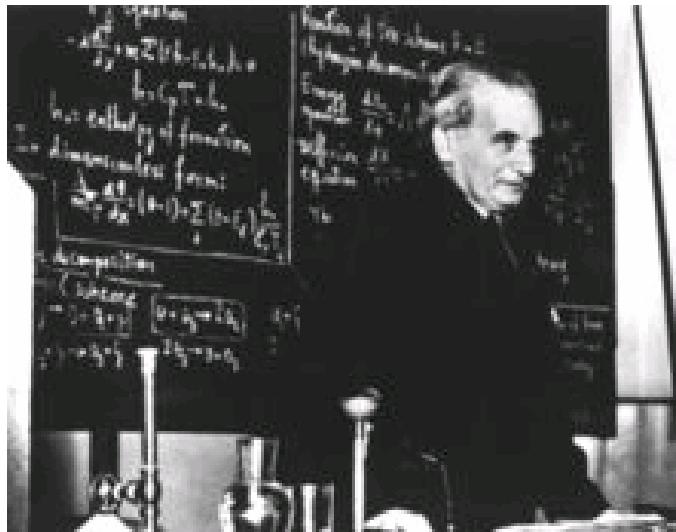


Overview of iGEM and synthetic biology

Andrew Hessel
University of Lethbridge, July 19 2007
ahessel@gmail.com



A Scientist discovers that which exists; an Engineer creates that which never was.

-- Theodore Von Kármán

“Synthetic biology is an emerging area of research that can broadly be described as the design and construction of novel artificial biological pathways, organisms or devices, or the redesign of existing natural biological systems.”

Technology of synthetic biology

DNA is fundamental...

It is the machine language program
for biochemical processes

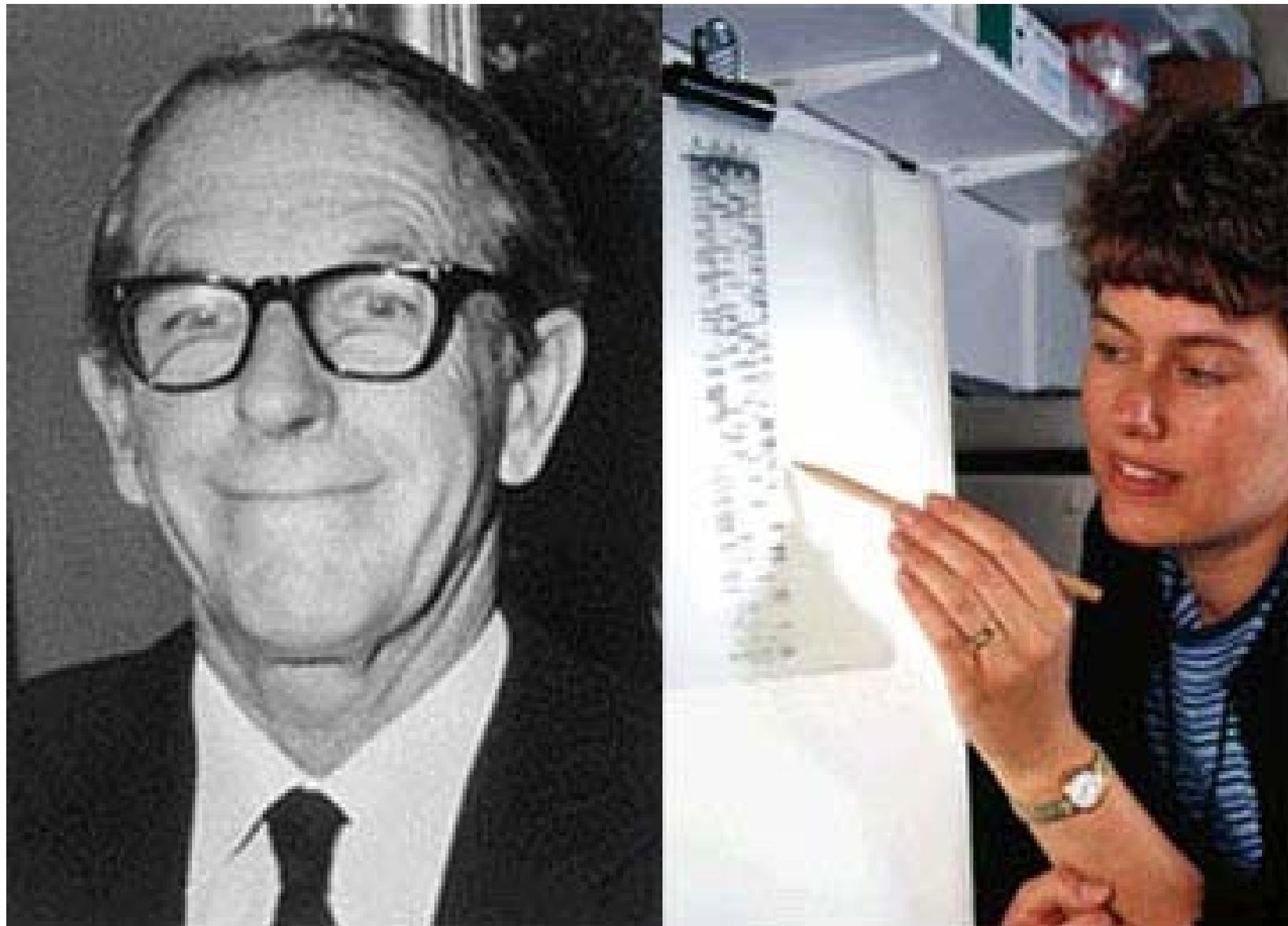
The ability to manipulate this one molecule allows virtually anything biological to be engineered!

DNA is to biology as the electron is to computing

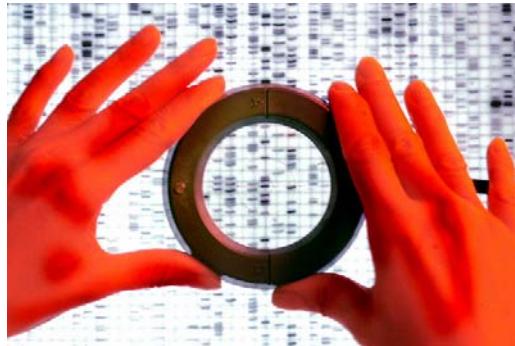


danielig 072006 - S3is

Reading code



Nobel foundation



1980
500 bp/day (manual)



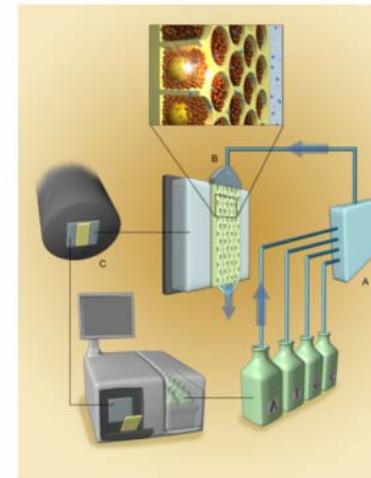
1987
36,000 bp/day (semi-auto)



1995
144,000 bp/day (semi-auto)

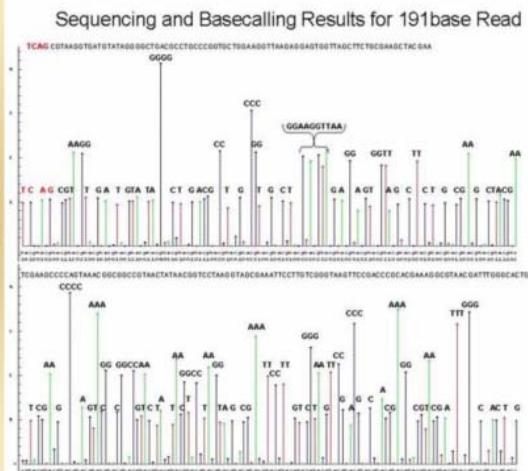


1998
500,000 bp/day (automatic)



2007 – Sequencing by Synthesis

1GB bp/day (automatic)





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The breakthrough of our lifetime...
the X PRIZE about each of us.

Revolution Through Competition.

► [TAKE ACTION](#)

Comprehension



Volume 16 Number 5 1988

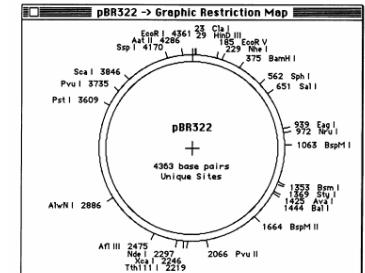
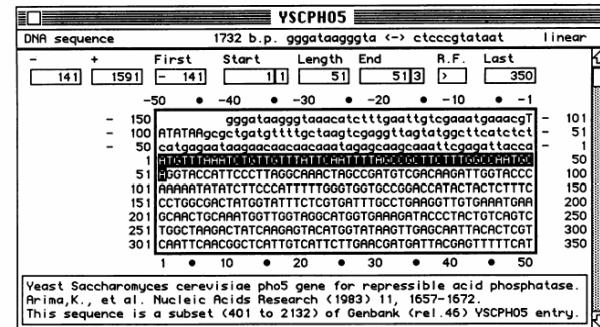
Nucleic Acids Research

'DNA Strider': a 'C' program for the fast analysis of DNA and protein sequences on the Apple Macintosh family of computers

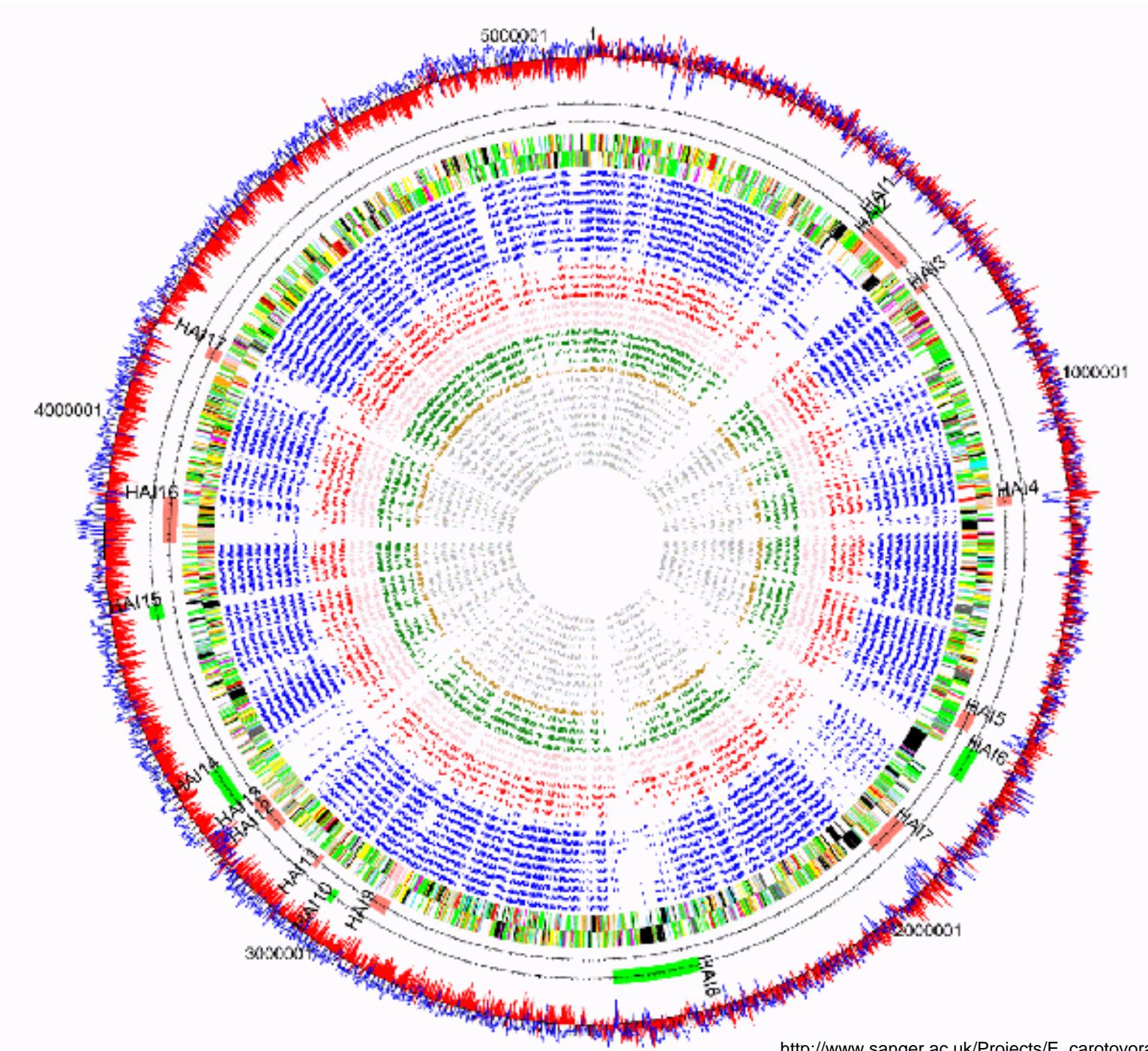
Christian Marck

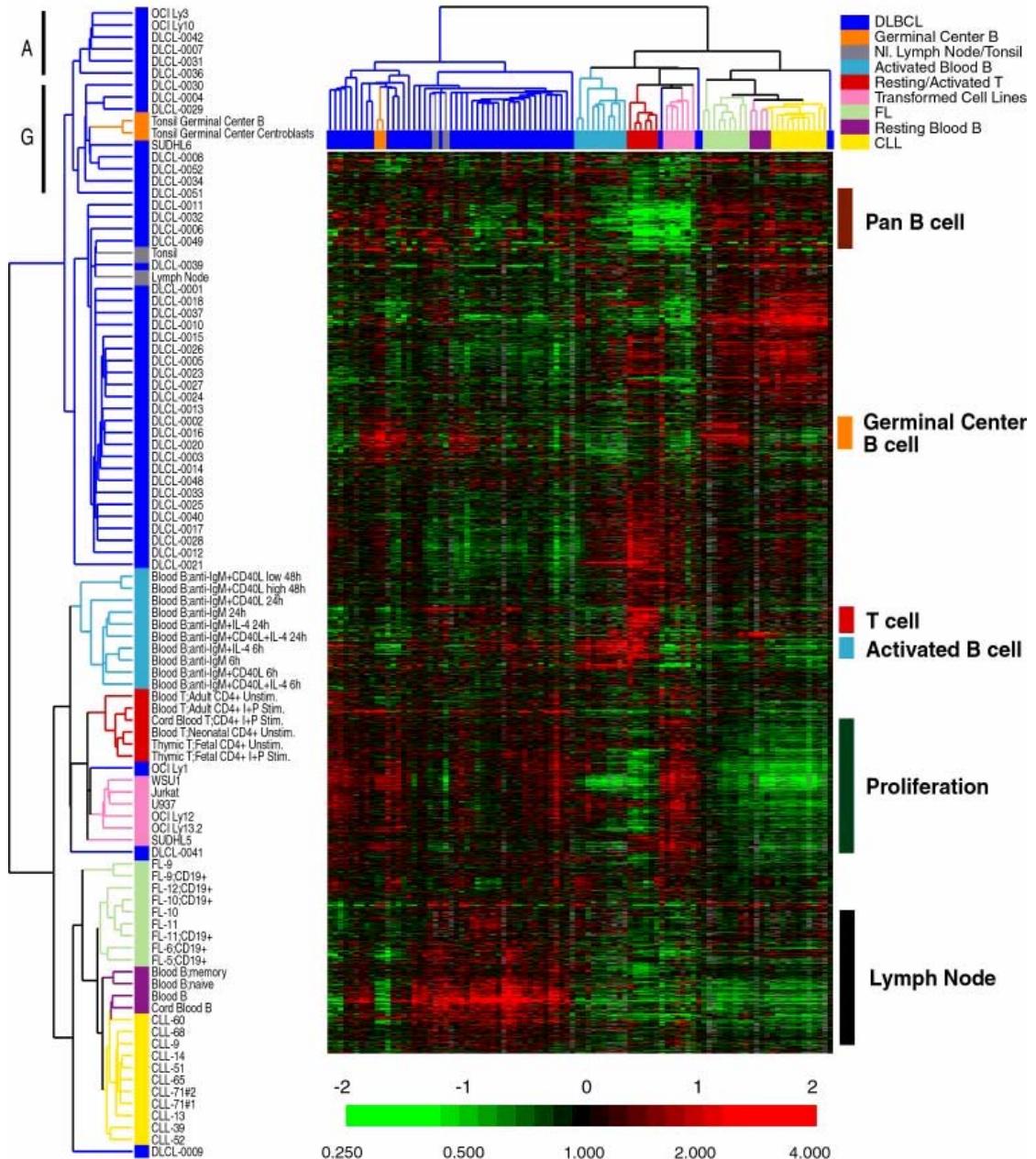
Service de Biochimie, Bâtiment 142, Département de Biologie, Centre d'Etudes Nucléaires de Saclay
91191 Gif-sur-Yvette Cedex, France

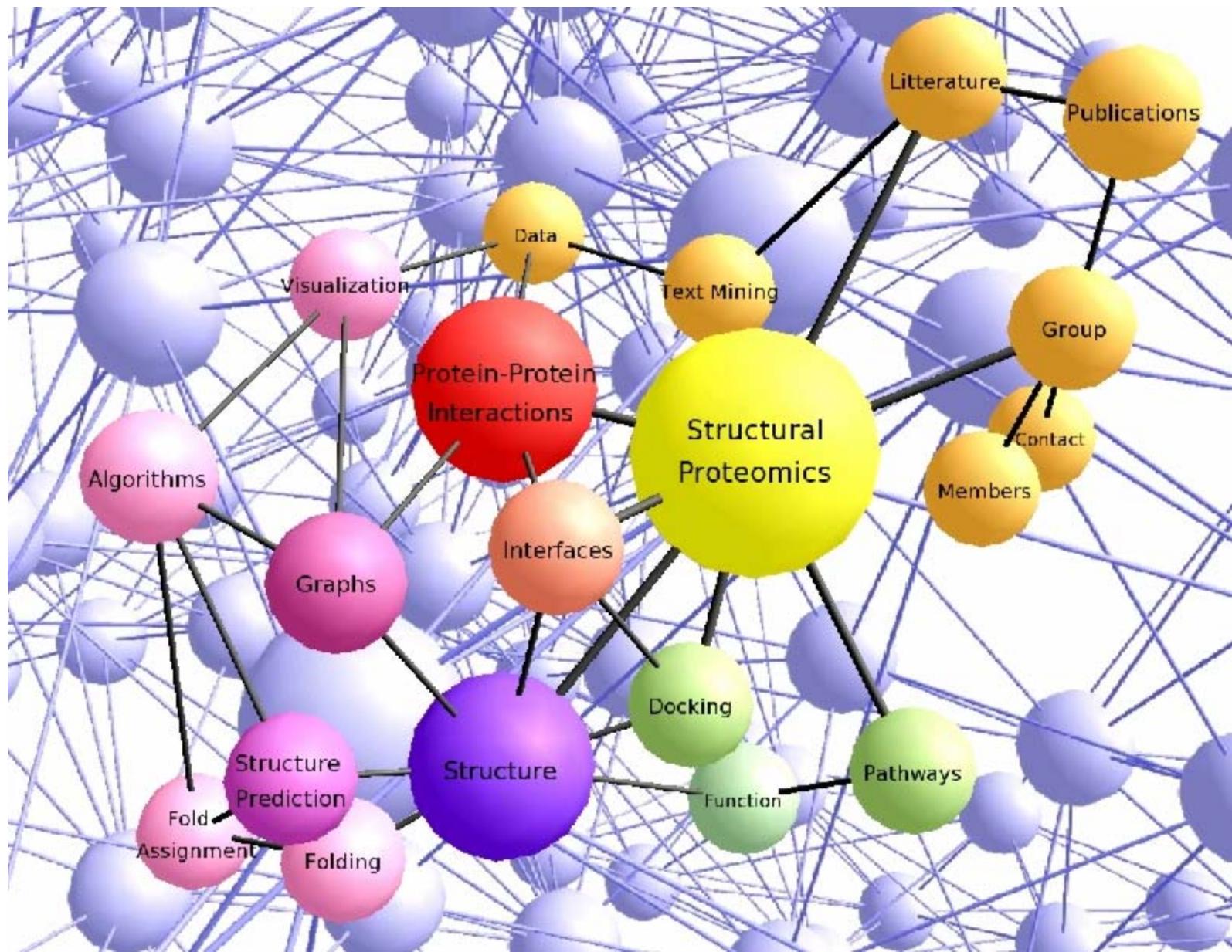
Received August 17, 1987; Revised and Accepted November 15, 1987



280.6 TFLOPS with 131072 nodes

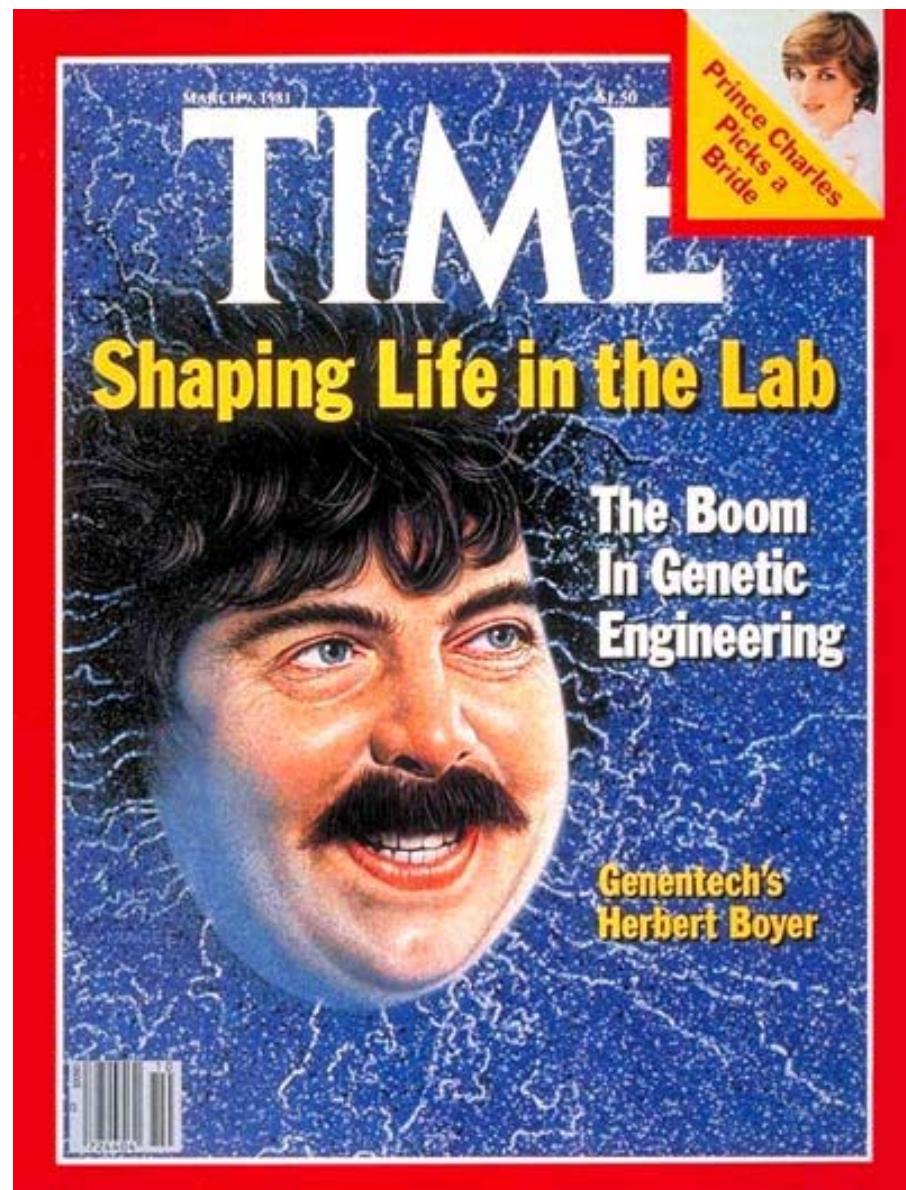
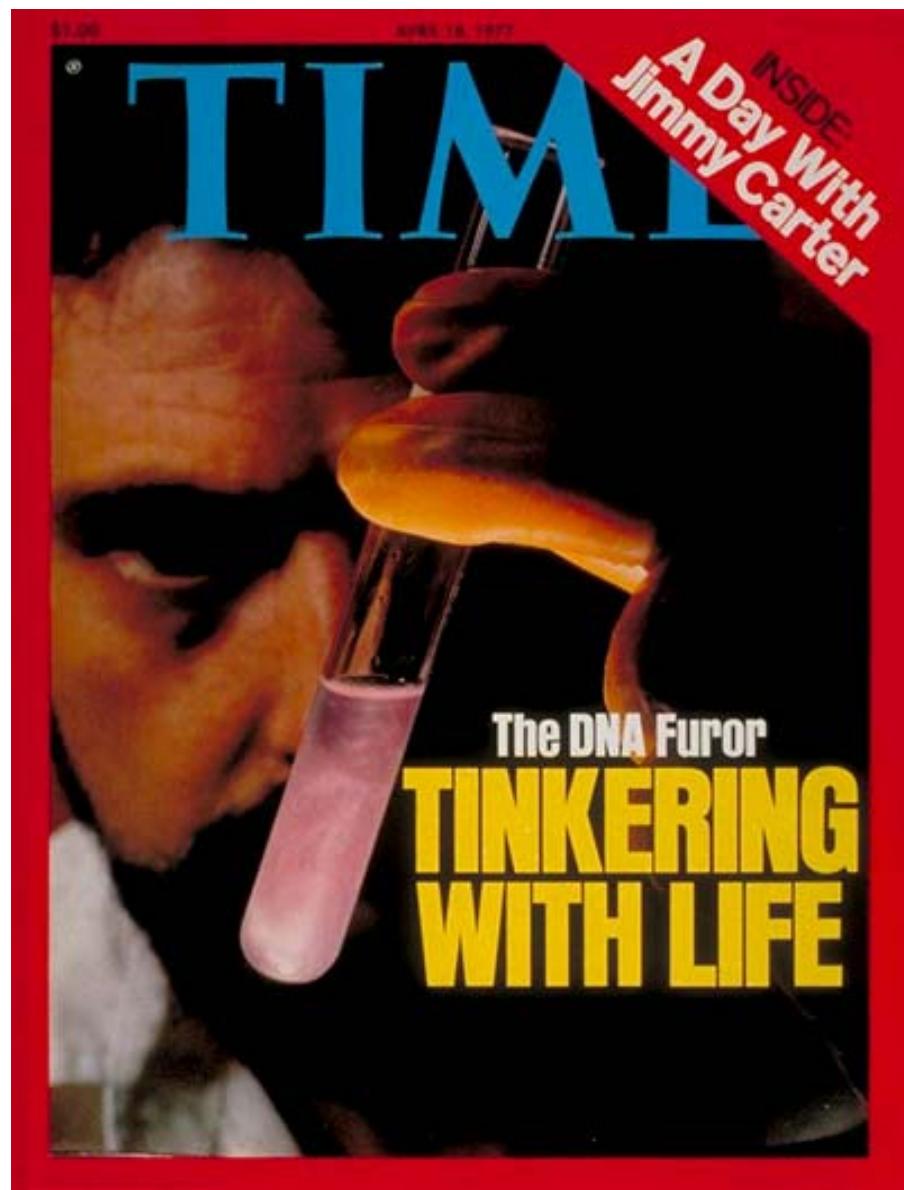






Writing code: synthesis

If we can't build it, we don't understand it.

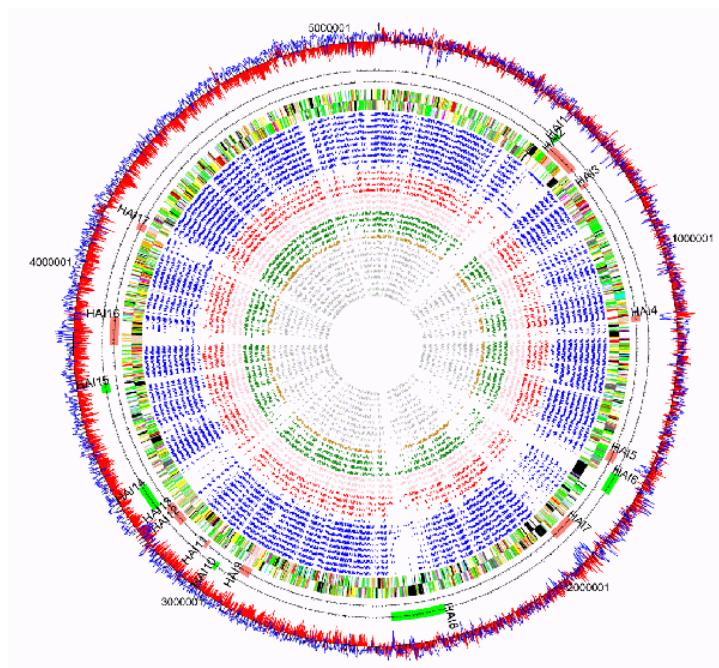




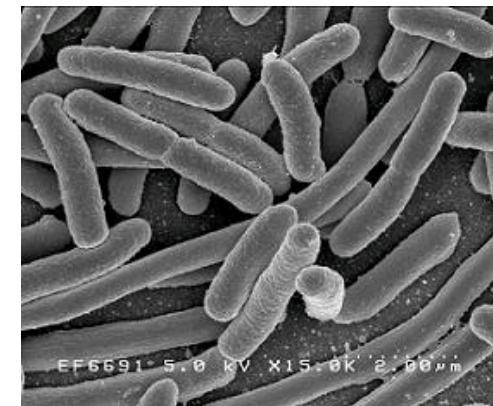
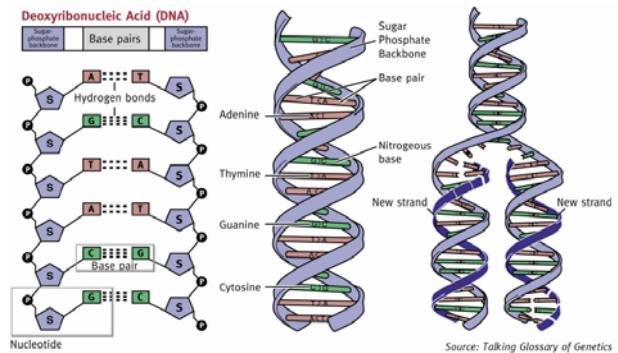
if you can WRITE DNA,

You'RE no LONGER liMITED

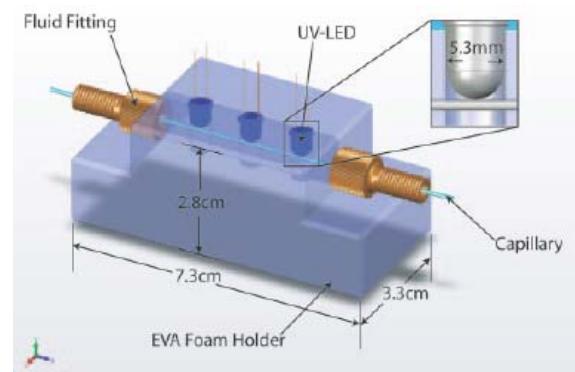
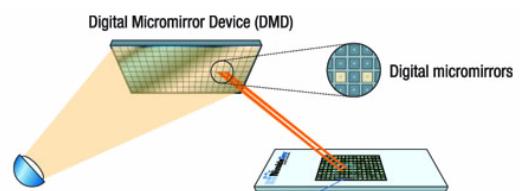
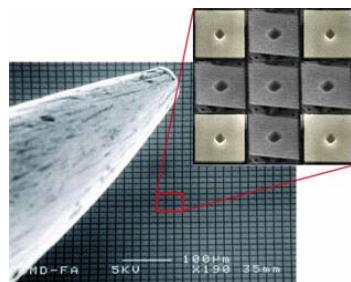
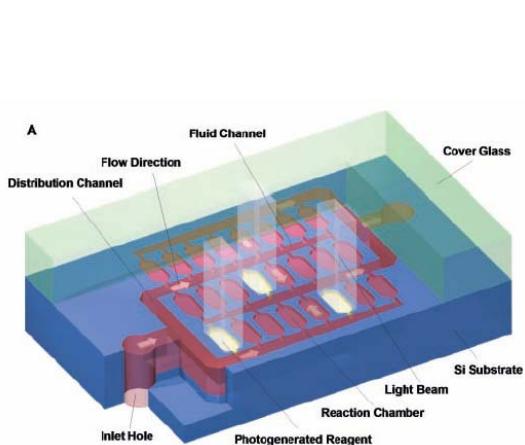
to "What IS IT" but TO what you could MAKE •

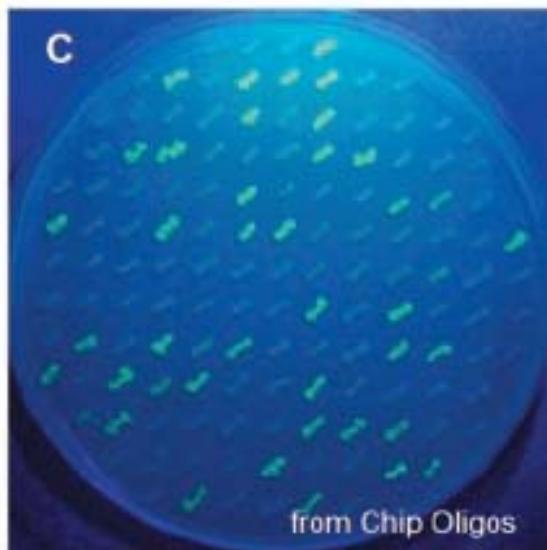
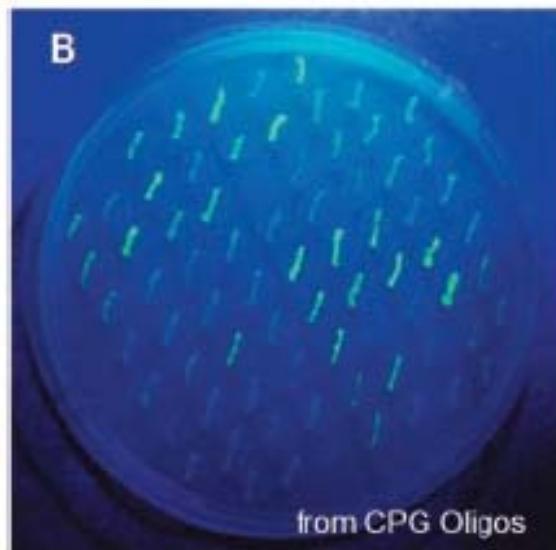


Digital DNA “design”



Physical DNA and outputs





EGFP gene 714 bp

D

Oligonucleotide set 1

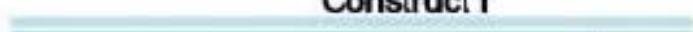


Oligonucleotide set 2



↓ ligation

Construct I



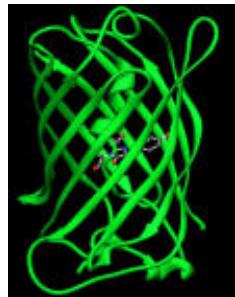
Construct II



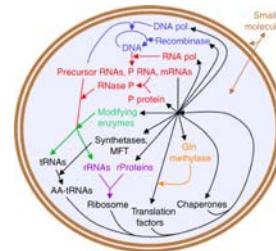
↓ PCR

DNA Construct

Applications dependent on synthetic capabilities



single genes*



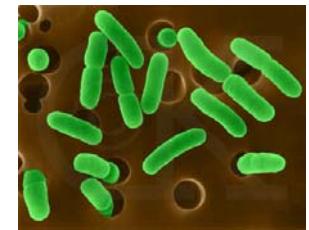
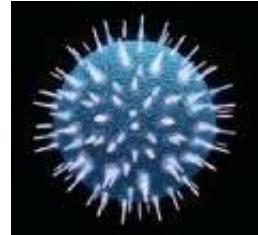
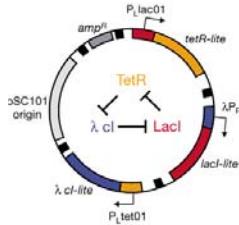
minimal life

base
pairs



genetic circuits, viruses, GEMs

Engineered organisms



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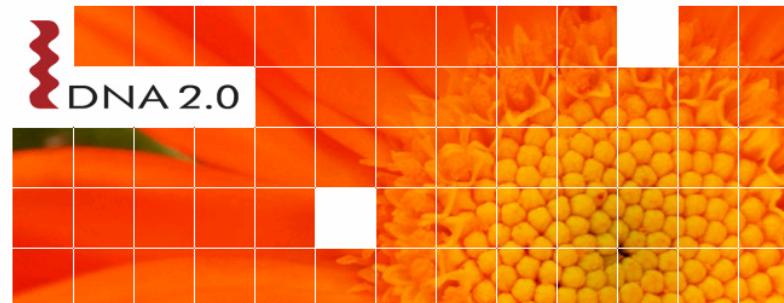
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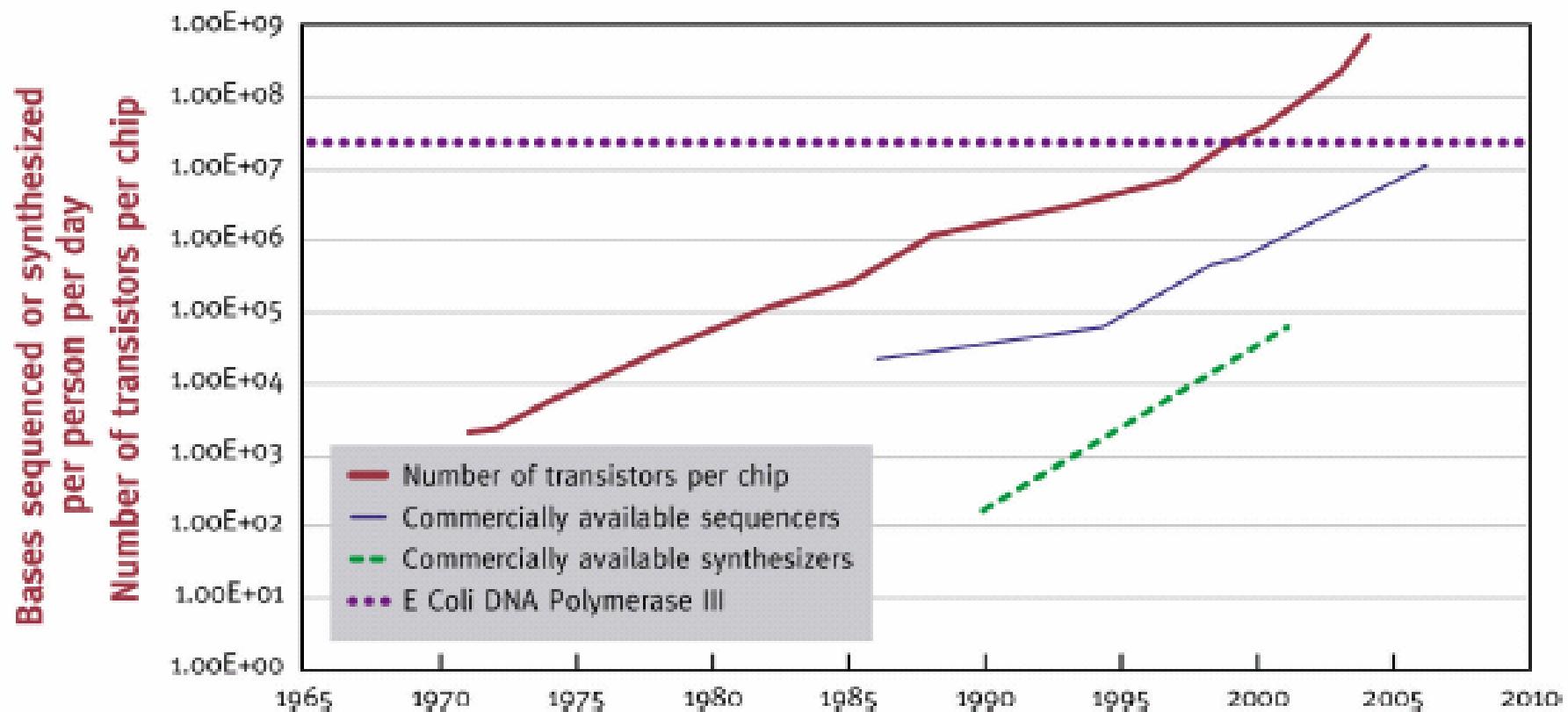
the constructive biology company

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BIOTECHNOLOGY

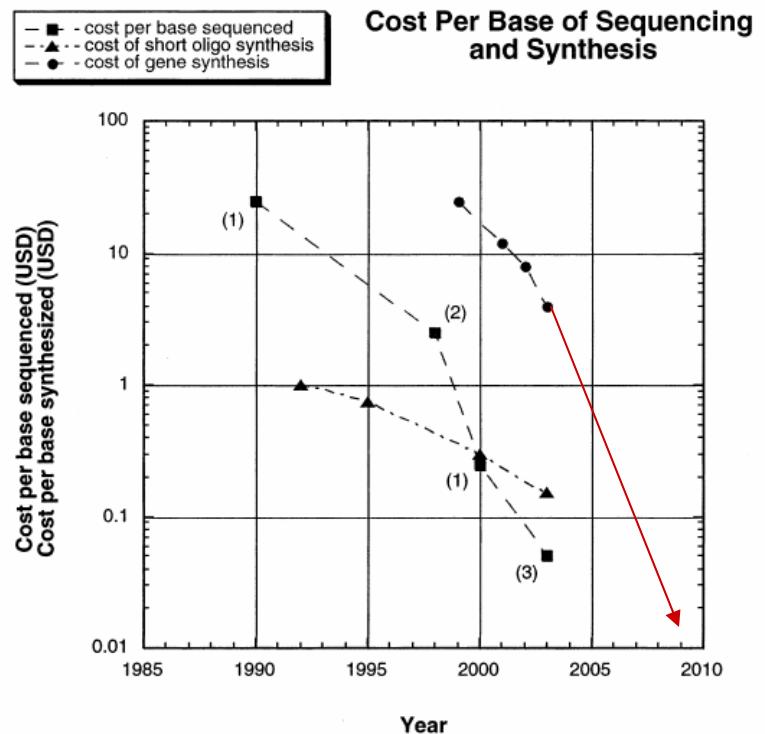
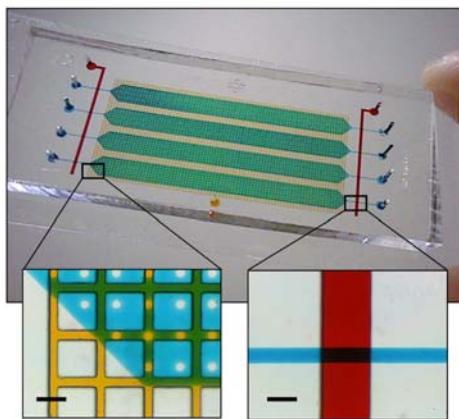
GENEART

THE GENE OF YOUR CHOICE

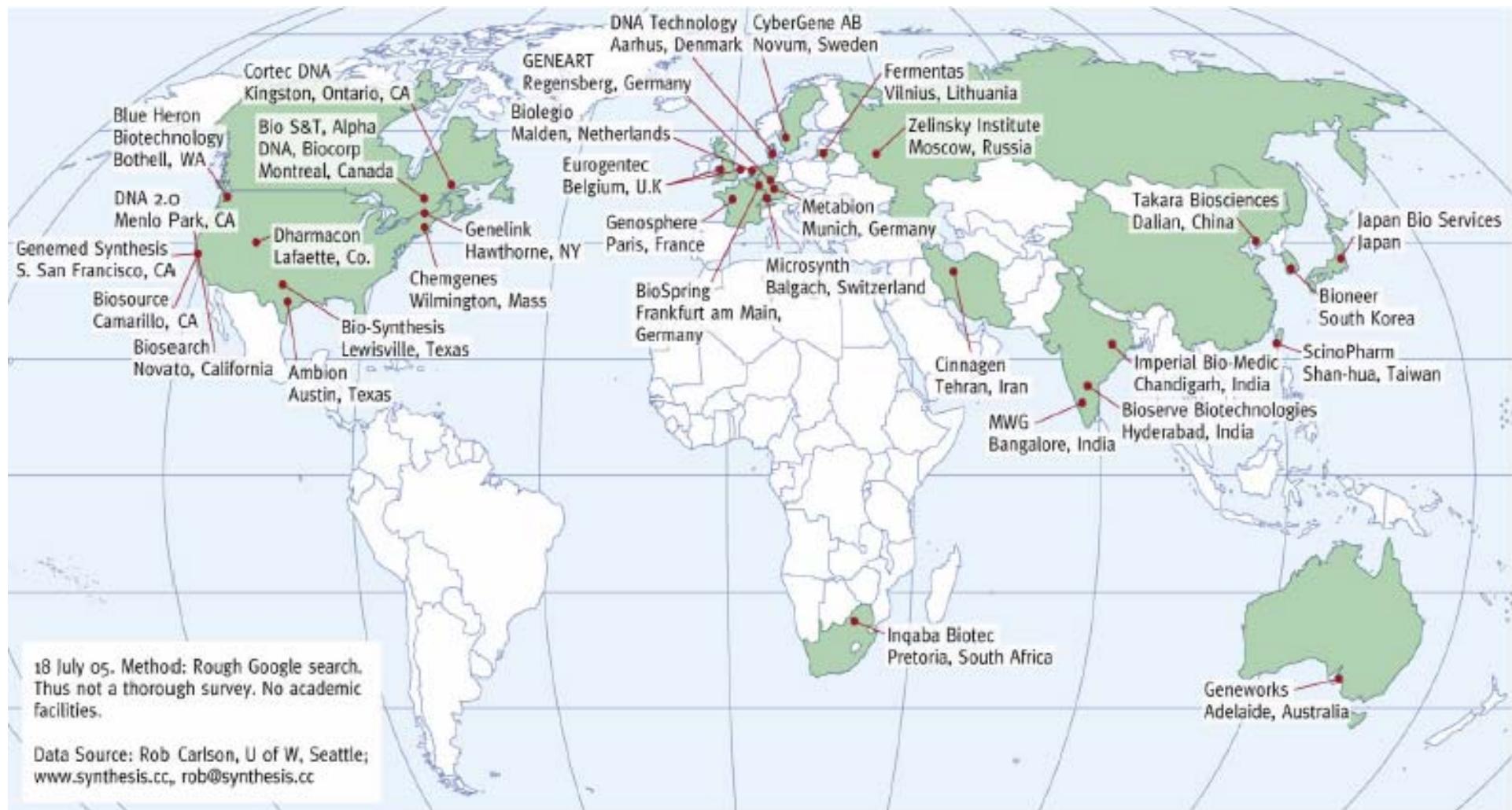


Source: R. Carlson, Bio-era.

- 5 years: 0.5 - 5kb, \$10-\$15/bp
- 0 years: 50 - 500kb \$0.50-\$1/bp
- +5 years: 5mb - 5gb <\$0.0001/bp

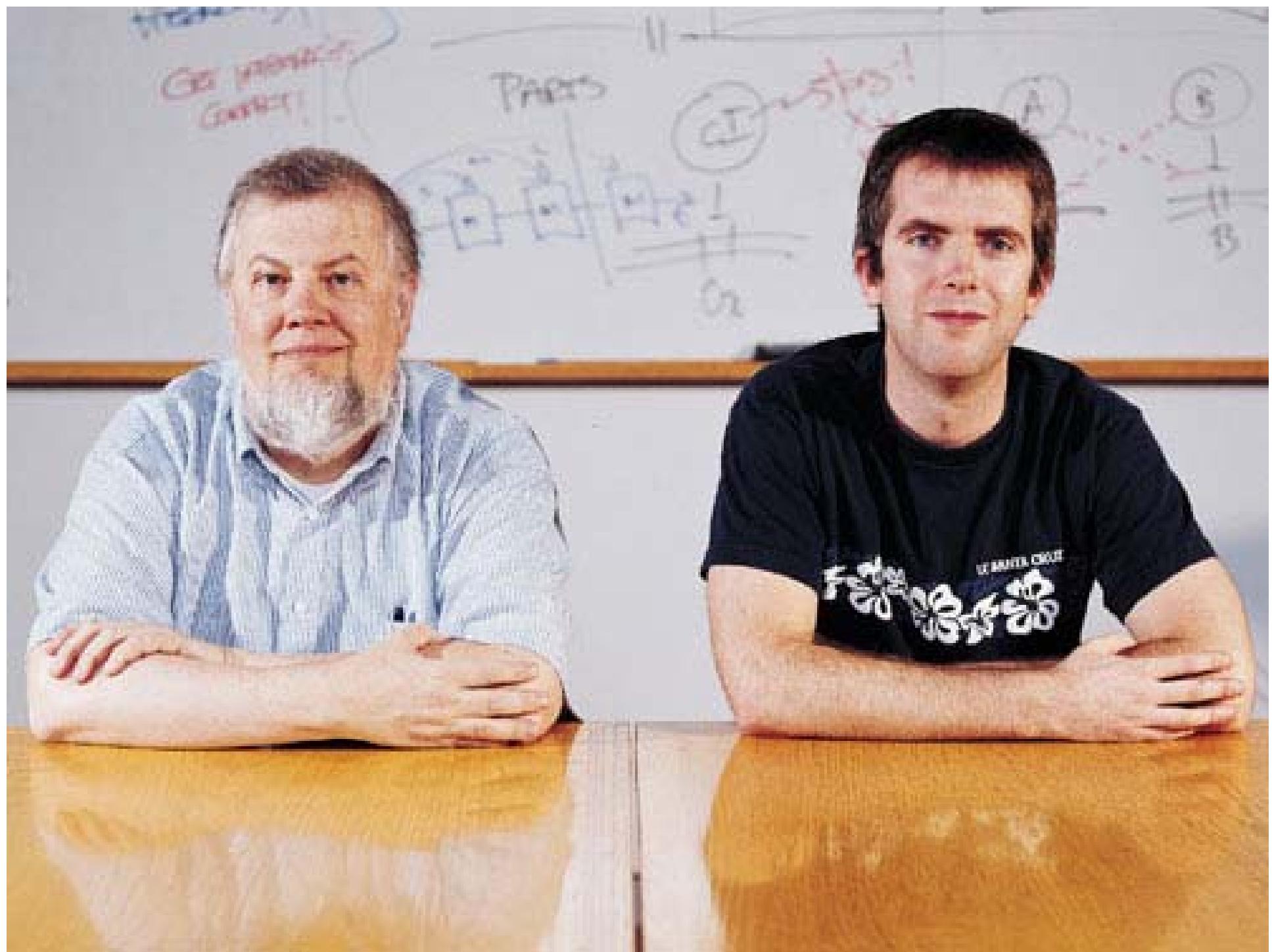


Carlson, R. (2003) The Pace and Proliferation of Biological Technologies

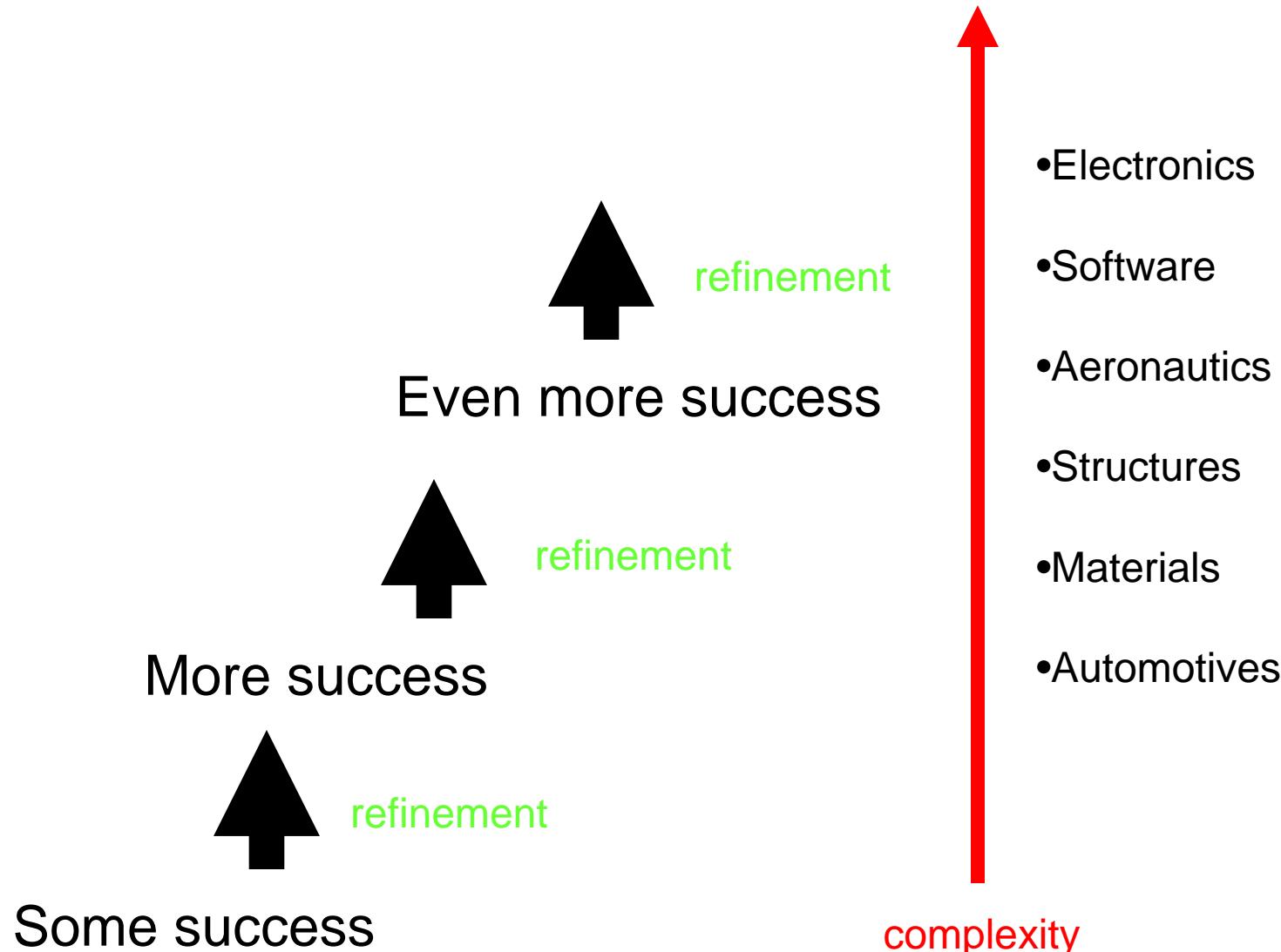


Sources: Source: R. Carlson, G. Epstein, A. Yu (2005)

Engineering philosophy



Engineering process...



F1760

Sender Device

B0015

terminator

Name: B0015

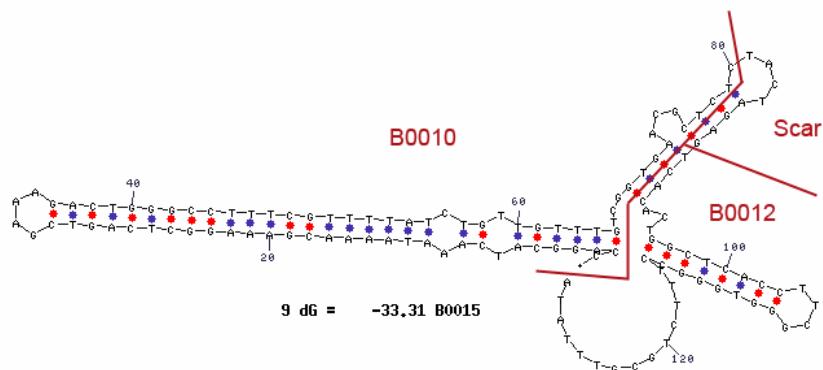
Type: Double terminator

Length 129 bp

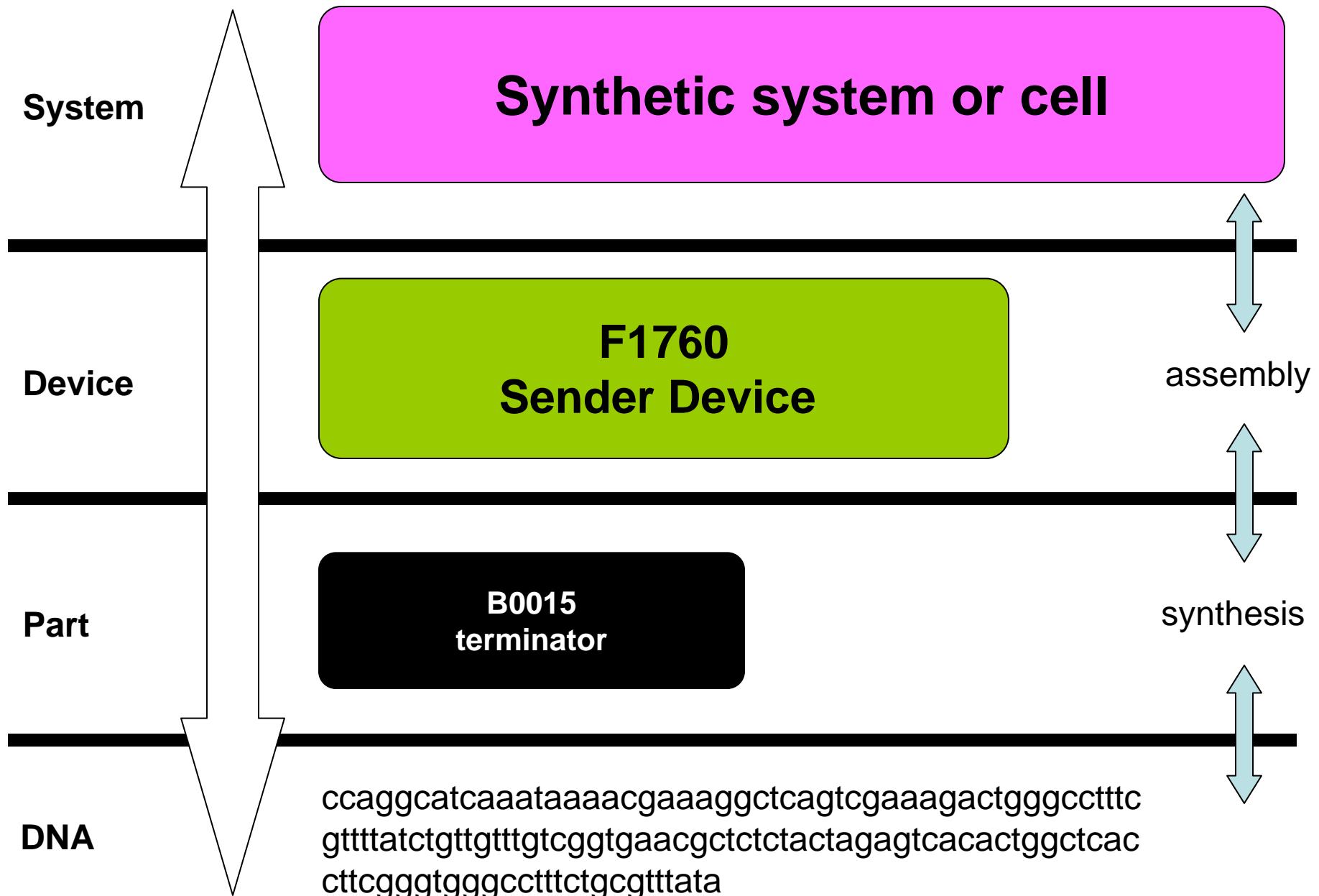
Designed by: Reshma Shetty

Forward efficiency: 0.984

Reverse efficiency: .295



STANDARDIZED DATA




[jump to part](#)
[BBa_](#)
navigation

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Transcriptional Regulators

Available repressible regulators (normally ON) [-?](#)
[Show 0 more parts](#)
[Edit](#)

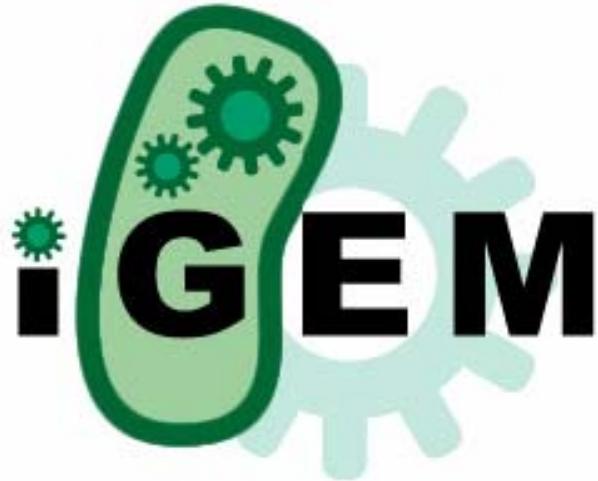
-?	Name	Description	Direction	Control -?	Output Low High	Length
A W	BBa_I14032	promoter P(Lac) IQ	Forward			37
A W	BBa_R0040	promoter (tetR, negative)	Forward	aTc, tetracycline		54
A W	BBa_R0051	promoter (lambda cl regulated)	Forward	lambda cl		49

Available inducible regulators (normally OFF) [-?](#)
[Show 0 more parts](#)
[Edit](#)

-?	Name	Description	Direction	Control -?	Output Low High	Length
A	BBa_I12007	Modified lambda Prm promoter (OR-3 obliterated)	Forward	cl		82
A	BBa_R0062	Promoter (luxR & HSL regulated -- lux pR)	Forward	luxR, HSL		55
A	BBa_R0079	Promoter (LasR & PAI regulated)	Forward	PAI		157
A	BBa_R0080	Promoter (AraC regulated)	Forward	araC		149

Available other regulators
[Show 172 more parts](#)
[Edit](#)

-?	Name	Description	Direction	Control -?	Output Low High	Length
A W	BBa_I0500	Inducible pBAD/araC	Forward	araC, arabinose		1210
A W	BBa_I13453	Pbad promoter				130
A W	BBa_J13002	TetR repressed POPS/RIPS generator	Forward	ATc		74
A W	BBa_J13023	3OC6HSL+LuxR dependent POPS/RIPS generator				117
A W	BBa_J23100	constitutive promoter family member				35
A W	BBa_J23101	constitutive promoter family member				35
A W	BBa_J23102	constitutive promoter family member				35
A W	BBa_J23103	constitutive promoter family member				35
A W	BBa_J23104	constitutive promoter family member				35
A W	BBa_J23105	constitutive promoter family member				35
A W	BBa_J23106	constitutive promoter family member				35
A W	BBa_J23107	constitutive promoter family member				35
A W	BBa_J23108	constitutive promoter family member				35
A W	BBa_J23109	constitutive promoter family member				35
A W	BBa_J23110	constitutive promoter family member				35
A W	BBa_J23111	constitutive promoter family member				35



Growing a community by
sharing:

- Physical DNA parts
(Biobricks)
- DNA code
- Protocols
- Experience
- Publications

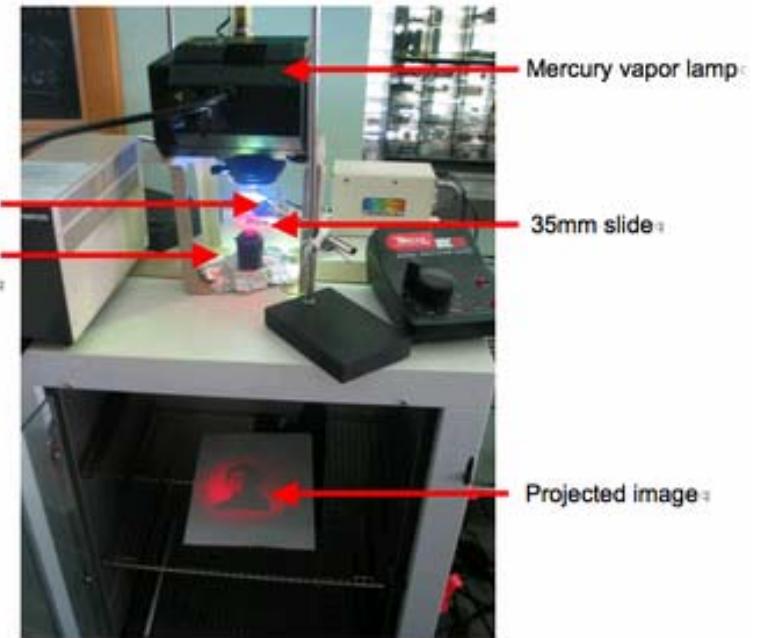
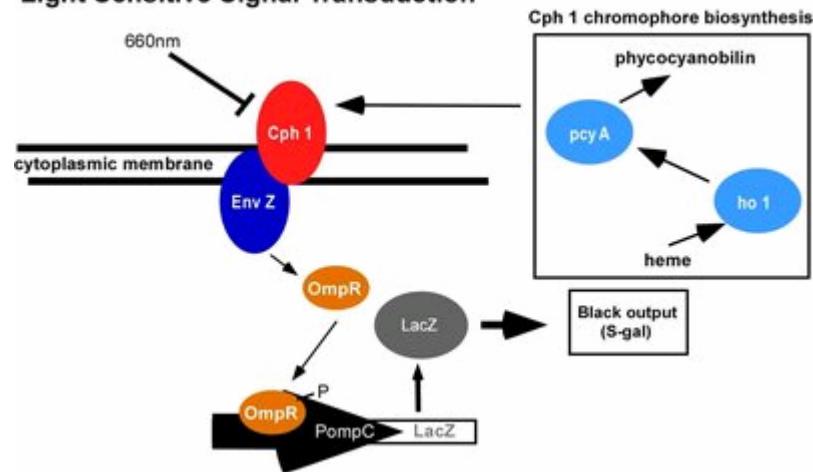
Encourages play, independence, creativity

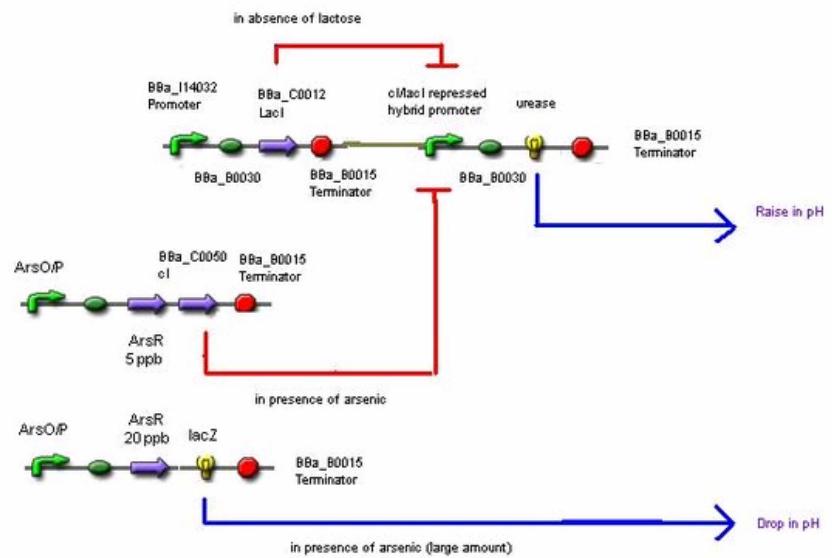




2006 Jamboree – 400 gengineers

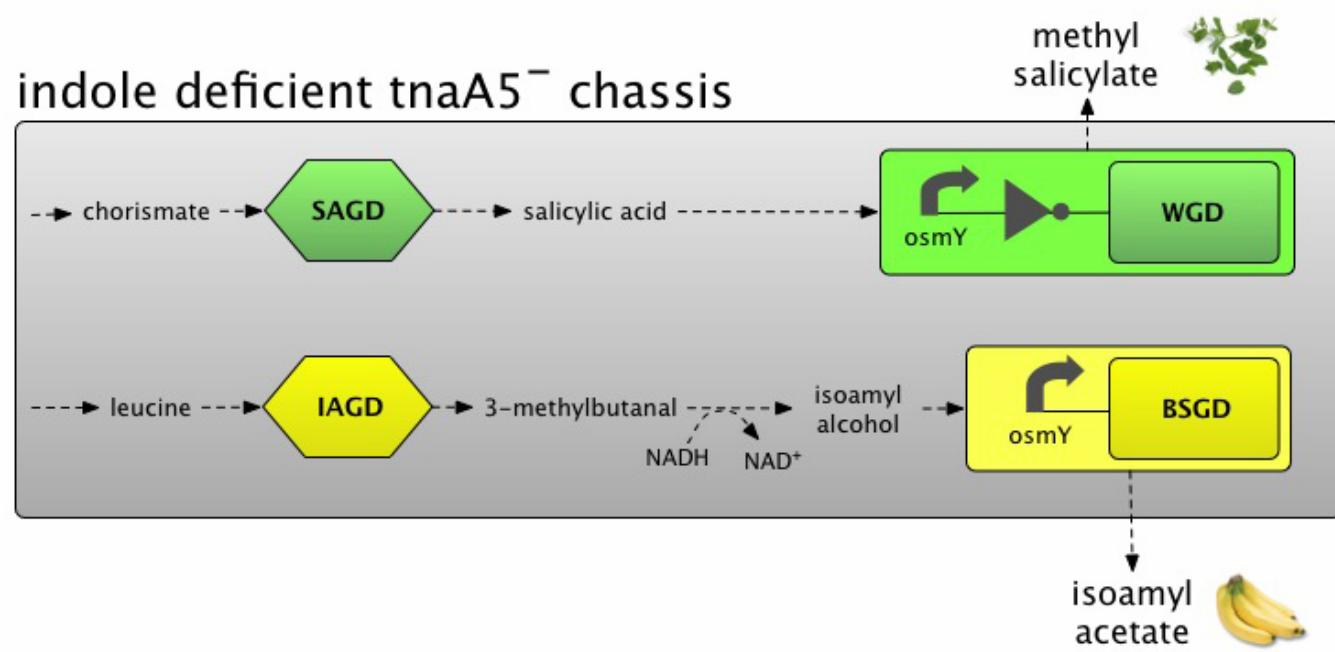
Light Sensitive Signal Transduction







indole deficient *tnaA5⁻* chassis

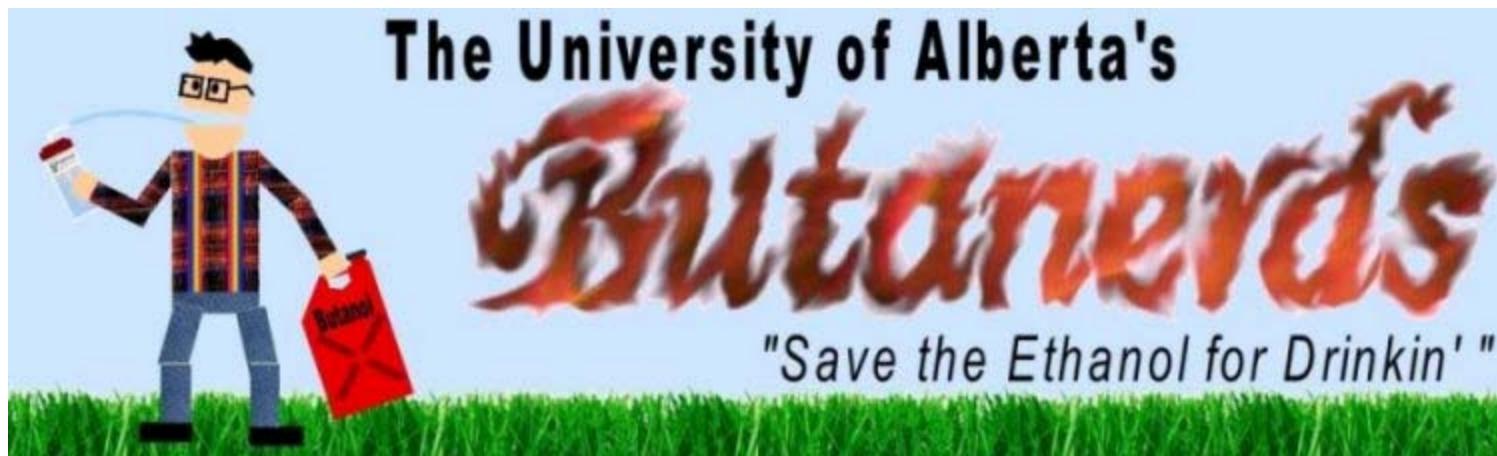


iGEM 2007

- 57 teams – 20 countries
- USA (26)
- Scotland (3)
- Colombia
- Italy (2)
- Mexico
- Taiwan
- Russia
- Germany
- South Africa
- Middle East
- Canada (6)
- Japan (2)
- Australia
- England
- Switzerland
- China (4)
- Spain
- India
- France
- **Slovenia**

U of A iGEM Team

- Biobutanol project – “*Plan B*”
- Moving metabolic pathway from *Clostridium* into *E. coli*



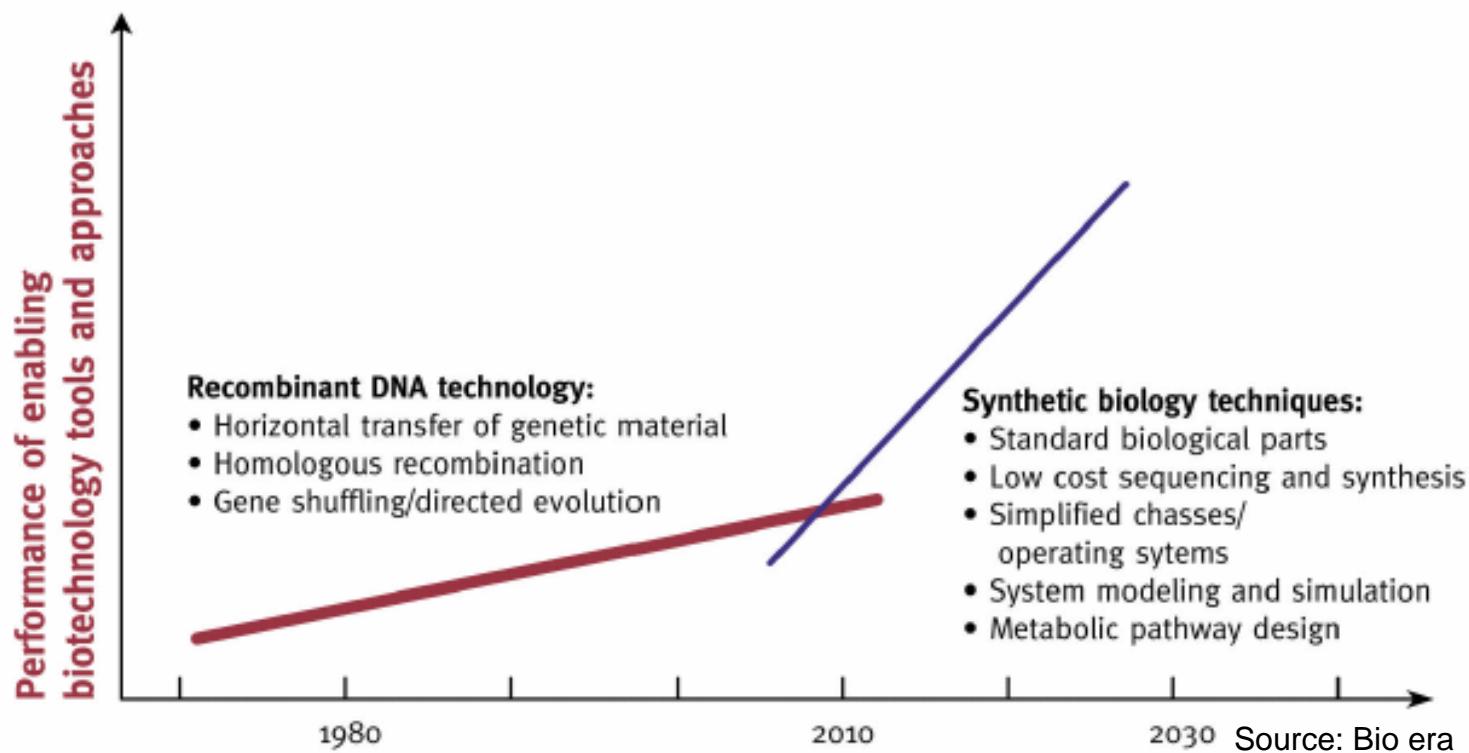
U of C iGEM team

- Combination of mechanical and biological devices
- 2D plotter system
- Switched agarase activation
- Allows precise “carving” of agarase medium



Opportunities for Alberta

Synthetic biology is going to grow fast!



PIMP MY GENOME!

SYNTHETIC BIOLOGY: A PLAN FOR ENGINEERING BIOLOGY



Wednesday April 4, 2007

University of Alberta, Telus Centre, Room 150
111 Street and 87 Avenue
Edmonton, AB

Doors open and refreshments - 3:00 PM
Presentation - 3:30 PM

Complimentary return bus transportation will be provided to guests from the University of Calgary.

Join Drew Endy, a leader in synthetic biology from MIT, for an engaging look at how biological engineering is changing. Find out how the latest advances in this new era of biology are helping make R&D faster, cheaper and easier.

Drew is a fellow in the Department of Biology and the Biological Engineering Division at MIT. He co-founded the MIT Synthetic Biology working group and the Registry of Standard Biological Parts. He is also co-founder of iGEM, the International Genetically Engineered Machine competition, Codon Devices Inc., a venture-funded startup that is working to develop next-generation DNA synthesis technology, and the BioBricks Foundation, a not-for-profit organization that is working to develop legal and economic strategies needed to support open biotechnology. Drew's work has been featured in *The Economist*, *Forbes*, *Wired*, *Scientific American* and the *New York Times*.

For registration and more information,
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The Alberta Ingenuity Fund supports science and engineering research at the highest calibre to create a prosperous future for the province. It draws Alberta down a \$1 billion endowment established and managed by the Government of Alberta to build the capacity for innovation, especially in areas with long lasting social and economic impact.

Engineering synthetic biological constructs will become the foundational technology of the 21st century Tom Knight, MIT, SB3

- Biology > Physics (\$, staff, discoveries)
- Biology is more important than physics, as measured by its economic outputs, ethical implications, and effects on human welfare
- Alberta already *has* a vibrant bio-economy
- Well-positioned to become a global leader in synthetic biotechnologies *if we act quickly and decisively*
- DNA has always been high impact, and this is a ground-floor opportunity

We need to start education programs and do outreach...



A JOINT PROGRAM OF THE CALIFORNIA INSTITUTE FOR QUANTITATIVE BIOMEDICAL RESEARCH (QB3)
AND LAWRENCE BERKELEY NATIONAL LABORATORY (LBNL)

The California Institute for Quantitative Biomedical Research (QB3) and Lawrence Berkeley National Laboratory (LBNL) have joined forces to accelerate the growth of synthetic biology, a new field that promises major new advances in preventing and treating disease, generating new energy sources, and preventing and mitigating environmental threats.

Opening in spring 2005 in a spacious, modern building in west Berkeley, the Berkeley Center for Synthetic Biology gives renowned scientists and engineers the chance to pool their talents and collaborate in new essential benefits for California's advances in biomedicine and economic growth.

the control and design of new organisms to solve a energy, and environmental solved using naturally es. The inherently



QB3 and LBNL scientists occupy lab space in a building renovated in 1997 for biotech research, previously leased by Bayer, featuring large labs, viral suites, and tissue culture rooms. UCSF Mission Bay and numerous biotech firms are nearby.

MIT establishes groundbreaking biological engineering major

February 17, 2005

The Massachusetts Institute of Technology faculty yesterday approved a new course of study for undergraduates, in biological engineering, the first entirely new curriculum established at the Institute in 29 years.

California Institute for Quantitative Biomedical Research



2/1/2007 - BP awards \$500 million bioenergy grant

Global energy firm BP has selected UC Berkeley, in partnership with Lawrence Berkeley National Laboratory and the University of Illinois, to lead an unprecedented \$500 million research effort to develop new sources of energy and reduce the impact of energy consumption on the environment. The funding will create the Energy Biosciences Institute, which initially will focus its research on biotechnology to produce biofuels. QB3 helped coordinate the research proposal and will help administer the project. [More >](#)



6/26/2007 - Bay Area partnership to host DOE bioscience center

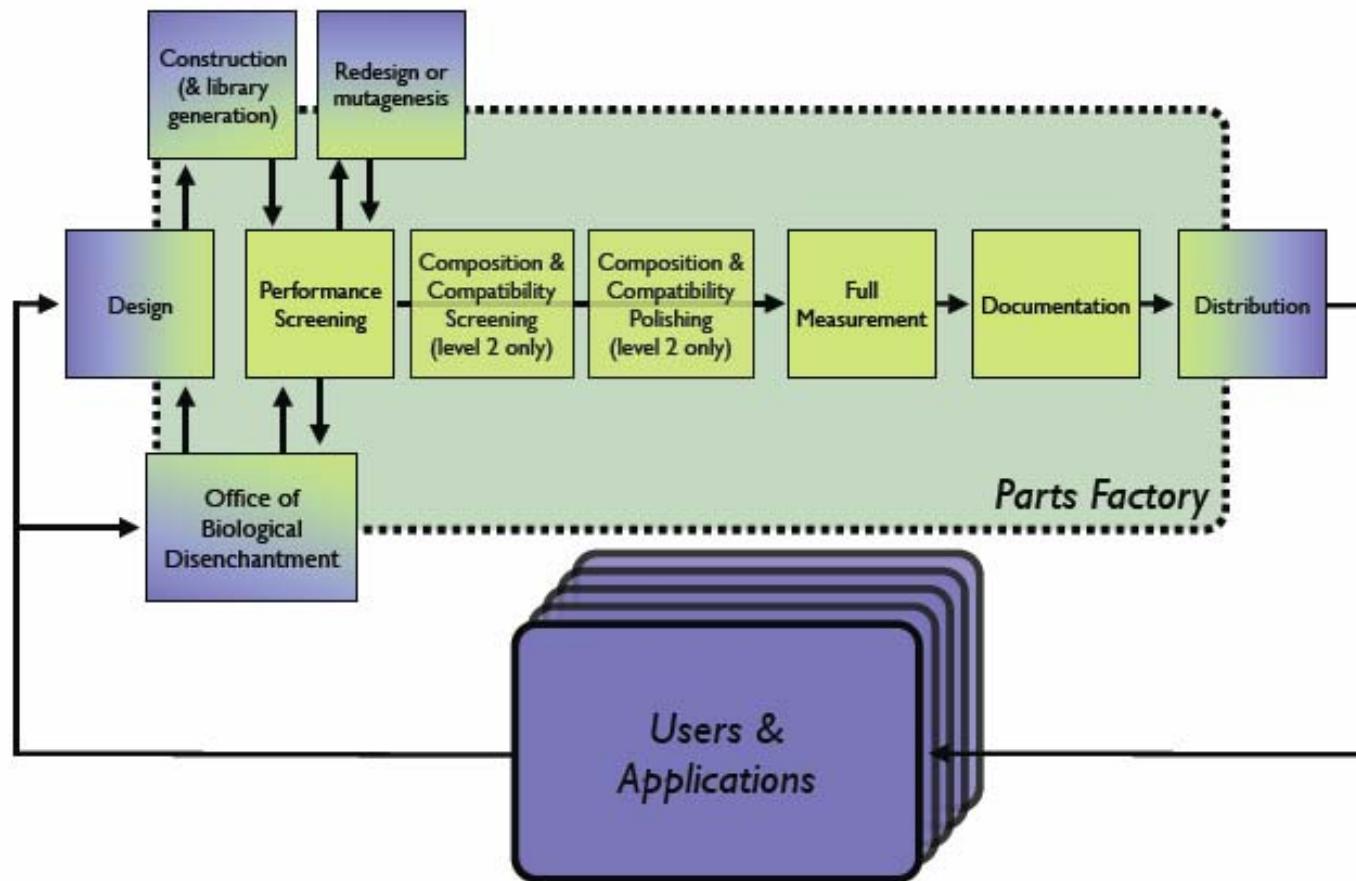
The U.S. Department of Energy has announced the creation of a new bioenergy research center, with UC Berkeley and Lawrence Berkeley National Laboratory as two of its six collaborating institutions. The Joint BioEnergy Institute – to be headquartered in the East Bay and led by Jay Keasling – will receive approximately \$125 million in DOE funding over five years. [More >](#)



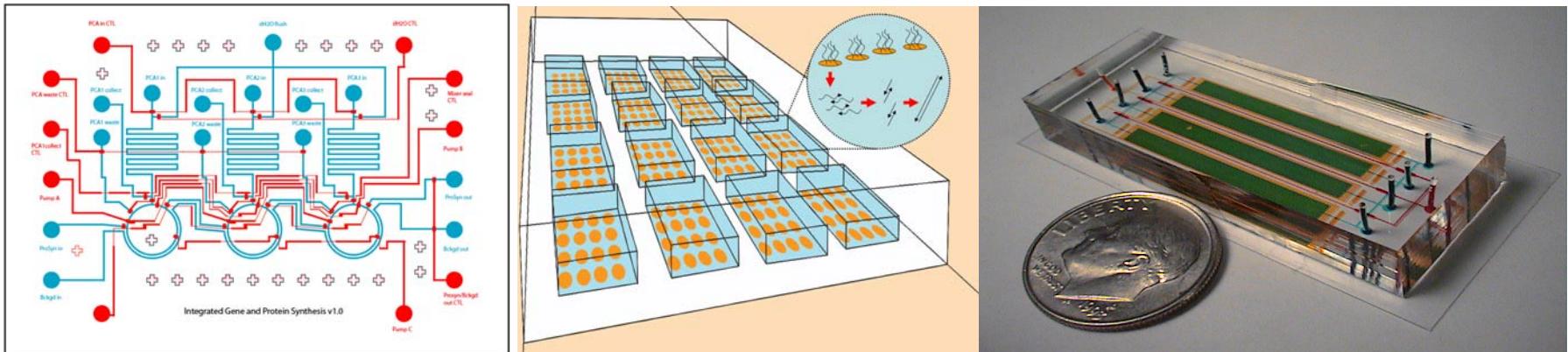
8/3/2006 - New center poised to transform biotech

Aided by a \$16 million NSF grant, QB3 has launched the Synthetic Biology Engineering Research Center at UC Berkeley, with collaborators at UC San Francisco, MIT, Harvard, and Prairie View A&M University. Researchers hope to make it as quick and easy to engineer biology as it now is to assemble microprocessors, hard drives, and memory chips into a computer. [More >](#)

Build a bio-fab to support research community and next-gen companies



Nanoscale biology



Christian Hilti is a member of the Alexander Pines research group and principal author of a paper in which it was demonstrated that Nuclear Magnetic Resonance or NMR spectroscopy can be used with microfluidic "lab-on-a-chip" devices.

IBM's nanoscale MRI breakthrough

By Stephen Withers

Monday, 23 April 2007

Researchers at IBM's Almaden Research Center have demonstrated 2D magnetic resonance imaging of nanoscale objects as small as 90nm.





Monday, April 09, 2007



DNA Factories

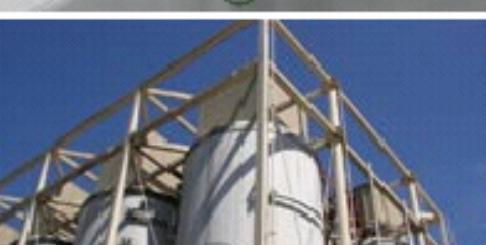
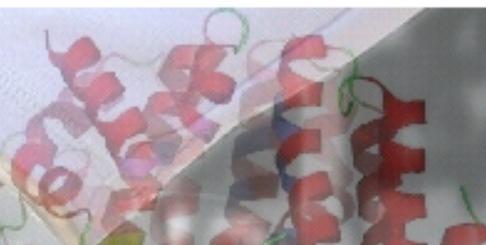
Cheaply churning out made-to-order DNA could revolutionize molecular biology.

By Emily Singer



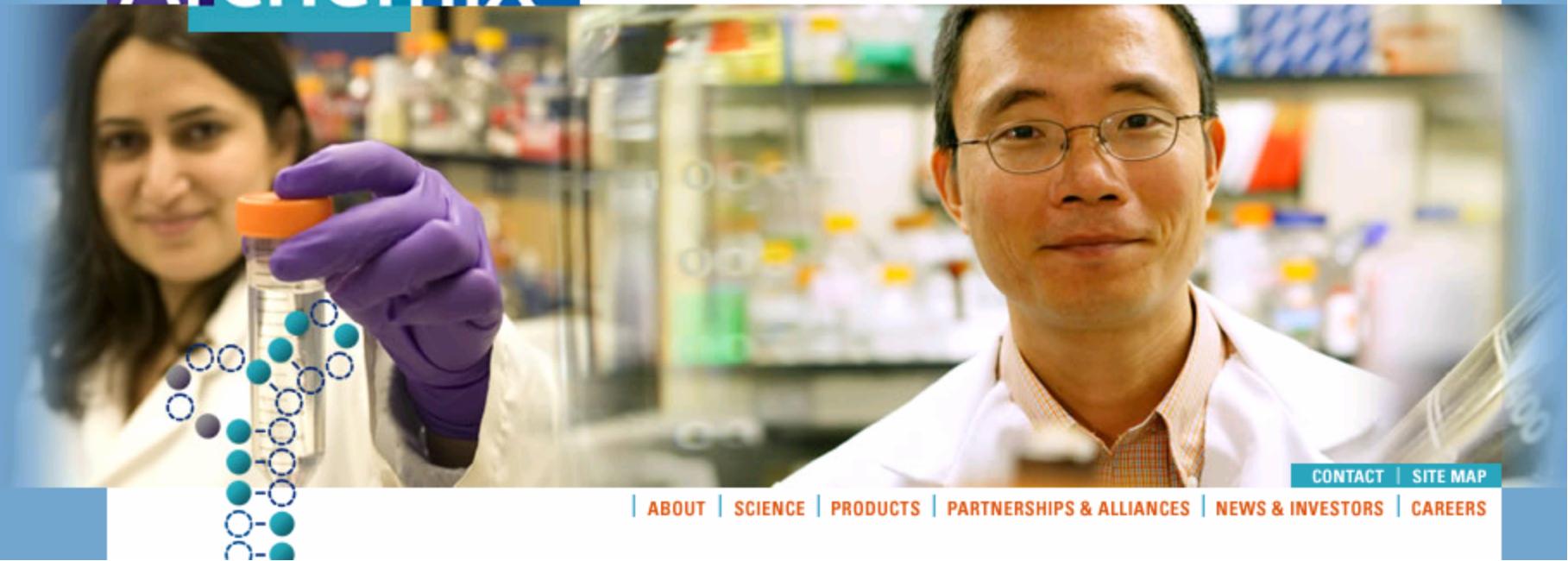
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Realizing the Promise of Synthetic Biology

COMPANY PROFILE

TECHNOLOGY

CURRENT PROJECTS

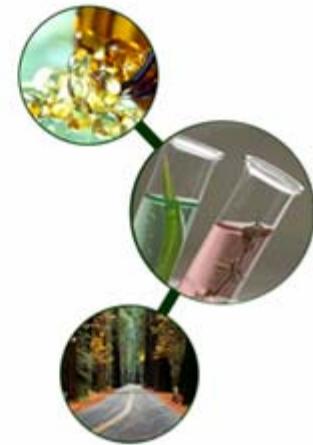
NEWS

CAREERS

Welcome



Amyris Biotechnologies is translating the promise of synthetic biology into solutions for real-world problems. Building on advances in molecular, cell and systems biology, we are engineering microbes capable of producing high-value compounds to address major global health and energy challenges. We are employing these living chemical factories to produce novel pharmaceuticals, renewable fuels, and specialty chemicals.



© 2006 AMYRIS BIOTECHNOLOGIES™

- *Applications (health, biofuels, bioproducts)
- Software: Metabolic and genomic design tools
- Hardware: Advanced synthesis hardware, biological test and measurement devices
- Ethics and social policy of synthetic biology
- Educational program development
- Next-generation biotechnology company development



MAY 3, 1982

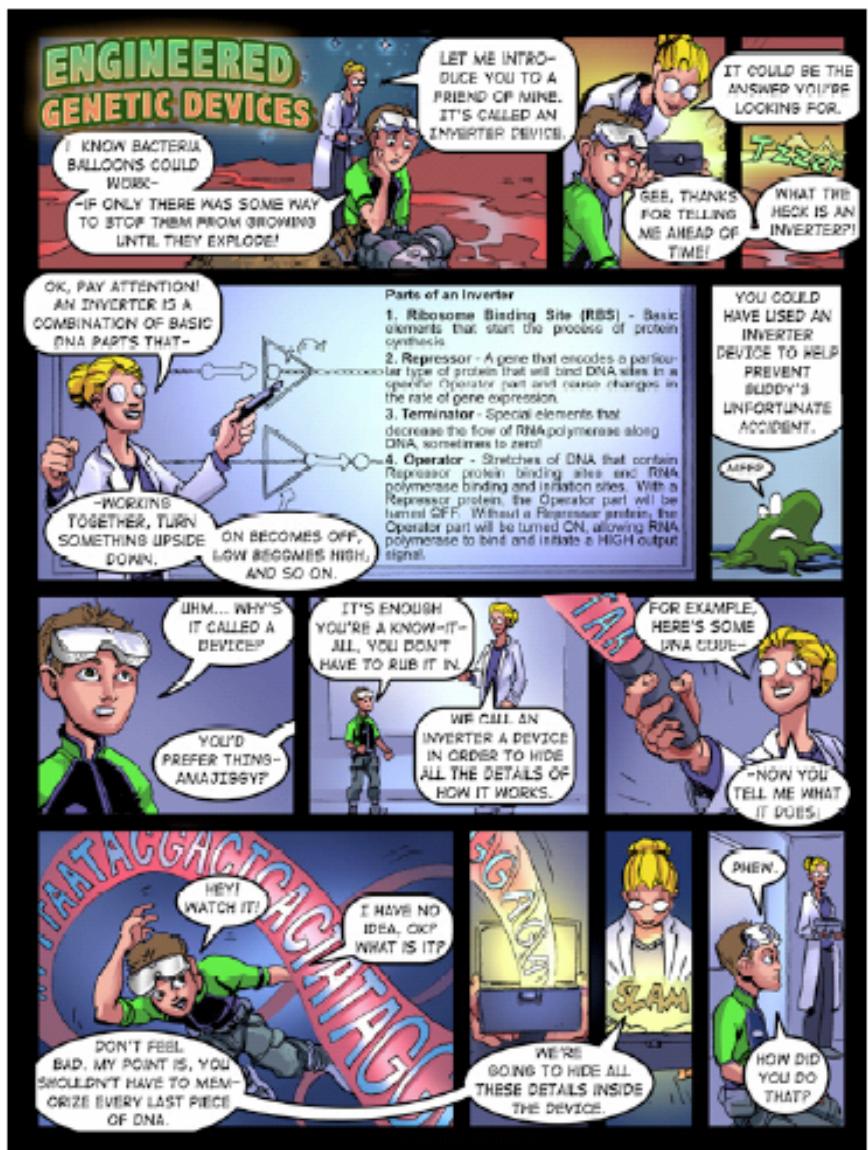
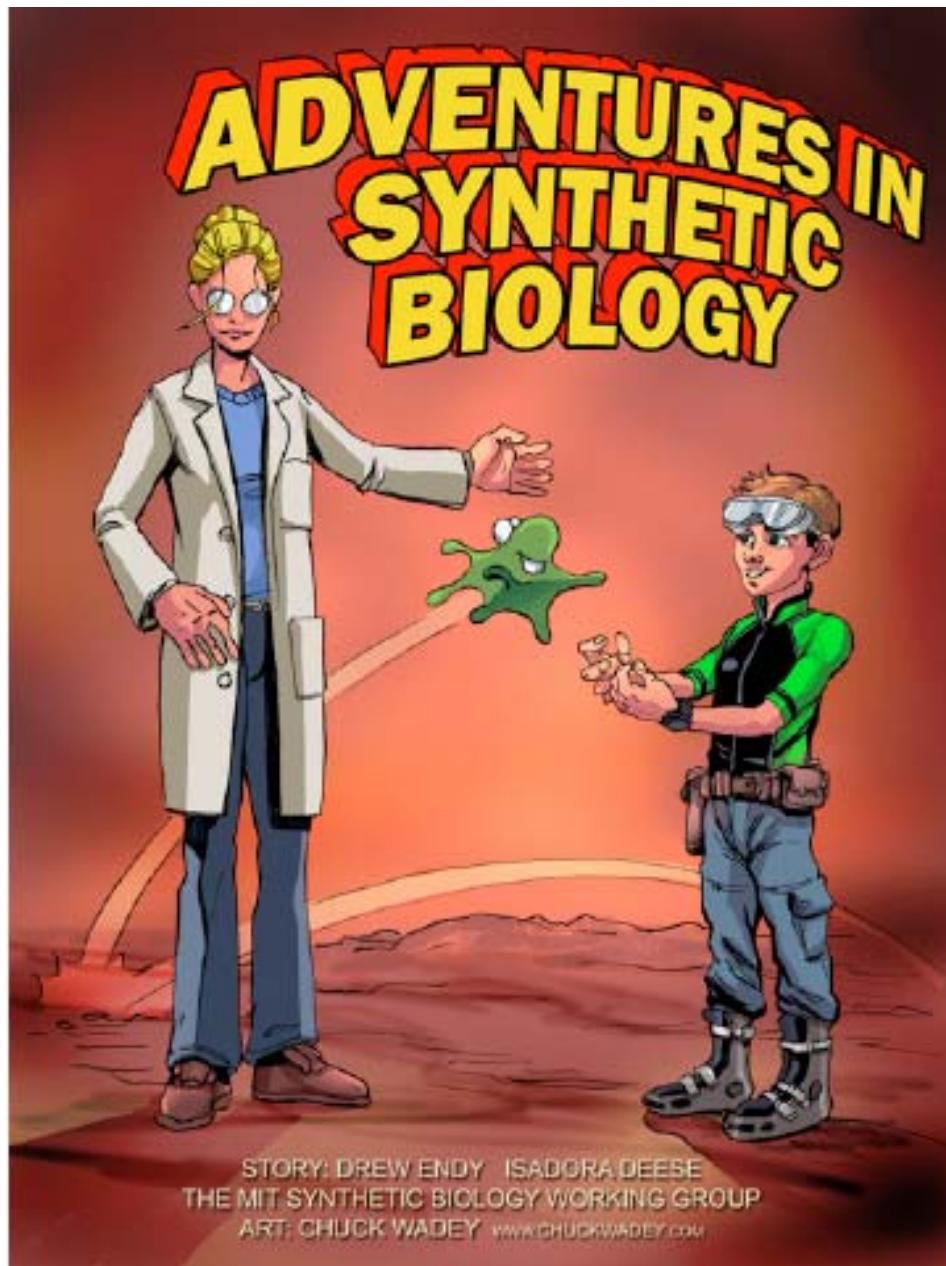
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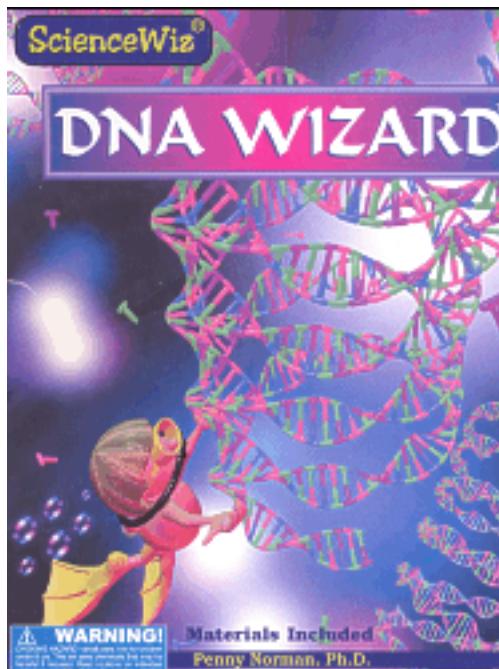
TIME

COMPUTER GENERATION A New Breed of Whiz Kids

1.3%
INFLATION VANISHES!
At Least for
A Month







Projects with DNA

For ages 8 and up
Adult Supervision Required

Materials included except for the items listed.
Through play, hands-on projects, patterns and puzzles
this book and kit explores the amazing DNA story.

The illustration shows various DNA-related projects and activities. A boy in a lab coat is shown with a white glove, with the text "Dress up for sterile techniques." nearby. There are several other activities depicted: "Extract DNA" (a beaker with green liquid), "Heat SHOCK!" (a beaker with a red liquid), "Decode the code of life" (a red bowl with a spoon), "Ooey, Gooey, DNA!" (a test tube and a dropper), "Is it a boy or girl?" (a circular image of a cell), "Grow glowing cells" (a green glowing cell in a petri dish), and "Solve the chromosome puzzle." (a grid of chromosomes). A DNA helix is shown at the top right.

Build a DNA ladder.

Extract DNA

Heat SHOCK!

Decode the code of life

Grow glowing cells

Is it a boy or girl?

Solve the chromosome puzzle.

Ooey, Gooey, DNA!

Dress up for sterile techniques.

Quality time, quality learning, quality play.