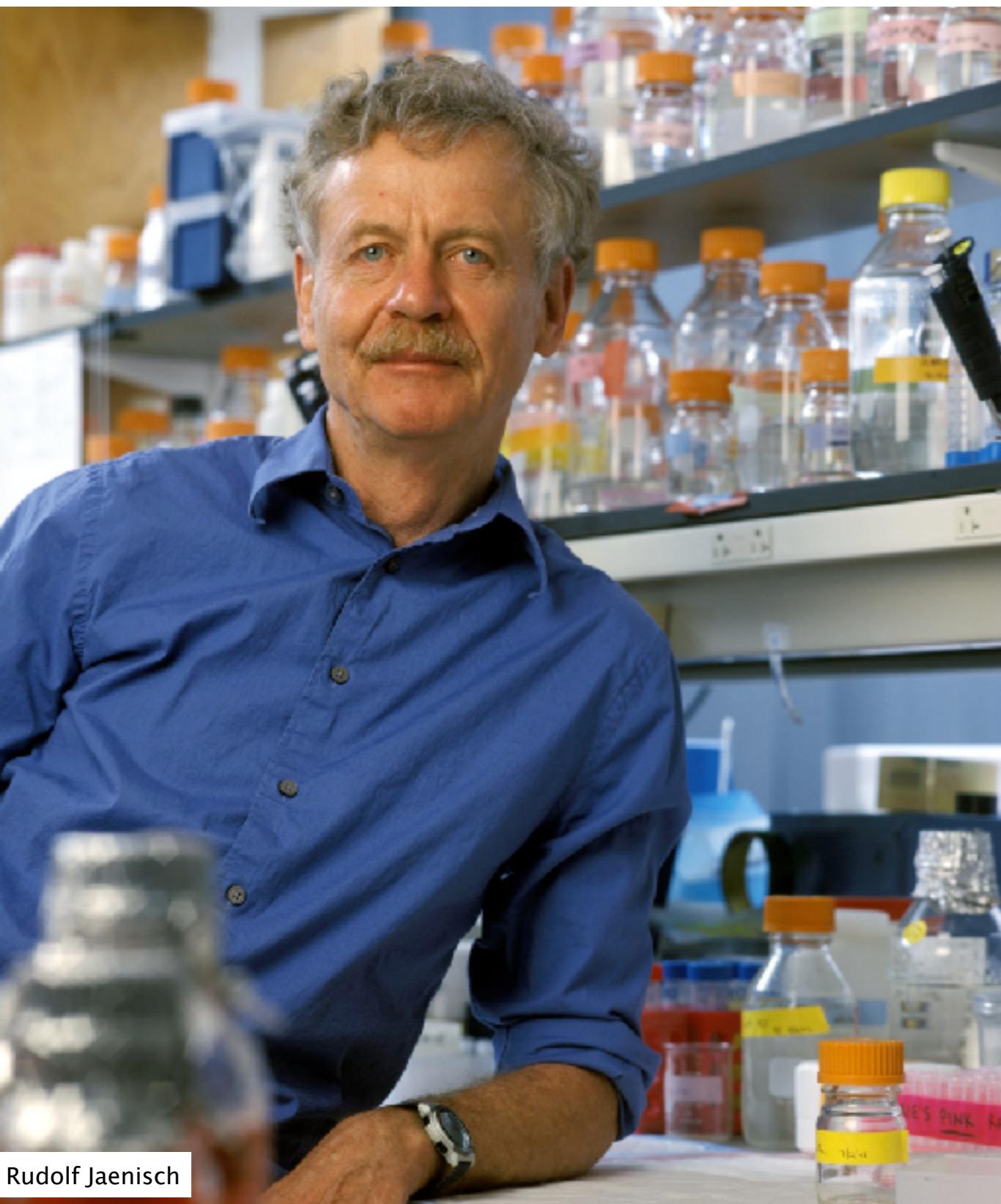
Price Per Base of DNA Sequencing and Synthesis

Rob Carlson, March 2016, www.synthesis.cc

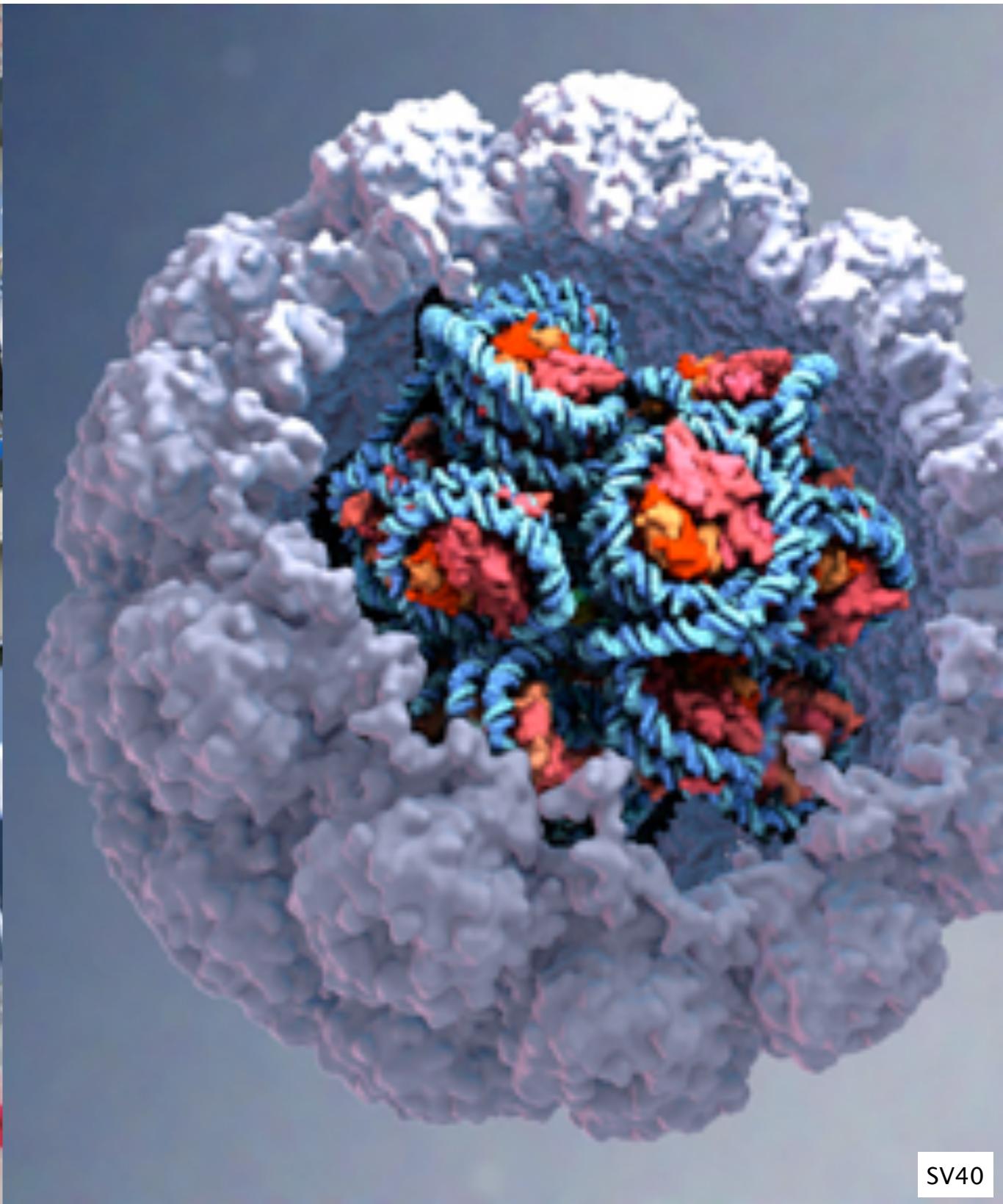




Transgenic Mouse, 1973



Rudolf Jaenisch



SV40



Transgenic Plant, 1983

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Thursday 20 November 2014

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letters to nature

Nature 304, 184 - 187 (14 July 1983); doi:10.1038/304184a0

A chimaeric antibiotic resistance gene as a selectable marker for plant cell transformation

MICHAEL W. BEVAN^{*}, RICHARD B. FLAVELL^{*} & MARY-DELL CHILTON[†]

^{*}Plant Breeding Institute, Maris Lane, Trumpington, Cambridge CB2 2LQ, UK

[†]Department of Biology, Washington University, St Louis, Missouri 63130, USA

The T-DNA region of *Agrobacterium tumefaciens* tumour-inducing plasmids of the nopaline type¹ contains a gene coding for the enzyme nopalinc synthase. This gene is expressed constitutively in host plant cells to which it is transferred during tumour induction². We have exploited the regulatory elements of this gene to construct a chimaeric gene that confers antibiotic resistance on transformed plant cells. The chimaeric gene encodes the expected chimaeric transcripts in plant cells, and confers on transformed cells the ability to grow in the presence of normally lethal levels of the antibiotic G418 (ref. 3). Experiments using *in vitro* transformation techniques on single plant cells indicate that this antibiotic resistance can be used as a selectable marker, and can therefore be used in selecting cells transformed by T-DNA vectors that have had the genes for hormone autotrophy deleted⁴. Plant cells transformed by such 'disarmed' T-DNA vectors can be regenerated into entire plants, whose sexual progeny contain unaltered copies of the inciting T-DNA⁵. The availability of this dominant selectable marker should allow a wider range of experiments to be undertaken using different host plants.

References

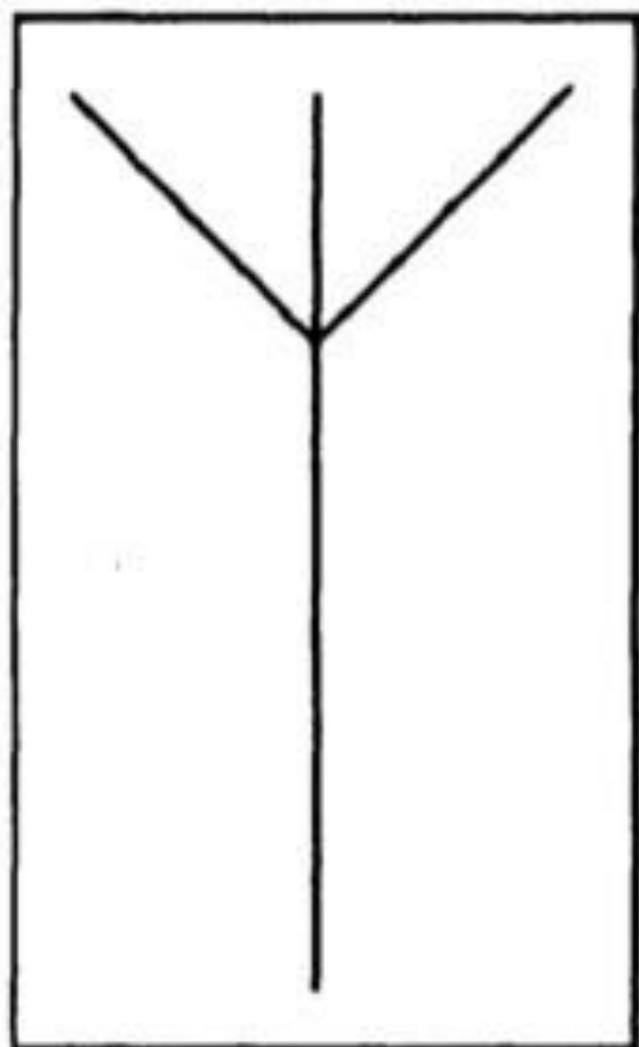


Oncogene mouse, Phil Leder, Tim Stewart 1984





Joe Davis, 1987



10101
01110
00**1**00
00**1**00
00**1**00
00**1**00
00**1**00



CCCCCCCAACGCGCGCCT

FIG. 1 *Microvenus* icon.



Bull Herman, Leiden 1990





Life finds a way, Jurassic Park 1993





Dolly the Sheep, Edinburgh 1996





Eduardo Kac – GFP Bunny, 2000





Science turned into technology

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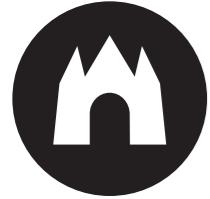
4 "AA" Batteries Required

Computer Not Included

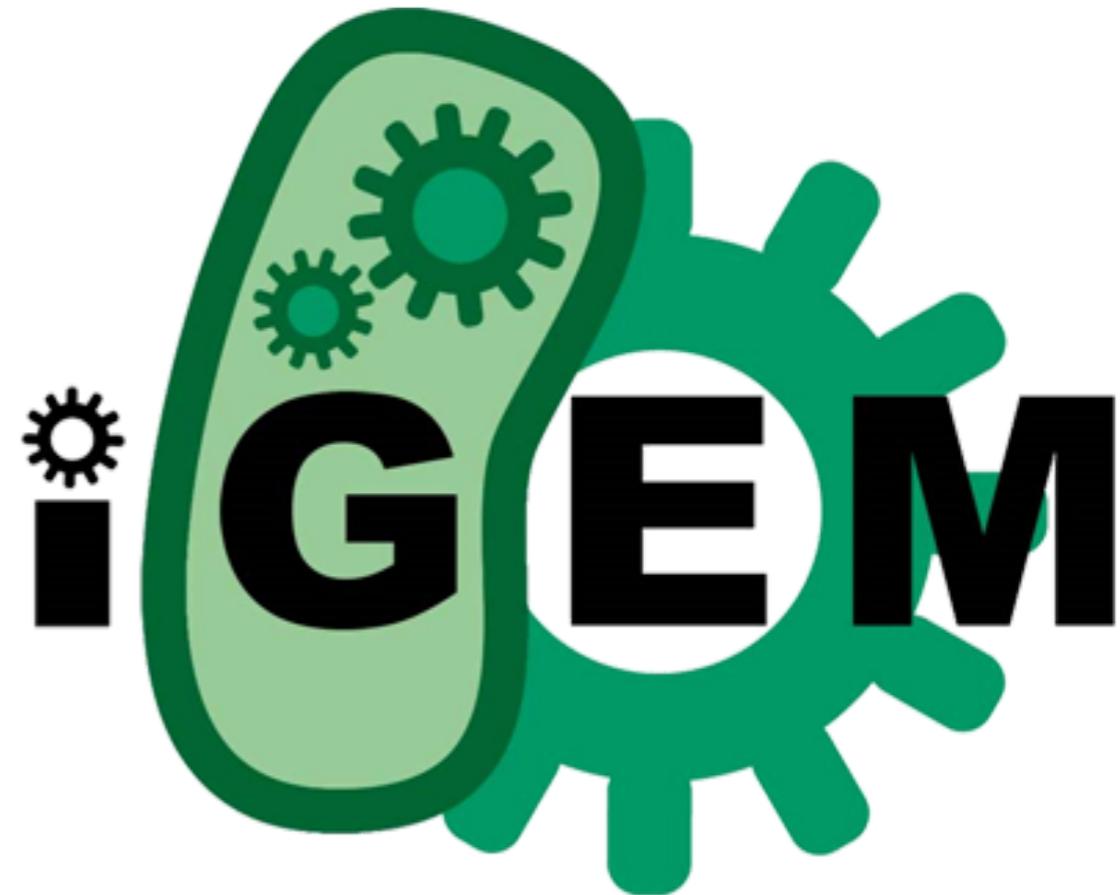
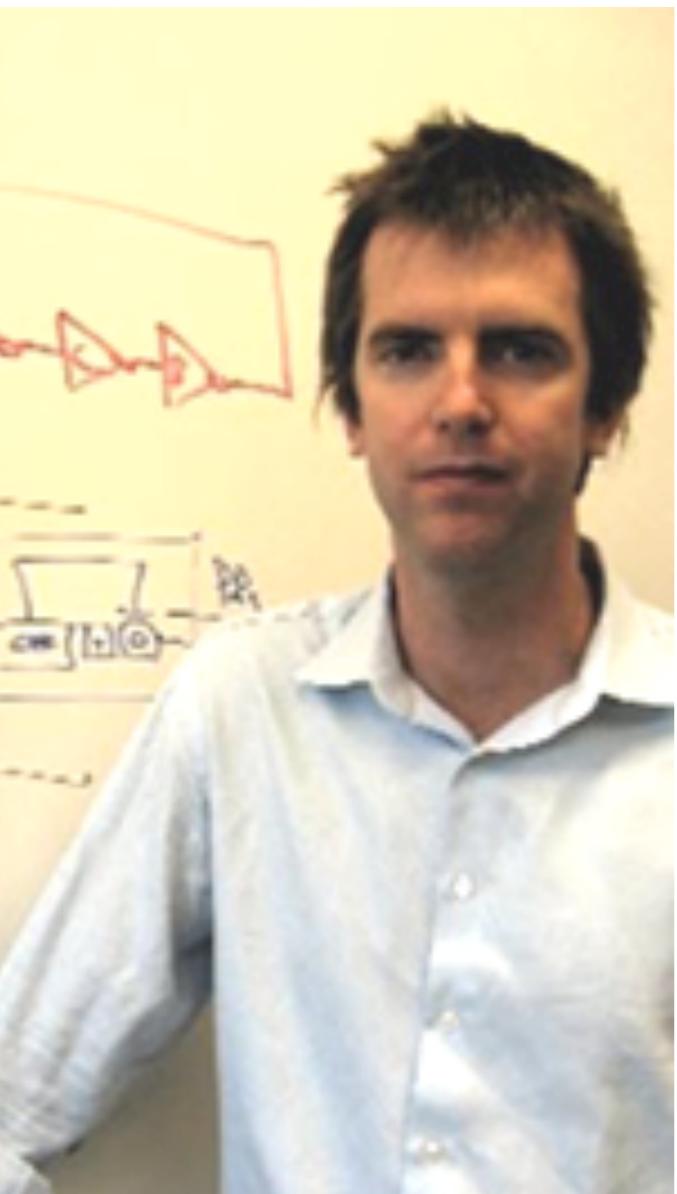
SNAP CIRCUITS

Have fun learning all about electronics

The image shows a detailed view of the Extreme Snap Circuits kit. The base plate is populated with various electronic components such as resistors, capacitors, and transistors, all interconnected by blue snap wires. A digital multimeter is prominently featured, connected to the circuit. A solar panel and a battery pack are also part of the setup. In the bottom right corner, a young boy is shown sitting at a desk with a computer monitor displaying a circuit diagram, illustrating how the kit can be used with a computer. The overall theme is hands-on learning and experimentation in the field of electronics.

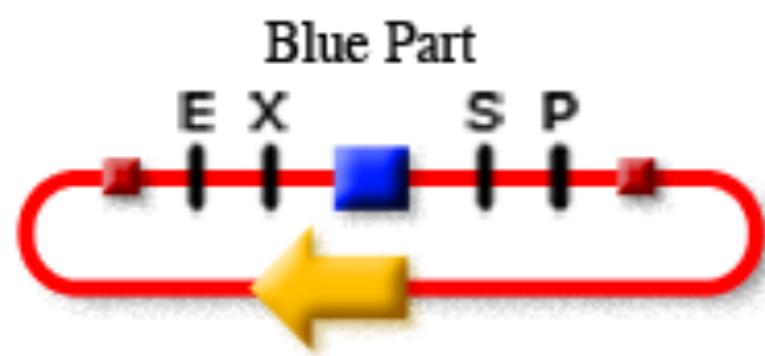


Drew Andy, Tom Knight

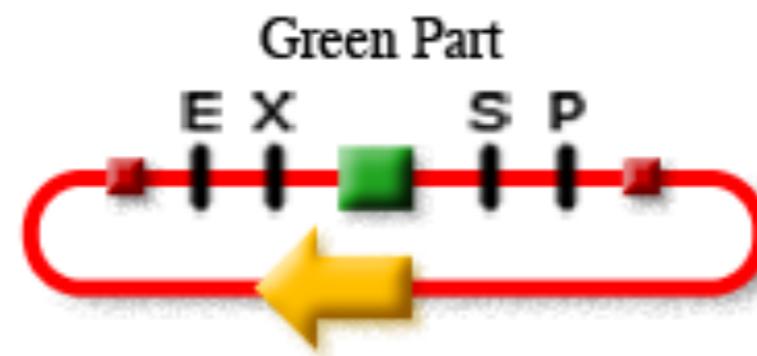
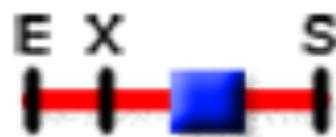




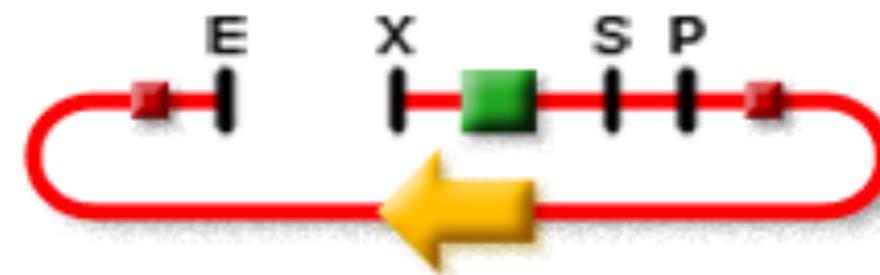
Biobrick standard 2003



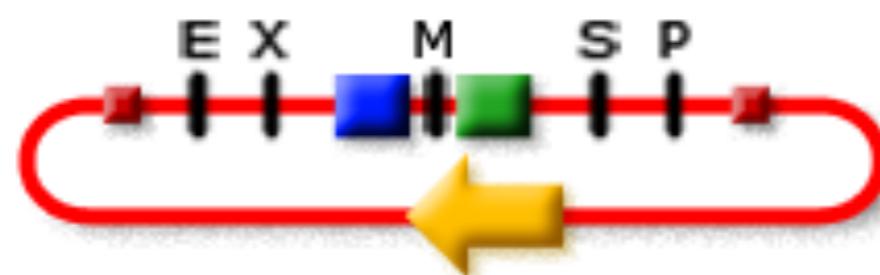
Cut with
EcoRI and SpeI



Cut with
EcoRI and XbaI

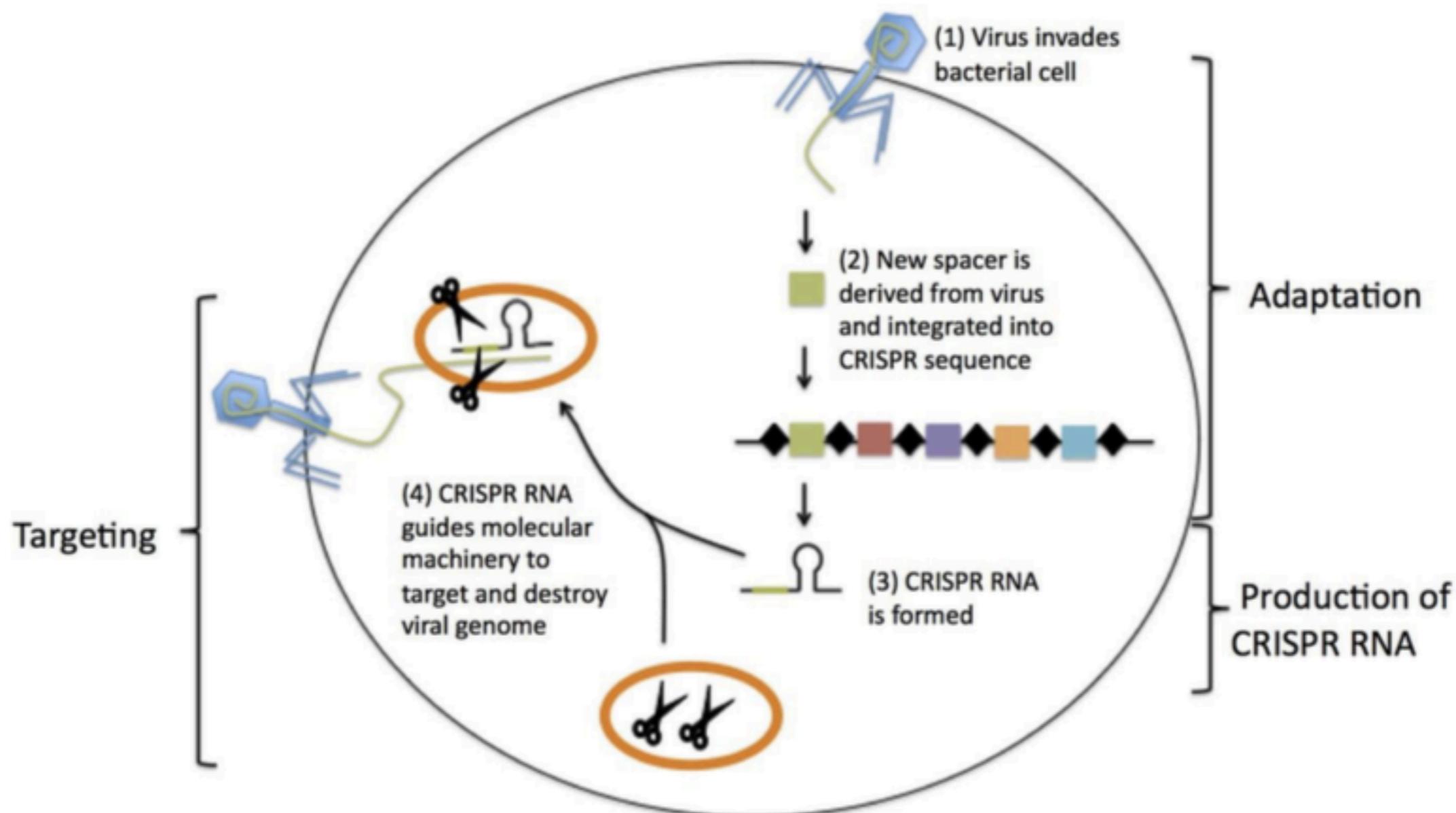


Mix and Ligate
(Blue-Green Part)





CRISPR – Cas9

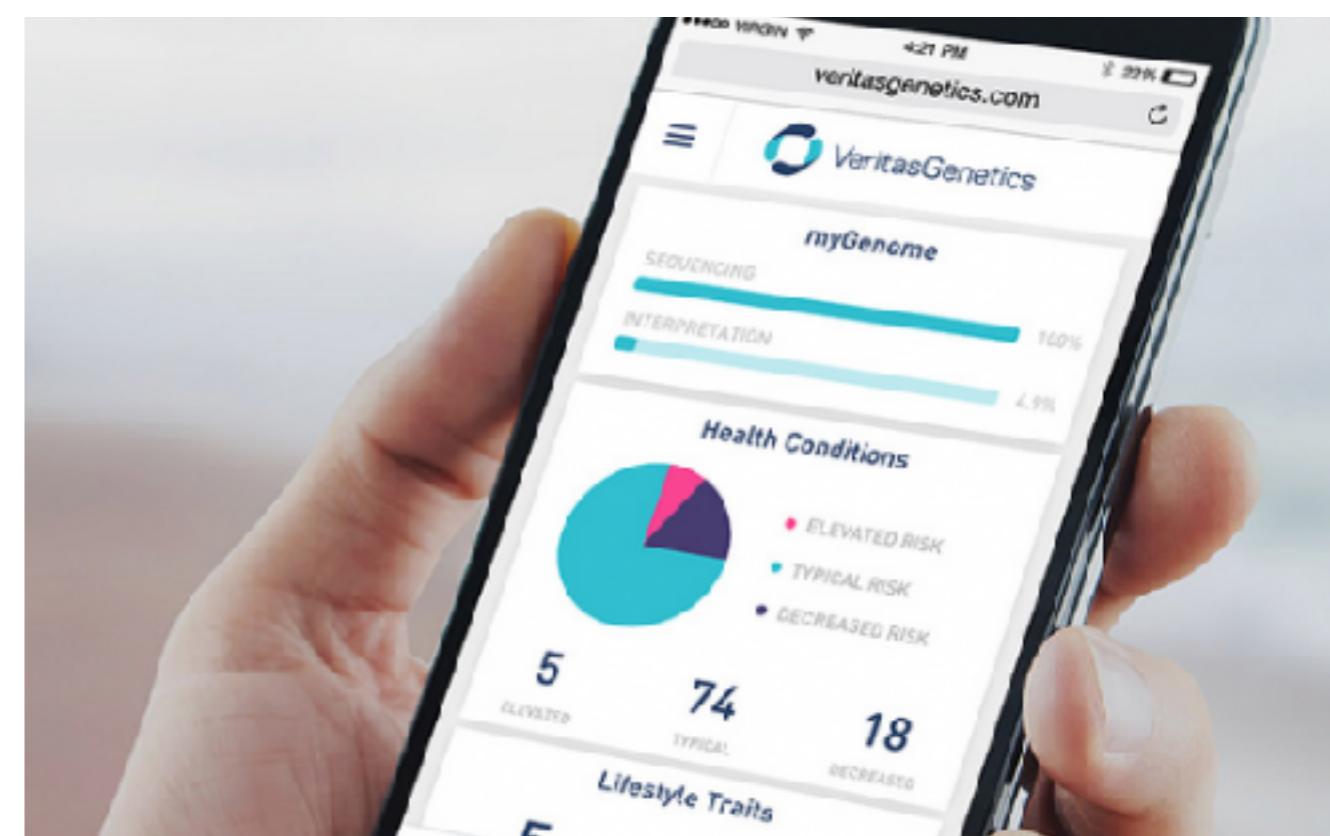




Labs as a service



Personal
Genome
Project





Center for Postnatural History – Rich Pell





Conclusions

- Biology:
 - No longer framed by the possible
 - Transformed from observation to engineering
 - Changing:
 - Value chains
 - Business models
 - Design process



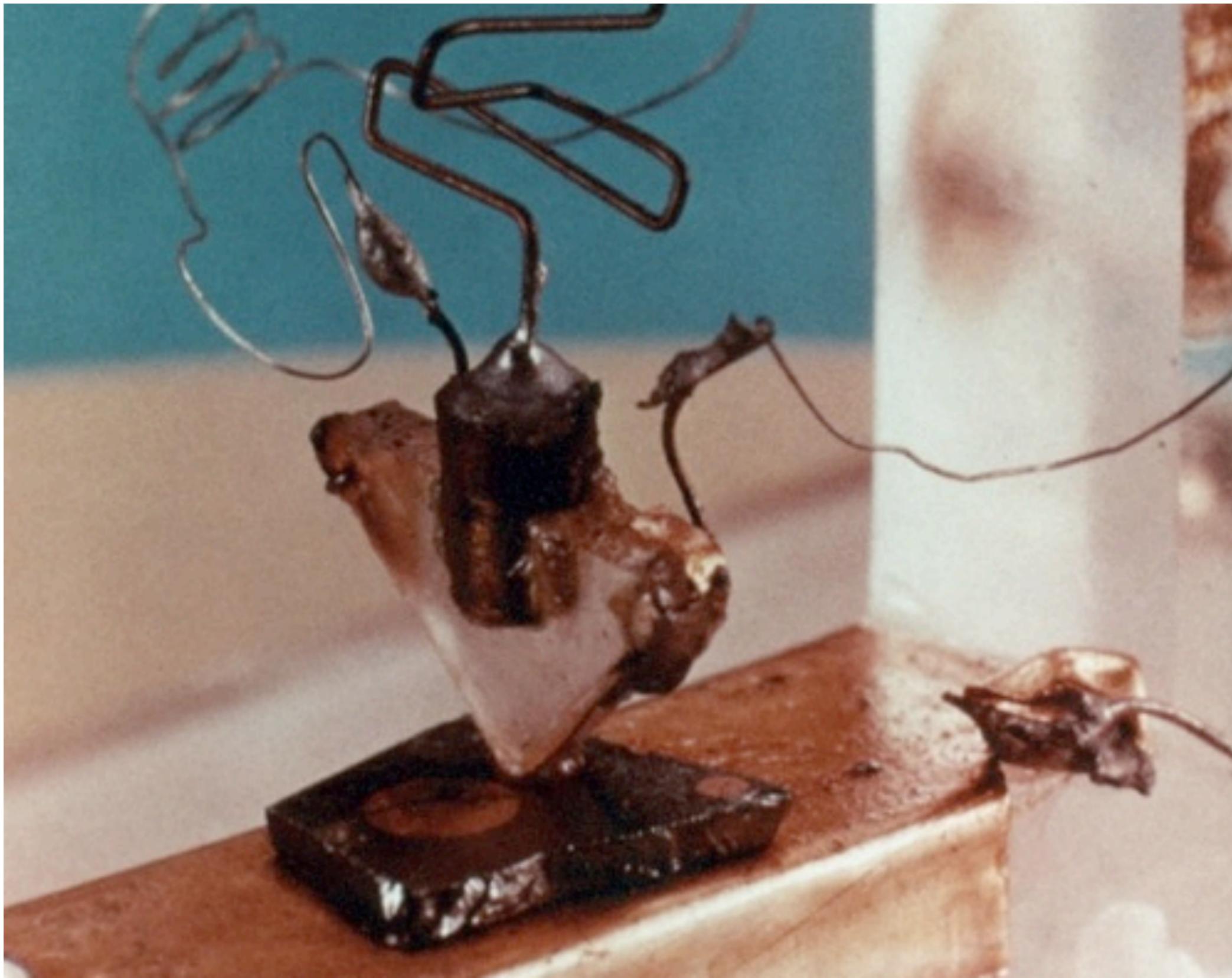
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Biology & hacking

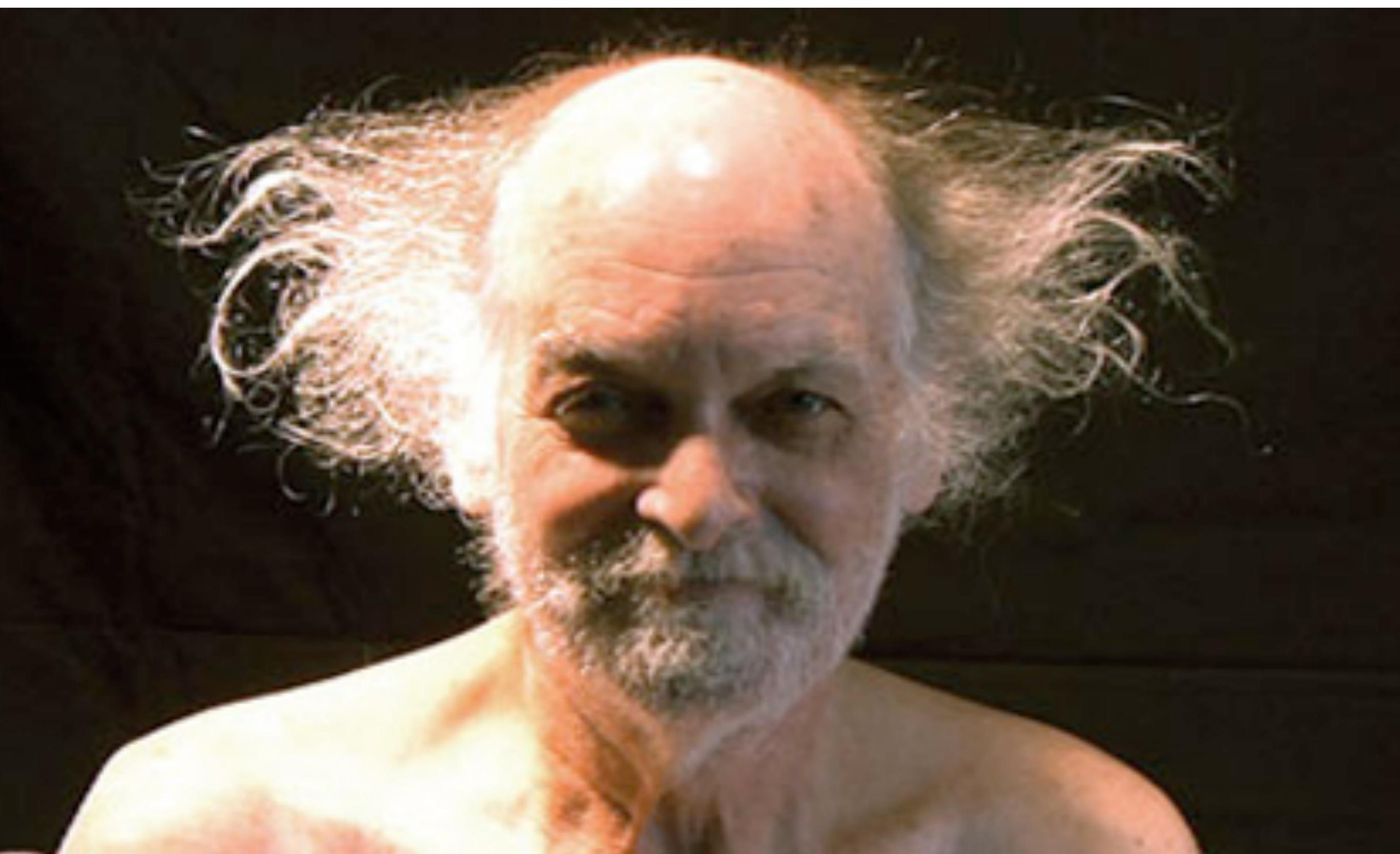


Inspiration & justification





Joe Davis





Critical Art Ensemble – Free Range Grain 2003



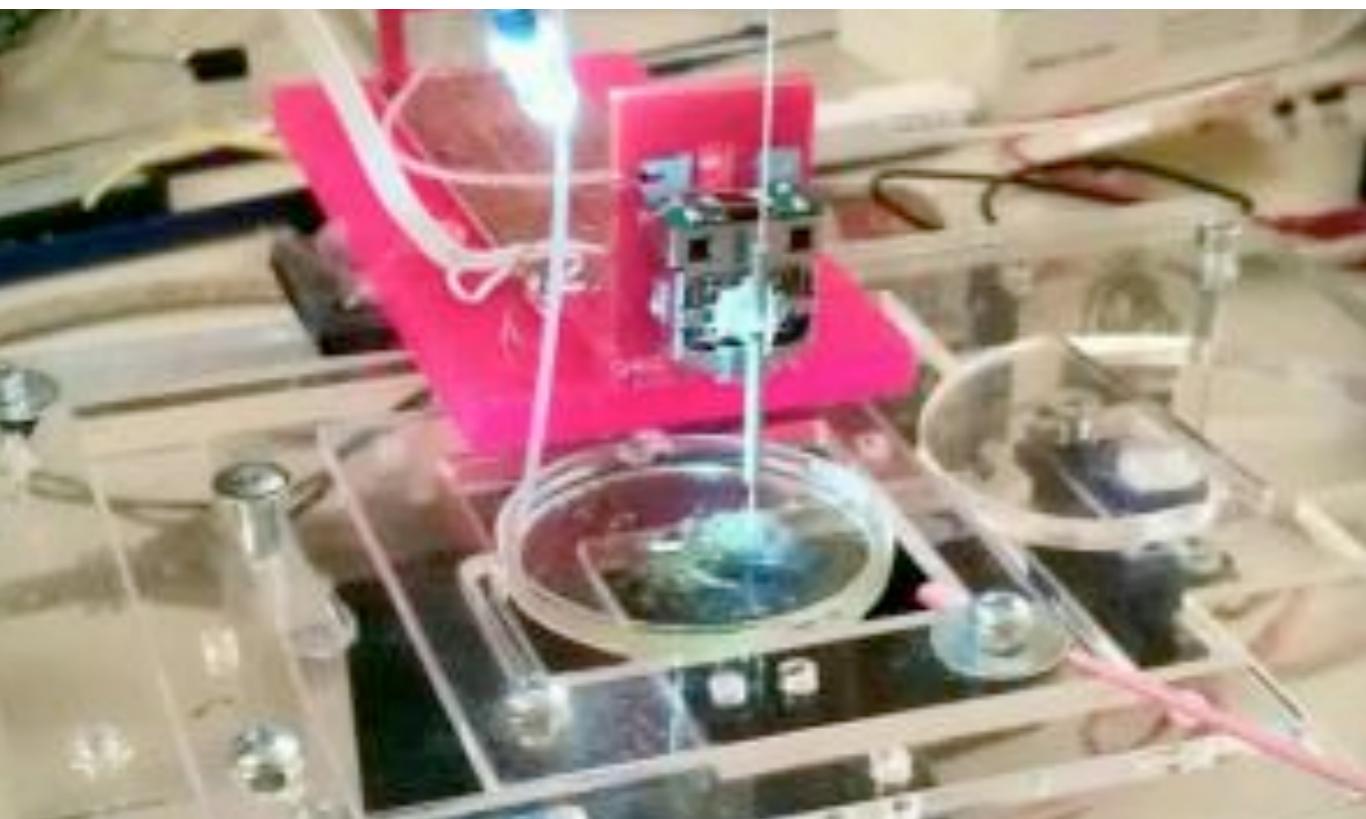


DIYBio 2008

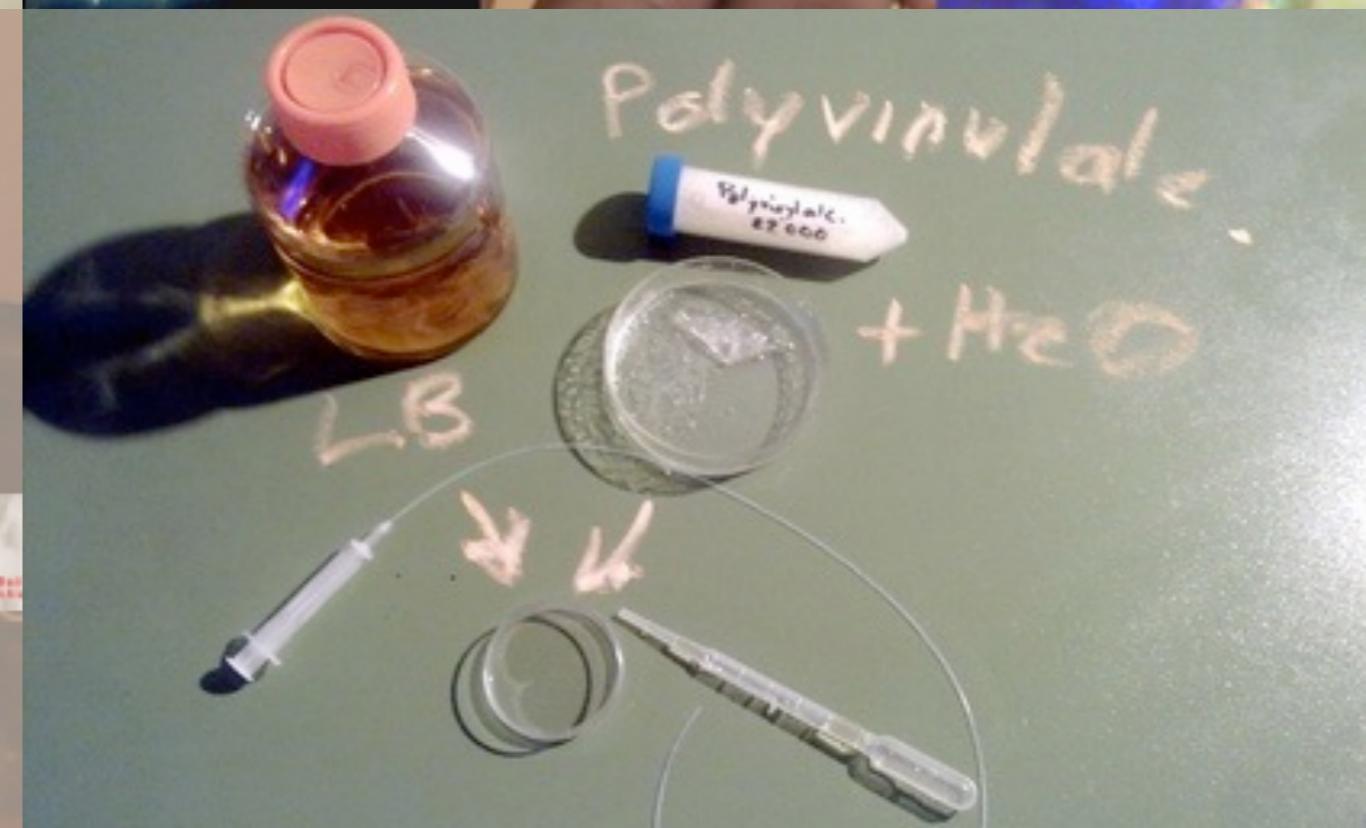




Hackteria, 2009



Biology|LifeSciences|Biotechnology





Paul Vanouse 2009





Kay Aull



Ellen Jorgensen - Genspace 2010





Meredith Patterson

Biopunk Manifesto 2011

“we assert that the right of freedom of inquiry, to do research and pursue understanding under one's own direction, is as fundamental a right as that of free speech or freedom of religion”



Cathal Garvey, Ireland 2012

Doing Biotech in My Bedroom

A new generation of biologists embraces the do-it-yourself ethic of computer programming.

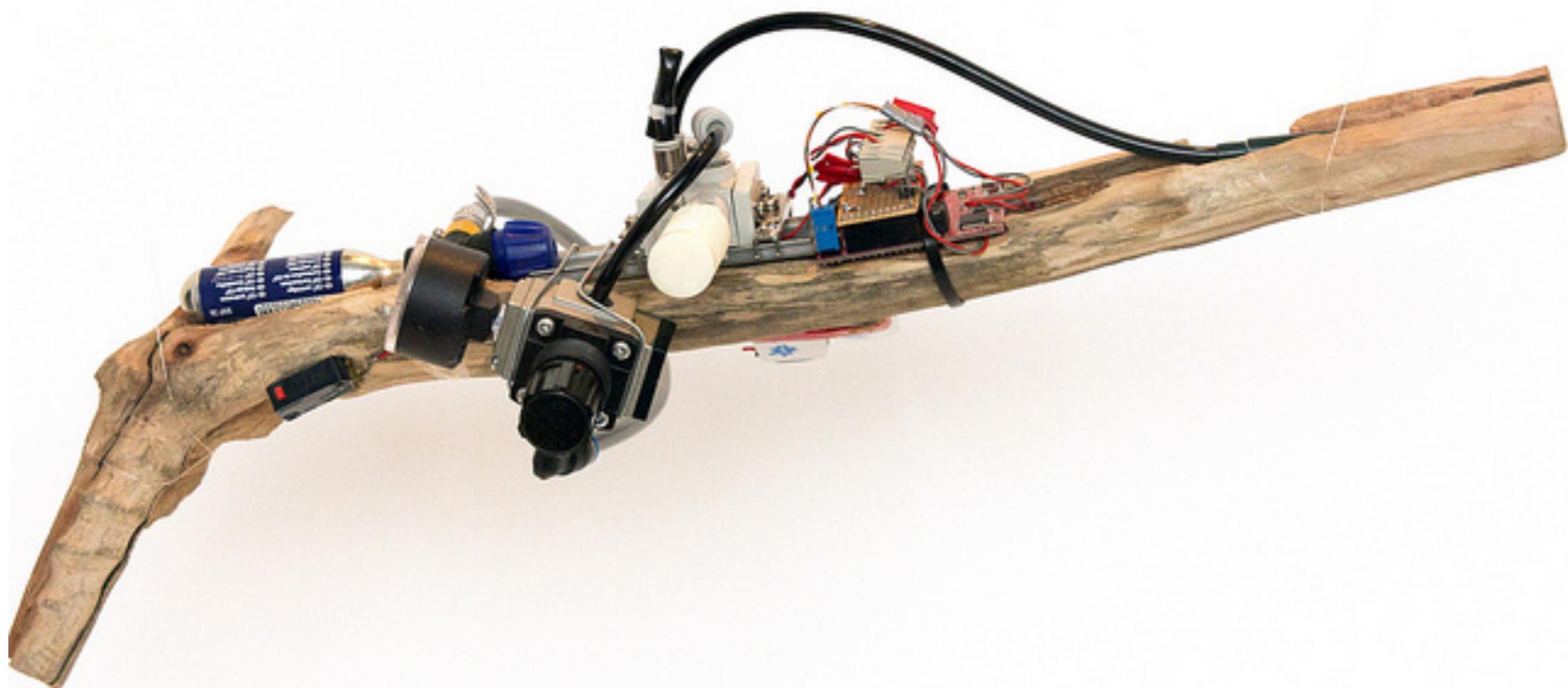
By Antonio Regalado on February 14, 2012

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DIY GeneGun 2012





Labs everywhere - diybio.org/local

EUROPE

Amsterdam	NL	http://www.meetup.com/Dutch-DIY-Bio/
Barcelona	ES	http://www.diybcn.org/
Berlin	DE	https://www.biotinkering-berlin.de/
Brussels	BE	http://www.openbiolab.be/
Budapest	HU	http://biodisplay.tyrell.hu/
Cambridge	UK	https://biomake.space/
Copenhagen	DK	http://biologigaragen.org/
Cork	IE	https://groups.google.com/forum/#!forum/diybio-ireland
Eindhoven	NL	http://bloartlab.com/
Geneva	CH	http://bioscope.ch/
Ghent	BE	http://reagentlab.org/
Graz	AT	https://www.facebook.com/OpenBioLabGraz
Groningen	NL	http://www.diybingroningen.org
Heidelberg	DE	http://www.biocap-heidelberg.de
Kiev	UA	https://groups.google.com/forum/#!forum/dlyblo-kiev
Lausanne	CH	http://www.eprouvette.ch
Lausanne/Renens	CH	http://wiki.hackuarium.ch/w/Main_Page
London	UK	https://london.hackspace.org/
London	UK	https://london.hackspace.org.uk/
London	UK	http://www.meetup.com/BioChanges/
Manchester	UK	http://dlyblo.medlab.org.uk/
Maribor	SI	http://irnas.eu/symbiolab.html
Moscow	RU	http://vk.com/biohax
Munich	DE	http://biogarage.de/
Namur	BE	http://www.diybio.be/
Nottingham	UK	http://opengenx.wordpress.com/
Paris	FR	http://www.lapallasse.org/
Prague	CZ	http://brmlab.cz/project/biolab
Stockholm	SE	http://www.bionyhken.se/
Switzerland / Slovenia	CH	http://hackteria.org/
Trento	IT	http://www.openwetlab.org/
Turin	IT	http://www.facebook.com/be.into.7



reagentlab.org - DIY bioreactor





Open Biolab Graz – BSL1



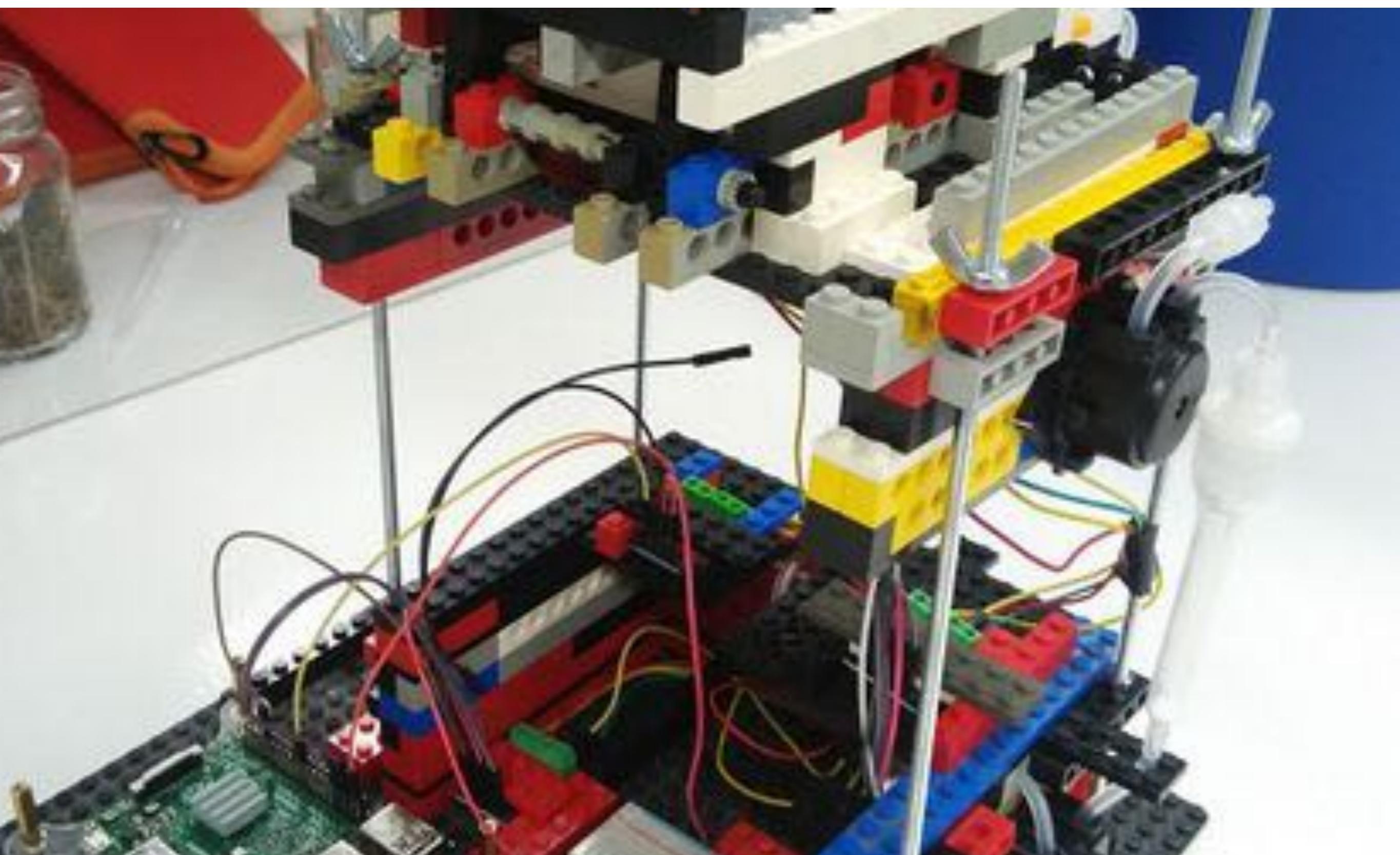


BeerDeCoded - Hackuarium



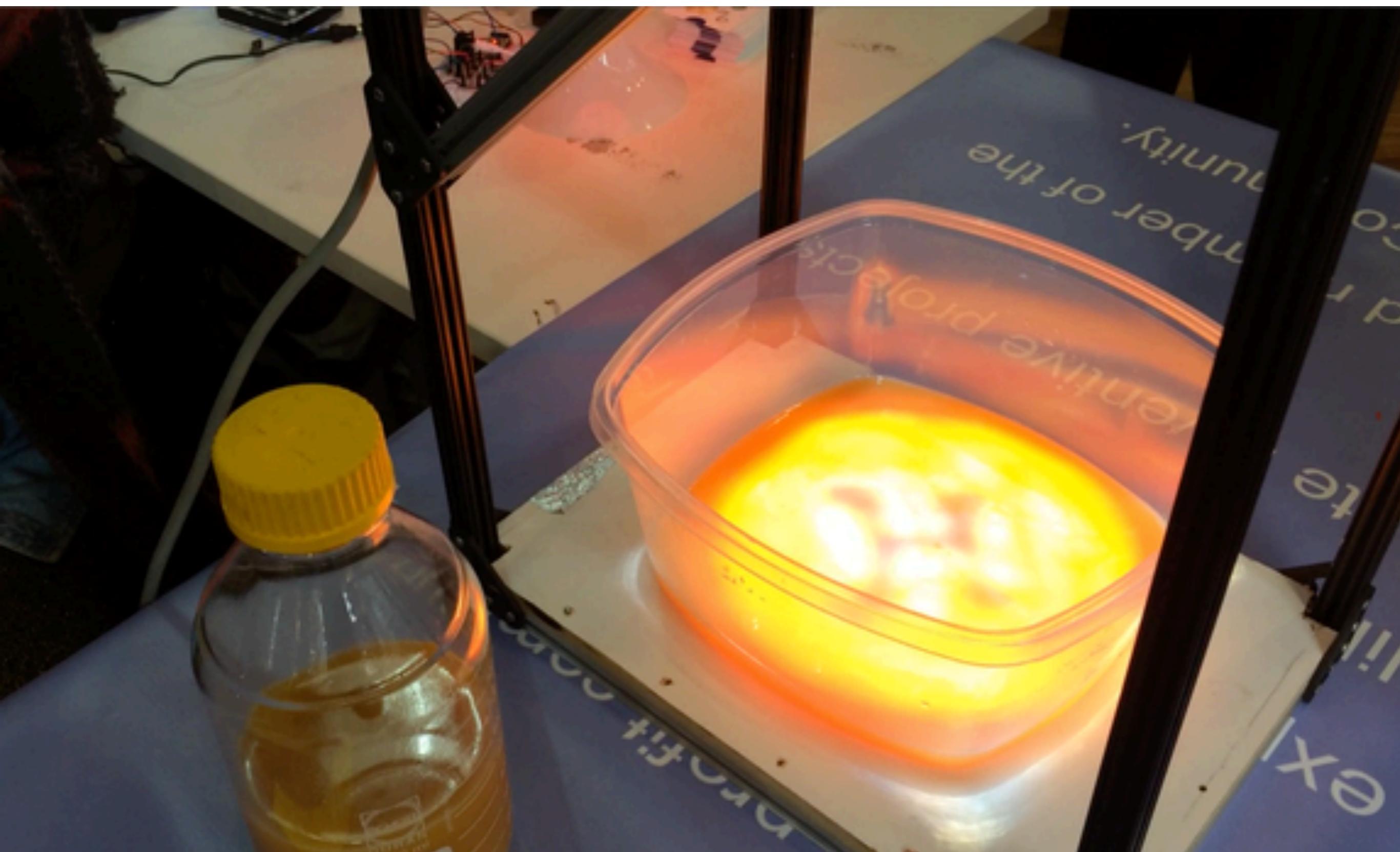


Protein purification - Hackuarium



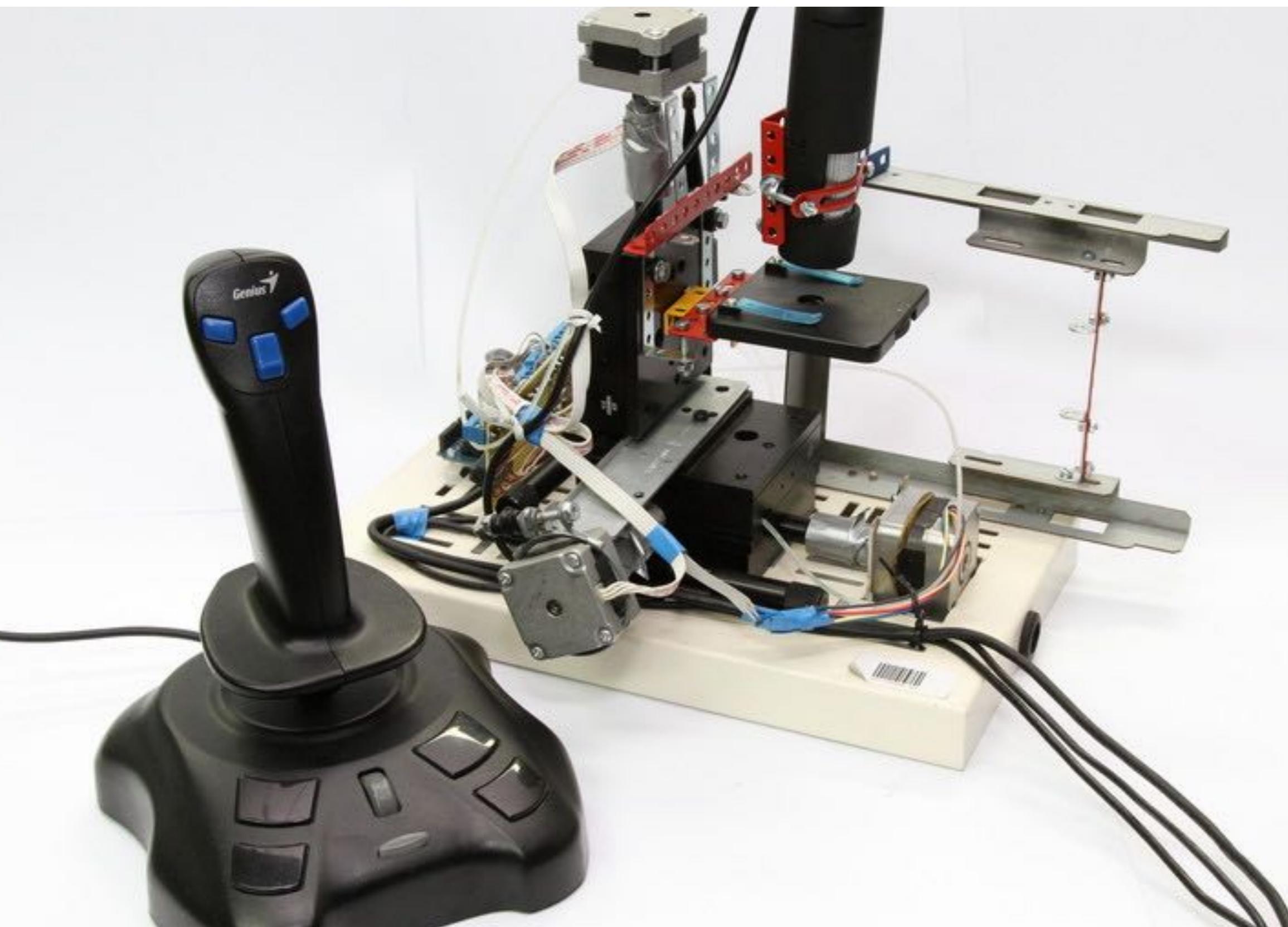


Juicyprint - London Biohack Space





BRMScope – BRMLab





NFC implants - Bionyfiken





Duckweed - Hackteria





Apple Ears – Andrew Telling





Ontology

- Biohacking / DIYBio is a mix of:
 - 1960 Do It Yourself culture
 - 1980 Open Source movement (software)
 - 1995 Internet powered Citizen science
 - 2003 Synthetic biology
 - 2007 Open Hardware



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Online communities

Biohack spaces as
distributed knowledge hubs



Networks

- hackteria.org
kitchen mailing list:
 - <http://lists.hackteria.org/cgi-bin/mailman/listinfo>
- diybio.org
International mailing list:
 - <https://groups.google.com/d/forum/diybio>
- Facebook
 - <https://www.facebook.com/groups/diybio/>
 - “Biohacking and Genetic Design Network”
 - <https://www.facebook.com/groups/769326966539324/>



Events

- Announced on the mailing lists
 - Hackteria Lab
 - CCC Hamburg
 - Pixelache Helsinki
 - OuiShare





Events

- Global Community Biosummit (biosummit.org)





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Market & non-market rationales

“Do it without”: pharma, agrotech

vs

Bio innovation



OpenPCR 2010

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OpenPCR - open source biotech on your desktop

by <http://OpenPCR.org> -- Tito and Josh

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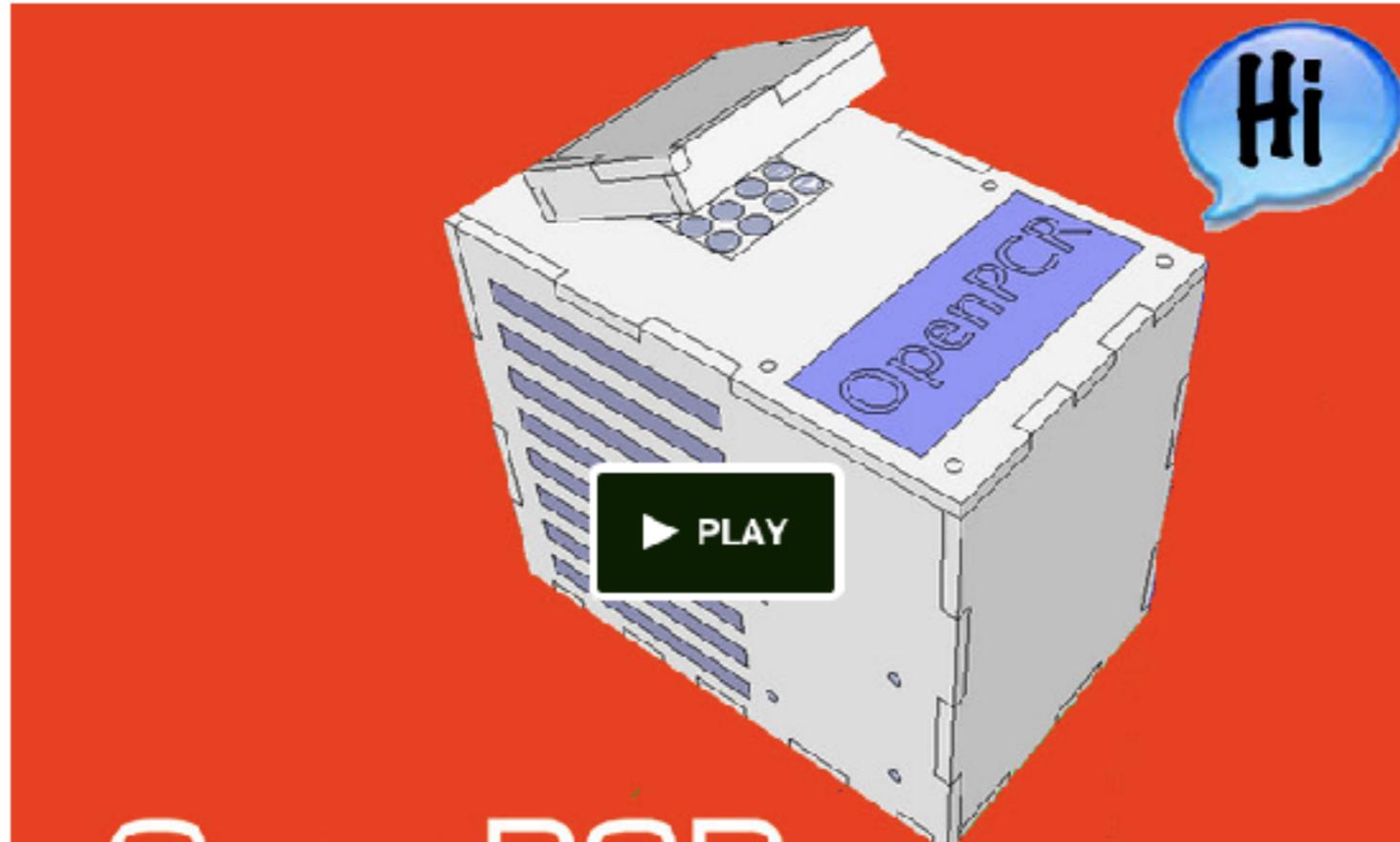
Backers 158

Comments 22

San Francisco, CA

Hardware

Funded! This project was successfully funded on July 23, 2010.



158

Backers

\$12,121
pledged of \$6,000 goal

0

seconds to go

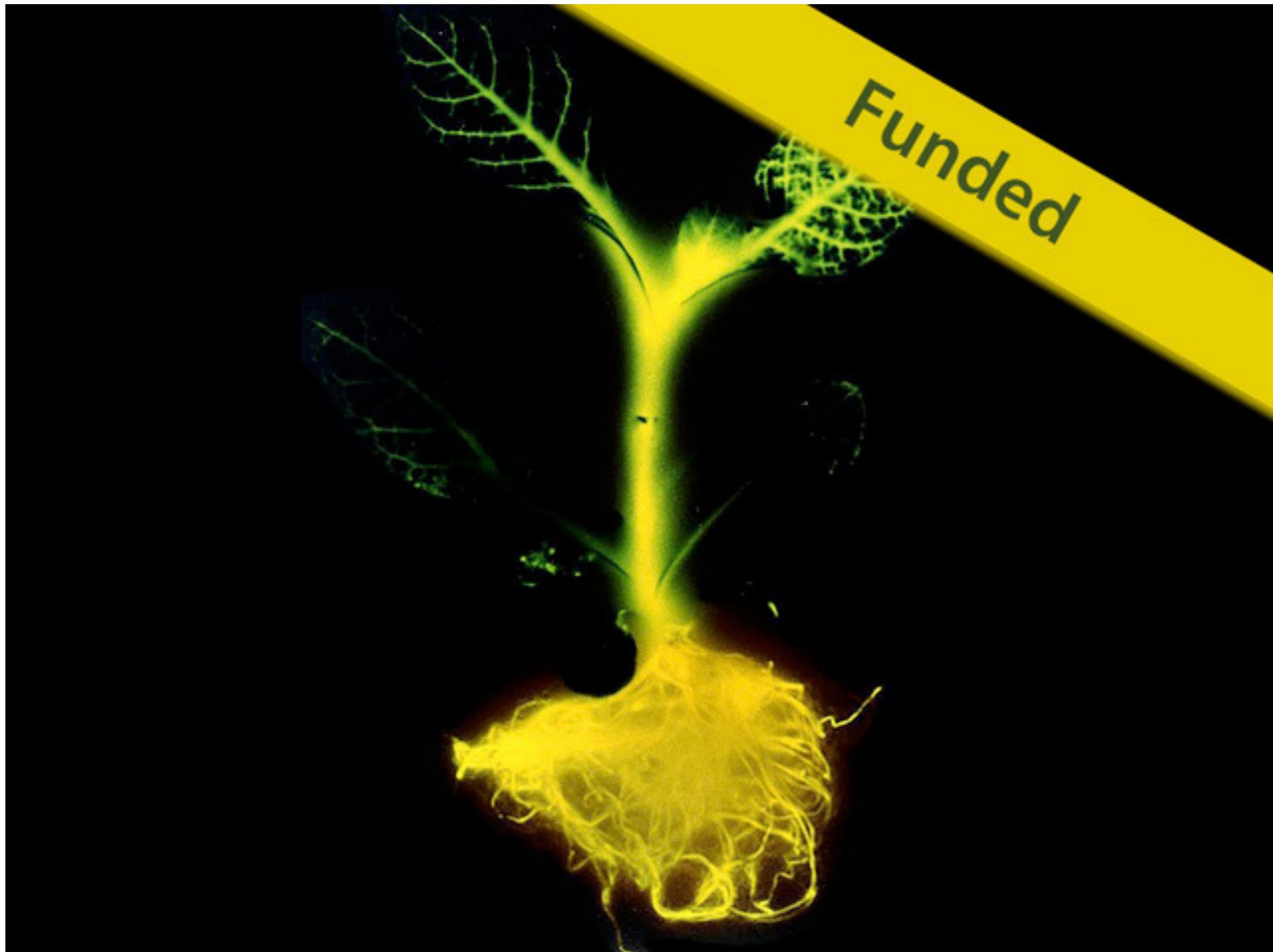


Project by

<http://OpenPCR.org> --
Tito and Josh
San Francisco, CA



Glowing Plant 2013





Indie Bio



INDIE BIO

San Francisco CA, USA



RebelBio

Cork, Ireland



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Super powers

What are the big players up to?



CRISPR edited embryos (2015)

nature International weekly journal of science

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News & Comment > News > 2017 > January > Article

NATURE | NEWS

Chinese scientists genetically modify human embryos

Rumours of germline modification prove true — and look set to reignite an ethical debate.

David Cyranoski & Sara Reardon

22 April 2015

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Moonshot!

Big science has a buzzword problem

Moonshots, road maps, frameworks and more are proliferating, but few can agree on what these names even mean.

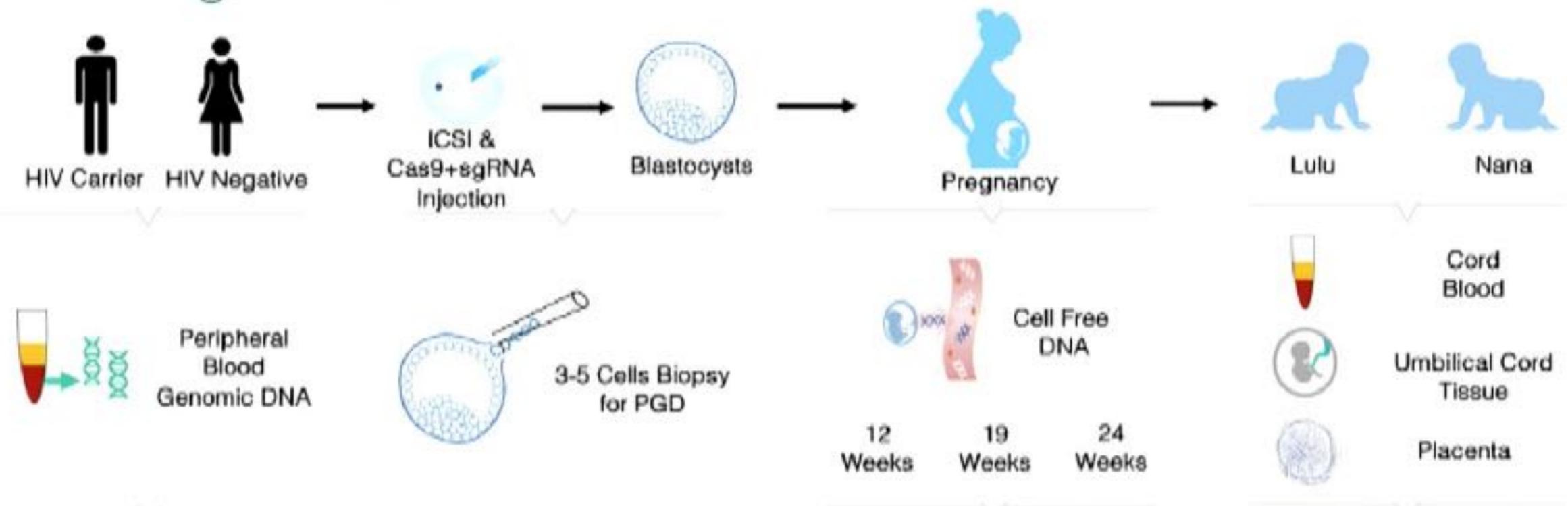
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Nature | 30 January 2017
2. Meet the scientists affected by Trump's immigration ban
Nature | 29 January 2017
3. Trump agenda threatens US legacy of science diplomacy
Nature | 27 January 2017



CRISPR edited humans (2018)

Overview of genomic data



Sanger Sequencing

30X WGS

Sanger Sequencing

30X WGS

MiSeq Targeted Sequencing

609 Cancer Genes
Ultra Deep Sequencing (40,000X)

Sanger Sequencing

MiSeq Targeted Sequencing

100X WGS

Parental Genomes Enable Calling *De Novo* Indels, Haplotype to Increase Sensitivity, and Personalized Off Target Hotspot Risk Pool

Screen for Whole Genome On-Target and Off-Target Activity + Large Deletions

Assess Off-Target Activity, Oncogene Status, CCR5 Editing

Assess Effects of Editing Across Sample Types



Curing cancer with viruses

nature International weekly journal of science

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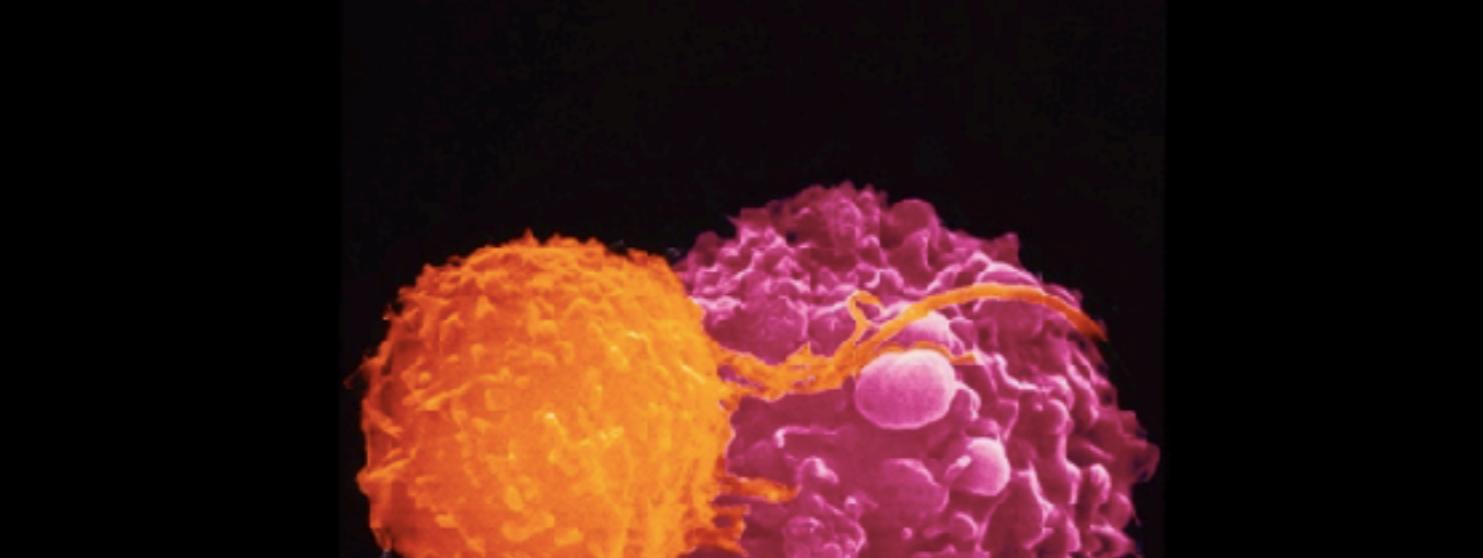
Cancer-fighting viruses win approval

US regulators clear a viral melanoma therapy, paving the way for a promising field with a chequered past.

Heidi Ledford

28 October 2015

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Moonshot!



Big science has a buzzword problem

Moonshots, road maps, frameworks and more are proliferating, but few can agree on what these names even mean.

f

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Nature | 30 January 2017
2. Meet the scientists affected by Trump's immigration ban
Nature | 29 January 2017
3. Trump agenda threatens US legacy of science diplomacy



Gene drive mosquito eradication

**MIT
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Biomedicine

Bill Gates Doubles His Bet on Wiping Out Mosquitoes with Gene Editing

But the technology for extinguishing species is dividing conservationists.

by Antonio Regalado September 6, 2016



Neurogenerative stem cell therapy

Experimental stem cell therapy helps paralyzed man regain use of arms and hands

The 21-year-old who suffered a cervical spine injury in March gains significant improvement in his motor function at Keck Hospital of USC

September 8, 2016





Changing photosynthesis

Rewriting Life

Gene engineers make super-size plants that are 40% larger

Researchers hope to create a new “green revolution” by improving photosynthesis.

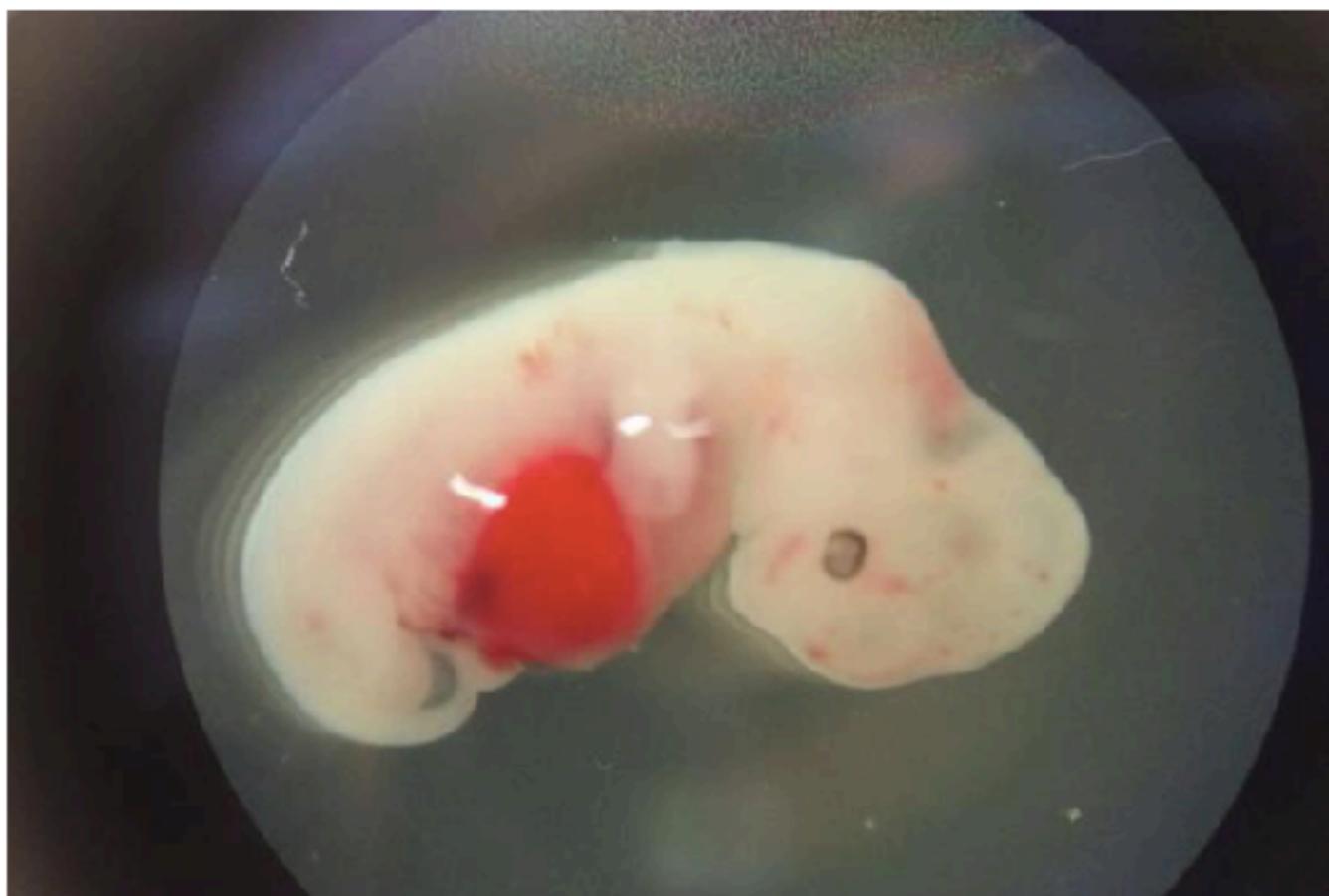




Human pig embryos

Human-Pig Hybrid Created in the Lab—Here Are the Facts

Scientists hope the chimera embryos represent key steps toward life-saving lab-grown organs.



This pig embryo was injected with human cells early in its development and grew to be four weeks old.

PHOTOGRAPH COURTESY JUAN CARLOS IZPISUA BELMONTE



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