iGEM and Synthetic Biology

Opportunities for Canada

Andrew Hessel

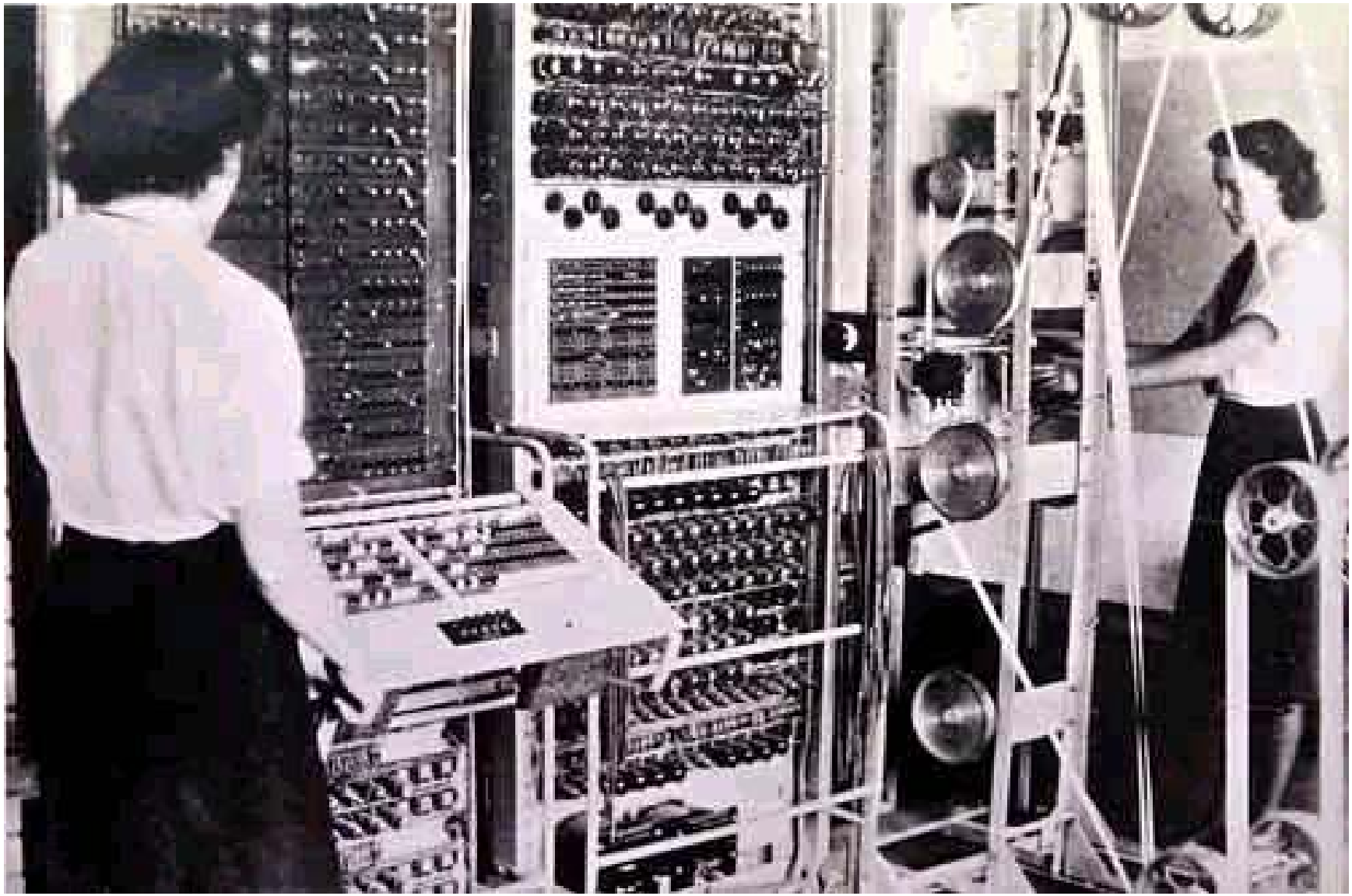
ahessel@gmail.com

University of Ottawa. November 23 2007

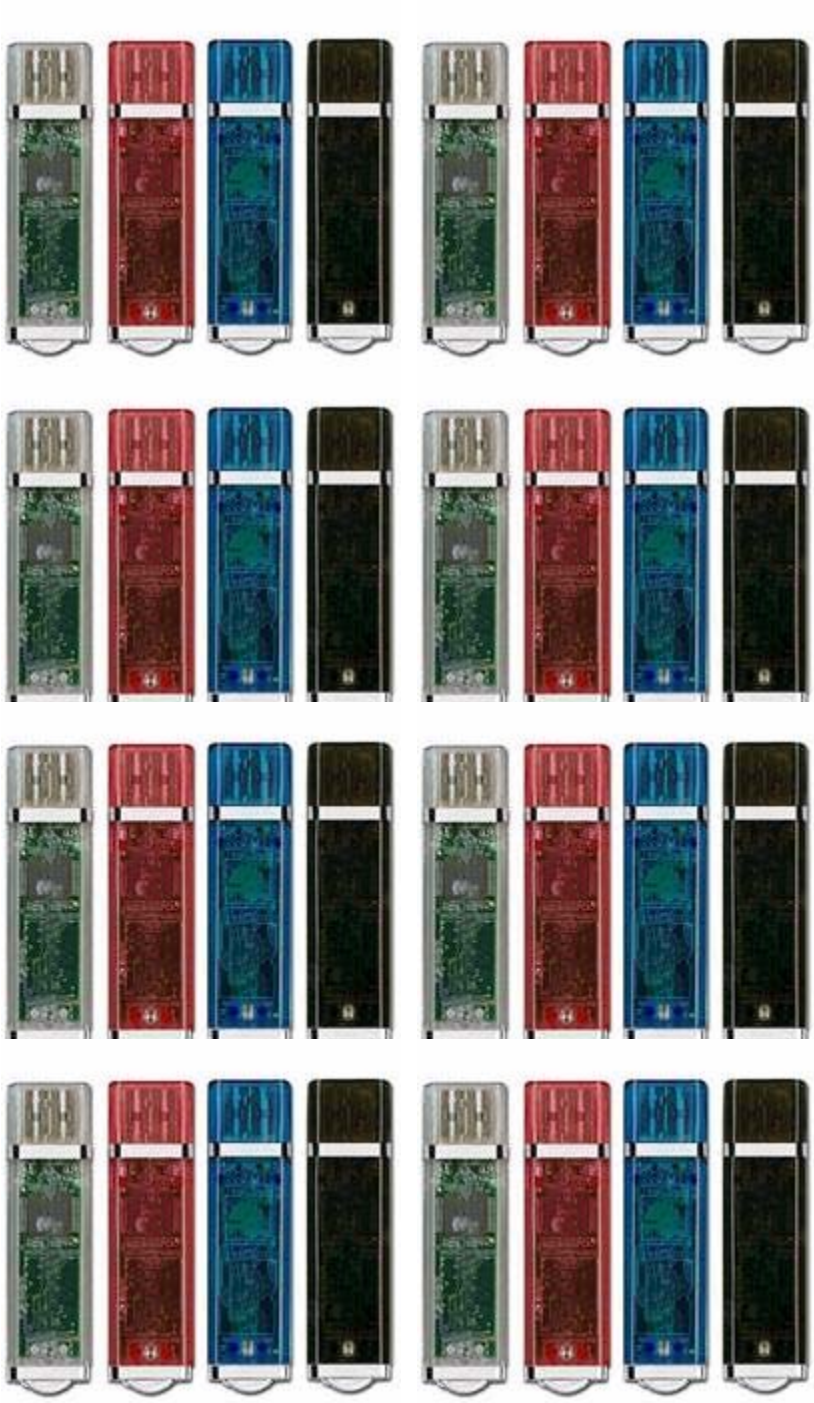
Synthetic biology is a basket of technologies that facilitate the engineering of living organisms

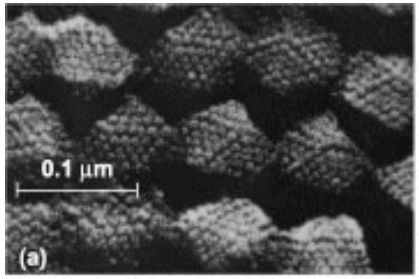
Potentially the single most important technology of this century…

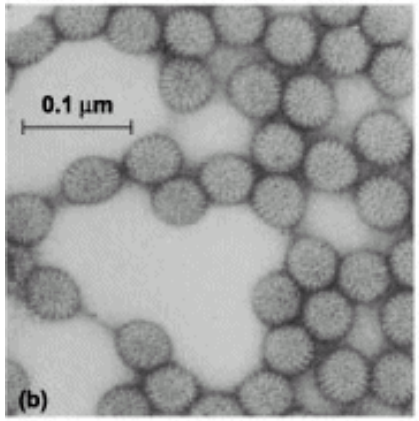

microelectronics group
A replica of the first transistor,
invented at Bell Labs,
December 23, 1947
Lucent Technologies
Bell Labs Innovations
50 Years and Counting...

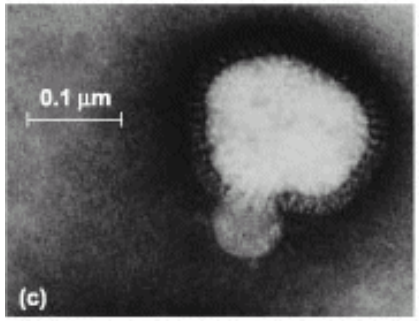


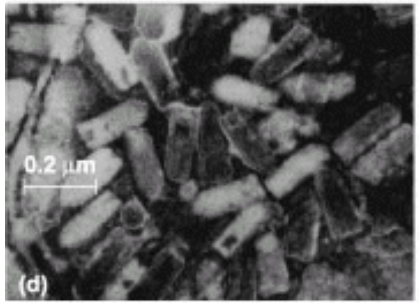

WARNING

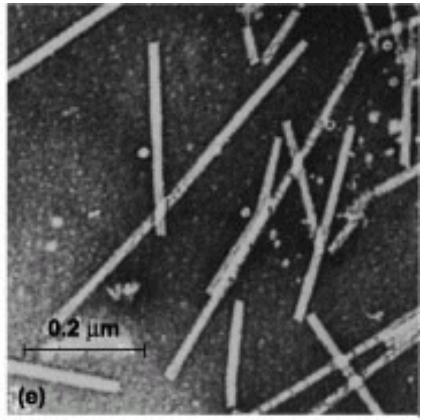


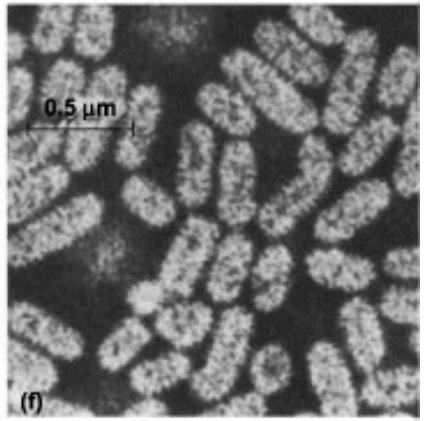


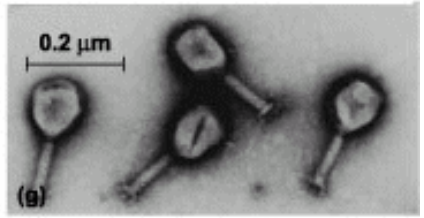


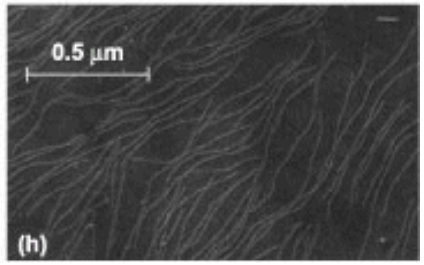












http://content.answers.com/main/content/img/McGrawHill/Encyclopedia/images/CE733500FG0010.gif

Bits (0s,1s) encode information for digital electronic processors (computers)

DNA encodes information for analog biochemical processors (cells)

DNA is source code for biological systems

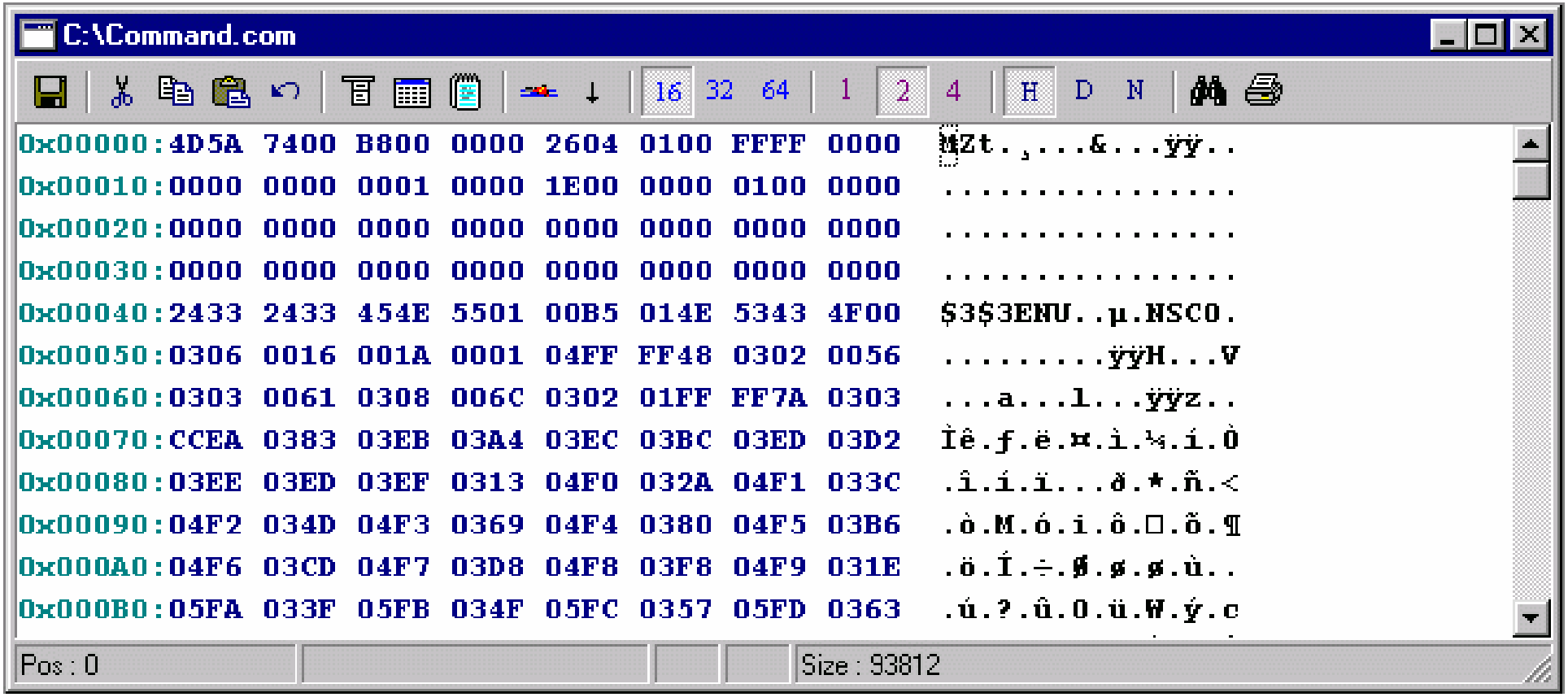
Change the code, change metabolism

Genomes are special programs that encode:

- Instructions for biochemical processors
- Machinery to duplicate the processor and install the program onto processors

Equivalent in computing not to an operating system but to all the software it would take to run a computer production line.


danielg 072006 - S3is


C:\Command.com
16 32 64 1 2 4 H D N
0x00000:4D5A 7400 B800 0000 2604 0100 FFFF 0000 MZt.¸...&...ÿÿ..
0x00010:0000 0000 0001 0000 1E00 0000 0100 0000 ....
0x00020:0000 0000 0000 0000 0000 0000 0000 0000 ....
0x00030:0000 0000 0000 0000 0000 0000 0000 0000 ....
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0x00050:0306 0016 001A 0001 04FF FF48 0302 0056 ....ÿÿH...V
0x00060:0303 0061 0308 006C 0302 01FF FF7A 0303 ...a...l...ÿÿz..
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0x000B0:05FA 033F 05FB 034F 05FC 0357 05FD 0363 .ú.?.û.O.ü.W.ý.c
Pos : 0
Size : 93812

http://www.colorado.edu/MCDB/MCDB1111/intrographics/bacterial%20chromosome.jpg

http://academy.asd20.org/kadets/lundberg/ethics/images/chromosomes.jpg

ATG-TCA-AAT-AAA-AGT-AAT-GAT-AAT-GGC-AGA-GCA-TAT-GAG-TTT-GCA-TTT-ATA-AAT-GAA-
TTA-GGA-CGC-ATT-GCA-ACT-CAA-AAT-CAG-AAT-ATA-AAT-ATC-GAA-AAG-AAT-TCT-AGC-TAT-
TAC-GTA-GTT-GAG-AAA-TCT-TGG-AGT-ACA-TTA-TCG-GAT-CTT-GAA-AAA-GAA-AAA-TAT-ACA-
AAA-AGT-GCA-ATT-GCT-GGT-ATC-AAT-CTT-ATA-ACA-AGC-TTA-GAG-CCA-ATA-ATA-GAA-GAT-
GGT-AAT-GGT-GTA-TTA-AAC-TTA-AAA-ATA-CAA-GCT-GAT-AAT-AAA-GGT-GAA-TTA-GGC-GAT-
ATT-AGA-GAT-ATT-TTA-ATT-CAA-AGA-GAA-AAT-ATT-AAT-TGG-GAA-ATT-GGT-TTA-AGT-TTA-
AAA-CAT-AAT-CAT-TTT-GCT-GTG-AAA-CAT-AGT-CGT-TTA-TCA-CAT-AAA-ATT-GAT-TTT-TCA-
GAA-AAA-TGG-TTC-CAA-TTA-CCT-TCT-TCT-CAA-AAT-TAT-TGG-GAT-AAT-ATA-CTC-CCT-ATT-
TTT-GAG-AAA-TTA-GAA-ATT-TAT-AAA-AAA-GAT-AAA-ATA-AAA-TGG-AGA-GAG-TTA-TCT-AAT-
AAA-GAA-GAT-TGC-ATT-TAT-TAT-CCC-ATA-CTT-AAA-TCA-TTT-ATA-GCA-GAA-ATT-AAA-GAA-
AAG-TAT-GAT-AAA-TAT-AAT-TCT-ATT-GTT-CCA-CAG-AGA-ATG-GTT-GAA-TAT-TTA-CTT-GGA-
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AGT-AAA-AAC-ACG-GTT-GAA-TTA-TAT-TTA-GAT-AAA-GGA-TGG-CAA-TTT-AGT-TTT-AGA-ATA-
CAT-AAT-GCT-TCT-ACT-ATT-ATT-GAA-CCG-AGC-TTG-AAA-TTT-GAT-ATA-AAA-CTT-ATT-GGT-
GTT-CCT-GCC-ACA-ATA-ATT-TGT-TTA-GAG-ACC-CCT-TGG-GAA-GAA-TGA

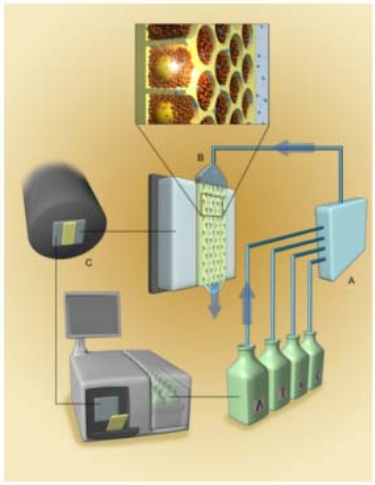
Nobel foundation

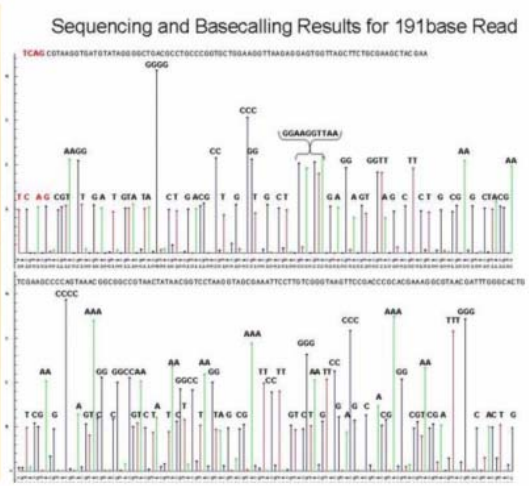
1980
500 bp/day (manual)

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

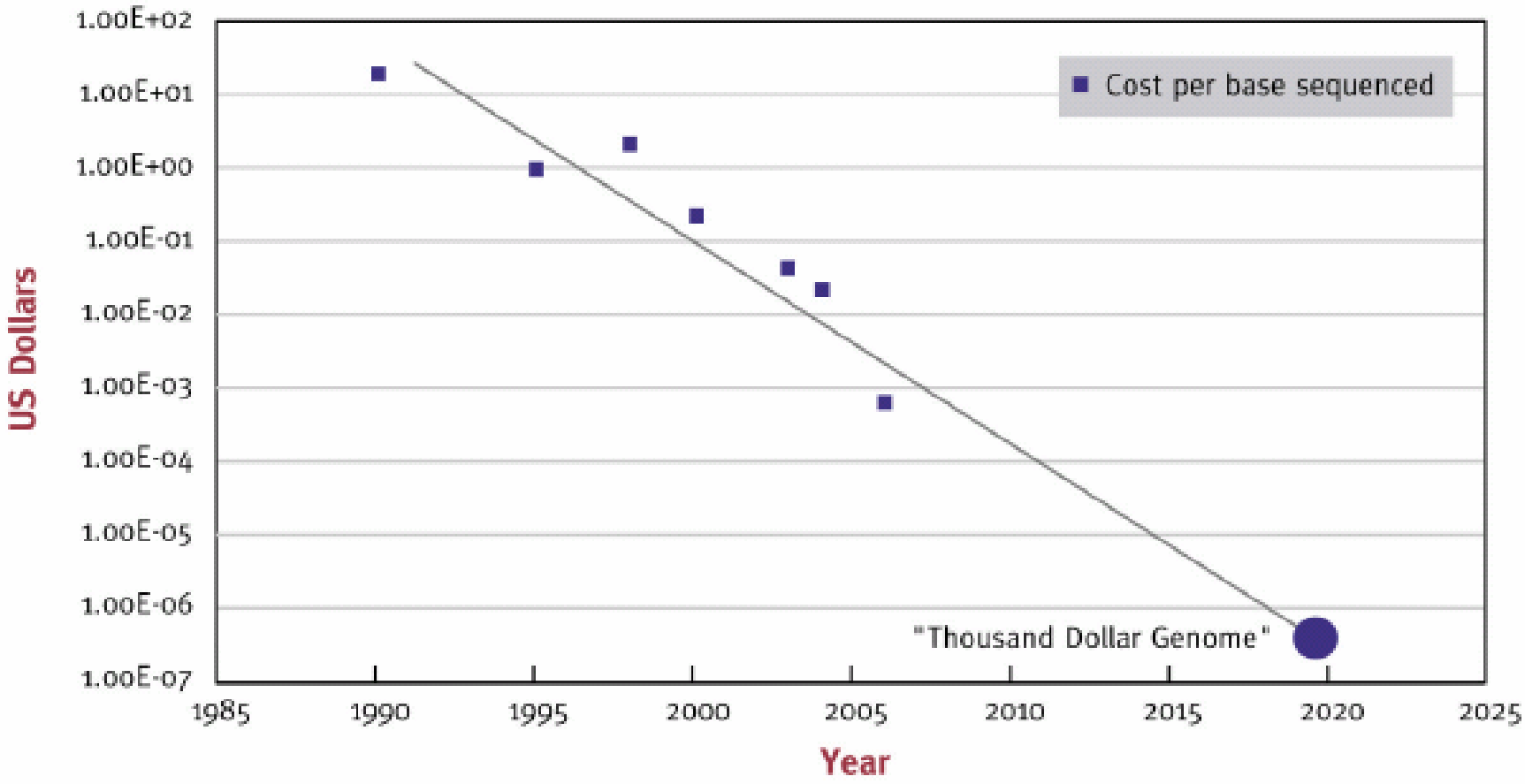
1995
144,000 bp/day (semi-auto)

1998
500,000 bp/day (automatic)



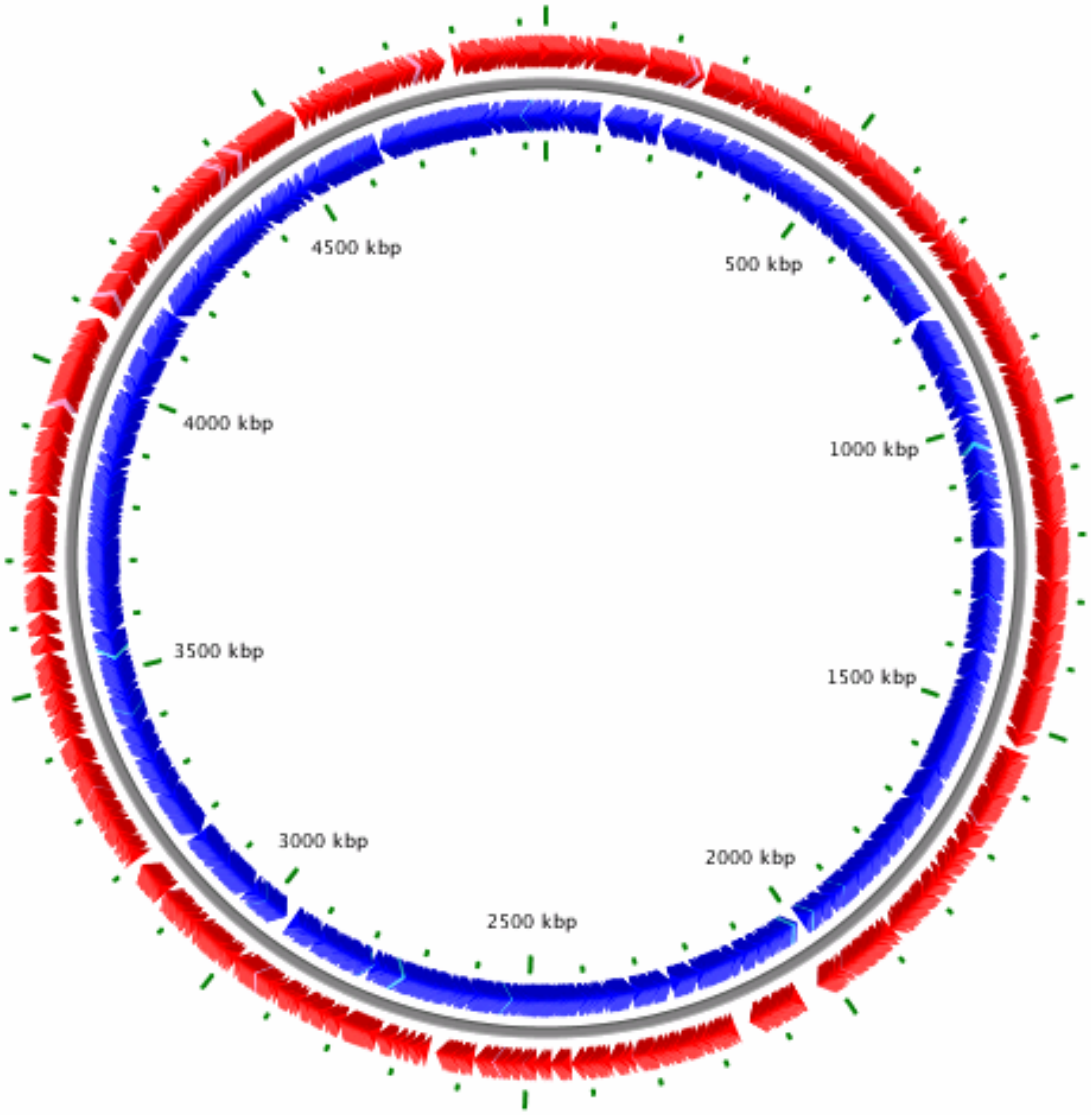


2007 – Sequencing by Synthesis
1GB bp/day (automatic)



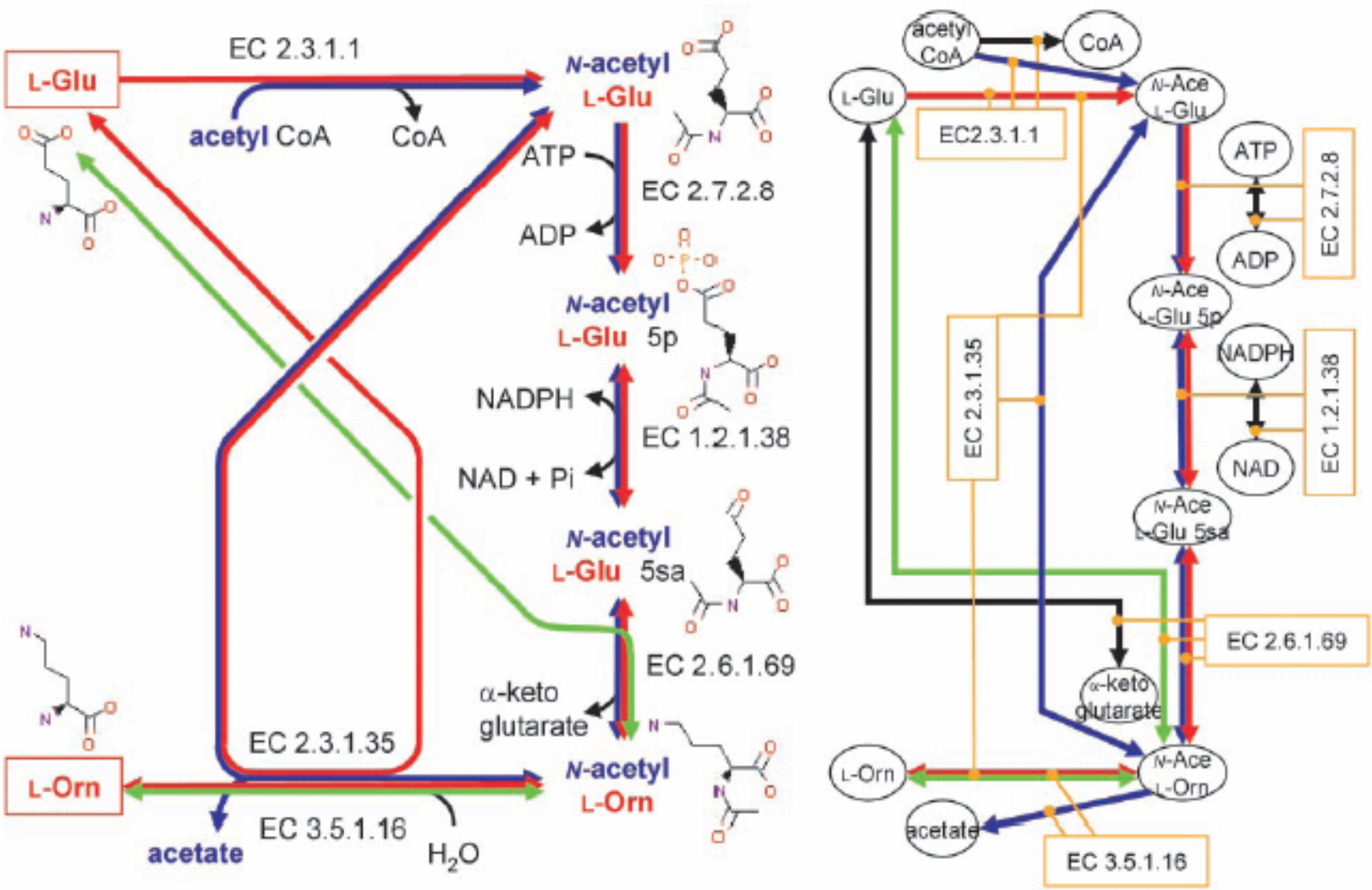
Source: R. Carlson, Bio-era

Escherichia coli 536, complete genome

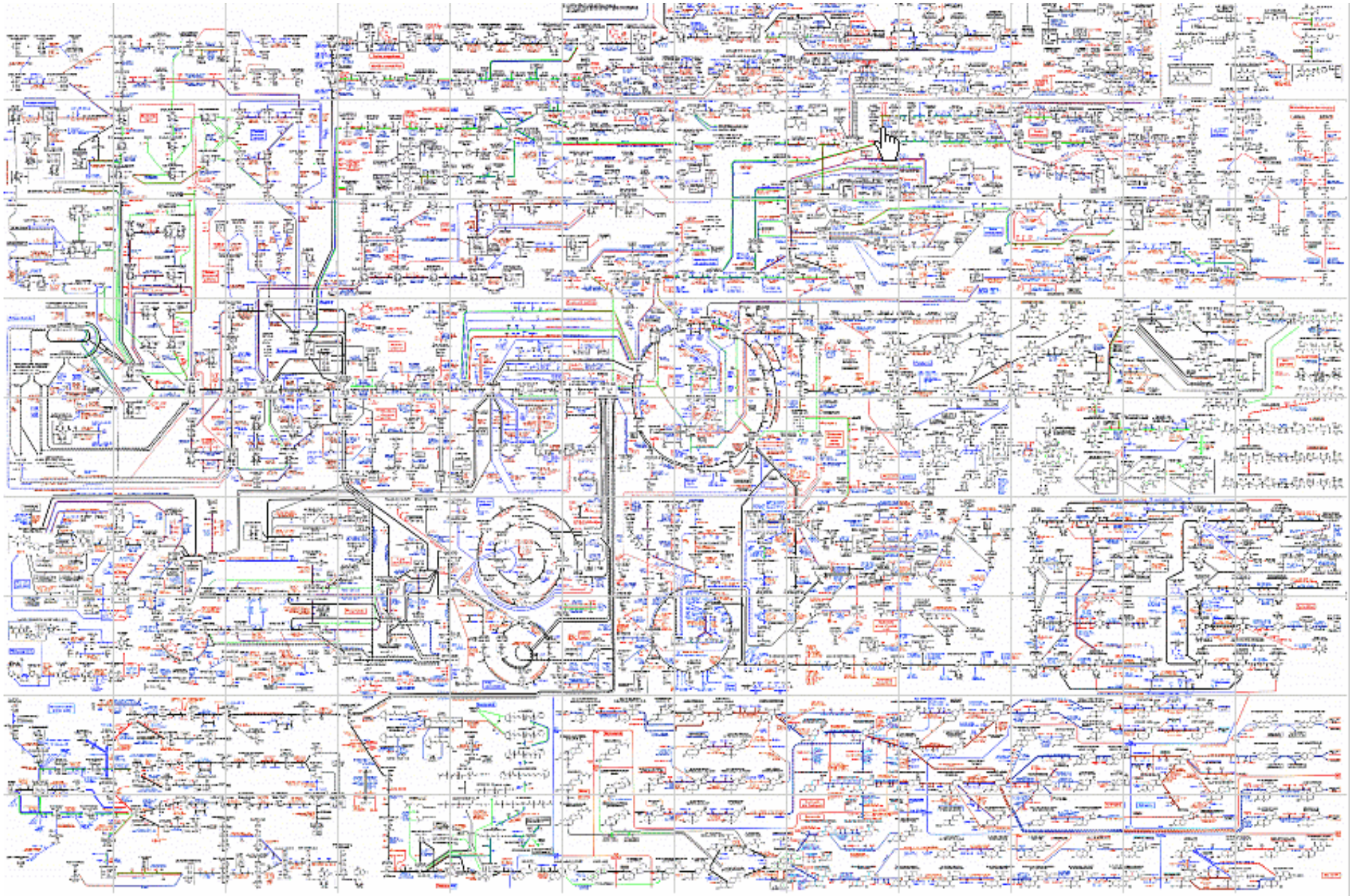


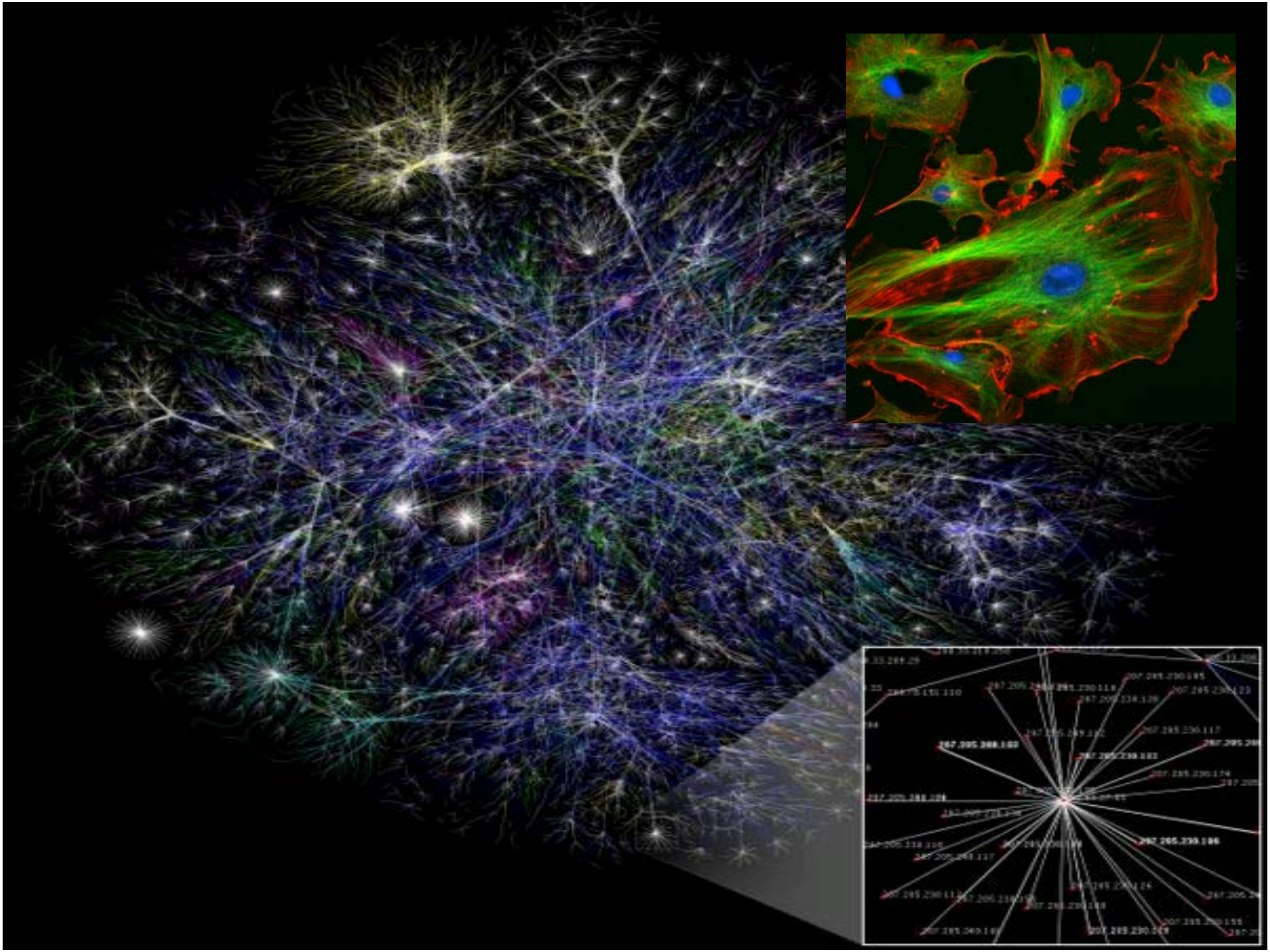
Accession: NC_008253

Topology: circular; Length: 4,938,920 bp; Genes: 4,732



Ornithine biosynthesis





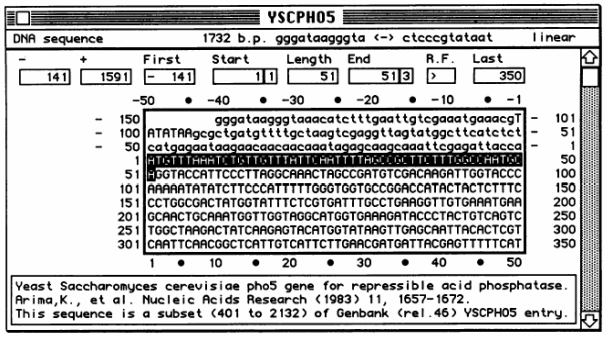
Volume 16 Number 5 1988 Nucleic Acids Research

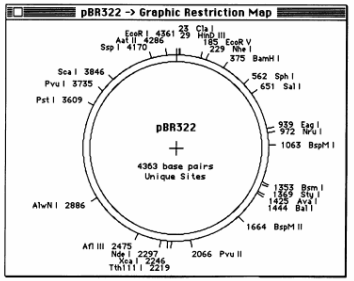
'DNA Strider': a 'C' program for the fast analysis of DNA and protein sequences on the Apple Macintosh family of computers

Christian Marck

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

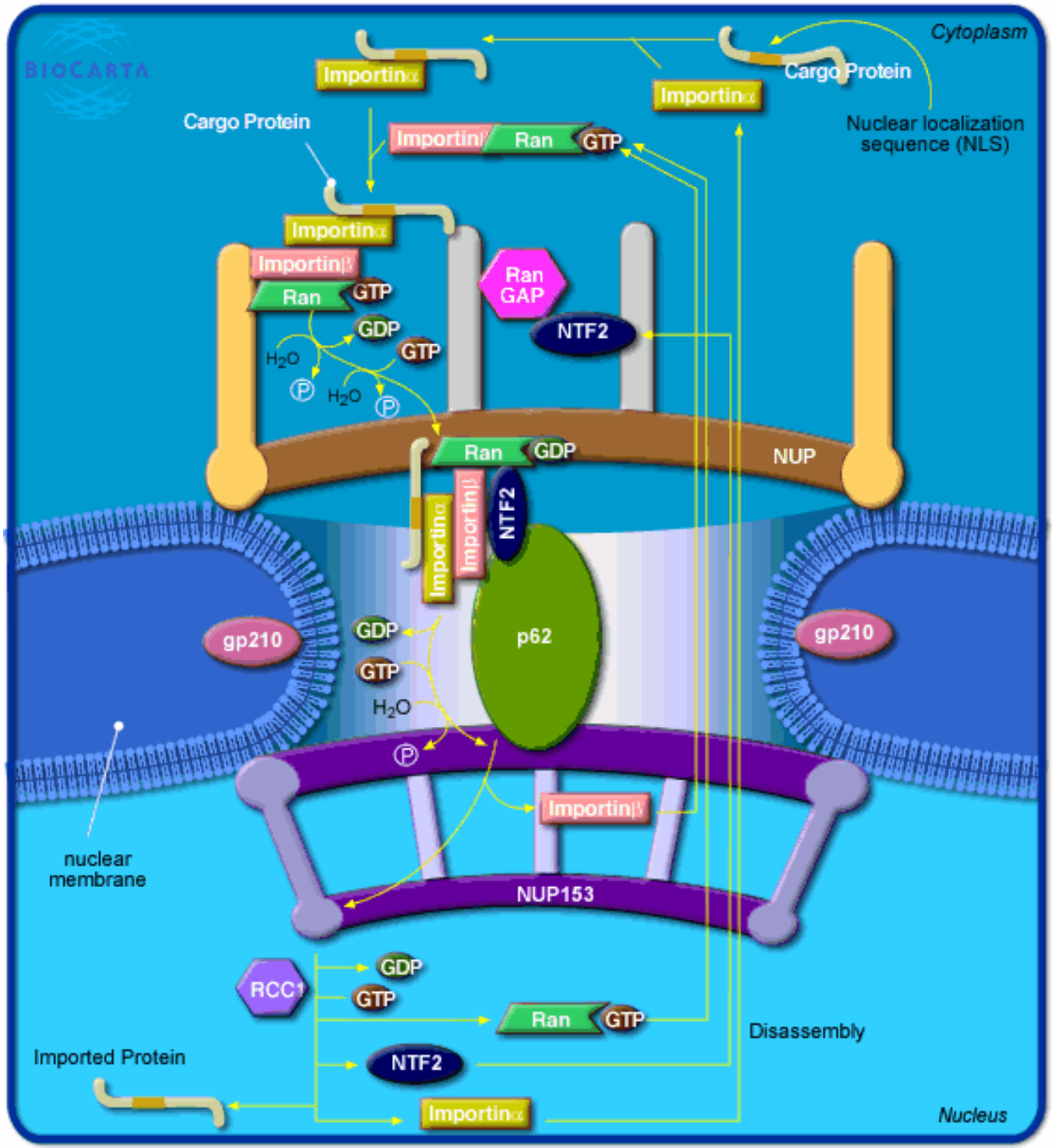
Received August 17, 1987; Revised and Accepted November 15, 1987

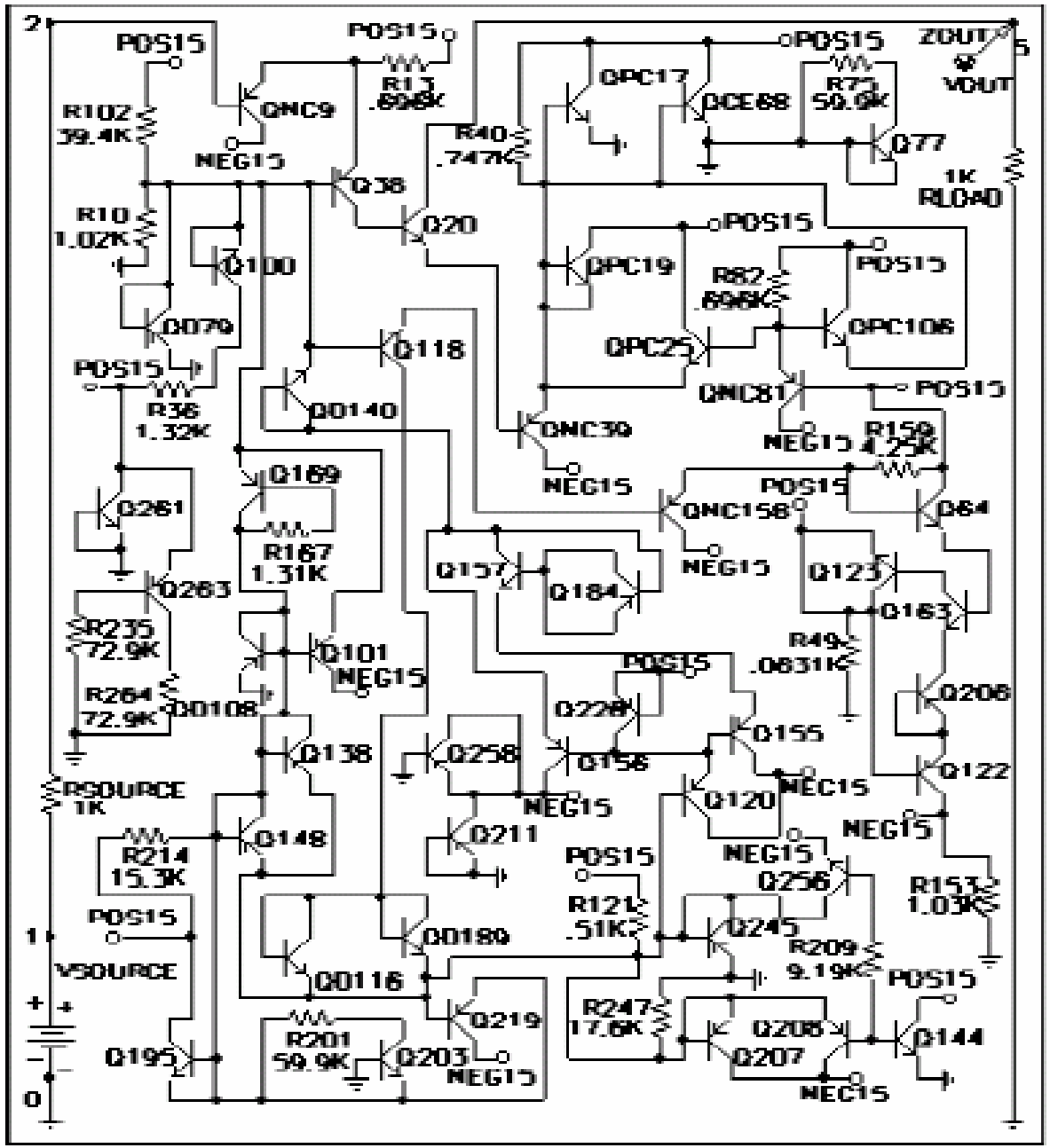




IBM's BlueGene/L: world's fastest supercomputer, 3 years running

478.2 TFLOPS with 131072 nodes

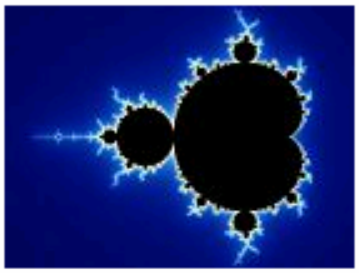

BIOCARTA
Cytoplasm
Importinα
Cargo Protein
Importinα
Cargo Protein
Nuclear localization sequence (NLS)
Cargo Protein
Importinβ
Ran
GTP
Importinα
Importinβ
Ran
GTP
Ran GAP
NTF2
GDP
GTP
H2O
P
H2O
P
Ran
GDP
NUP
Importinα
Importinβ
NTF2
gp210
GDP
GTP
H2O
p62
gp210
P
Importinβ
nuclear membrane
NUP153
RCC1
GDP
GTP
Ran
GTP
Disassembly
Imported Protein
NTF2
Importinα
Nucleus



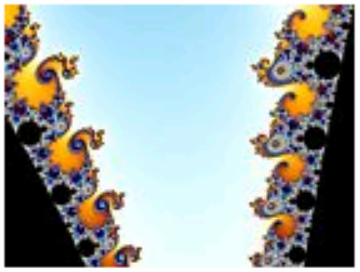
J.R. Koza et al.
Automatic creation of computer programs for designing electrical circuits using genetic programming.

http://www.genetic-programming.com/jkpdf/acdm1998.pdf

$$M = \left\{ c \in \mathbb{C} : \sup_{n \in \mathbb{N}} |f_c^n(0)| < \infty \right\}.$$


Start


Step 1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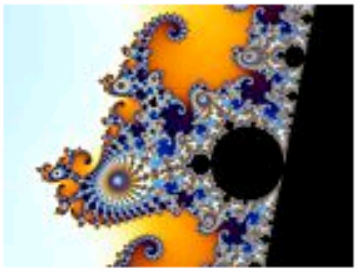
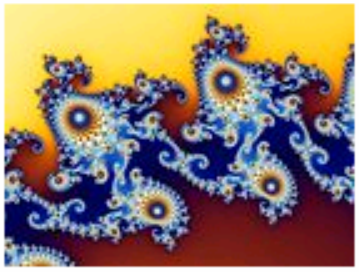

Step 3


Step 4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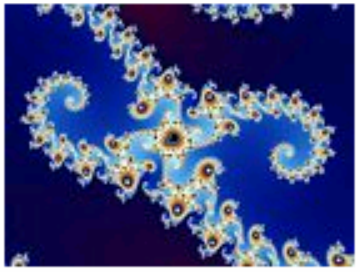
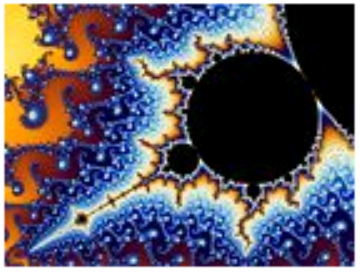
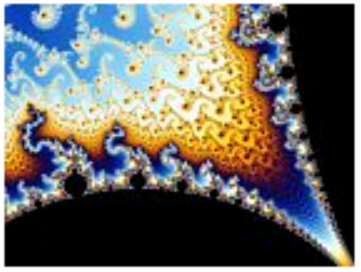
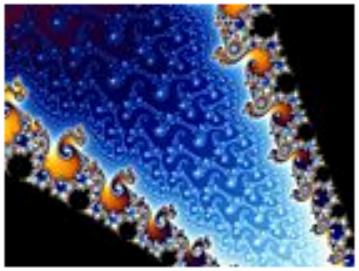

Step 6


Step 7


Step 8


Step 9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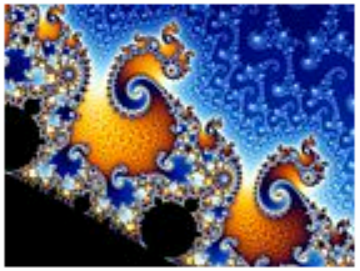
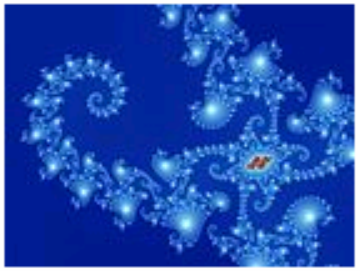
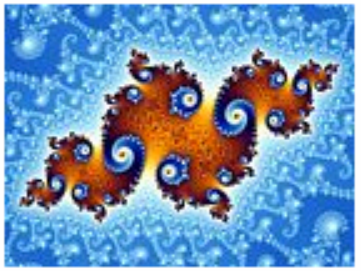
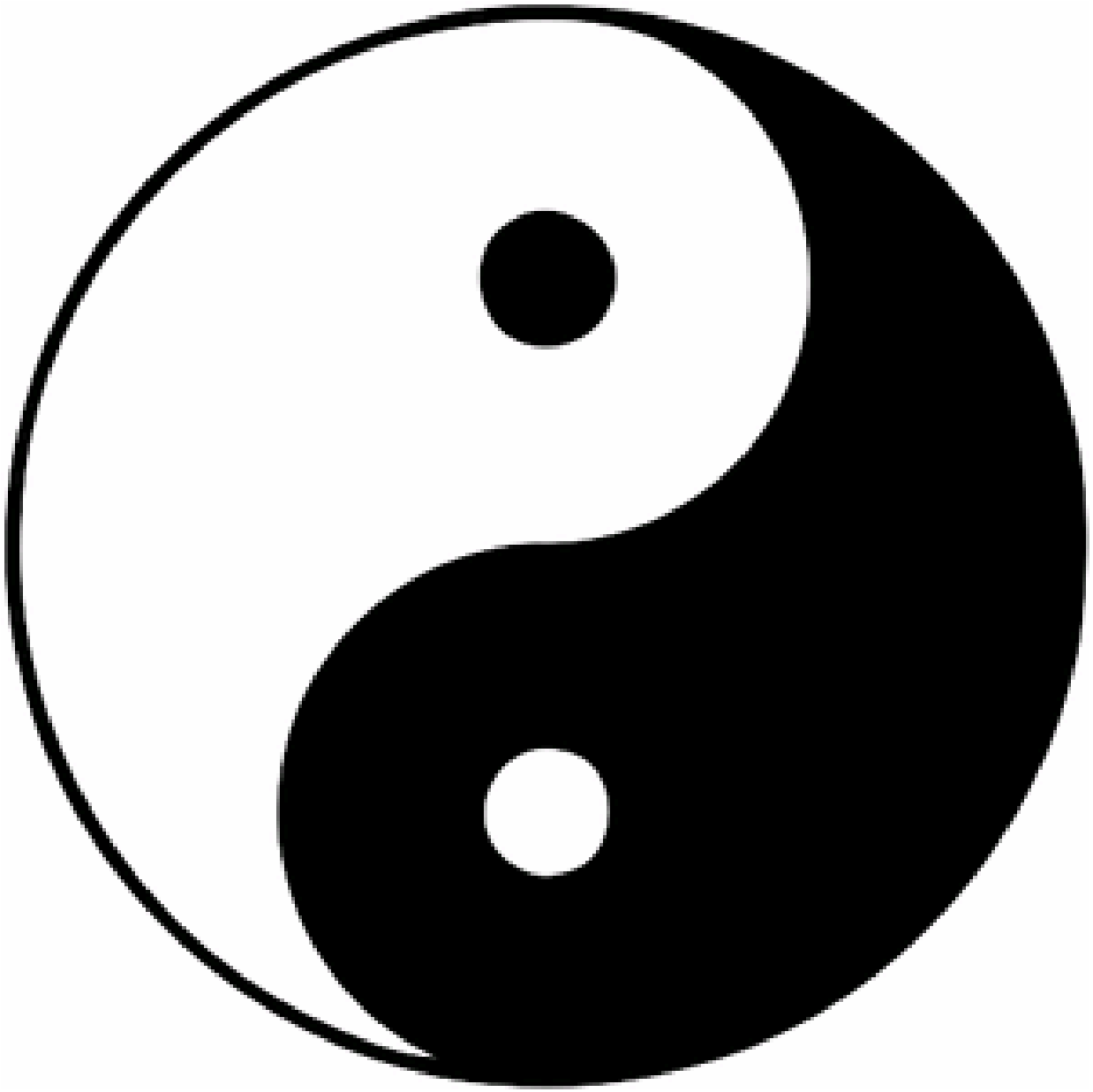

Step 11


Step 12


Step 13


Step 14

Reduction | Complexity



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

Genetic “Engineering”

Writing code

Proc. Nat. Acad. Sci. USA
Vol. 69, No. 10, pp. 2904–2909, October 1972

Biochemical Method for Inserting New Genetic Information into DNA of Simian Virus 40: Circular SV40 DNA Molecules Containing Lambda Phage Genes and the Galactose Operon of *Escherichia coli*

(molecular hybrids/DNA joining/viral transformation/genetic transfer)

DAVID A. JACKSON*, ROBERT H. SYMONS†, AND PAUL BERG

Department of Biochemistry, Stanford University Medical Center, Stanford, California 94305

Contributed by Paul Berg, July 31, 1972

Proc. Nat. Acad. Sci. USA
Vol. 70, No. 11, pp. 3240–3244, November 1973

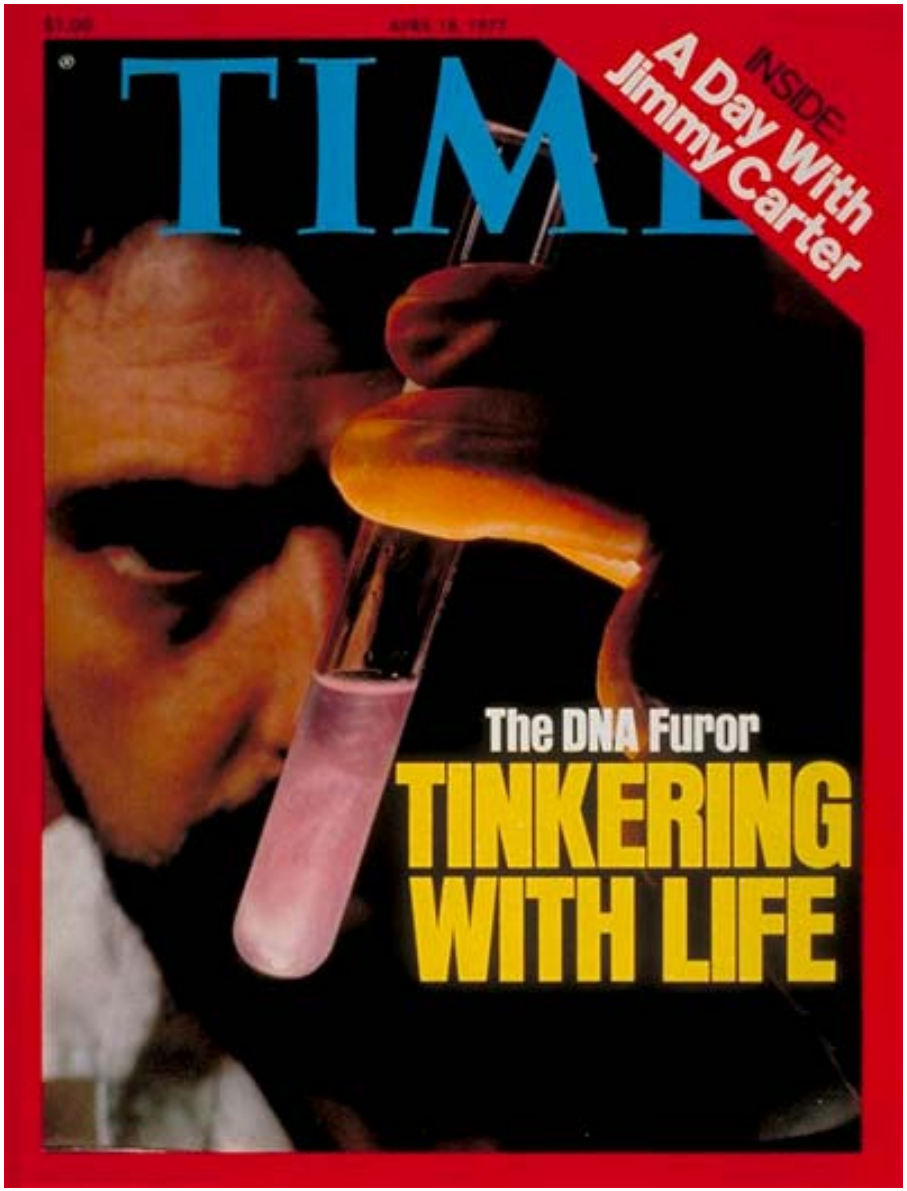
Construction of Biologically Functional Bacterial Plasmids *In Vitro*

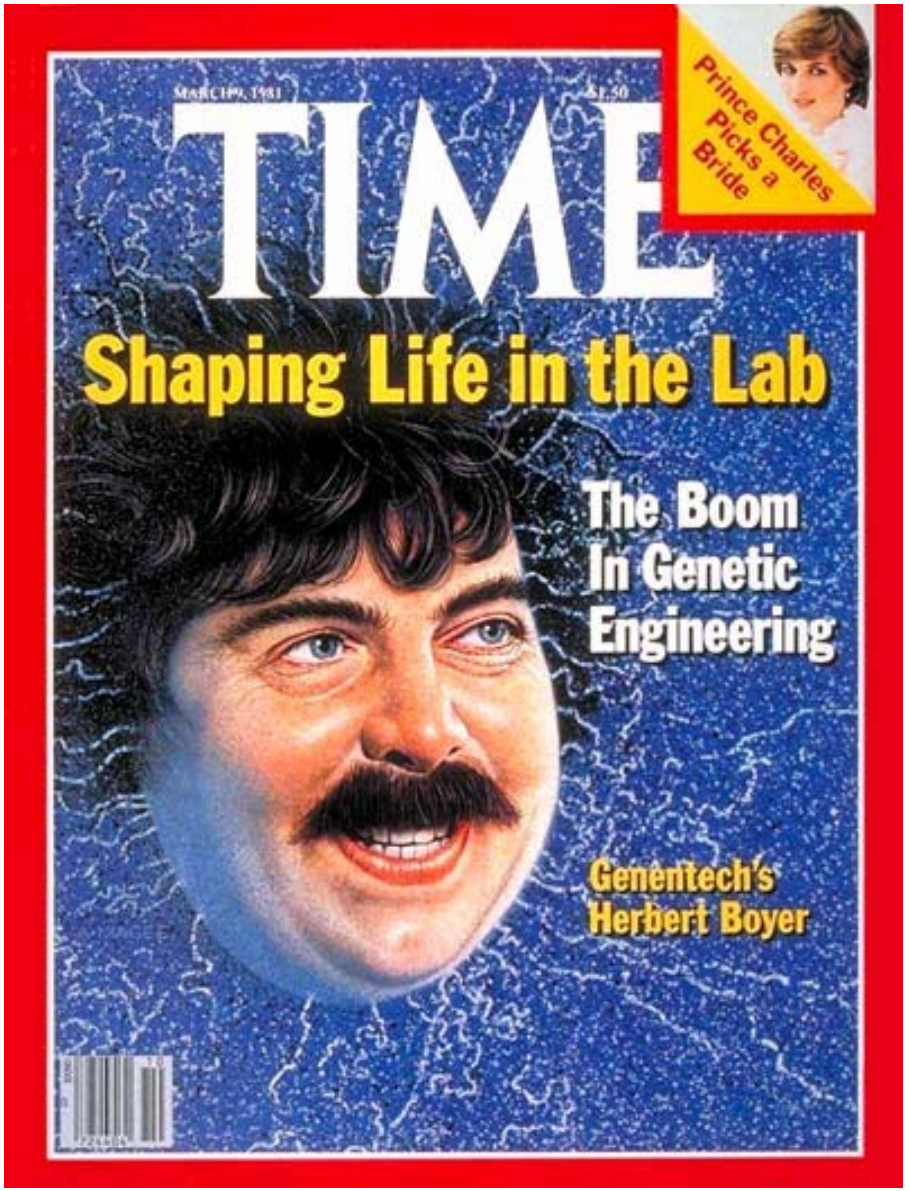
(R factor/restriction enzyme/transformation/endonuclease/antibiotic resistance)

STANLEY N. COHEN*, ANNIE C. Y. CHANG*, HERBERT W. BOYER†, AND ROBERT B. HELLING†

* Department of Medicine, Stanford University School of Medicine, Stanford, California 94305; and † Department of Microbiology, University of California at San Francisco, San Francisco, Calif. 94122

Communicated by Norman Davidson, July 18, 1973


TIME
INSIDE
A Day With Jimmy Carter
The DNA Furor
TINKERING WITH LIFE


TIME
Prince Charles Picks a Bride
Shaping Life in the Lab
The Boom In Genetic Engineering
Genentech's Herbert Boyer

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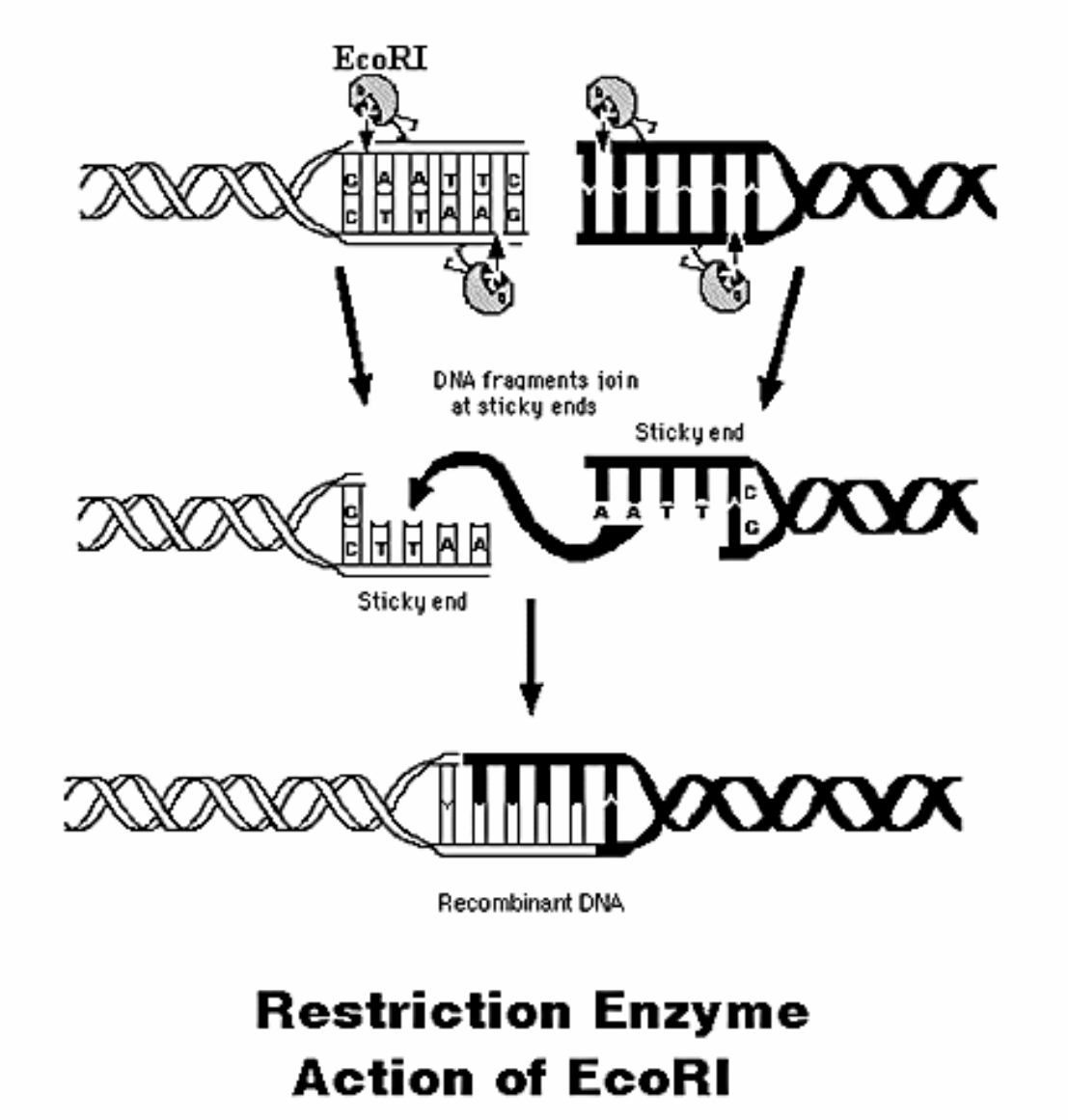
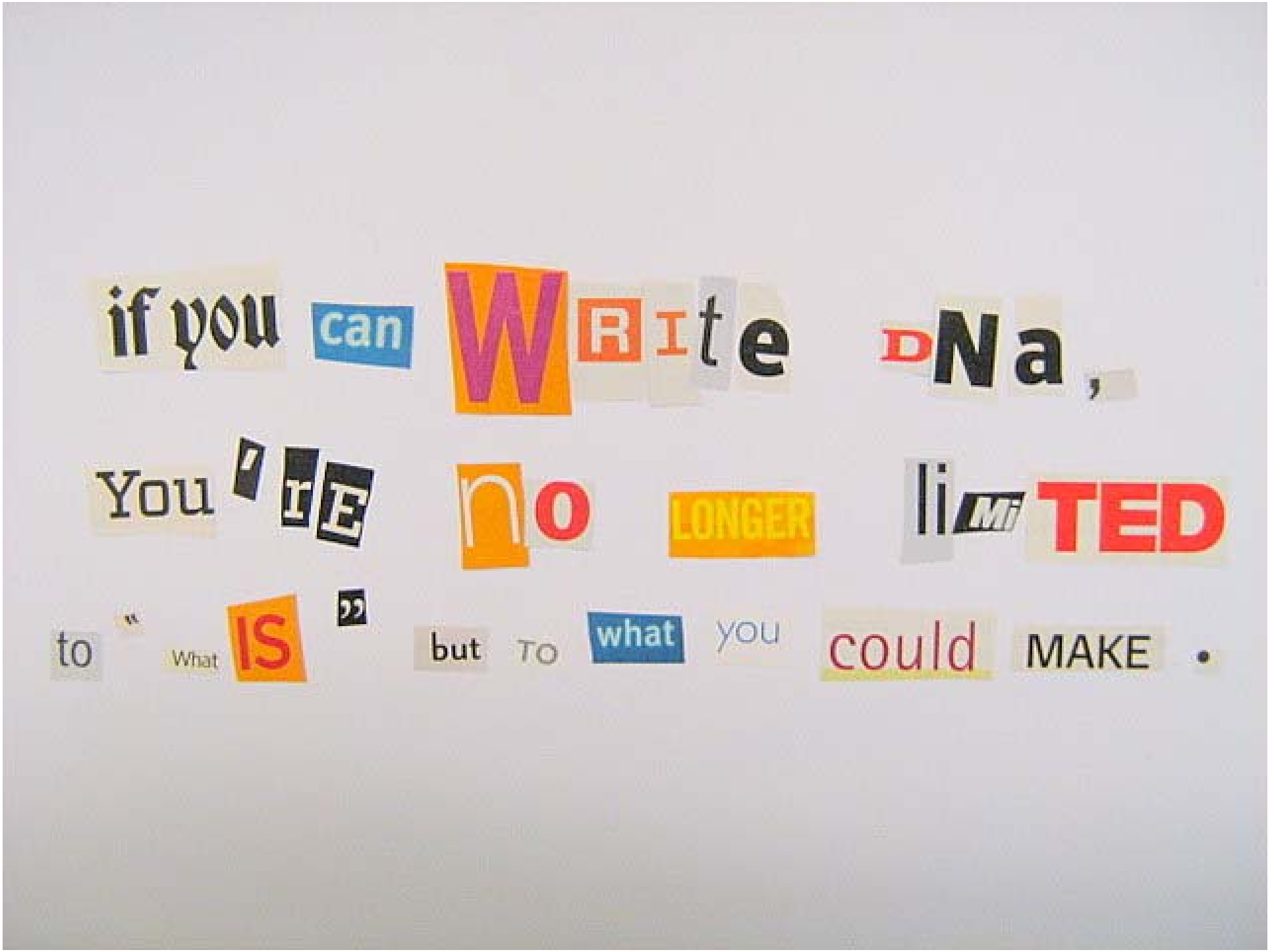


Restriction Enzyme Action of EcoRI

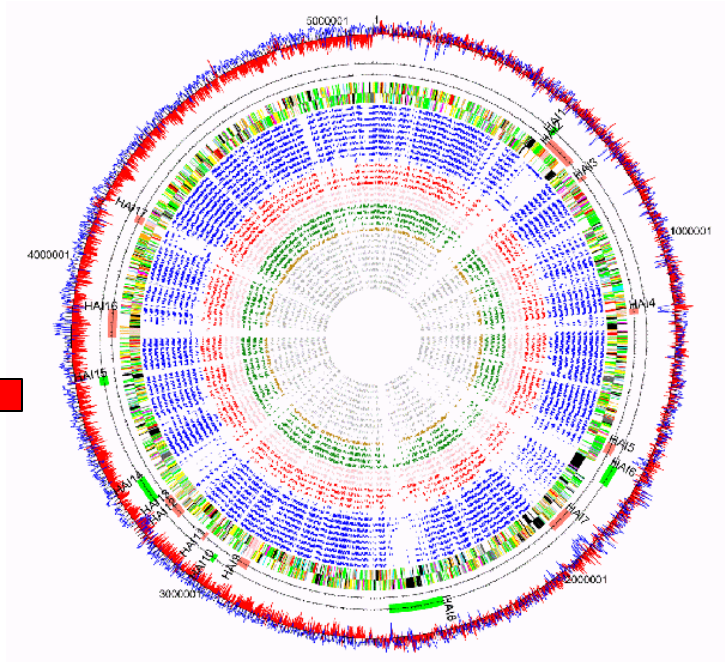

if you can WRIte DNa,
You 're no LONGER limiTED
to " What IS " but TO what you could MAKE .

http://en.wikipedia.org/wiki/Image:Metal_movable_type.jpg

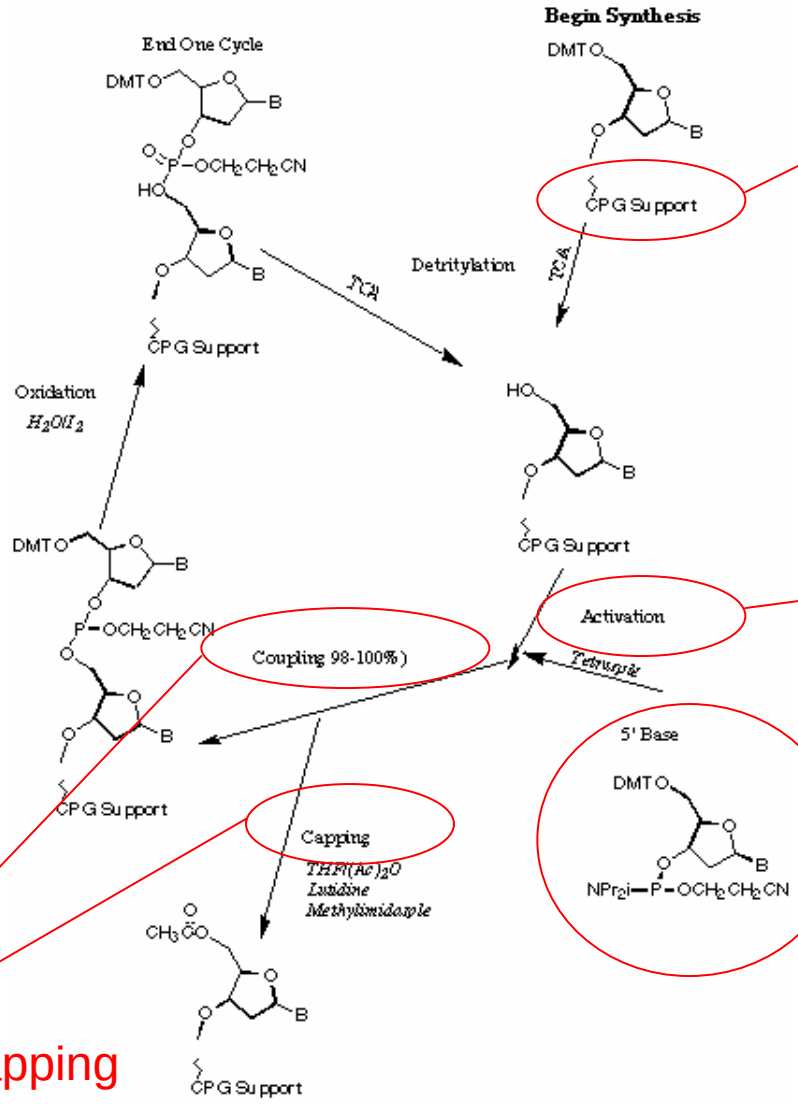
Physical DNA

sequencing

synthesis



Digital DNA

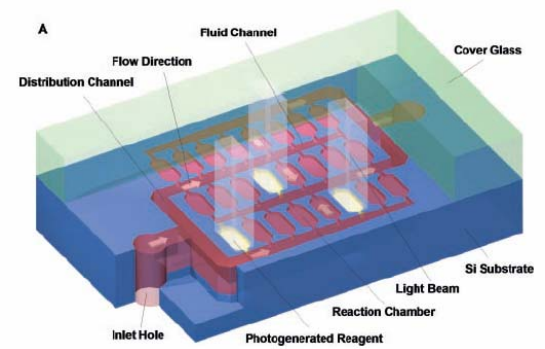


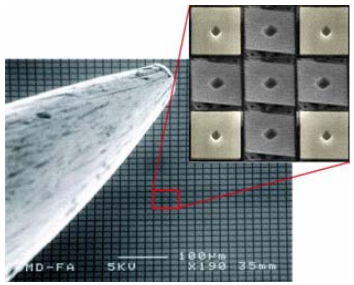
Controlled Pore Glass Solid Support

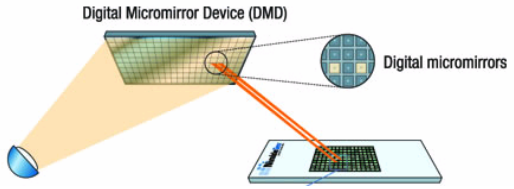
Activation (acid) and new base addition

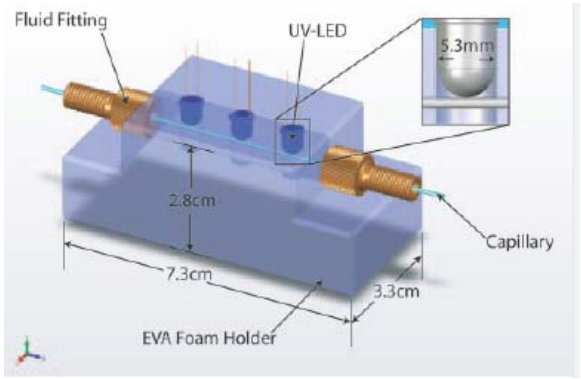
Coupling and Capping


BECKMAN


A
Fluid Channel
Flow Direction
Distribution Channel
Cover Glass
Si Substrate
Light Beam
Reaction Chamber
Inlet Hole
Photogenerated Reagent




Digital Micromirror Device (DMD)
Digital micromirrors


Fluid Fitting
UV-LED
5.3mm
2.8cm
Capillary
7.3cm
3.3cm
EVA Foam Holder

MILLIGEN / MILLIPORE DNA SYNTHESIZER CYCLONE PLUS 8400

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1 of 9

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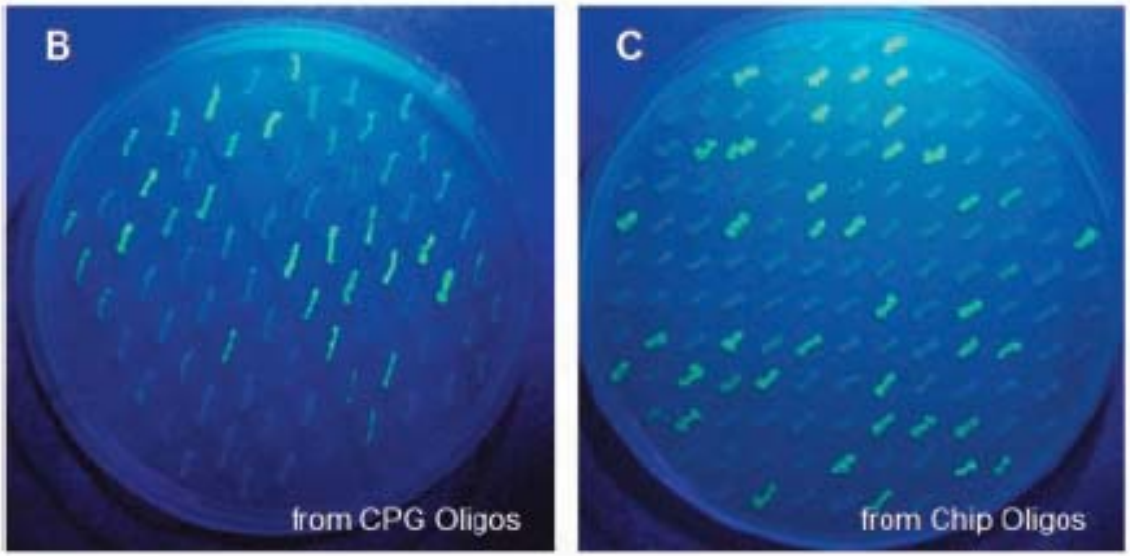
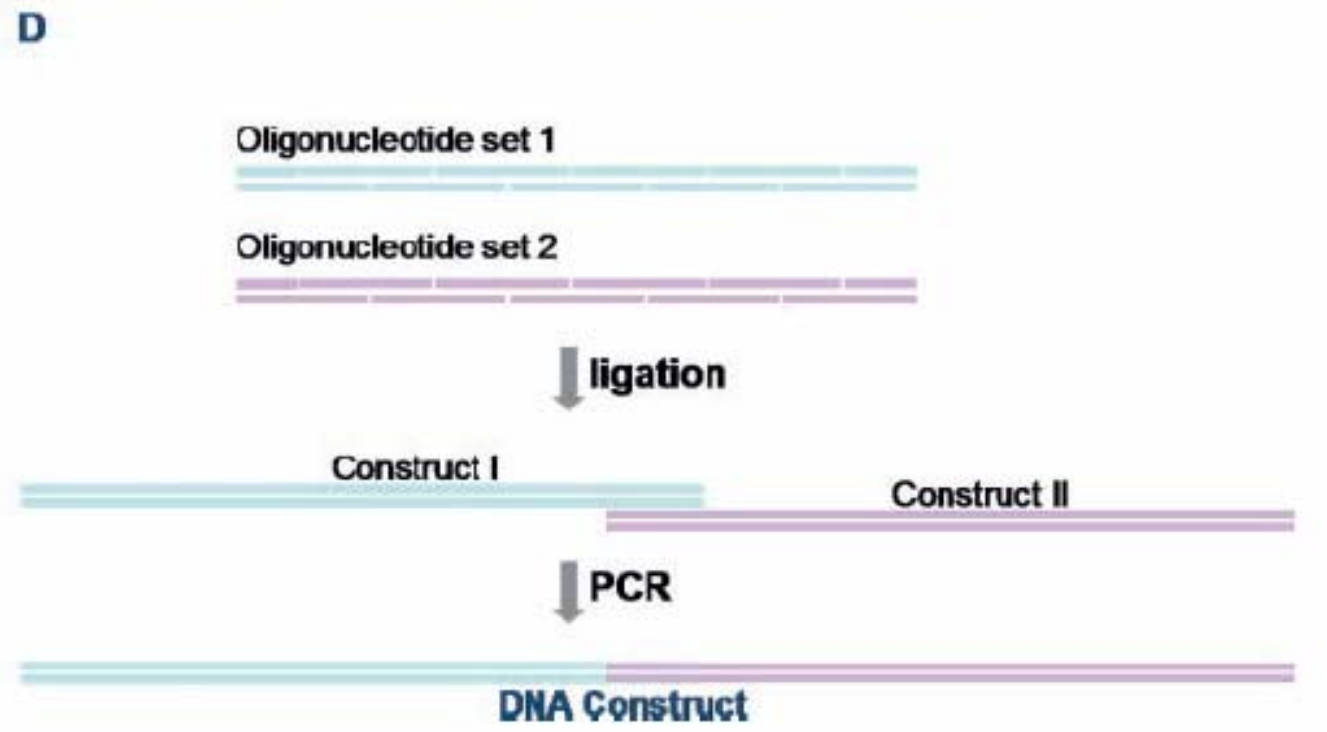


EGFP gene 714 bp



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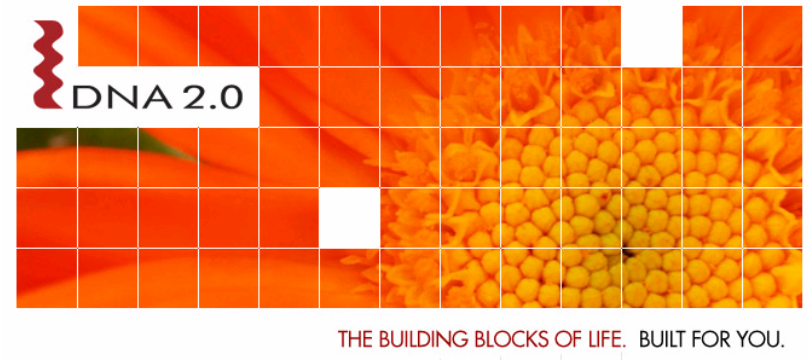
www.blueheronbio.com



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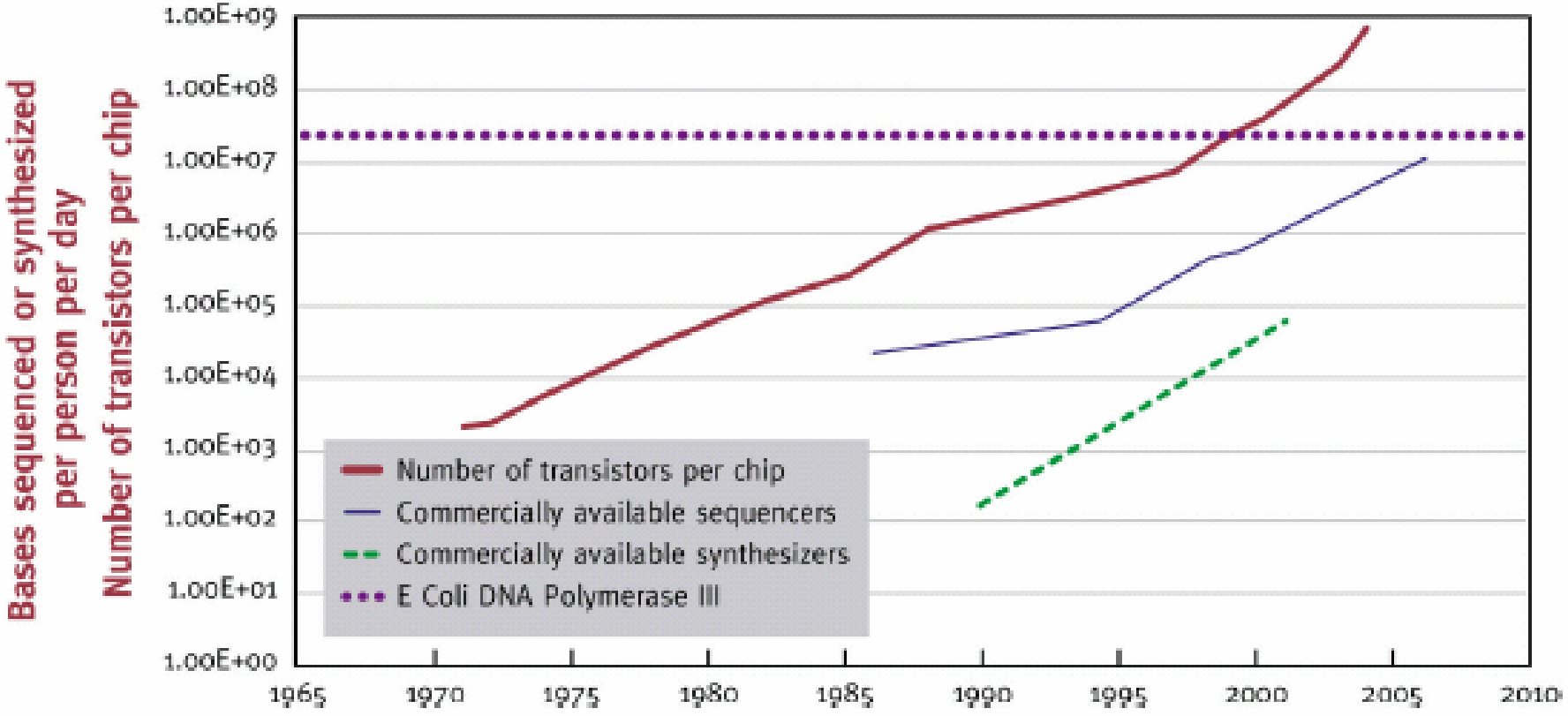
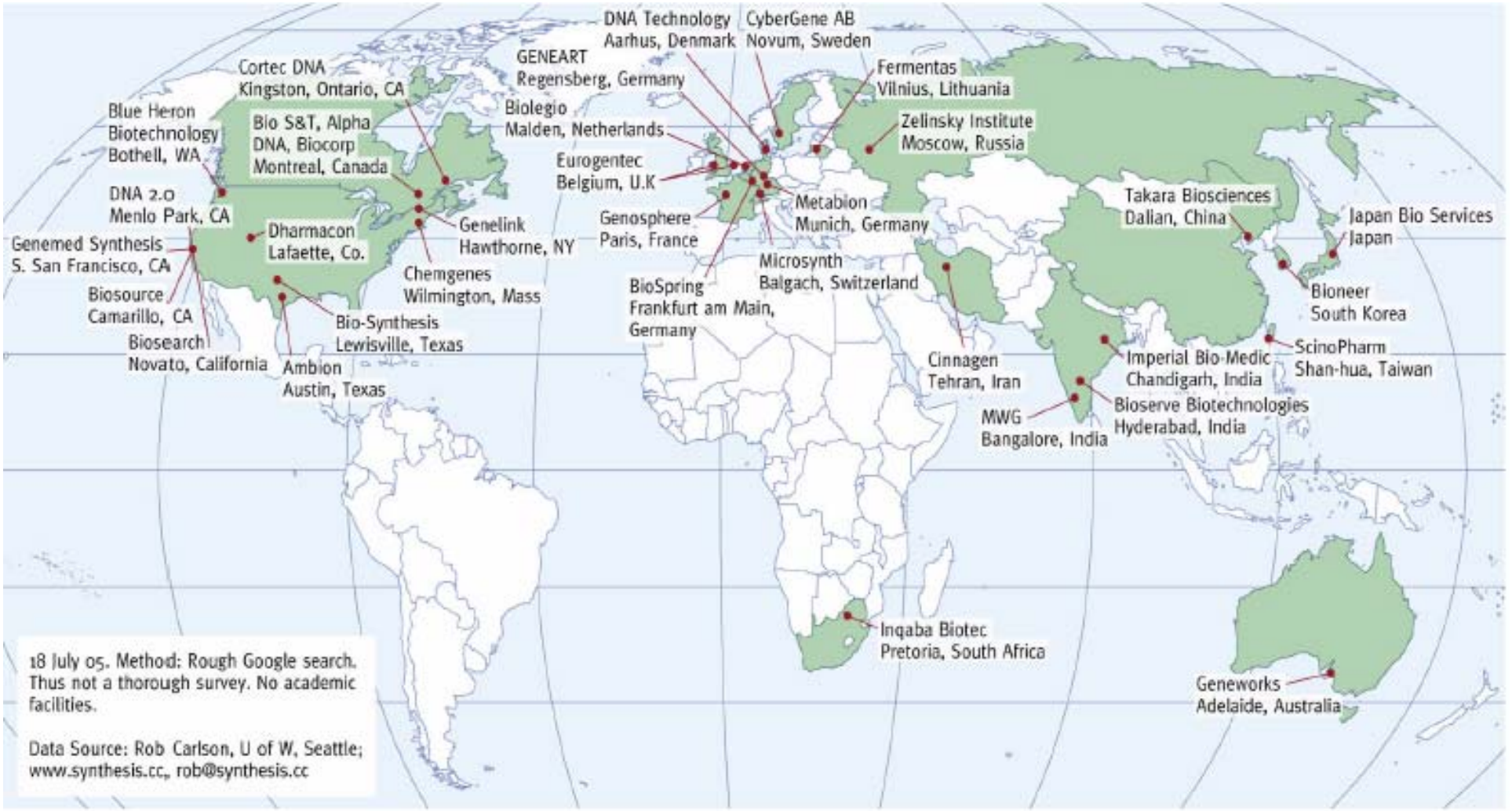
BIOTECHNOLOGY



Source: R. Carlson, Bio-era.



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

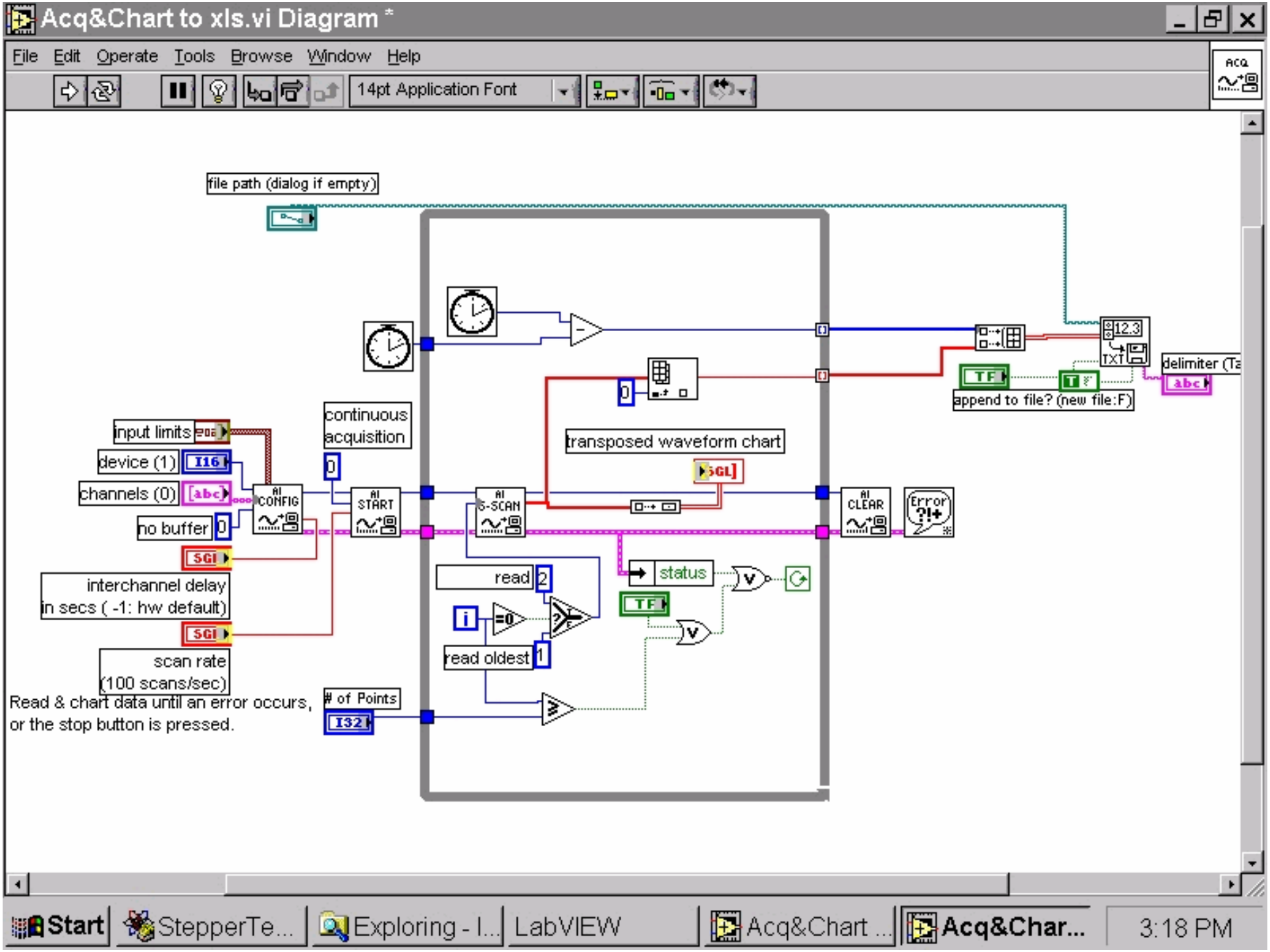
Designed for
Microsoft®
Windows NT®
Windows® 98

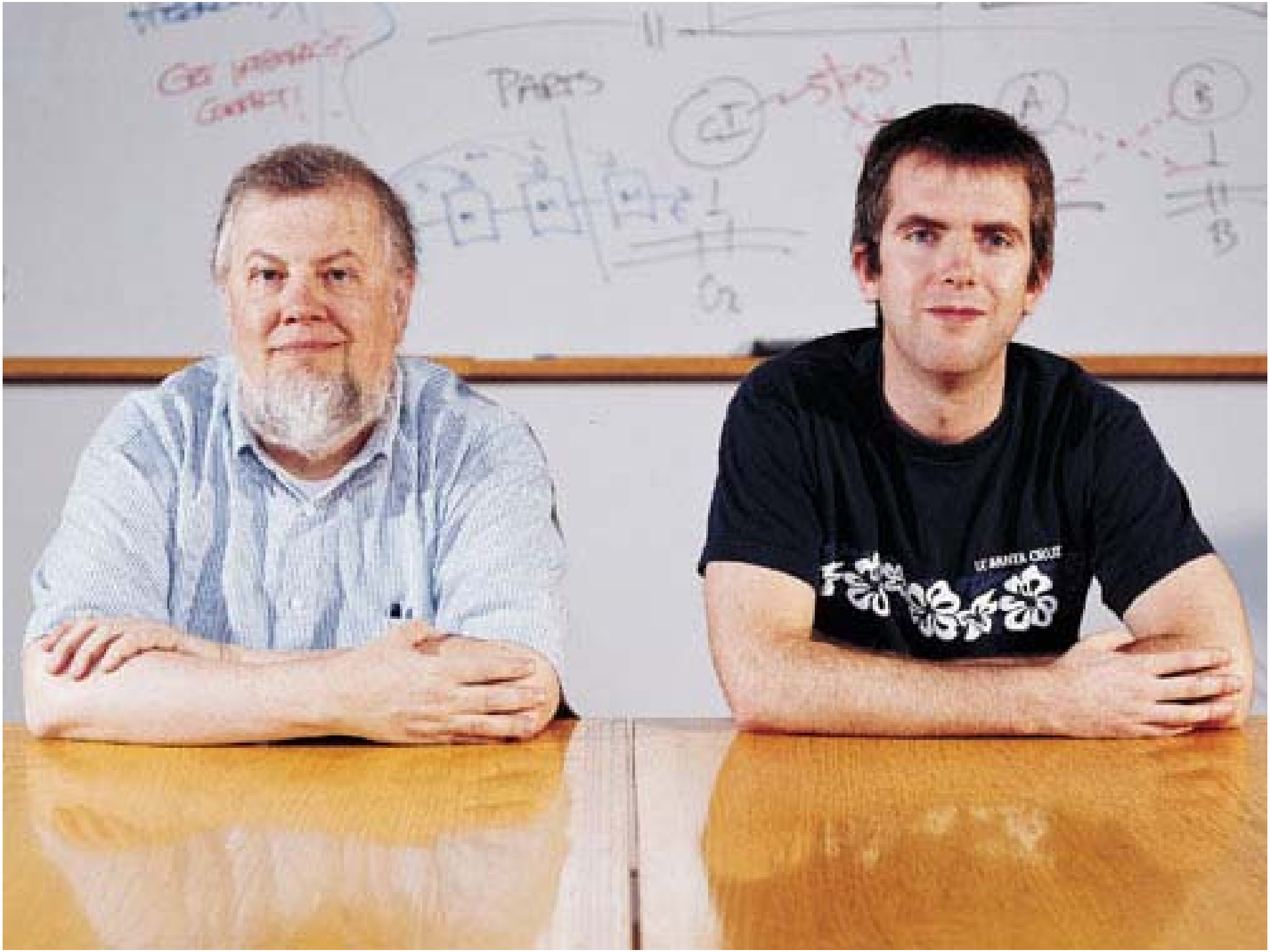
Microsoft®

Microsoft® Word 2000

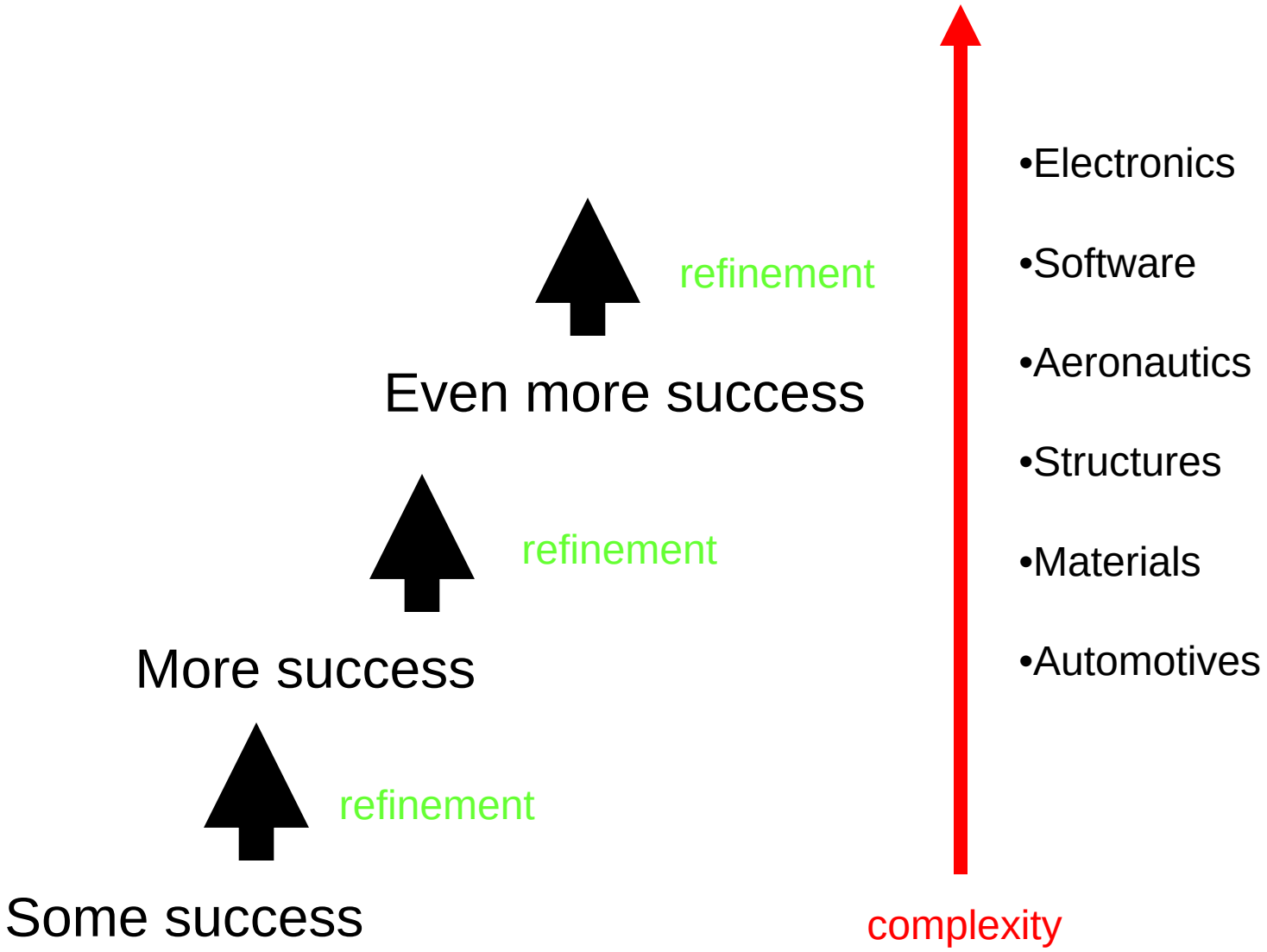
Microsoft Office Application

The Microsoft Office Word Processor


Acq&Chart to xls.vi Diagram *
File Edit Operate Tools Browse Window Help
14pt Application Font
ACQ
file path (dialog if empty)
input limits
device (1)
channels (0)
no buffer
interchannel delay
in secs (-1: hw default)
scan rate
(100 scans/sec)
Read & chart data until an error occurs,
or the stop button is pressed.
continuous
acquisition
# of Points
AI CONFIG
AI START
AI S-SCAN
AI CLEAR
transposed waveform chart
read
read oldest
status
append to file? (new file:F)
delimiter (Ta
Error
Start
StepperTe...
Exploring - I...
LabVIEW
Acq&Chart ...
Acq&Char...
3:18 PM


PARTS

Engineering process…



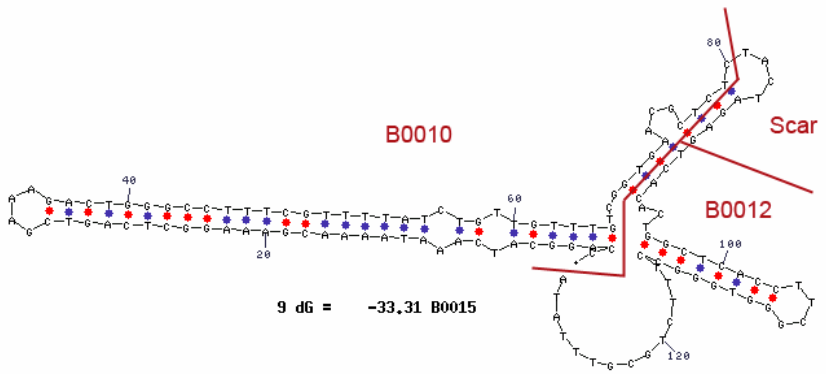
F1760

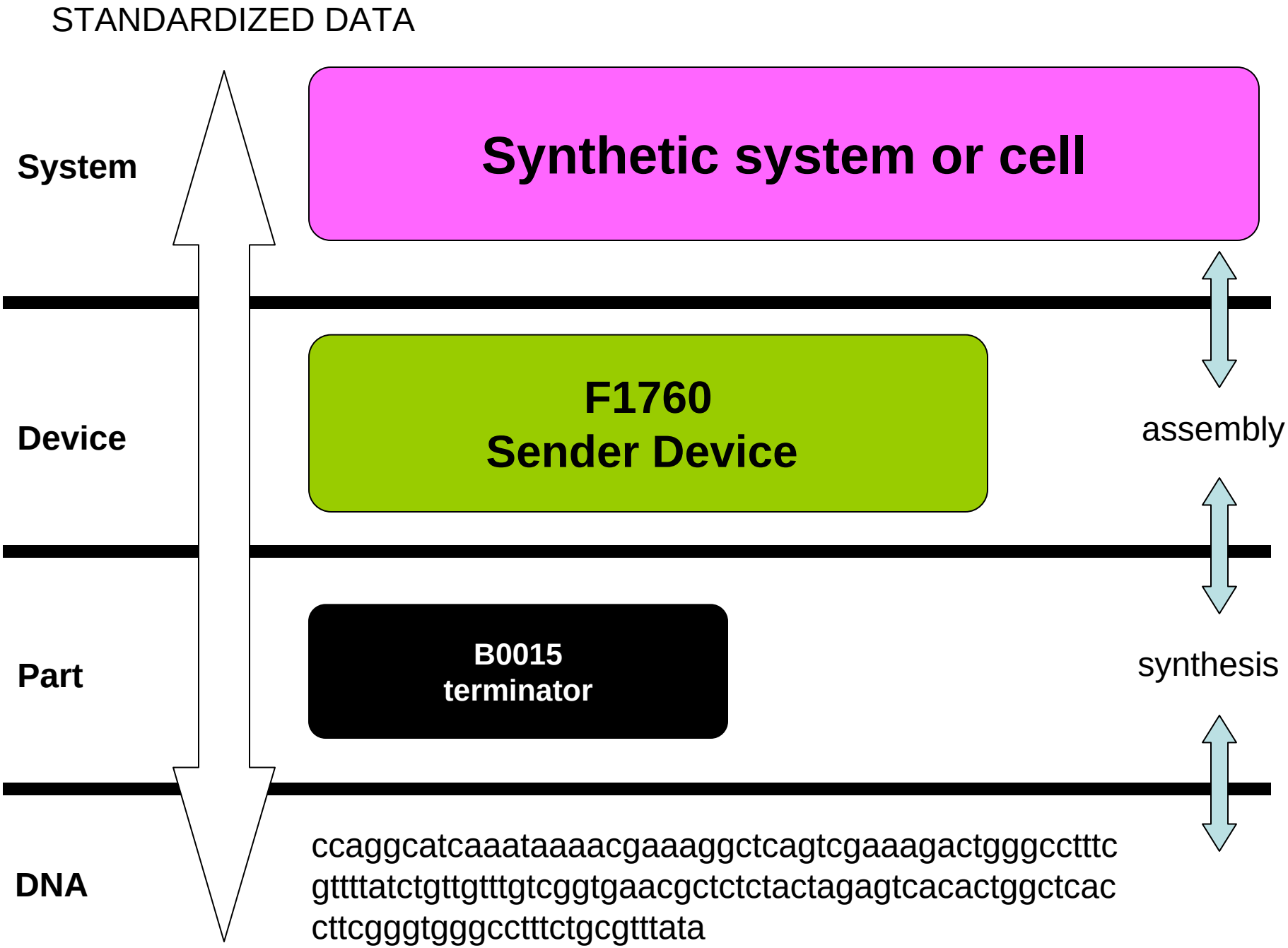
Sender Device

B0015

terminator

Name: B0015
Type: Double terminator
Length 129 bp
Designed by: Reshma Shetty
Forward efficiency: 0.984
Reverse efficiency: .295




STANDARDIZED DATA
System
Synthetic system or cell
Device
F1760
Sender Device
assembly
Part
B0015
terminator
synthesis
DNA
ccaggcatcaaataaaacgaaaggctcagtcgaaagactgggcctttc
gttttatctgttgtttgtcggtgaacgctctctactagagtcacactggctcac
cttcgggtgggcctttctgcgtttata

Transcriptional Regulators

jump to part

BBa_

navigation

- Main Page
- Browse Part Types
- iGEM Wiki
- Community portal
- Recent changes
- Recent part changes

resources

- User Accounts
- Add a Part
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- Sequence Analysis
- Assembly Tool
- Help

search

Go Search

toolbox

- What links here

Available repressible regulators (normally ON) -?-

Show 0 more parts

Edit

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

Available inducible regulators (normally OFF) -?-

Show 0 more parts

Edit

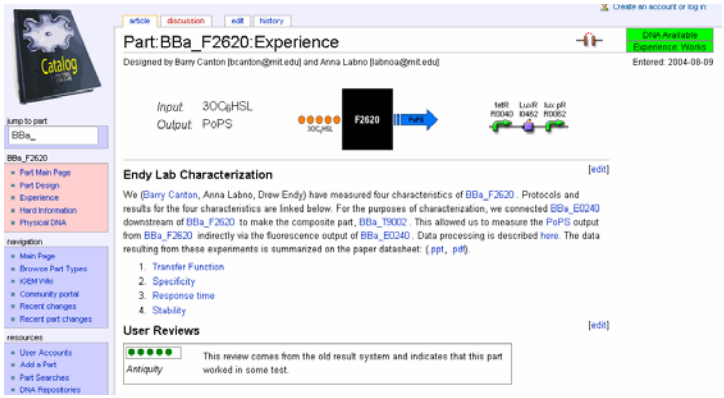
-?-	Name	Description	Direction	Control -?-	Output Low	Output High	Length
A	BBa_I12007	Modified lambda Prm promoter (OR-3 obliterated)	Forward	cI			82
A	BBa_R0062	Promoter (luxR & HSL regulated -- lux pR)	Forward	luxR, HSL			55
A	BBa_R0079	Promoter (LasR & PAI regulated)	Forward	PAI			157
A	BBa_R0080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

Available other regulators

Show 172 more parts

Edit

-?-	Name	Description	Direction	Control -?-	Output Low	Output 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



BBa_F2620

3OC$_6$HSL → PoPS Receiver

http://parts.mit.edu/registry/index.php/Part:BBa_F2620

Authors:
Barry Canton [bcanton@mit.edu]
Anna Labno [labnoa@mit.edu]

Last Update: 15 January 2007

Description

A transcription factor (LuxR, BBa_C0062) that is active in the presence of cell-cell signaling molecule 3OC$_6$HSL is controlled by a TetR-regulated operator (BBa_R0040). Device input is 3OC$_6$HSL. Device output is PoPS from a LuxR-regulated operator. If used in a cell containing TetR then a second input signal such as aTc can be used to produce a Boolean AND function.

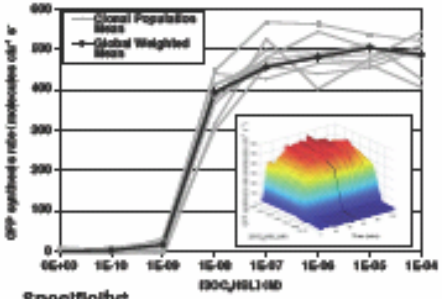
Characteristics

Input Swing: 1E-9 to 1E-6 M 3OC$_6$HSL, exogenous
Output Swing: 0±1 to 503±1 GFP molecules cfu^{-1} s^{-1}
Switch Point: 7±1 nM 3OC$_6$HSL, exogenous
LH Response: 9 min ($t_{50\%}$), 27 min ($t_{90\%}$)

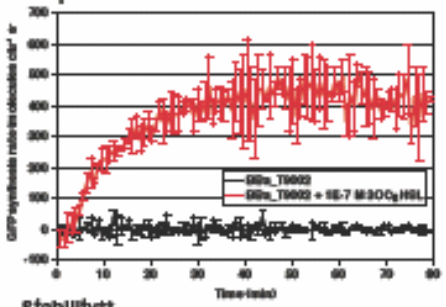
Key Parts

BBa_R0040: TetR-regulated operator
BBa_C0062: luxR ORF
BBa_R0062: LuxR-regulated operator

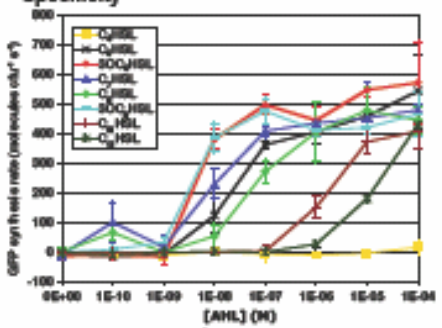
Transfer Function*



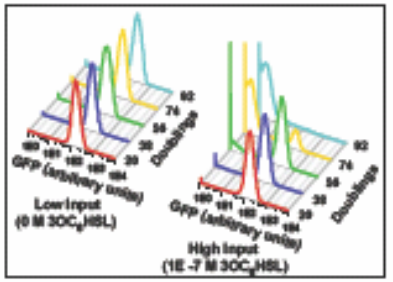
Response Time*



Specificity*



Stability**



Demand (low/high input)

Translational: 256/8048 ribosomes cfu^{-1}
3.8E3/1.2E5 charged tRNA cfu^{-1} s^{-1}

Stability (low/high input)

Genetic: >92/74 replication events**
Performance: >92/74 replication events**

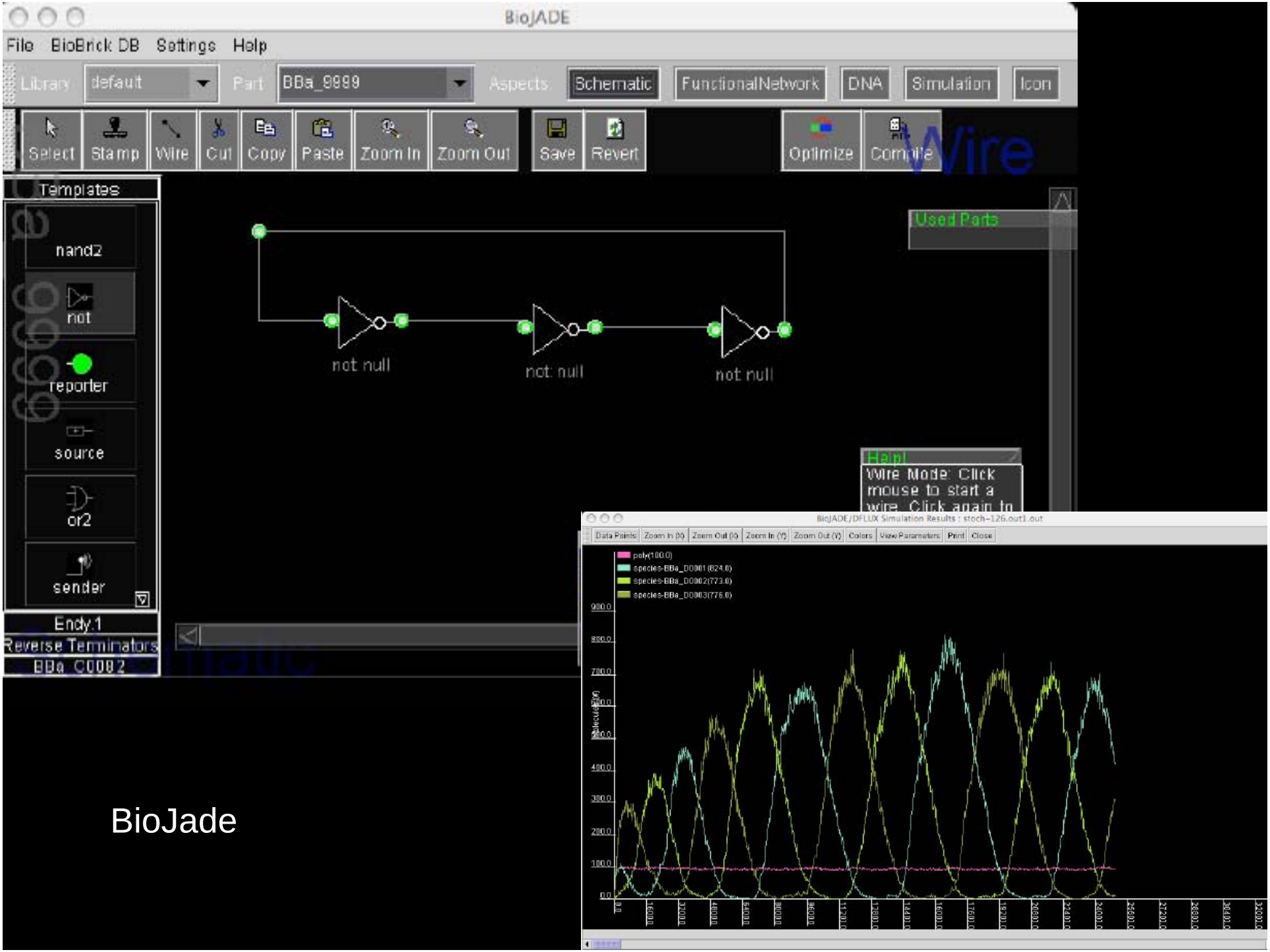
Compatibility

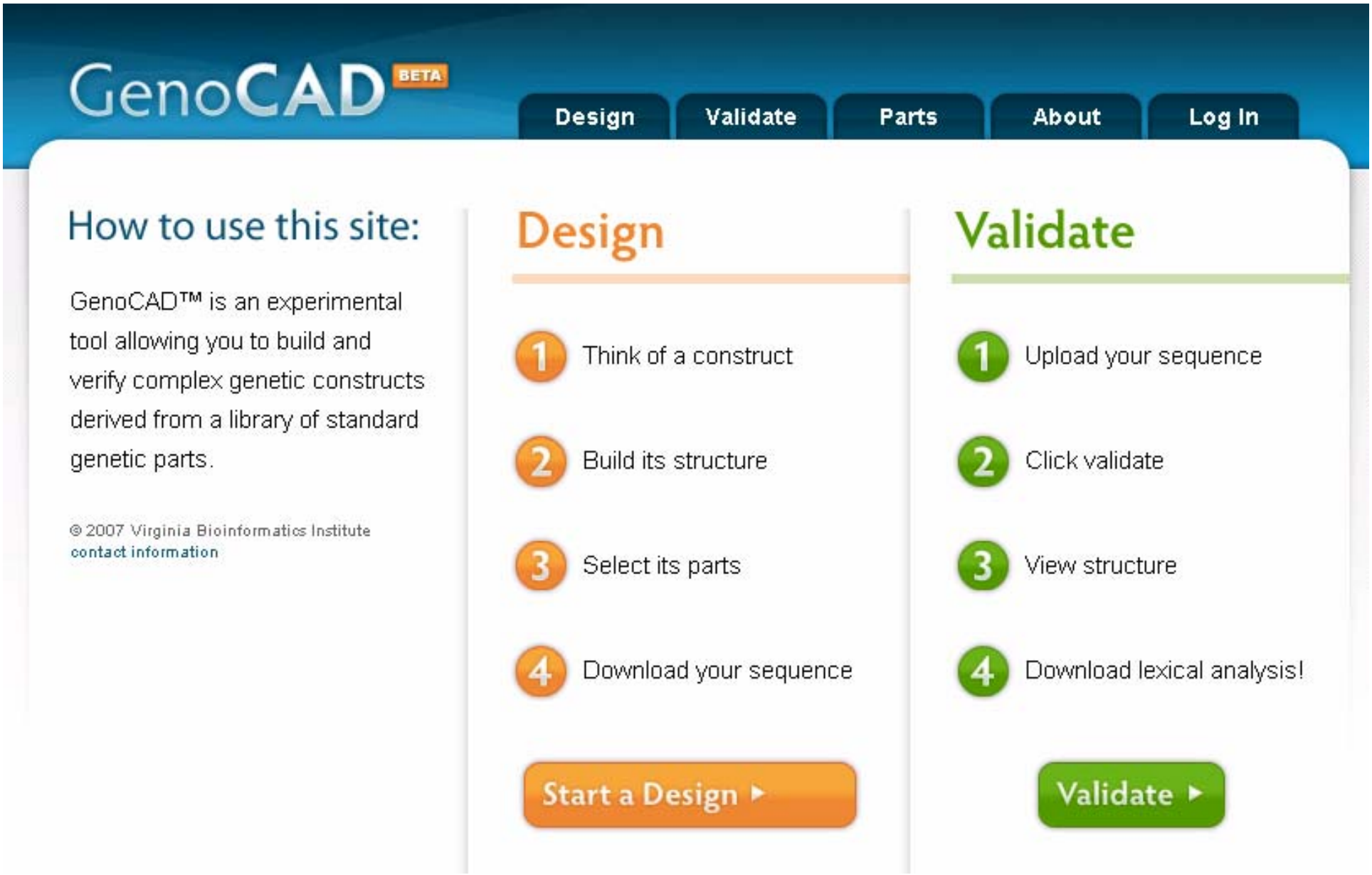
Chassis: Compatible with *MC4100*, *MG1655*, and *DH5α*
Plasmids: Compatible with *pSB3K3* and *pSB1A2*
Devices: Compatible with *E0240*, *E0430* and *E0434*
Crosstalk with systems containing *TetR (C0040)*
Signaling: Crosstalk with input molecules similar to 3OC$_6$HSL

Conditions (abridged)

Output: Indirect via *BBa_E0240*
Vector: pSB3K3
Chassis: MG1655
Culture: Supplemented M9, 37°C
**Equipment:* PE Victor3 plate reader
***Equipment:* BD FACScan cytometer

Signaling Devices


BioJADE
File BioBrick DB Settings Help
Library default
Part BBa_9999
Aspects Schematic FunctionalNetwork DNA Simulation Icon
Select Stamp Wire Cut Copy Paste Zoom In Zoom Out Save Revert
Optimize Compile
Templates
nand2
not
reporter
source
or2
sender
Endy.1
Reverse Terminators
BBa_C0082
not null
not null
not null
Used Parts
Help!
Wire Mode: Click mouse to start a
BioJADE/DFLUX Simulation Results : stoch-126.out1.out
Data Points
Zoom In (X)
Zoom Out (X)
Zoom In (Y)
Zoom Out (Y)
Colors
View Parameters
Print
Close
poly(100.0)
species-BBa_D0001(824.0)
species-BBa_D0002(773.0)
species-BBa_D0003(776.0)
BioJade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Parts
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contact information
Design
1 Think of a construct
2 Build its structure
3 Select its parts
4 Download your sequence
Start a Design
Validate
1 Upload your sequence
2 Click validate
3 View structure
4 Download lexical analysis!
Validate

Training DNA programmers

Synthetic biology requires an unprecedented level of interdisciplinary cooperation, fewer laboratory skills, and less overhead than conventional genetic engineering.

Cooperative yet competitive

Open education format…
Shares:

- DNA parts
- DNA code
- Protocols
- Experience
- Publications
- One big rule: share back!

iGEM 2007 Wiki

International Genetically Engineered Machine Competition

Go Search

article discussion edit history Create an account or log in

teams jamboree participate help about registry

Cambridge & Melbourne Leap Together

Cambridge University & Melbourne Univeristy leap together after co-winning the Best BioBrick Part award.

iGEM?

Hundreds of undergraduates all over the world spend their summer making Synthetic Biology a reality by participating in the annual International Genetically Engineered Machine competition.

iGEM through the years

- 2008
- 2007
- 2006

Learn More

Results of the Jamboree

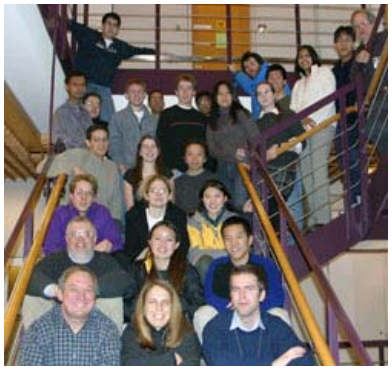
sat & sun, nov 3-4

iGEM 2007 is now officially concluded! Congratulations to all!

- Results
- See the medal winners
- Media (including links to videos and flickr™ photo gallery)
- Learn about iGEM 2008

calendar

Jamboree roster + fees due	*fri 12 oct 12*
iGEM wiki frozen + parts postmarked	*fri 26 Oct 07*
Jamboree!	*sat-sun 3-4 nov 07*
Registry + BioBrick foundation workshops	*sun-tue 4-6 nov 07*

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Naples


iGEM
07

blogs covering iGEM

(email meagan{at}igem{dot}org with blog posts that do not appear below)

Discover Hybrid Cars and **Biopact Blog** talk about the Alberta team project.
The Scientist has several blog posts about iGEM and the Jamboree written by Alla Katsnelson who attended the Jamboree.
Alexis Madrigal at **Wired** writes about several iGEM 2007 teams as well as the "Adventures in Synthetic Biology" comic book.
The **Proyecto de Bioseguridad Puerto Rico** writes about iGEM.
Jimmy from the **UCSF team blogs** about his experience.

news articles about iGEM

(email meagan{at}igem{dot}org with news articles that do not appear below)

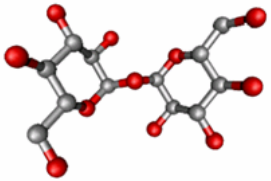
- **Brown Daily Hearald:** Students win gold for glowing mold
- **NY Times:** English, Algebra, Phys Ed ... and Biotech
- **San Francisco Chronicle:** High school biowizards break new ground in winning competition
- **Cnews.ca:** ButaNerds pumped
- **Medical News Today:** Young Slovenian Synthetic Biologists Devise A Mutation Independent Defense Against HIV
- **Science Daily:** Students Devise Novel Way To Detect Urinary Catheter Infections
- **The Brown Daily Herald:** Students win gold for glowing mold
- **The University of Melbourne Voice:** Bioengineering Gold: University of Melbourne students won a team Gold Medal and share
  2007
- **Mississippi Agricultural News:** MSU students excel in new scientific field
- **Wired.com:** Genetic-Engineering Competitors Create Modular DNA Dev Kit
- **Genome Technology Online:** "We Think of It as the Synthetic Biology Sweatshop"
- **The University of Lethbridge:** Biochemistry Researcher and iGEM Team Leader Receives Alberta Ingenuity New Faculty Aw
- **Imperial College London:** Going for gold – Imperial students impress judges at genetic engineering competition
- **Taipei Times:** National Yang Ming University students win science gold
- **MIT News:** Hundreds attend iGem Jamboree
- **Marketwire:** GENEART Sponsors Winning iGEM Teams
- **Daily Princetonian:** Cellular warriors: Team develops new approach to fighting breast cancer
- **Livemint.com - The Wall Street Journal:** Indian students win MIT prize, strike blow for synthetic biology
- **The Rolla Daily News:** UMR team to develop yeast-cell breathalyzer
- **Rice News:** Students use designer virus to attack bacterial drug resistance
- **University of Alberta Express News:** Alberta's ButaNerds iGEM team (w/ video!)
- **UCSF Today:** UCSF's all-highschool team

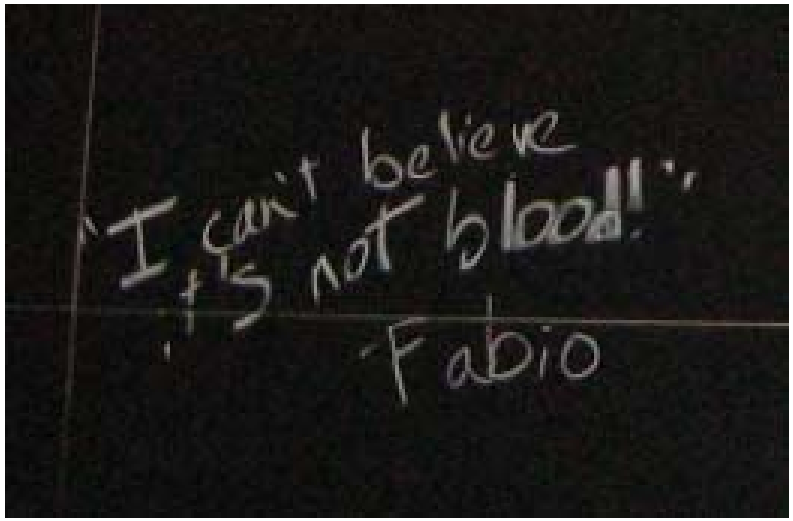
WIRED

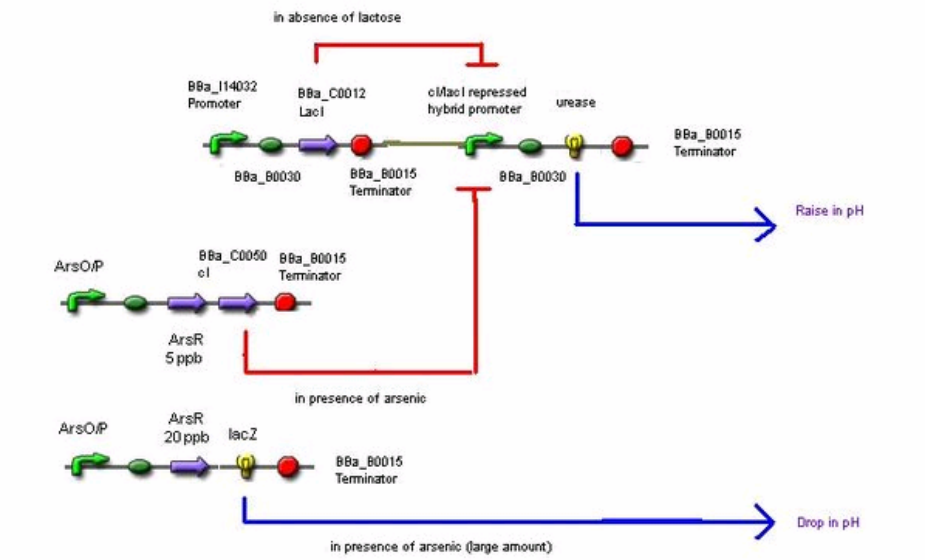
BACTOBLOOD

The necessity of inexpensive, disease-free, and universally compatible blood substitutes is undisputed. There are currently no blood substitutes approved for use in the US or the UK, and whole blood is almost always in short supply. Developing countries have the greatest need for blood transfusions, yet many lack the necessary donation and storage infrastructure and the required pool of healthy donors. To address this problem, we are developing a cost-effective red blood cell substitute constructed from engineered *E. coli* bacteria. Our system is designed to safely transport oxygen in the bloodstream without inducing sepsis, and to be stored for prolonged periods in a freeze-dried state.

Support for Berkeley iGEM 2007 was generously provided by SynBERC and The Camille and Henry Dreyfus Foundation, Inc.






in absence of lactose
BBa_I14032
Promoter
BBa_C0012
LacI
cI/lacI repressed
hybrid promoter
urease
BBa_B0015
Terminator
BBa_B0030
BBa_B0015
Terminator
BBa_B0030
Raise in pH
ArsO/P
BBa_C0050
cI
BBa_B0015
Terminator
ArsR
5 ppb
in presence of arsenic
ArsO/P
ArsR
20 ppb
lacZ
BBa_B0015
Terminator
Drop in pH
in presence of arsenic (large amount)

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Sci-Tech

Under a magnification of 6836x, this scanning electron micrograph (SEM) depictes a number of Gram-negative Escherichia coli bacteria of the strain O157:H7. (Courtesy of Centers of Disease Control and Prevention)

Alberta team trying to turn E. coli into fuel

Updated Mon. Nov. 5 2007 8:12 AM ET

The Canadian Press

CAMBRIDGE, Mass. -- A University of Alberta team trying to turn E. coli into fuel has earned a first place finish in the energy category at an international genetic engineering competition at MIT.

Andrew Hessel, a consultant with the Alberta Ingenuity Fund who has helped teams from three Alberta universities compete, says while none of the teams from the University of Calgary, the University of Lethbridge or the U of A made it to the final competition, he calls it a fantastic educational experience.

USER TOOLS

BERKELEY CENTER FOR SYNTHETIC BIOLOGY

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 ways, with enormous potential benefits for California's citizens in the form of advances in biomedicine and energy renewables and economic growth.

Synthetic biologists study the control and design of biological components and new organisms to solve a host of important health, energy, and environmental problems that cannot be solved using naturally occurring biological entities. 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.


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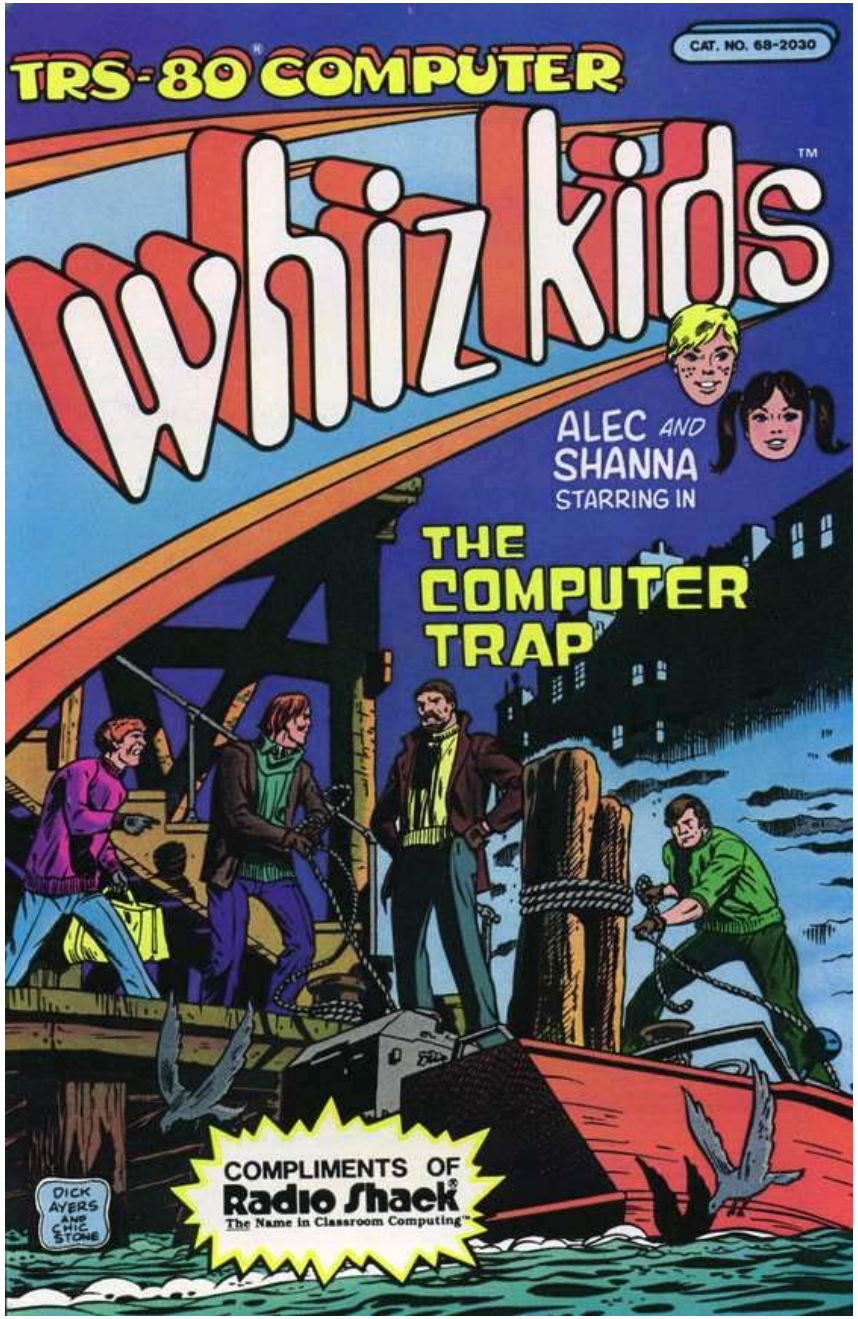
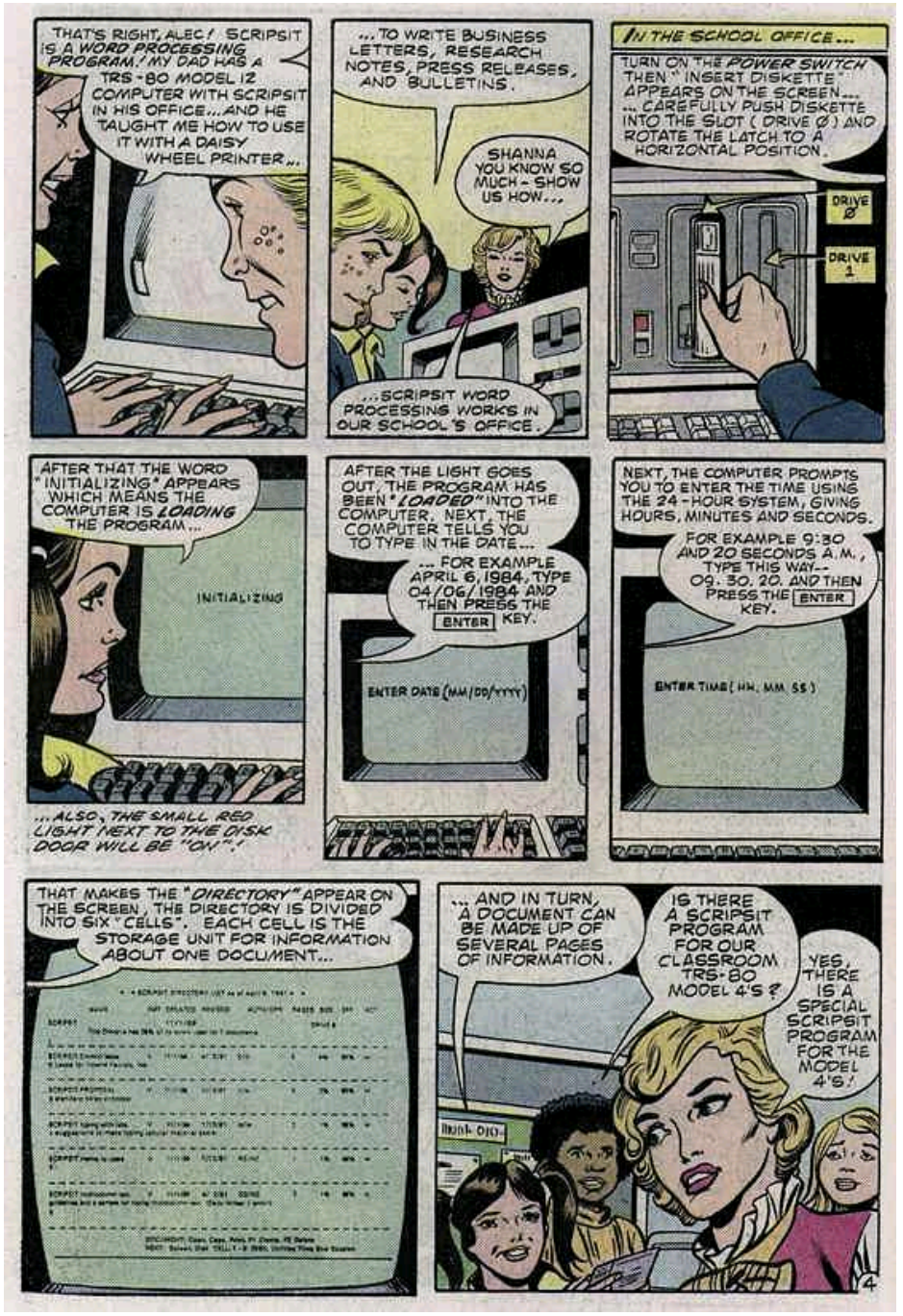
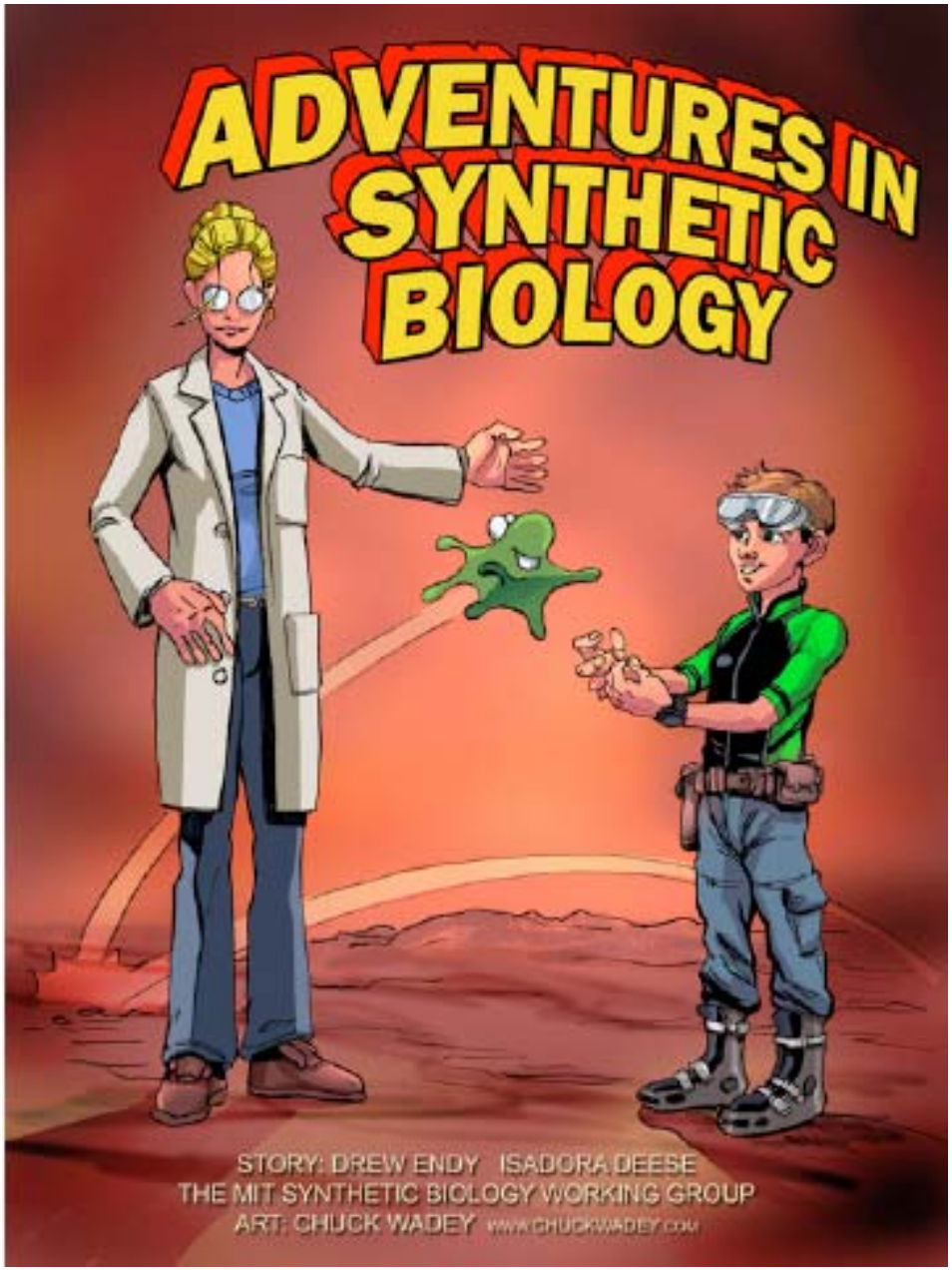
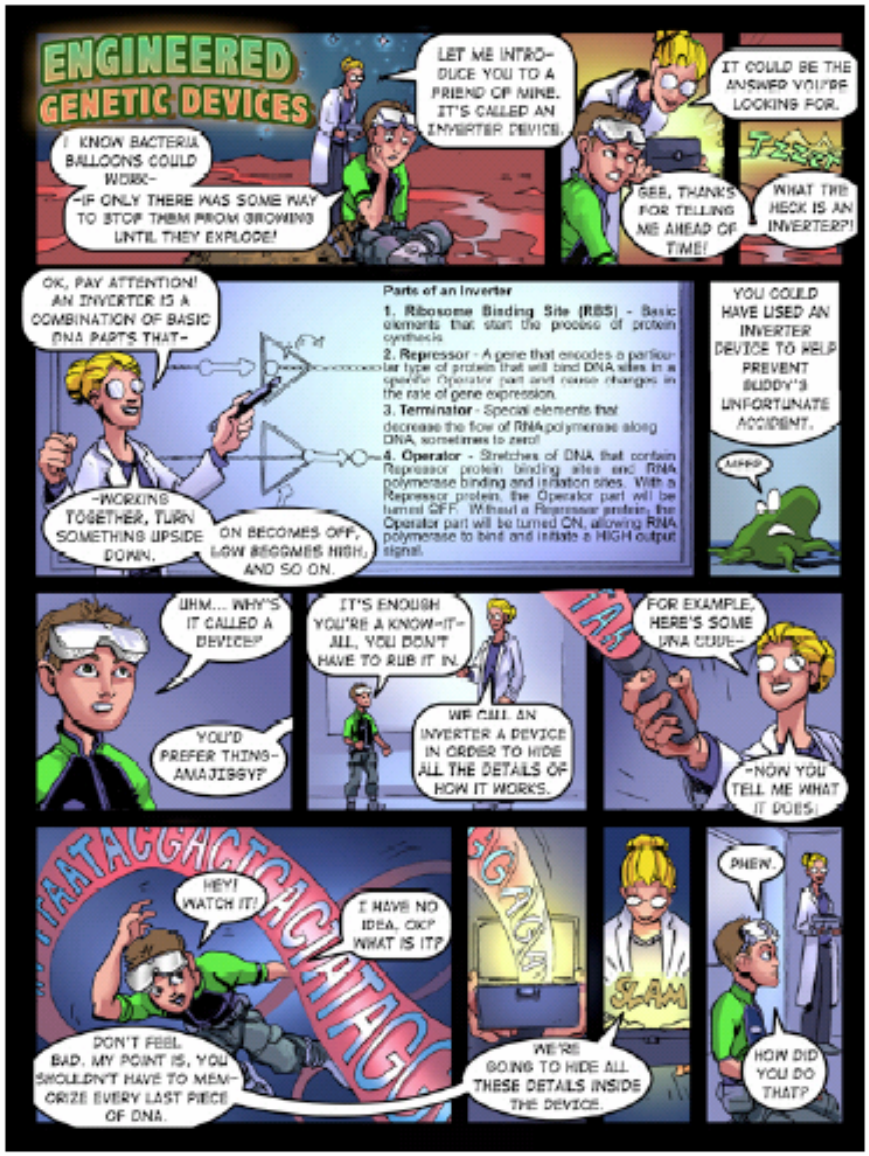
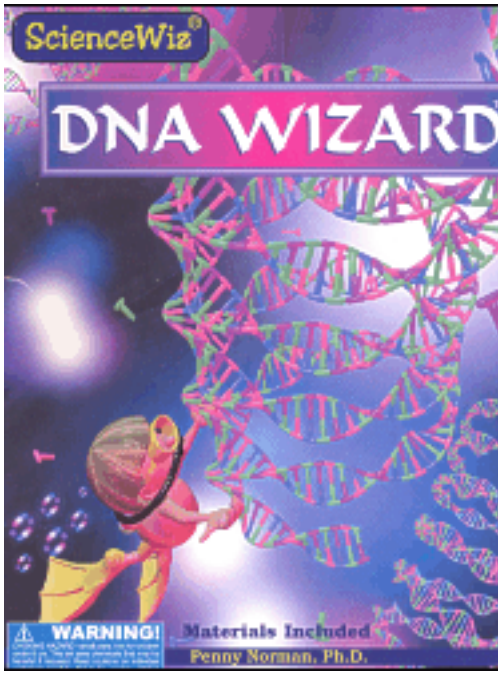
TIME
-.3%
INFLATION VANISHES!
At Least for A Month
COMPUTER GENERATION
A New Breed of Whiz Kids


TRS-80® COMPUTER
CAT. NO. 68-2030
whizkids™
ALEC AND SHANNA STARRING IN
THE COMPUTER TRAP
COMPLIMENTS OF
Radio Shack®
The Name in Classroom Computing™
DICK AYERS AND CHIC STONE


THAT'S RIGHT, ALEC! SCRIPSIT IS A WORD PROCESSING PROGRAM! MY DAD HAS A TRS-80 MODEL 12 COMPUTER WITH SCRIPSIT IN HIS OFFICE... AND HE TAUGHT ME HOW TO USE IT WITH A DAISY WHEEL PRINTER...
...TO WRITE BUSINESS LETTERS, RESEARCH NOTES, PRESS RELEASES, AND BULLETINS.
SHANNA YOU KNOW SO MUCH - SHOW US HOW...
...SCRIPSIT WORD PROCESSING WORKS IN OUR SCHOOL'S OFFICE.
IN THE SCHOOL OFFICE...
TURN ON THE POWER SWITCH THEN "INSERT DISKETTE" APPEARS ON THE SCREEN... ...CAREFULLY PUSH DISKETTE INTO THE SLOT (DRIVE Ø) AND ROTATE THE LATCH TO A HORIZONTAL POSITION.
DRIVE Ø
DRIVE 1
AFTER THAT THE WORD "INITIALIZING" APPEARS WHICH MEANS THE COMPUTER IS LOADING THE PROGRAM...
INITIALIZING
...ALSO, THE SMALL RED LIGHT NEXT TO THE DISK DOOR WILL BE "ON"!
AFTER THE LIGHT GOES OUT, THE PROGRAM HAS BEEN "LOADED" INTO THE COMPUTER. NEXT, THE COMPUTER TELLS YOU TO TYPE IN THE DATE...
... FOR EXAMPLE APRIL 6, 1984, TYPE 04/06/1984 AND THEN PRESS THE ENTER KEY.
ENTER DATE (MM/DD/YYYY)
NEXT, THE COMPUTER PROMPTS YOU TO ENTER THE TIME USING THE 24-HOUR SYSTEM, GIVING HOURS, MINUTES AND SECONDS.
FOR EXAMPLE 9:30 AND 20 SECONDS A.M., TYPE THIS WAY-- 09.30.20. AND THEN PRESS THE ENTER KEY.
ENTER TIME (HH.MM.SS)
THAT MAKES THE "DIRECTORY" APPEAR ON THE SCREEN. THE DIRECTORY IS DIVIDED INTO SIX "CELLS". EACH CELL IS THE STORAGE UNIT FOR INFORMATION ABOUT ONE DOCUMENT...
... AND IN TURN, A DOCUMENT CAN BE MADE UP OF SEVERAL PAGES OF INFORMATION.
IS THERE A SCRIPSIT PROGRAM FOR OUR CLASSROOM TRS-80 MODEL 4'S?
YES, THERE IS A SPECIAL SCRIPSIT PROGRAM FOR THE MODEL 4'S!
4

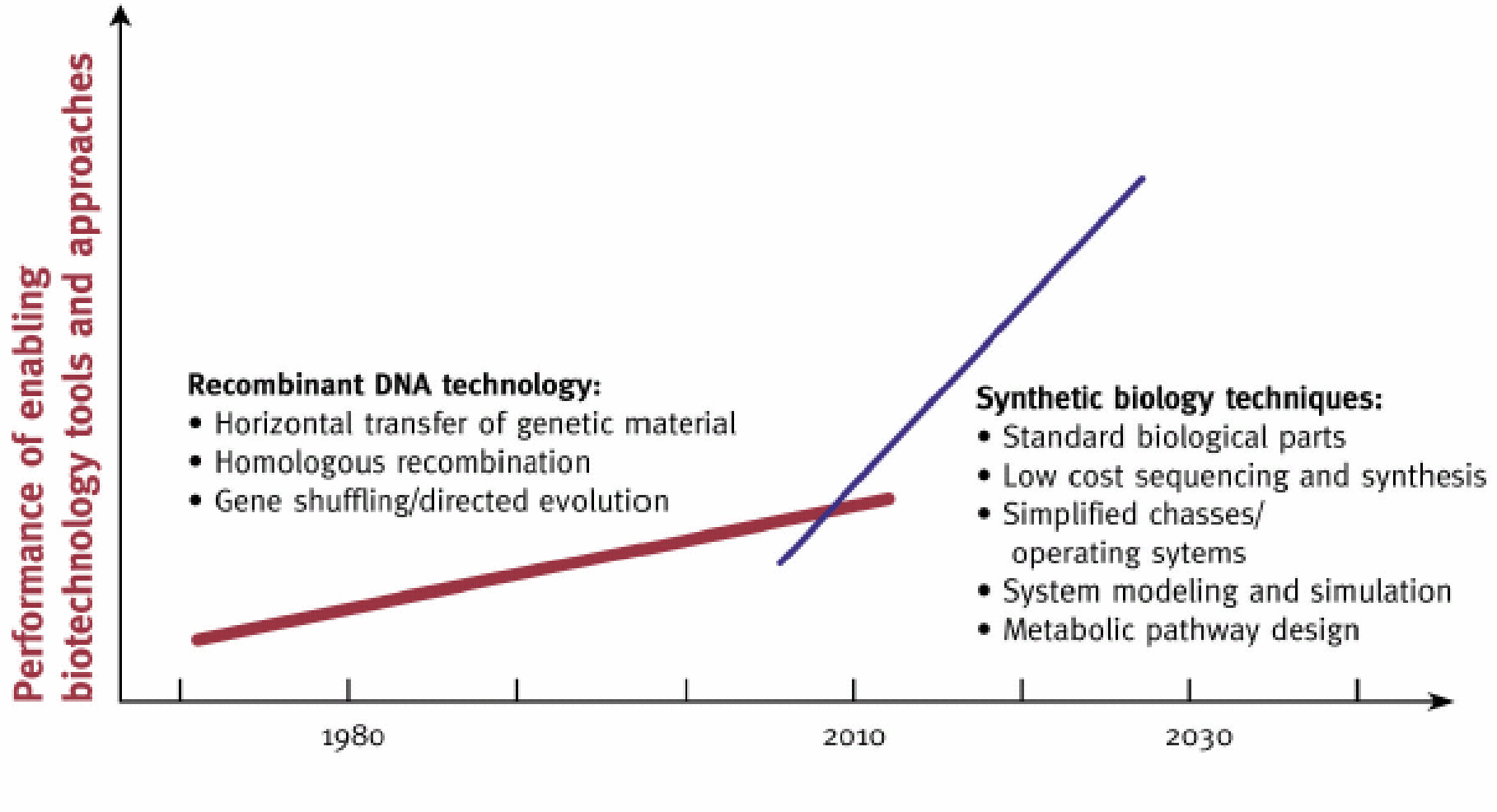

ADVENTURES IN SYNTHETIC BIOLOGY
STORY: DREW ENDY ISADORA DEESE
THE MIT SYNTHETIC BIOLOGY WORKING GROUP
ART: CHUCK WADEY WWW.CHUCKWADEY.COM


ENGINEERED GENETIC DEVICES
I KNOW BACTERIA BALLOONS COULD WORK-
-IF ONLY THERE WAS SOME WAY TO STOP THEM FROM GROWING UNTIL THEY EXPLODE!
LET ME INTRODUCE YOU TO A FRIEND OF MINE. IT'S CALLED AN INVERTER DEVICE.
IT COULD BE THE ANSWER YOU'RE LOOKING FOR.
GEE, THANKS FOR TELLING ME AHEAD OF TIME!
WHAT THE HECK IS AN INVERTER?!
OK, PAY ATTENTION! AN INVERTER IS A COMBINATION OF BASIC DNA PARTS THAT-
-WORKING TOGETHER, TURN SOMETHING UPSIDE DOWN.
ON BECOMES OFF, LOW BECOMES HIGH, AND SO ON.
Parts of an Inverter
1. Ribosome Binding Site (RBS) - Basic elements that start the process of protein synthesis.
2. Repressor - A gene that encodes a particular type of protein that will bind DNA sites in a specific Operator part and cause changes in the rate of gene expression.
3. Terminator - Special elements that decrease the flow of RNA polymerase along DNA, sometimes to zero!
4. Operator - Stretches of DNA that contain Repressor protein binding sites and RNA polymerase binding and initiation sites. With a Repressor protein, the Operator part will be turned OFF. Without a Repressor protein, the Operator part will be turned ON, allowing RNA polymerase to bind and initiate a HIGH output signal.
YOU COULD HAVE USED AN INVERTER DEVICE TO HELP PREVENT BUDDY'S UNFORTUNATE ACCIDENT.
MMMF
UHM... WHY'S IT CALLED A DEVICE?
YOU'D PREFER THING-AMAJIBBY?
IT'S ENOUGH YOU'RE A KNOW-IT-ALL. YOU DON'T HAVE TO RUB IT IN.
WE CALL AN INVERTER A DEVICE IN ORDER TO HIDE ALL THE DETAILS OF HOW IT WORKS.
FOR EXAMPLE, HERE'S SOME DNA CODE-
-NOW YOU TELL ME WHAT IT DOES!
HEY! WATCH IT!
I HAVE NO IDEA. OK? WHAT IS IT?
DON'T FEEL BAD. MY POINT IS, YOU SHOULDN'T HAVE TO MEMORIZE EVERY LAST PIECE OF DNA.
WE'RE GOING TO HIDE ALL THESE DETAILS INSIDE THE DEVICE.
SLAM
PHEW.
HOW DID YOU DO THAT?

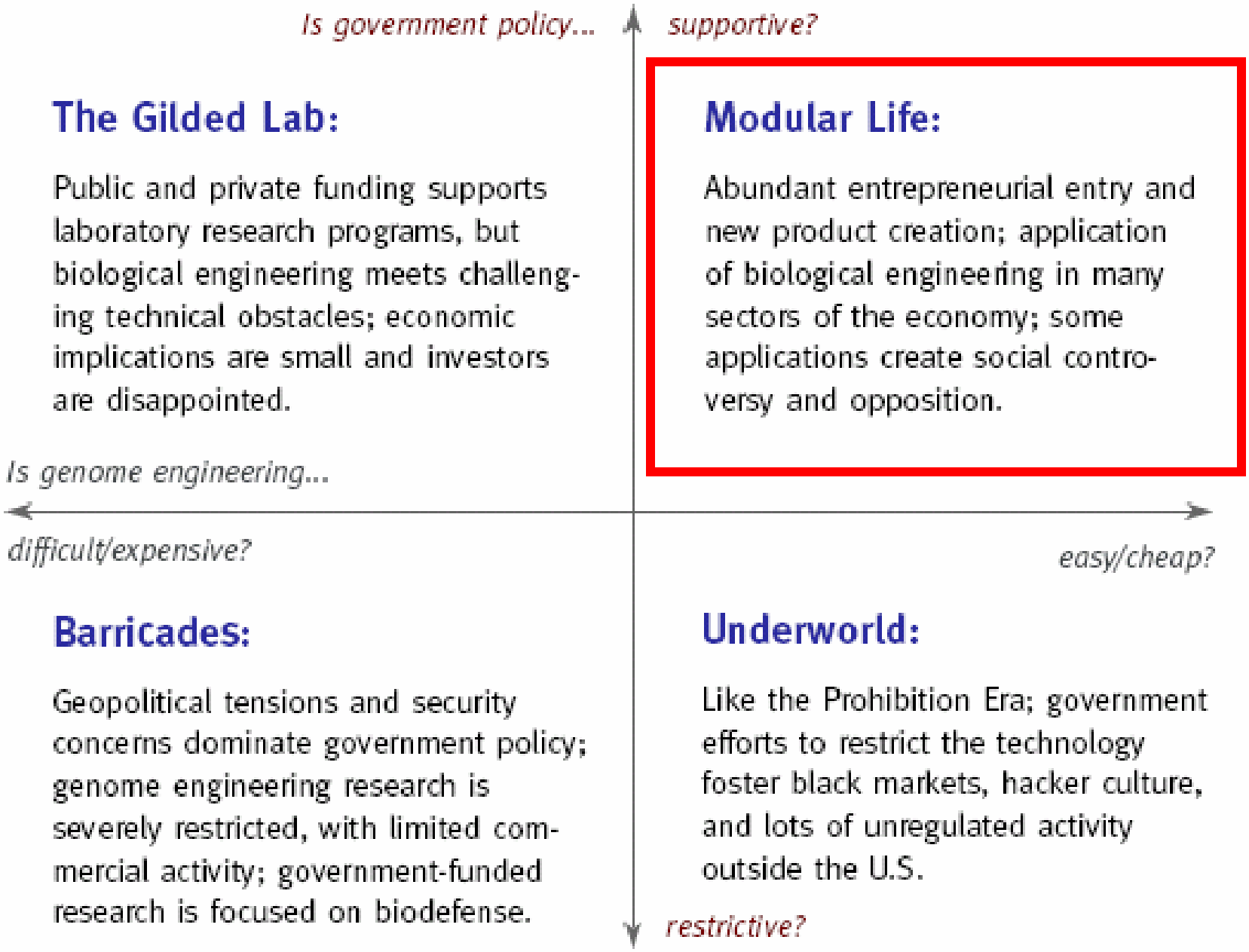


http://www.electrowiz.com/

Looking forward



Source: Bio era



Source: Bio era

Photo Credit: By Joby Warrick -- The Washington Post Photo

Sciencexpress Research Article

Genome Transplantation in Bacteria: Changing One Species to Another

Carole Lartigue, John I. Glass,* Nina Alperovich, Rembert Pieper, Prashanth P. Parmar, Clyde A. Hutchison III, Hamilton O. Smith, J. Craig Venter

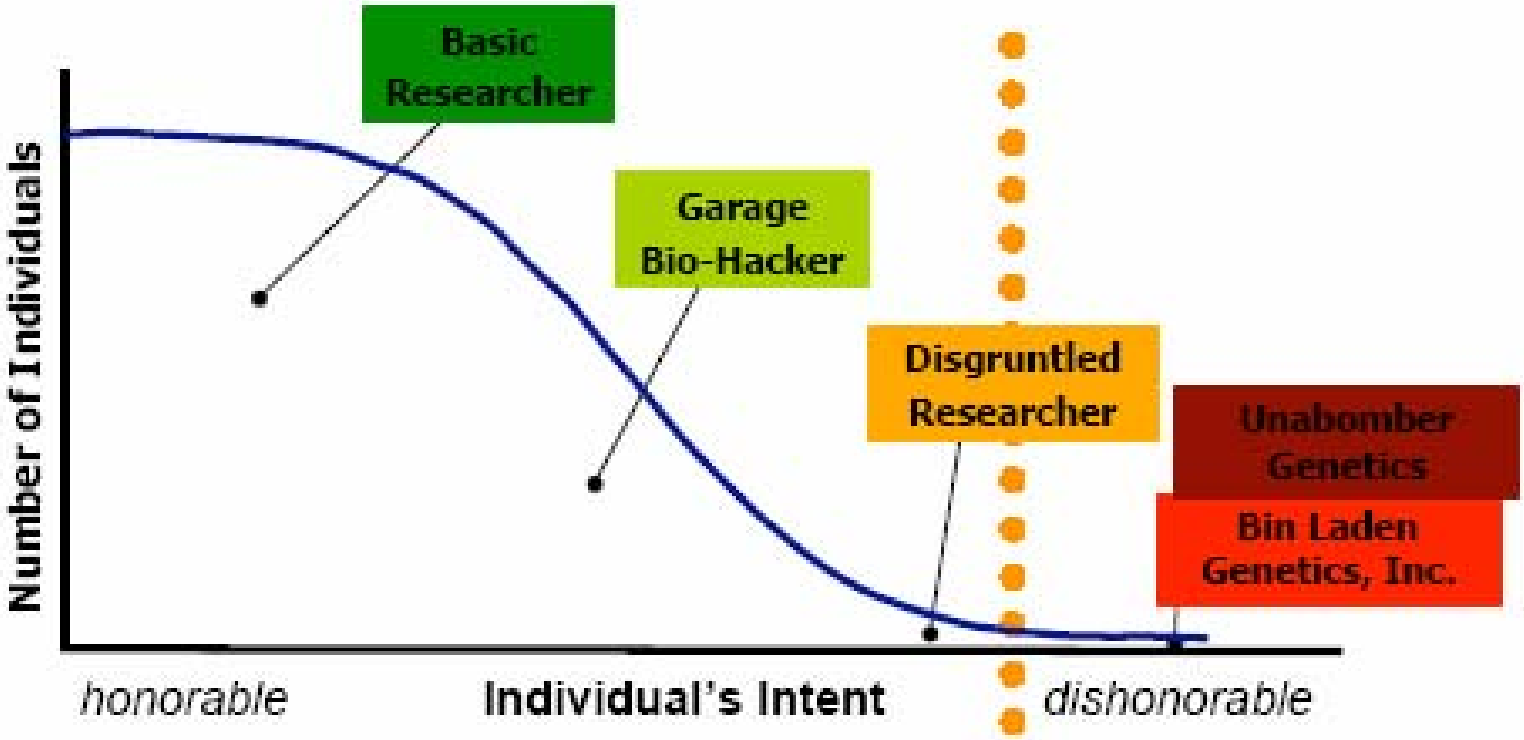
The J. Craig Venter Institute, Rockville, MD 20850, USA.

science theguardian

I am creating artificial life, declares US gene pioneer

- Scientist has made synthetic chromosome
- Breakthrough could combat global warming

Suite of solutions

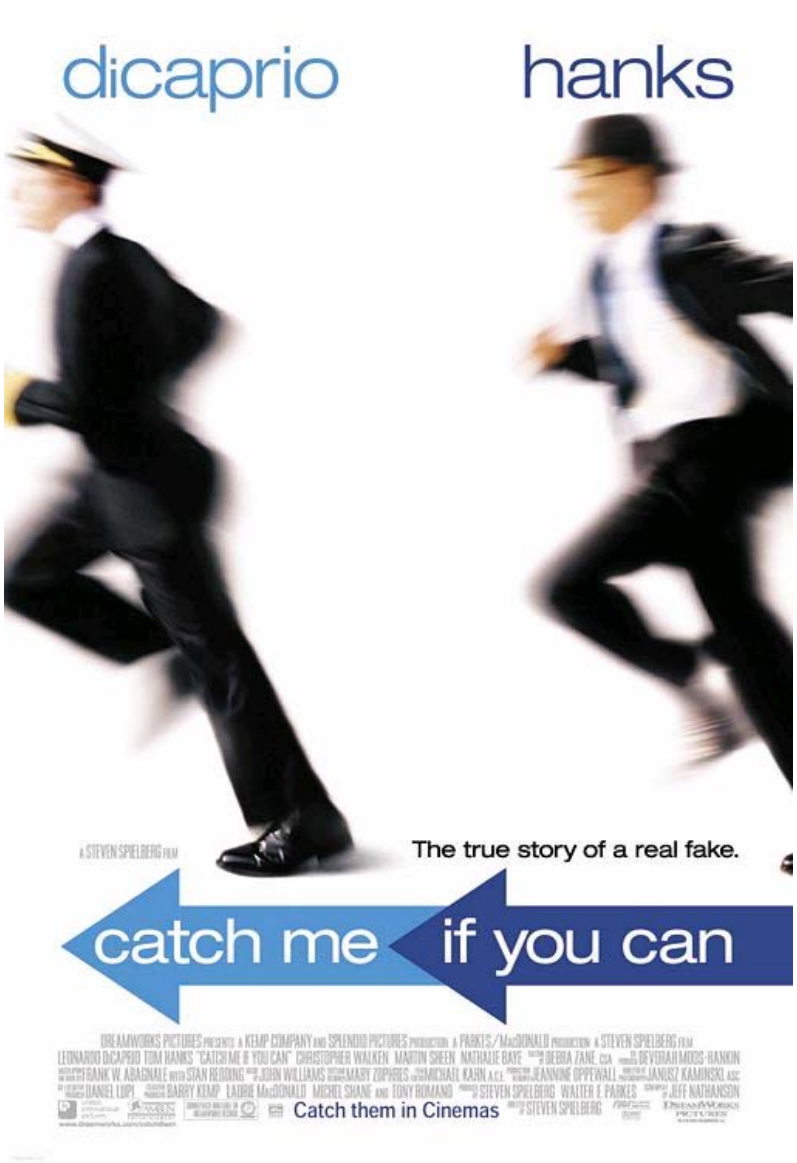


SYNTHETIC GENOMICS | *Options for Governance*

Michele S. Garfinkel, *The J. Craig Venter Institute, Rockville, Maryland;* **Drew Endy,** *Massachusetts Institute of Technology; Cambridge, Massachusetts;* **Gerald L. Epstein,** *Center for Strategic and International Studies; Washington, District of Columbia and* **Robert M. Friedman,** *The J. Craig Venter Institute, Rockville, Maryland*

October 2007

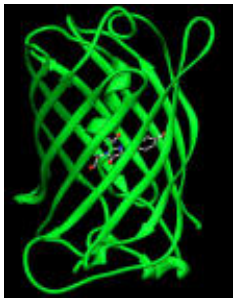
J. Craig Venter Institute CSIS



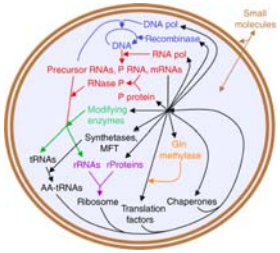
Q&A: Former fraudster Frank Abagnale offers IT security advice

Next generation biotechnology

Applications dependent on synthetic capabilities



single genes*

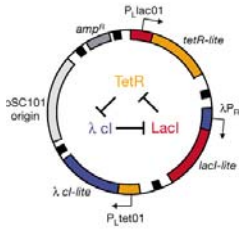


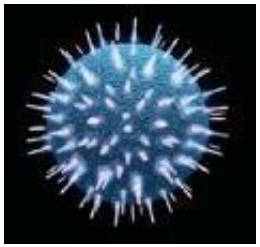
minimal life

base pairs

10^2 10^3 10^4 10^5 10^6 10^7

genetic circuits, viruses, GEMs





Engineered organisms

LS9, INC.

the renewable petroleum company™

AMYRIS
BIOTECHNOLOGIES

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.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The Constructive Biology Company™
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Products
Applications
Order
Support
Science and Technology
Stop Cloning Genes
SYNTHESIZE THEM!
Rapid, high-quality,
low-cost gene synthesis
Gene Synthesis
Constructed Variant Libraries
Constructed Operons & Operon Variant Libraries
Genomic Engineering

Archemix

The Aptamer Therapeutics Company™

Investors

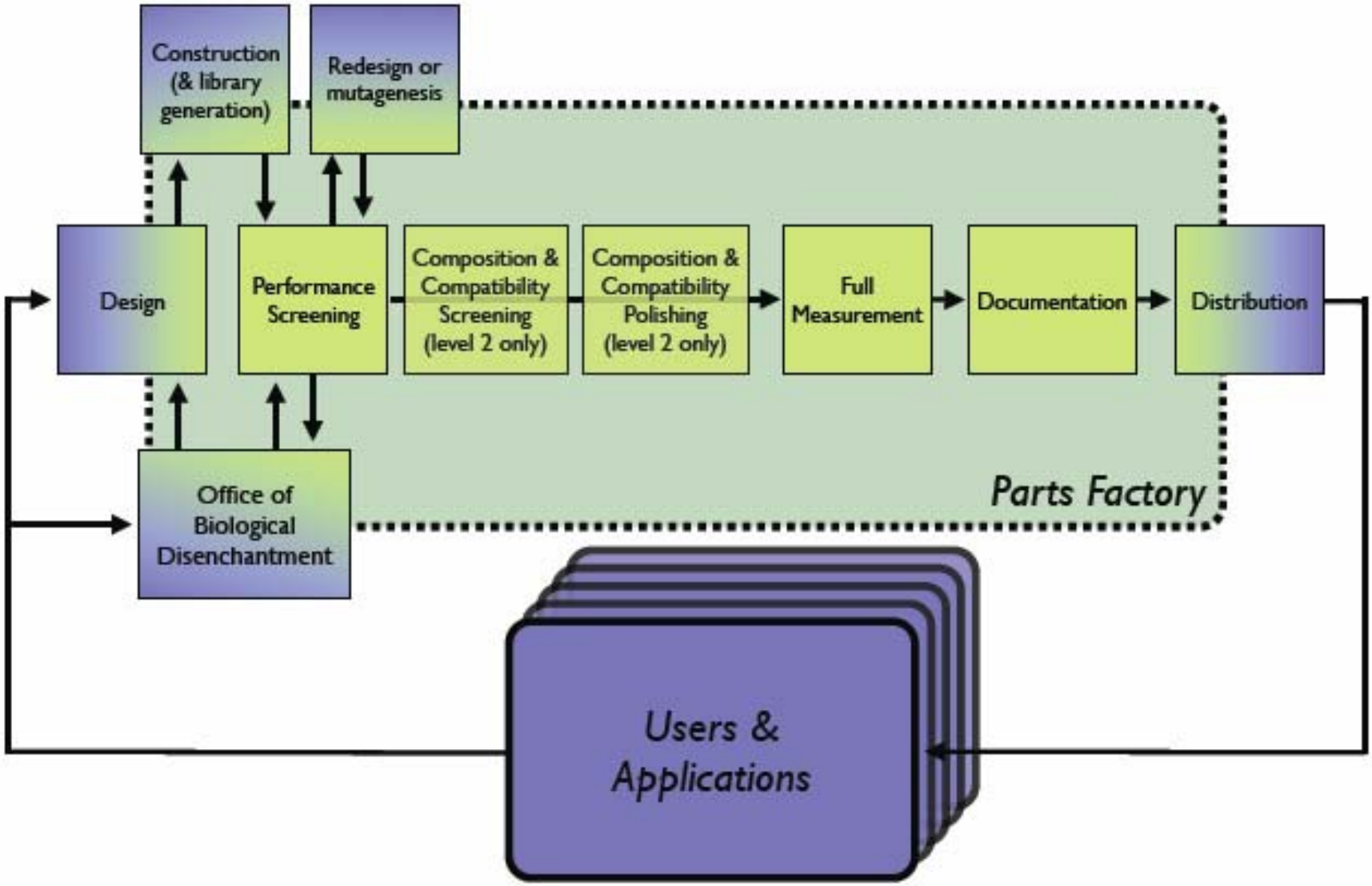
Funded by a syndicate of well-respected, top-tier venture capital firms, Archemix has raised over $100 million to date.

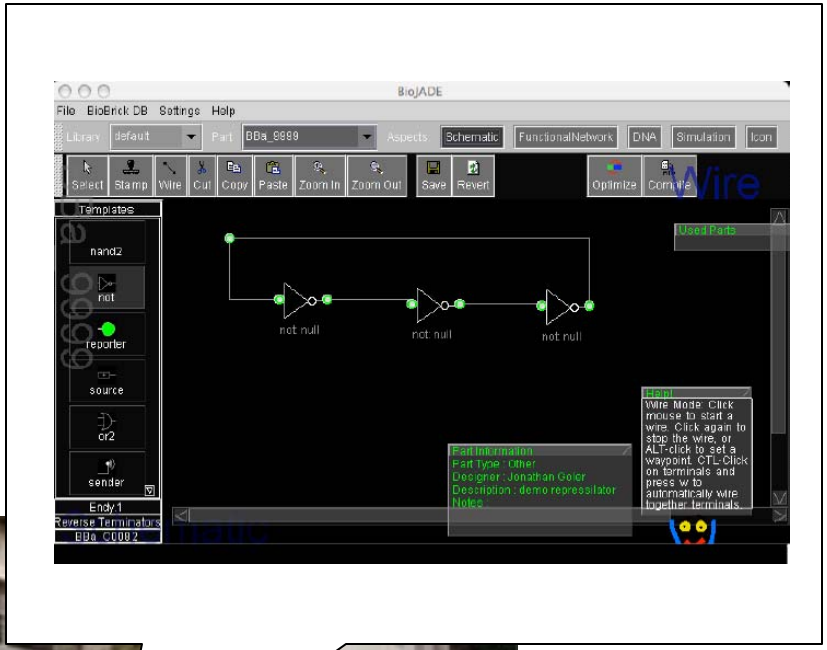
The Series B round ($53M, completed 1Q 2004) was led by Highland Capital Partners, and included all of the Series A investors and Athenian Venture Partners.

The Series A round ($52M, completed 3Q 2002) included lead investors Atlas Venture, Prospect Venture Partners and SV Life Sciences. Other investors included Rho Ventures, Care Capital, MDS Capital, POSCO BioVentures, and US Trust Private Equity.

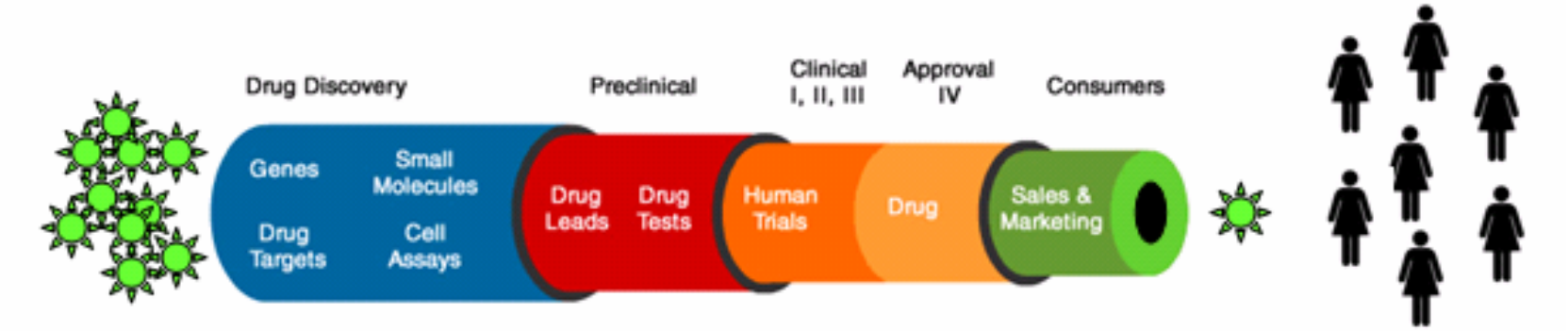
Archemix and Merck KGaA Sign Strategic Alliance

Collaboration to Focus Primarily on Cancer Therapeutics Using Novel Aptamer Technology


Construction (& library generation)
Redesign or mutagenesis
Design
Performance Screening
Composition & Compatibility Screening (level 2 only)
Composition & Compatibility Polishing (level 2 only)
Full Measurement
Documentation
Distribution
Office of Biological Disenchantment
Parts Factory
Users & Applications

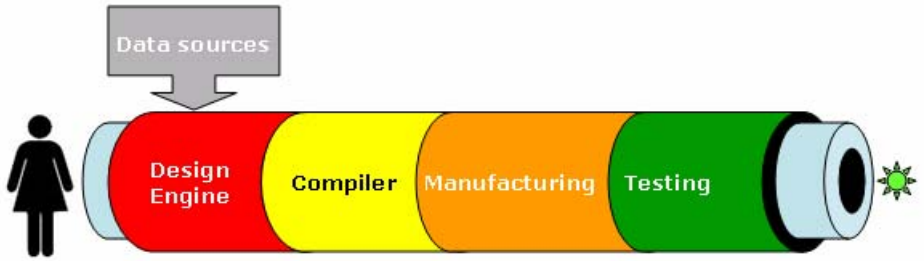

BioJADE
File BioBrick DB Settings Help
Library default
Part BBa_9999
Aspects
Schematic
FunctionalNetwork
DNA
Simulation
Icon
Select
Stamp
Wire
Cut
Copy
Paste
Zoom In
Zoom Out
Save
Revert
Optimize
Compile
Templates
nand2
not
reporter
source
or2
sender
Endy1
Reverse Terminators
BBa_C0062
not null
not null
not null
Used Parts
Wire Mode: Click mouse to start a wire. Click again to stop the wire, or ALT-click to set a waypoint. CTL-Click on terminals and press w to automatically wire together terminals.
Part Information
Part Type : Other
Designer : Jonathan Goler
Description : demo repressilator
Notes

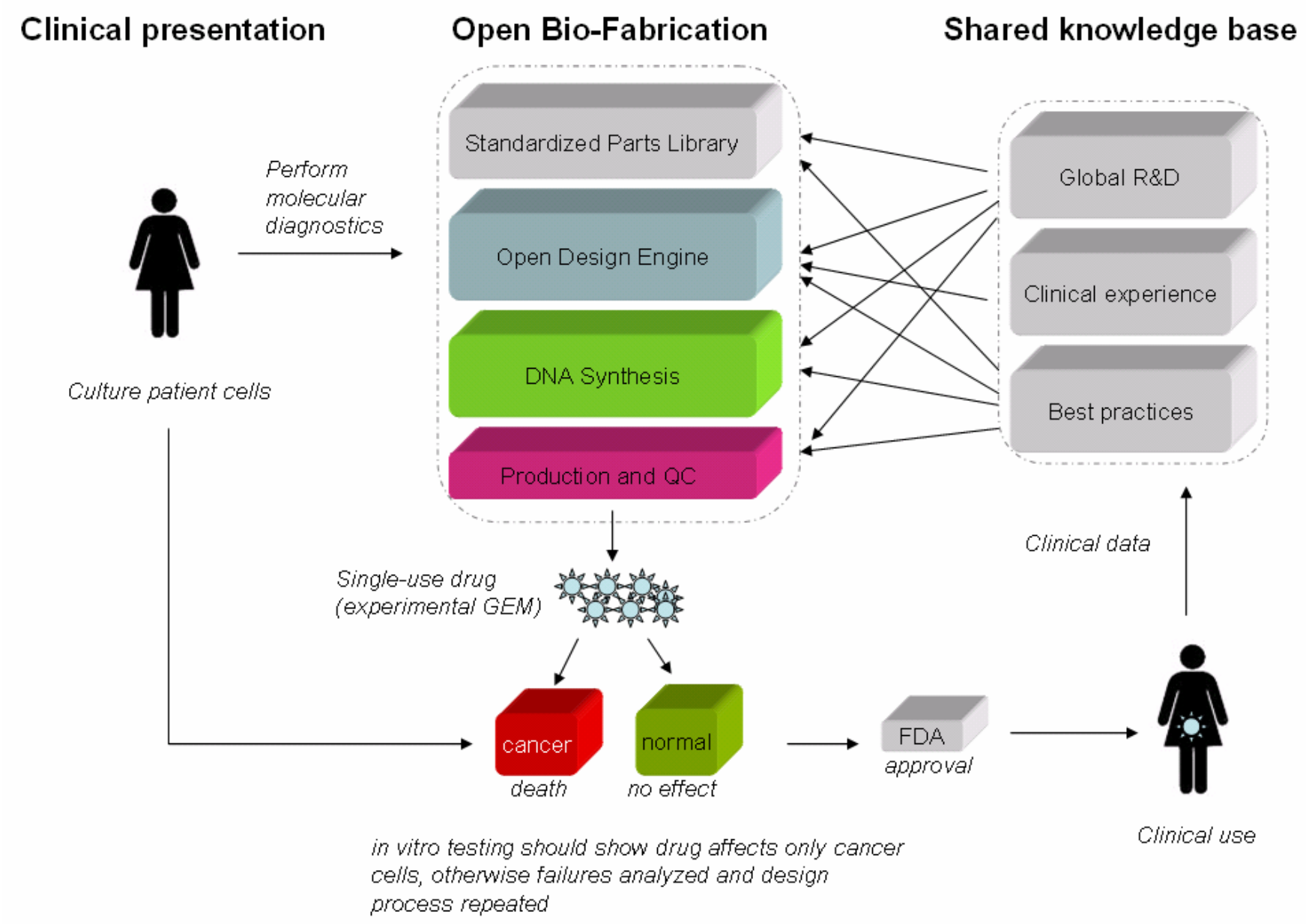
Toward a New Drug Development Pipeline Suitable for Personalized Cancer Therapeutics

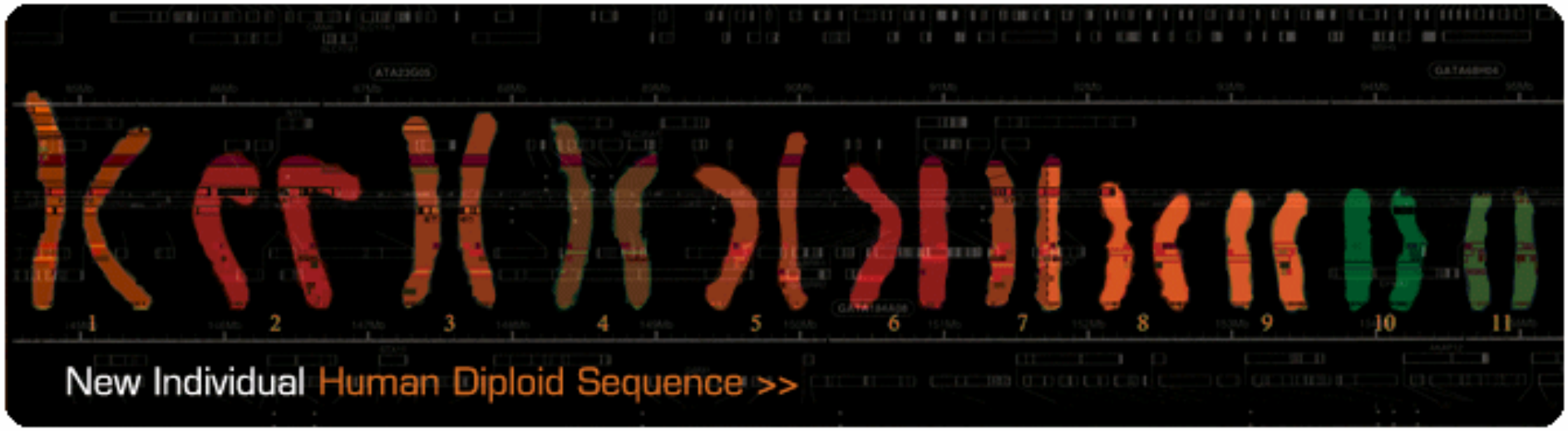


Ideally, a next-generation pipeline for effective cancer drugs would:

- As an output, produce personalized medicines
- Be able to produce a targeted medicine for every cancer, newly diagnosed or recurring
- Allow for rapid and sustainable development of these outputs
- Have favorable drug development economics, ie. the cost of producing drugs decreases over time
- Make a failure of any drug in the pipeline a trivial event
- Be able to grow in output capacity to satisfy the needs of a global market
- Continuously incorporate the latest understanding and data from molecular biology, oncology, and related sciences, plus growing clinical experience with personalized medicines
- And, finally, ensure the highest possible standards of safety and oversight



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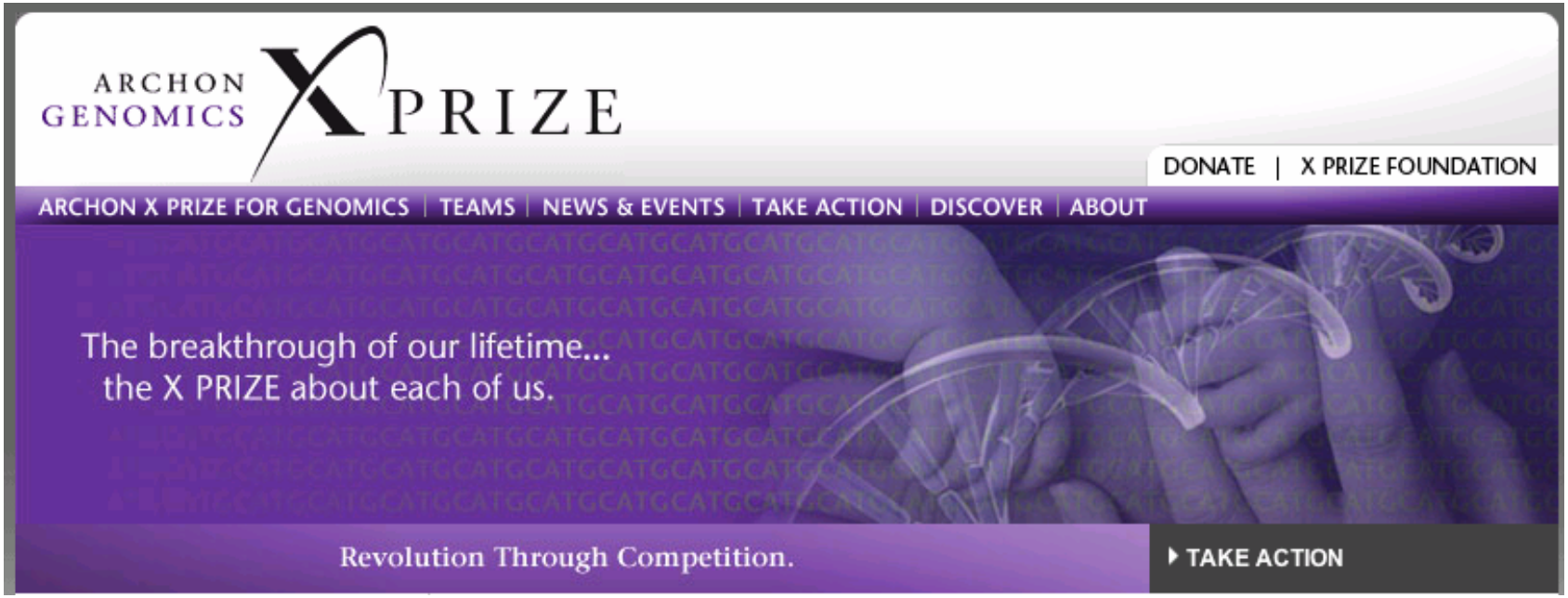
11
New Individual Human Diploid Sequence >>


ARCHON GENOMICS X PRIZE
DONATE | X PRIZE FOUNDATION
ARCHON X PRIZE FOR GENOMICS | TEAMS | NEWS & EVENTS | TAKE ACTION | DISCOVER | ABOUT
The breakthrough of our lifetime...
the X PRIZE about each of us.
Revolution Through Competition.
TAKE ACTION

23andMe genetics just got personal.

sign in | help
have a claim code?

our service | genetics 101 | for the experts | store | about us

discover your genome at 23andMe **order now**

[replay animation]

1866: Gregor Mendel discovers the laws of inheritance.

200,000 years ago: *Homo sapiens* walks the Earth.

2003: The Human Genome Project maps a single person's genome.

2007: 23andMe introduces the first Personal Genome Service.

Unlock the secrets of your own DNA. Today.

175,000 years ago: The mother of all present-day humans is born in Africa.

1953: Watson and Crick uncover the double-helix structure of DNA.

Welcome to 23andMe, a web-based service that helps you read and understand your DNA. After providing a saliva sample using an at-home kit, you can use our interactive tools to shed new light on your distant ancestors, your close family and most of all, yourself.

Part 1: What are genes?

Find out about the basics of cells, chromosomes, and the genes contained in your DNA.

Part 2: What are SNPs?

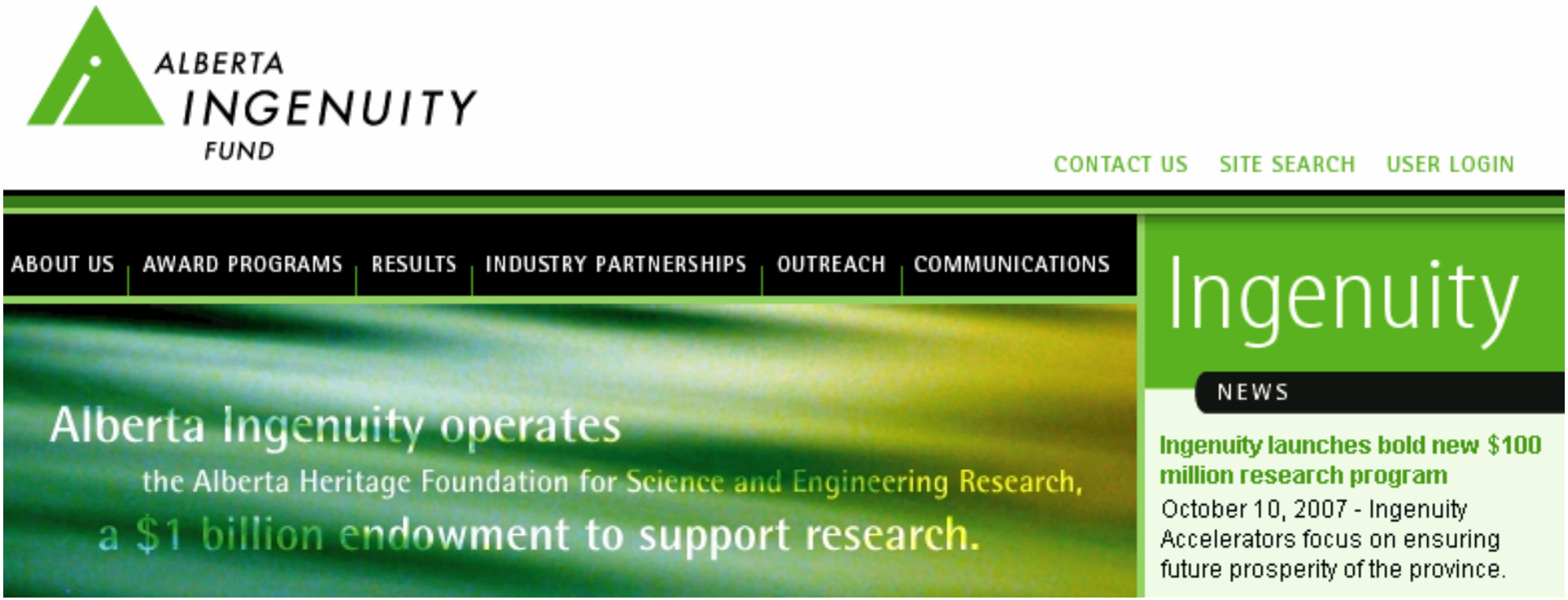
Learn about the variations in human DNA called SNPs, and how they can be used to understand relationships between people.

Opportunities for Canada if..

- Can think ***BIG*** and move ***Fast***
- *Tear down barriers* between professions and institutions and think global in scale
- Streamline and reform biological engineering education
- Invest in core resources (informational and physical)
- Select engaging and valuable applications where it can become recognized leader
- Support next-generation industry development

Progress in Alberta

- Expanding provincial government support and recognition for iGEM and synthetic biology
- More teams on the horizon
- Course creation/outreach programs
- Digital Biology Network to facilitate professional-grade standards-based biology
- Application-based, ground-up approach


ALBERTA
INGENUITY
FUND
CONTACT US
SITE SEARCH
USER LOGIN
ABOUT US
AWARD PROGRAMS
RESULTS
INDUSTRY PARTNERSHIPS
OUTREACH
COMMUNICATIONS
Alberta Ingenuity operates
the Alberta Heritage Foundation for Science and Engineering Research,
a $1 billion endowment to support research.
Ingenuity
NEWS
Ingenuity launches bold new $100 million research program
October 10, 2007 - Ingenuity Accelerators focus on ensuring future prosperity of the province.