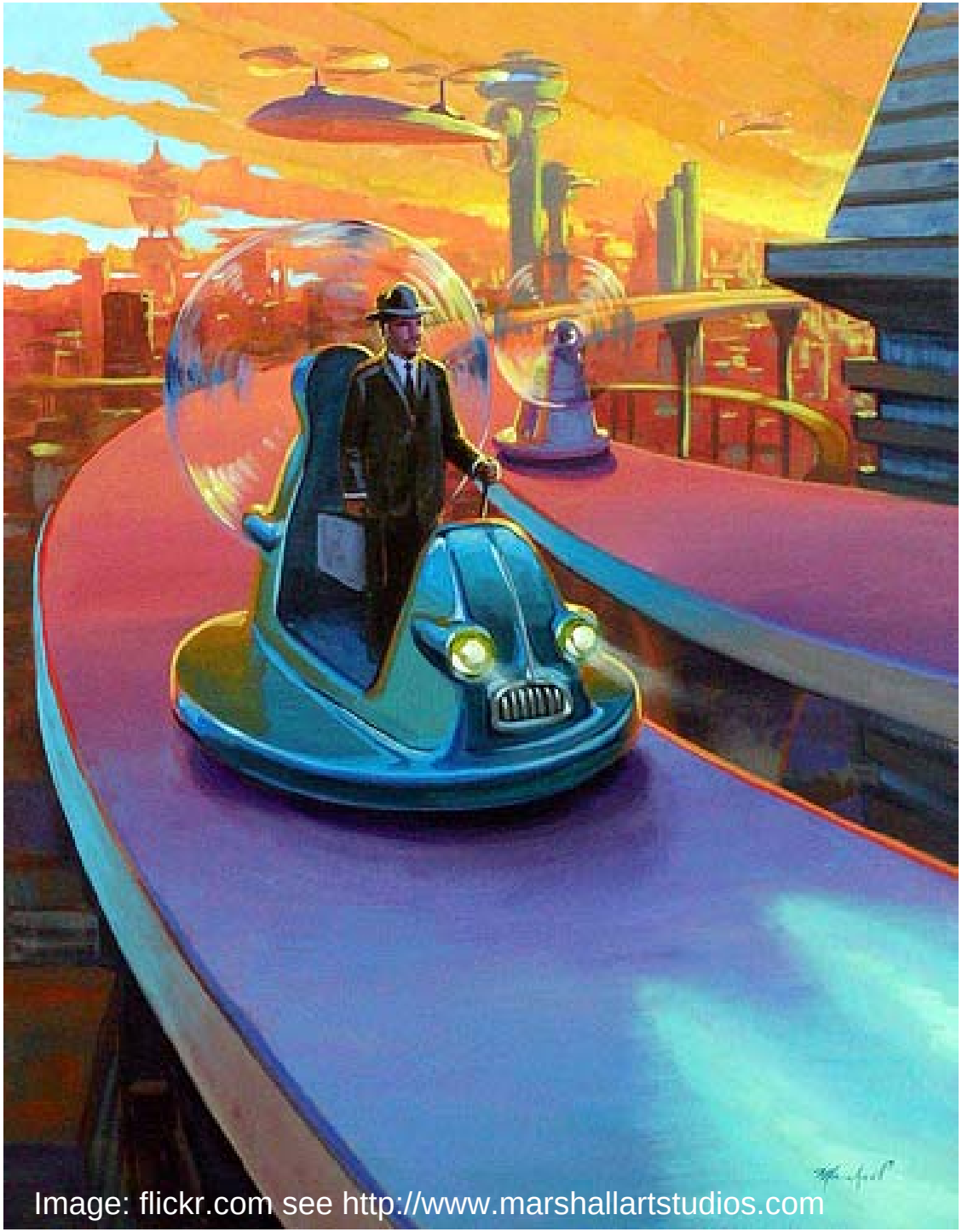


Synthetic Biology

an overview
bits and bases

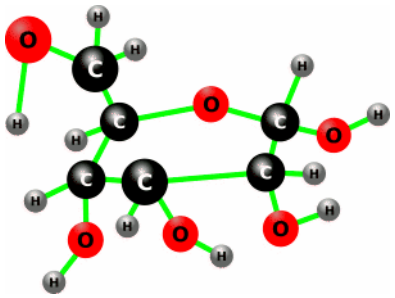
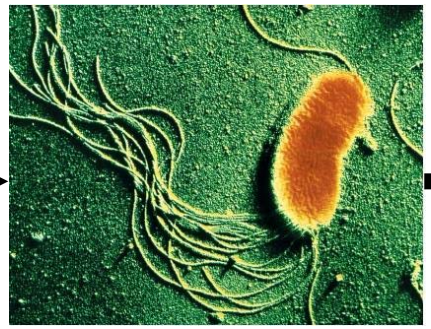
April 14, 2008
Washington DC

Andrew Hessel
ahessel@gmail.com

DNA is a programming language

Input(s) → “Computer” → Output(s)



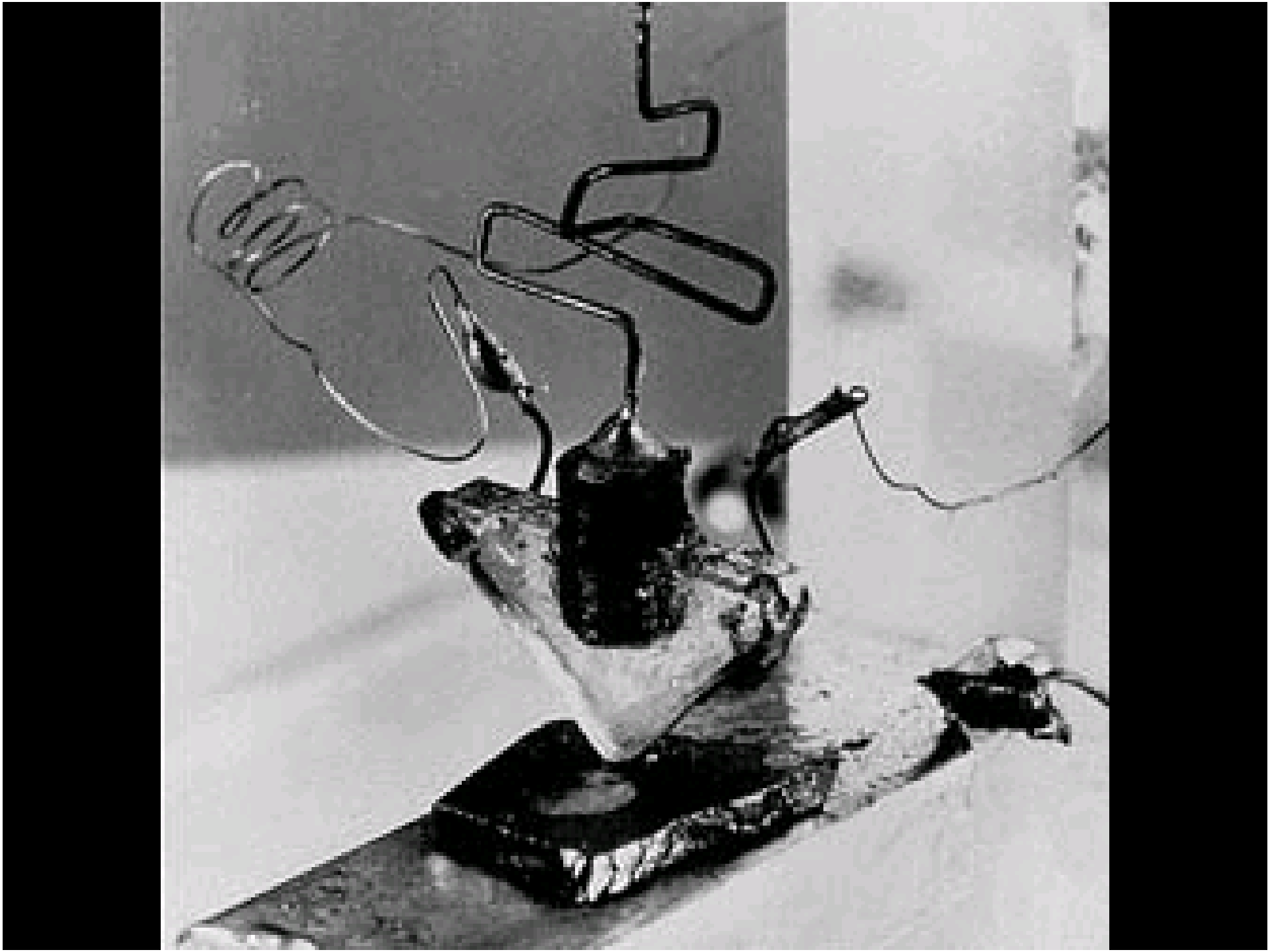
Swim toward sugar

Bits *(0,1's)* encode software for electronic processors

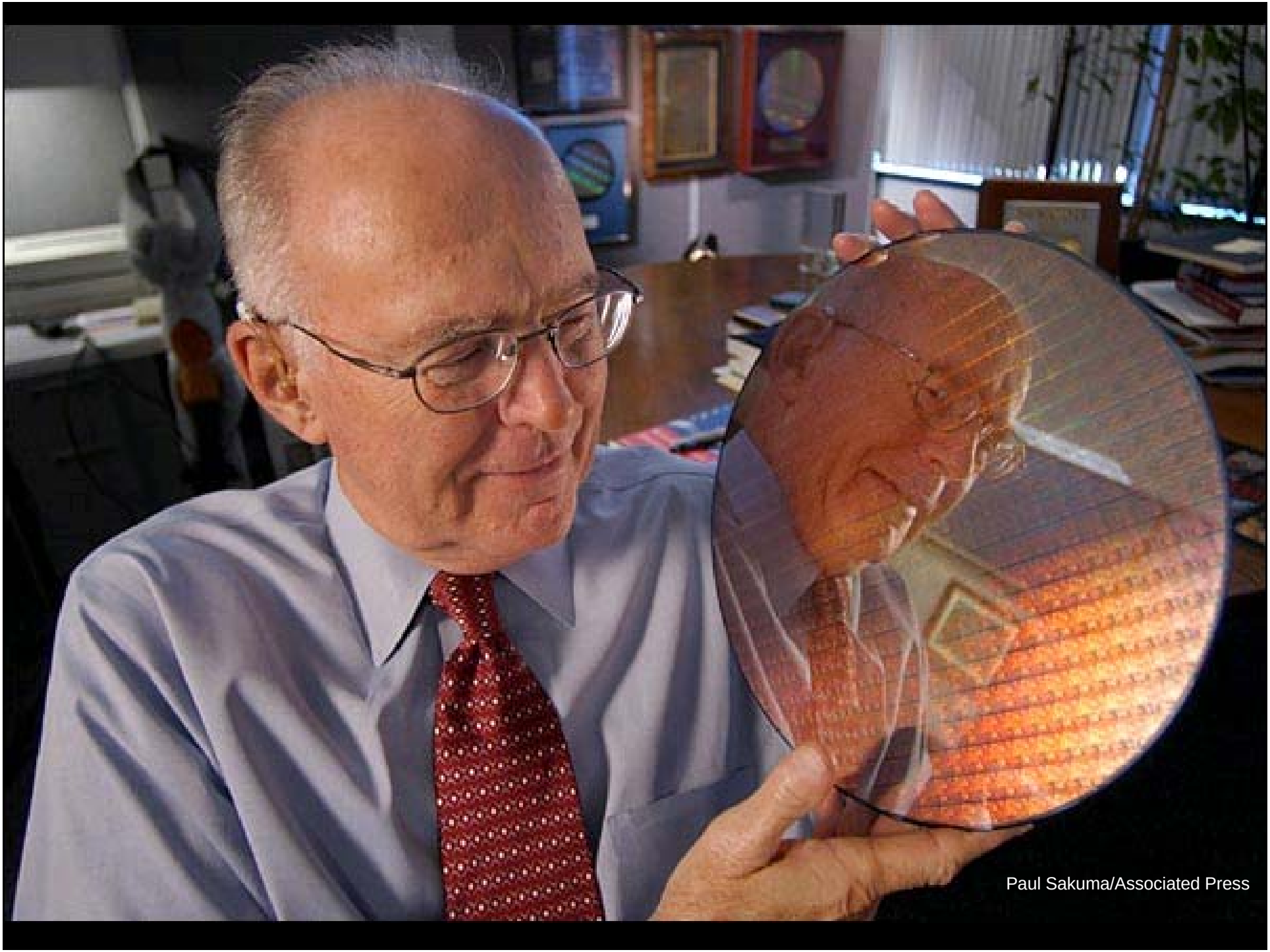
Bases (A,T,G,C's) encode software for cells

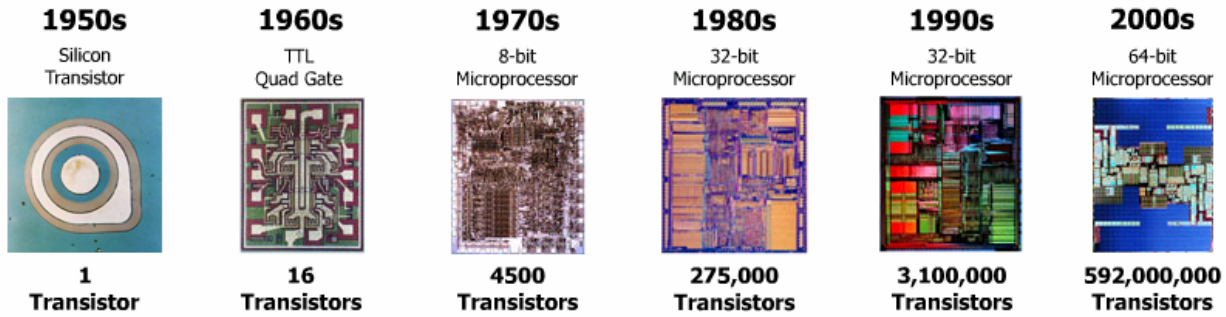
DNA is source code for cells.

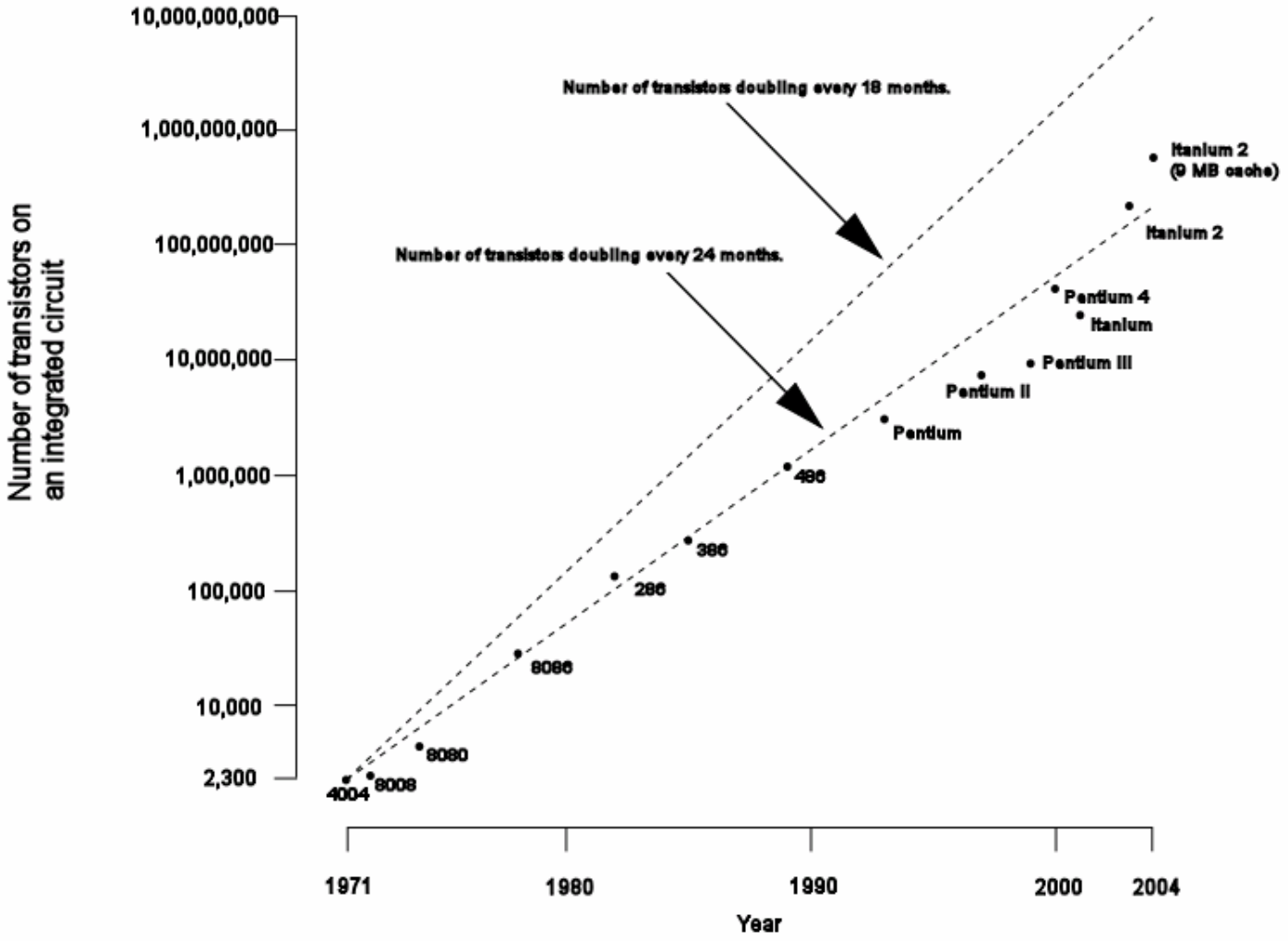
Synthetic biology is about how to program cells efficiently and reliably



IBM 701 1953


Paul Sakuma/Associated Press





Computer History Museum

1956


danielg 072006 - S3is


Microdrive
CF+™ Type II
Model : DSCM-14000
HITACHI
DO NOT SEAL THIS HOLE
www.hgst.com/microdrive
Hitachi Microdrive
©2003 Griff Wasson


PRETEC
8GB
SD HC


cruzer
sandisk


Transcend
JetFlash
16GB


DELL
DELL
DELL
MAERSK

Apple Store, Fifth Avenue

Computer Services

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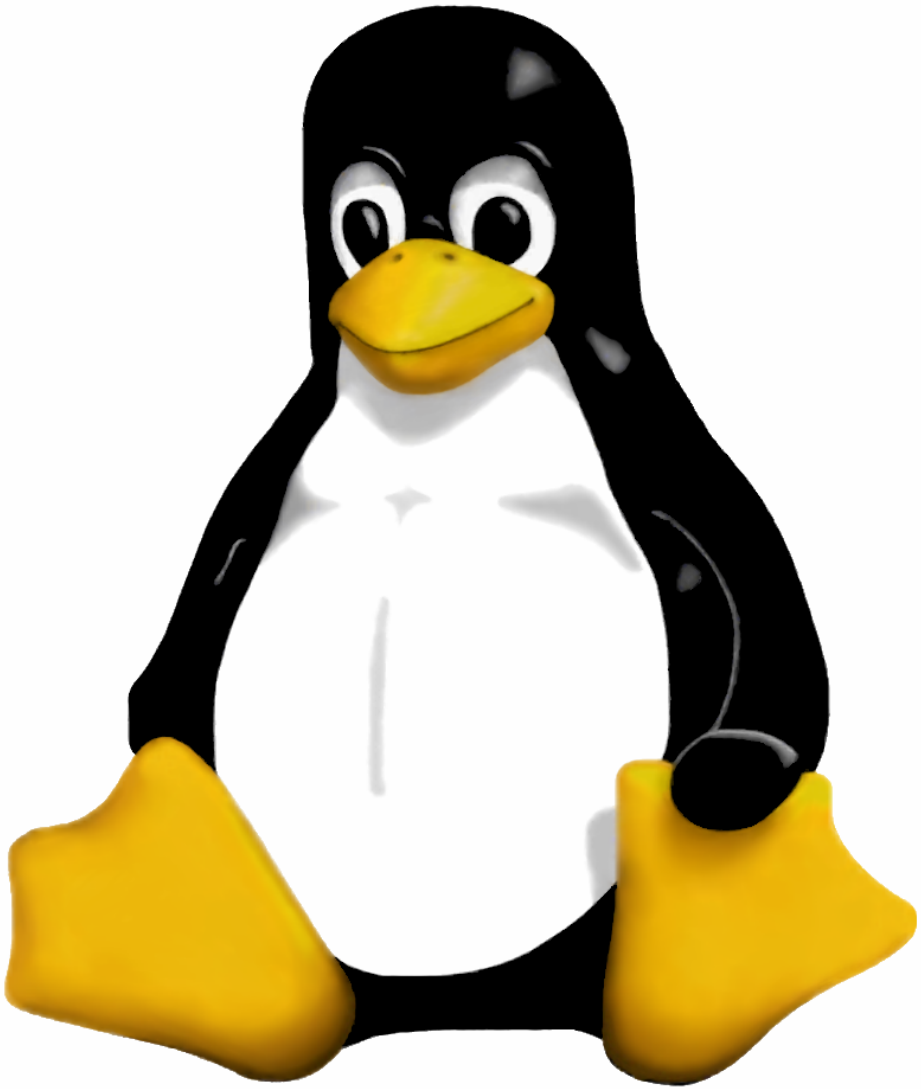
- Set Up and Security
- Repair and Upgrade
- Protect and Save
- Data Recovery
- Accessories
- Tutorials

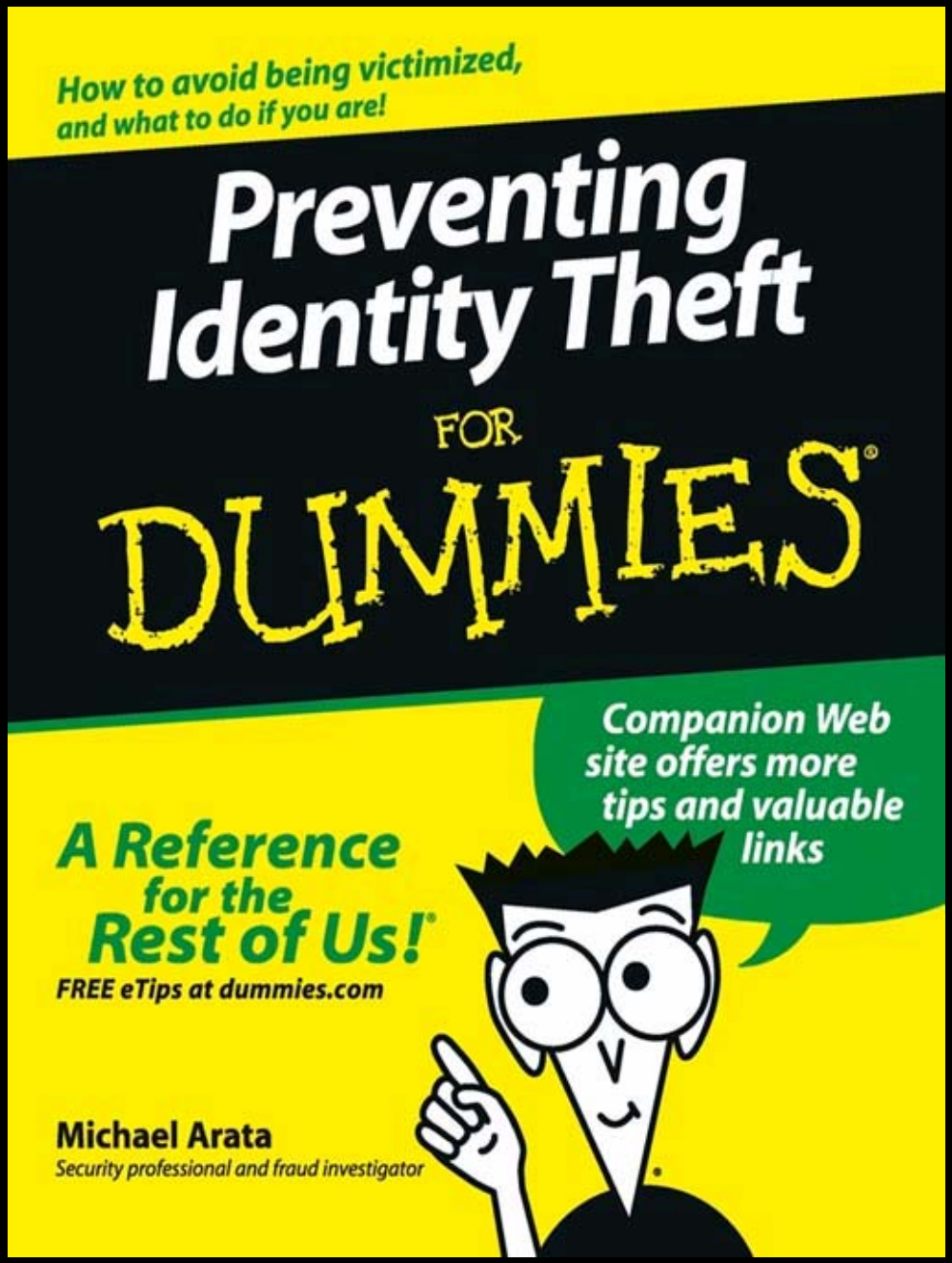
Home Theater Services

- Consultation
- Setup
- TV Mounting
- Speaker Mounting
- Remote Control Programming
- Enhancements

Services


Windows Vista™




How to avoid being victimized, and what to do if you are!
Preventing Identity Theft
FOR
DUMMIES®
Companion Web site offers more tips and valuable links
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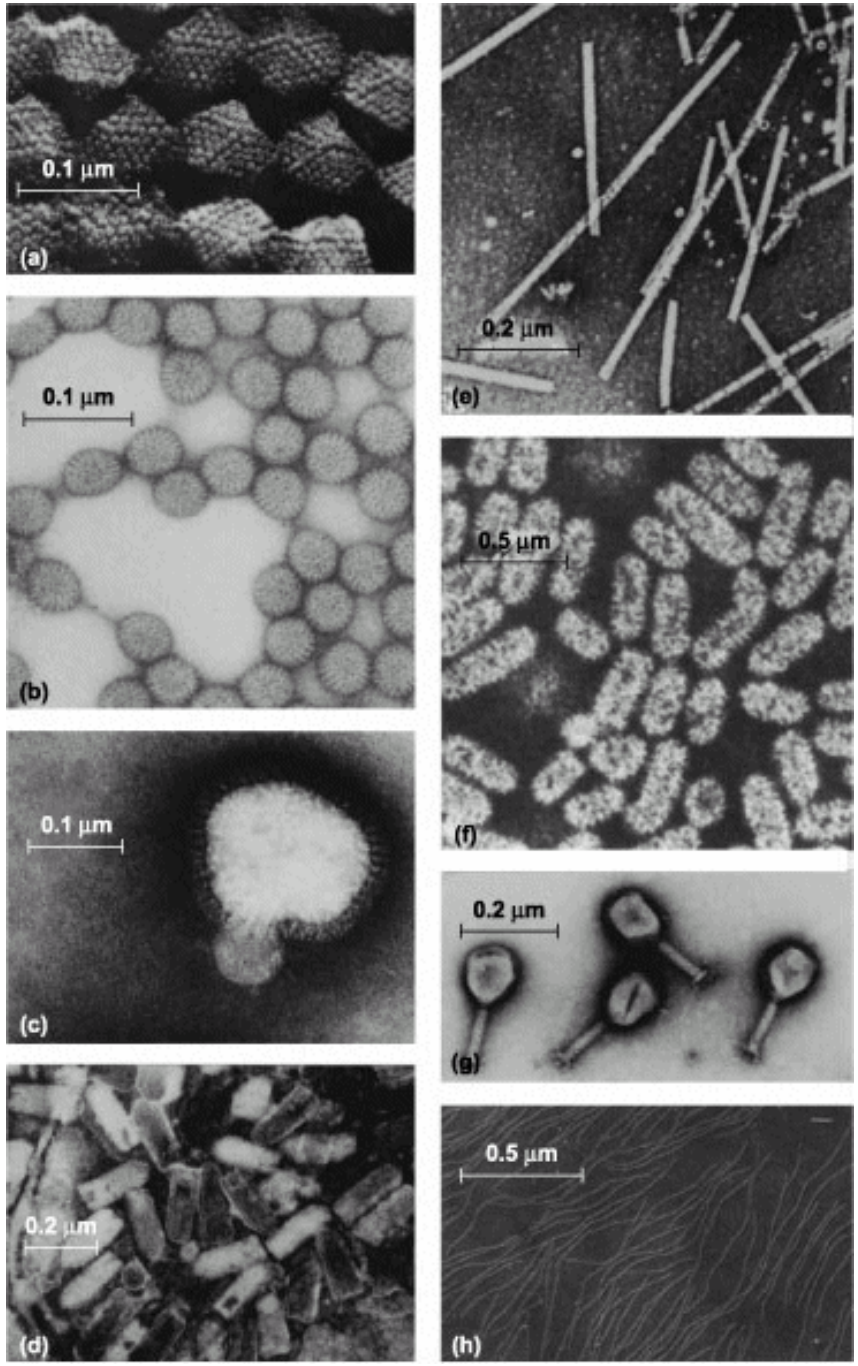
Michael Arata
Security professional and fraud investigator


HE'S GONE: Jerry Garcia Dead at 53
TIME
CYBER WAR
The U.S. rushes to turn computers into tomorrow's weapons of destruction. But how vulnerable is the home front?

So what about biological processors?

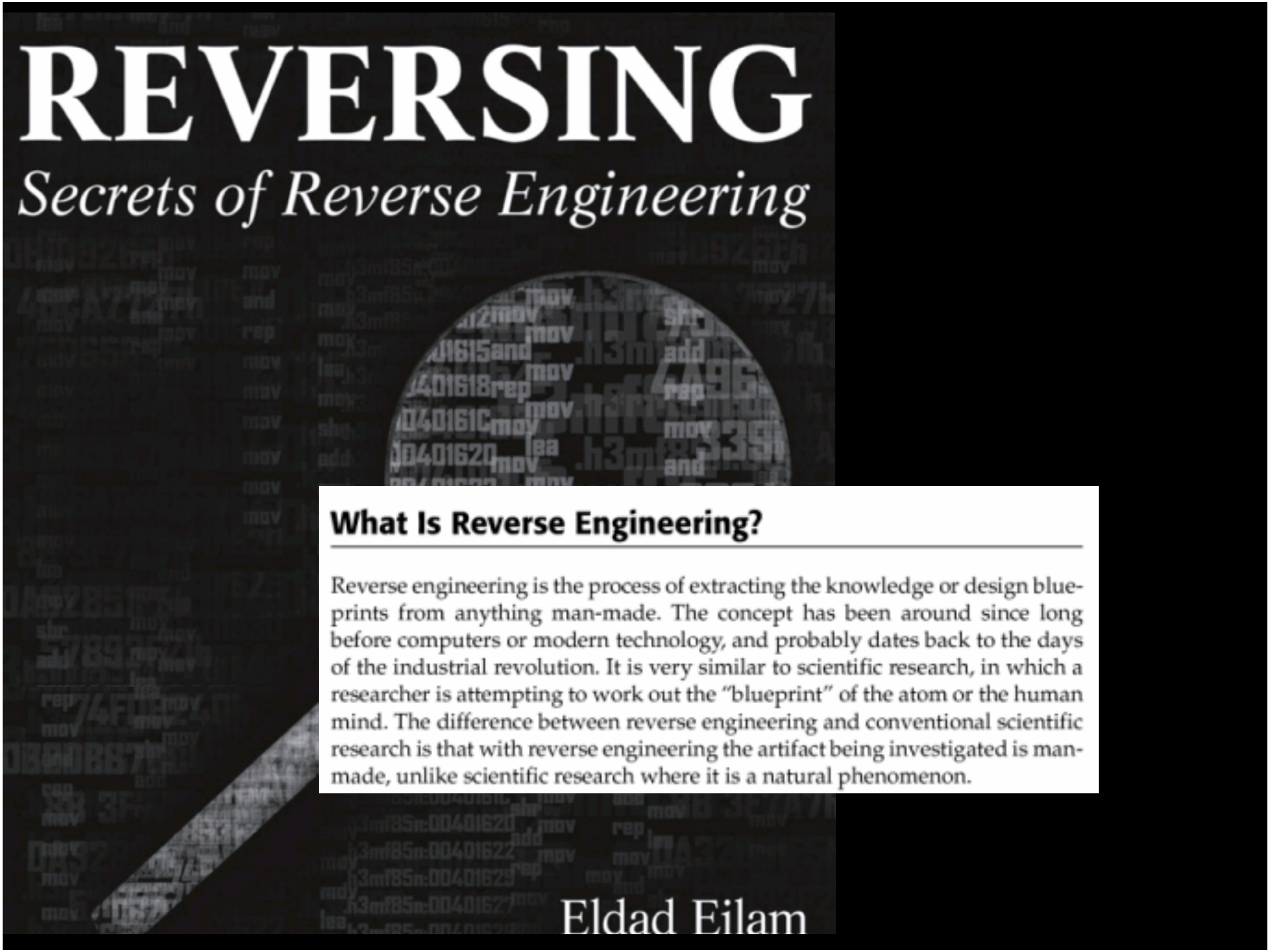
http://www.colorado.edu/MCDB/MCDB1111/introgra phics/bacterial%20chromosome.jpg

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



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

So why aren’t programmed cells an everyday thing today, like computers?


REVERSING
Secrets of Reverse Engineering
What Is Reverse Engineering?
Reverse engineering is the process of extracting the knowledge or design blueprints from anything man-made. The concept has been around since long before computers or modern technology, and probably dates back to the days of the industrial revolution. It is very similar to scientific research, in which a researcher is attempting to work out the "blueprint" of the atom or the human mind. The difference between reverse engineering and conventional scientific research is that with reverse engineering the artifact being investigated is man-made, unlike scientific research where it is a natural phenomenon.
Eldad Eilam

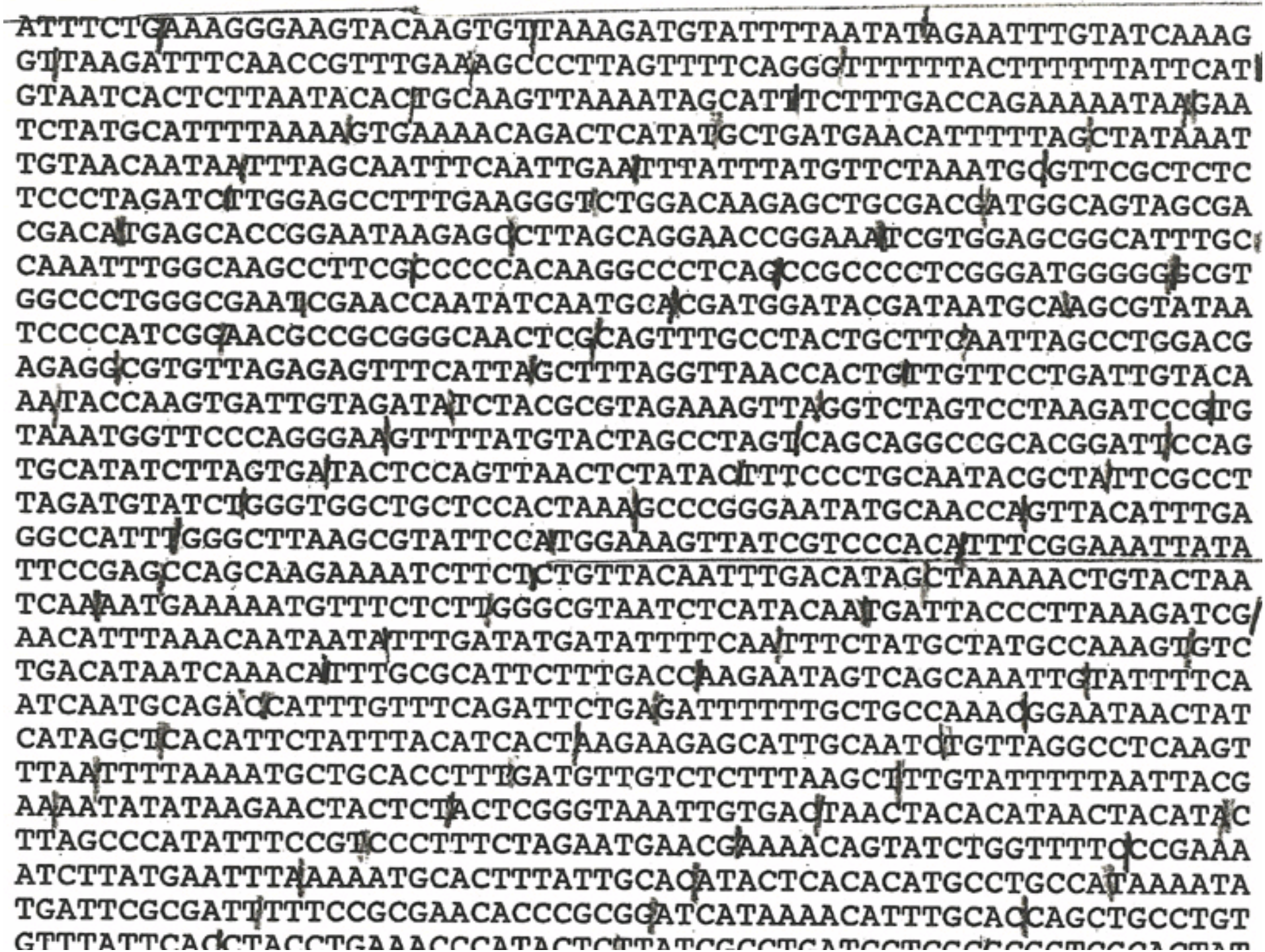
C:\Command.com

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  ................
0x00040:2433 2433 454E 5501 00B5 014E 5343 4F00  $3$3ENU..µ.NSCO.
0x00050:0306 0016 001A 0001 04FF FF48 0302 0056  .........ÿÿH...V
0x00060:0303 0061 0308 006C 0302 01FF FF7A 0303  ...a...l...ÿÿz..
0x00070:CCEA 0383 03EB 03A4 03EC 03BC 03ED 03D2  Ìê.ƒ.ë.¤.ì.¼.í.Ò
0x00080:03EE 03ED 03EF 0313 04F0 032A 04F1 033C  .î.í.ï...ð.*.ñ.<
0x00090:04F2 034D 04F3 0369 04F4 0380 04F5 03B6  .ò.M.ó.i.ô.□.õ.¶
0x000A0:04F6 03CD 04F7 03D8 04F8 03F8 04F9 031E  .ö.Í.÷.Ø.ø.ø.ù..
0x000B0:05FA 033F 05FB 034F 05FC 0357 05FD 0363  .ú.?.û.O.ü.W.ý.c
```

Pos : 0 Size : 93812

Nobel foundation

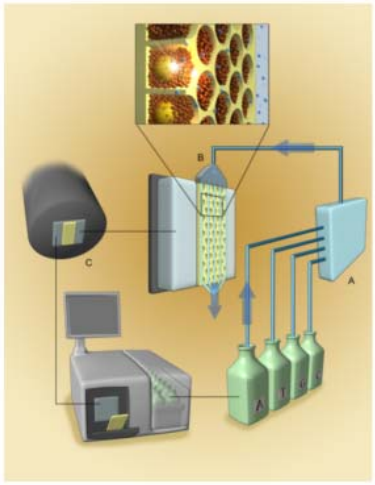


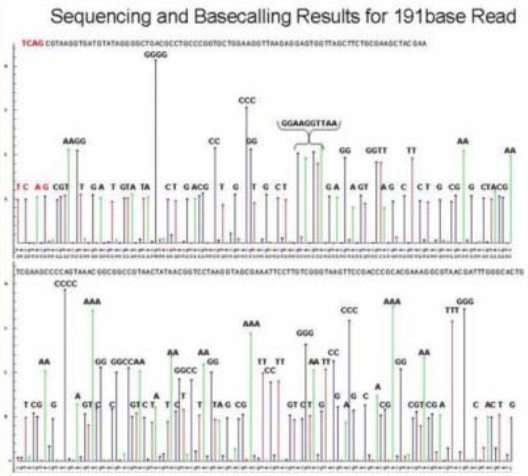
1980
500 bp/day (manual)

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

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

1998
500,000 bp/day (automatic)

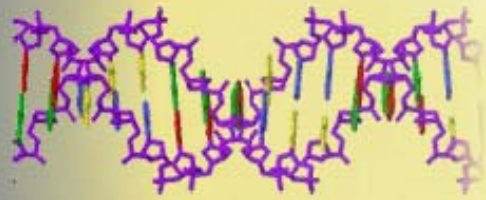




2007 – Sequencing by Synthesis
1GB bp/day (automatic)

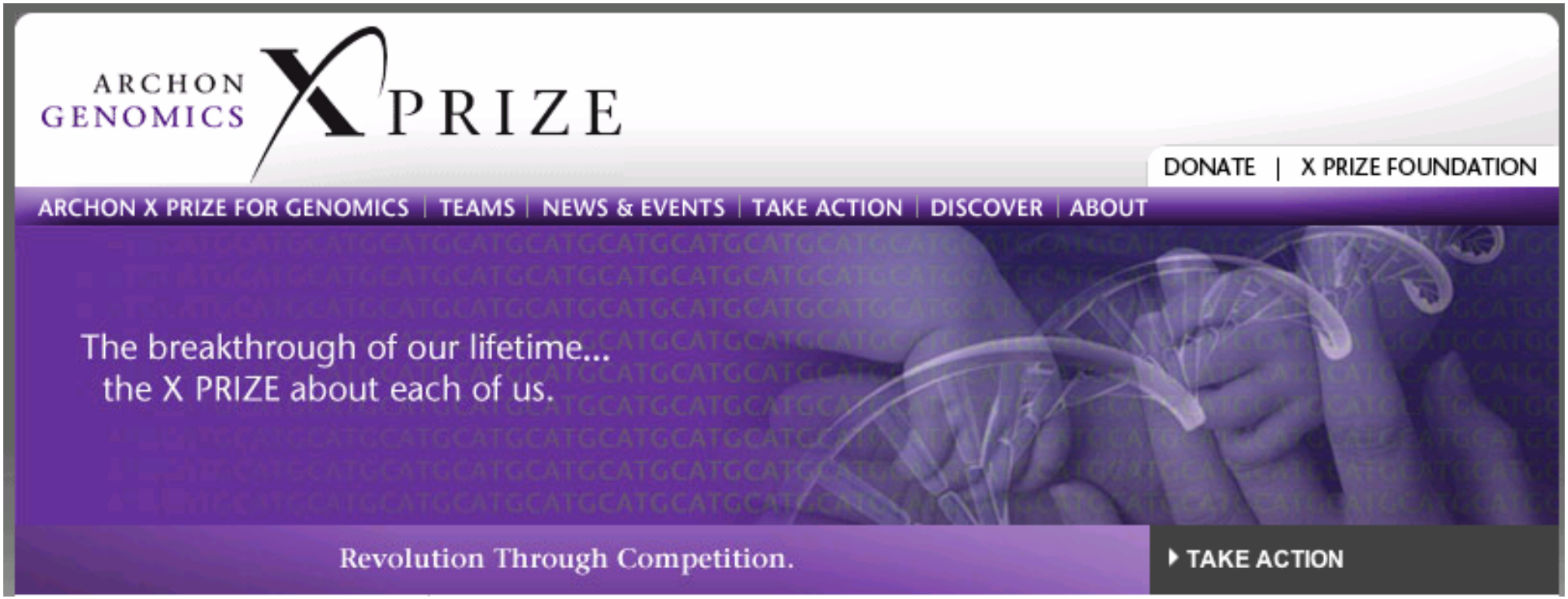
THE POLONATOR G.007

Welcome | The Vision | Ecosystem | Instrument | Protocols | Software | Reagent Kits | Flow Cells | Community | About Us | Contact



C A A T C C C A A T C C
| | | | | | | | | | | |
G T T A G G G T T A G G

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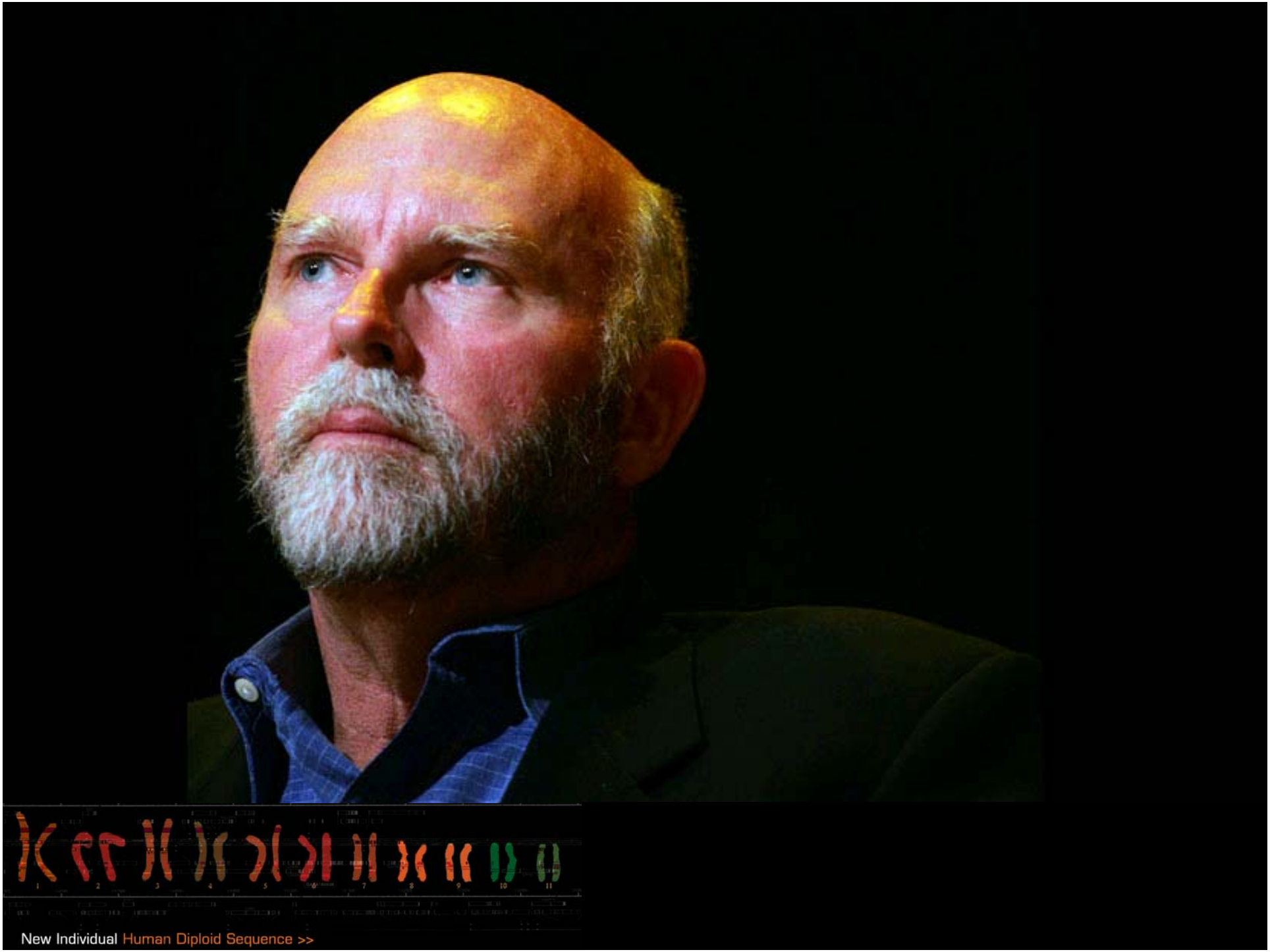
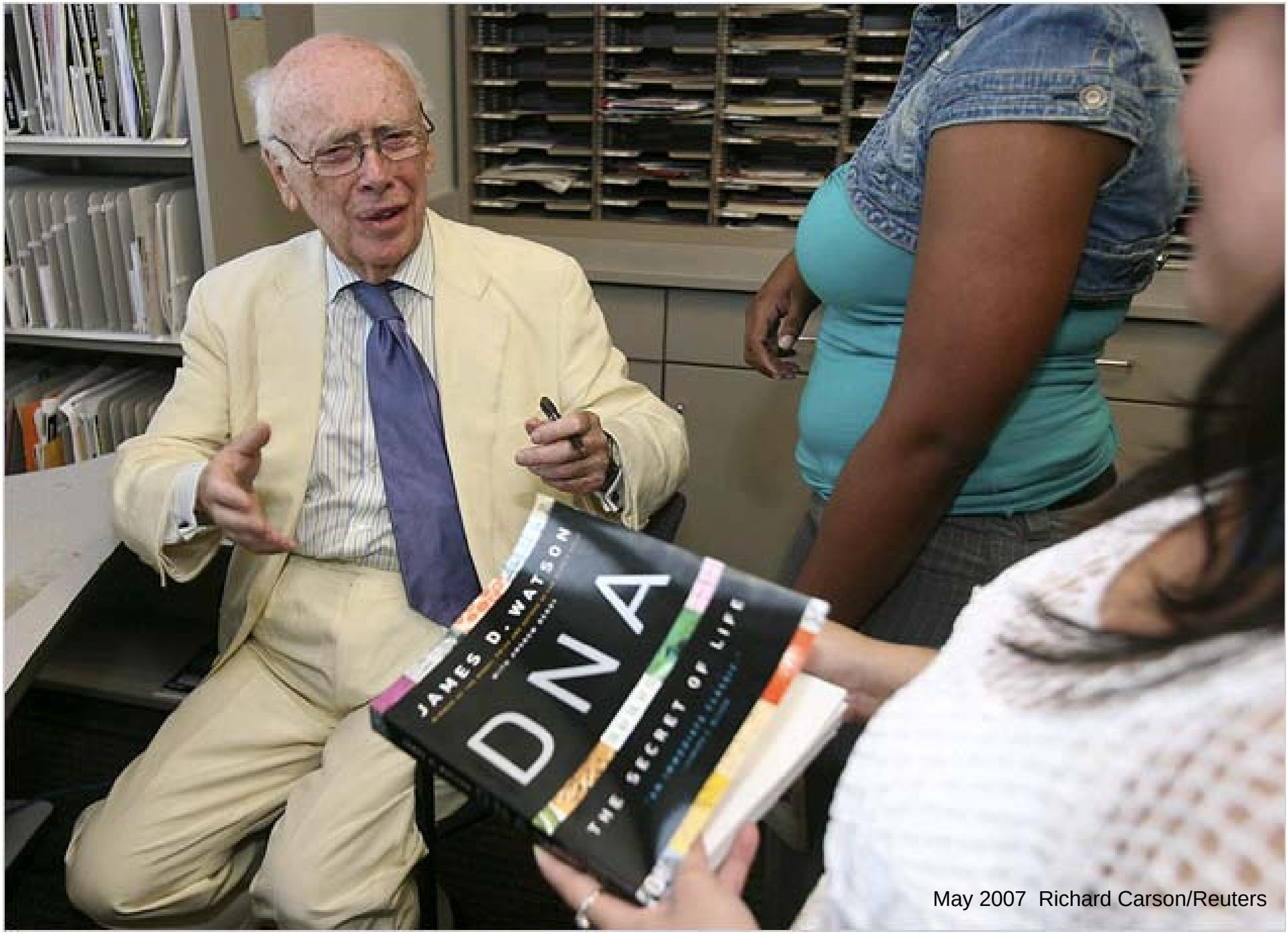
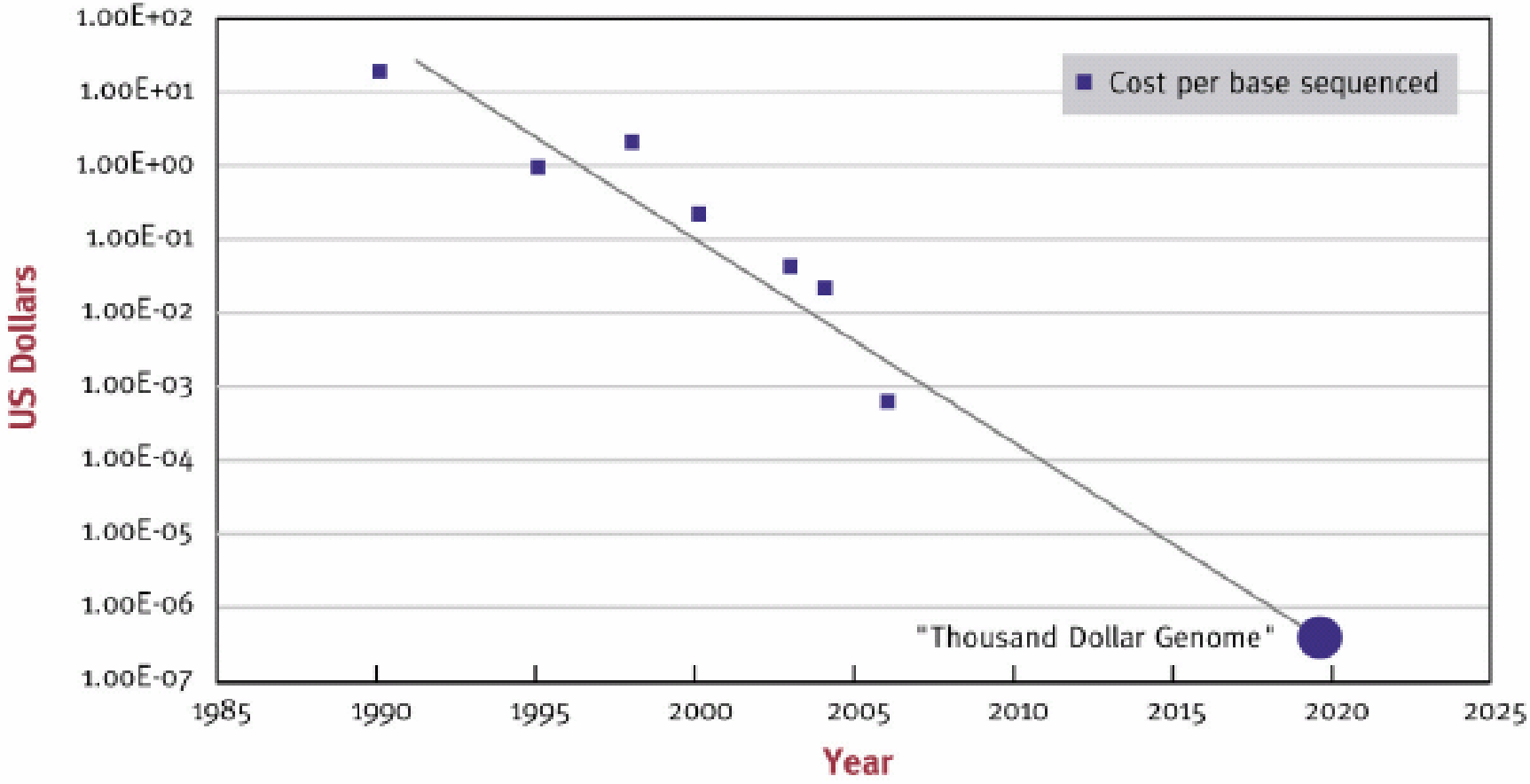
ARCHON X PRIZE FOR GENOMICS | TEAMS | NEWS & EVENTS | TAKE ACTION | DISCOVER | ABOUT
The breakthrough of our lifetime...
the X PRIZE about each of us.
Revolution Through Competition.
TAKE ACTION


New Individual Human Diploid Sequence >>



May 2007 Richard Carson/Reuters



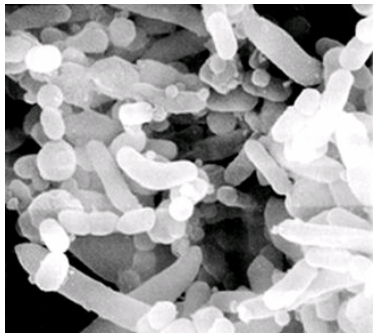
Source: R. Carlson, Bio-era

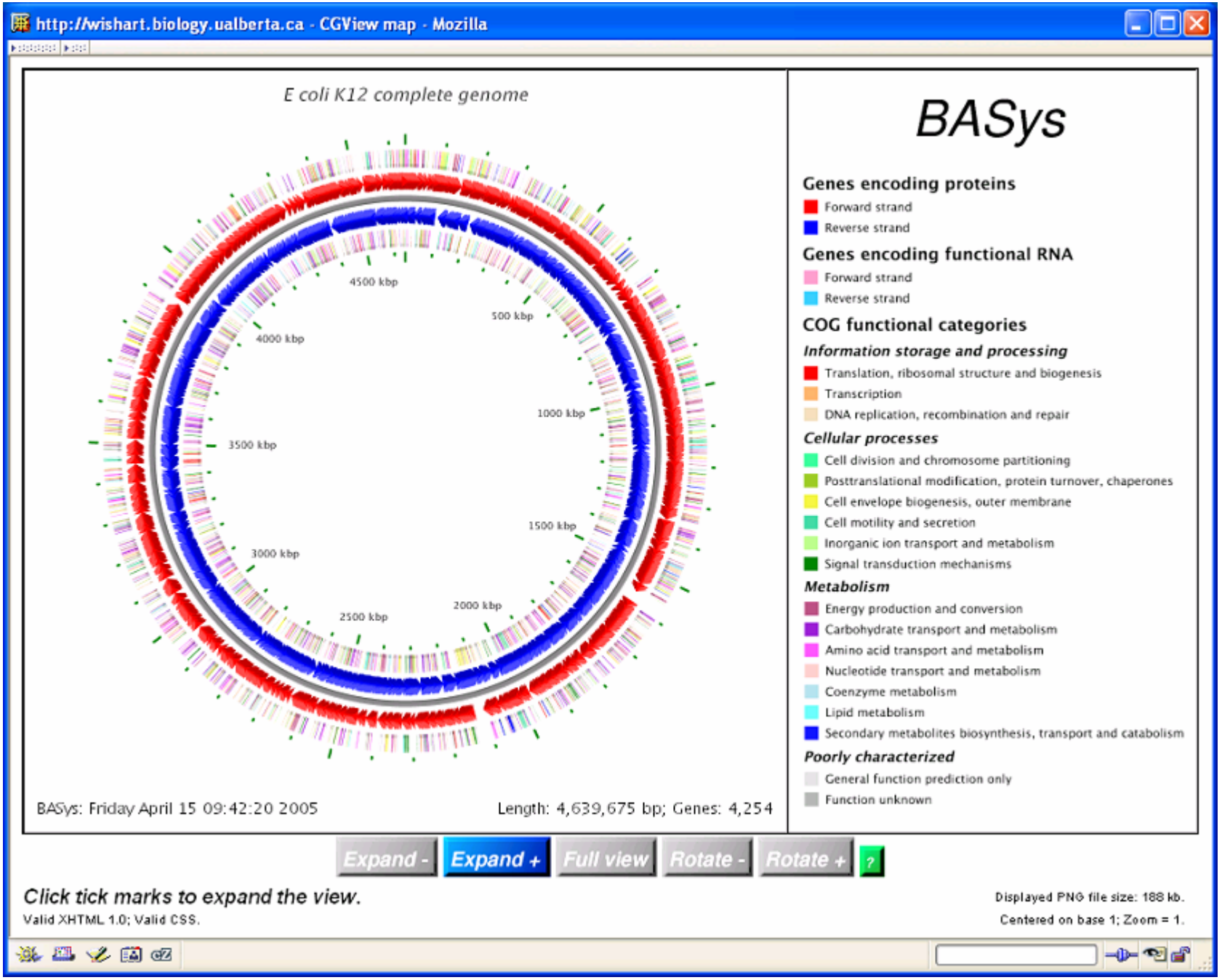
Environmental Shotgun Sequencing: Its Potential and Challenges for Studying the Hidden World of Microbes

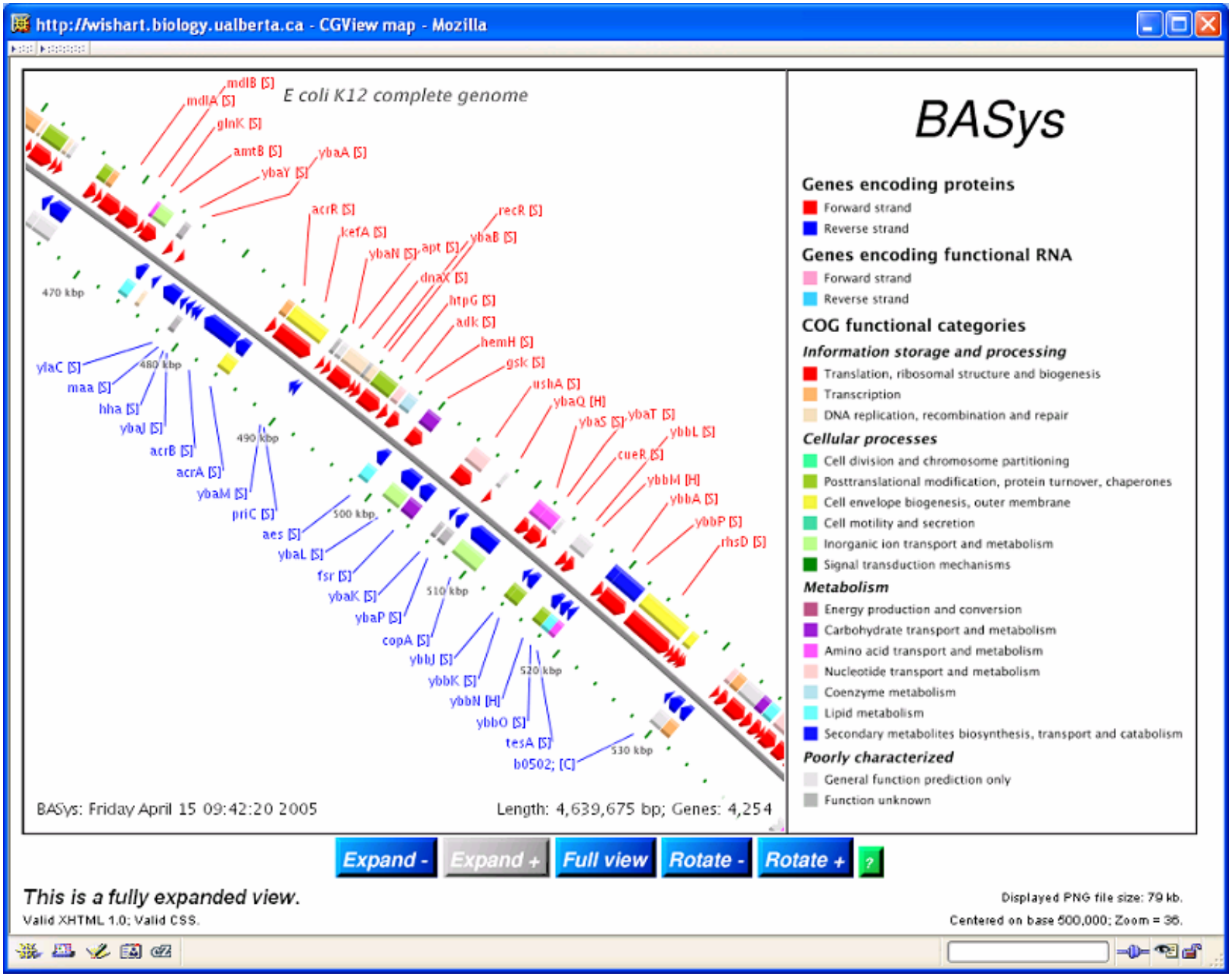


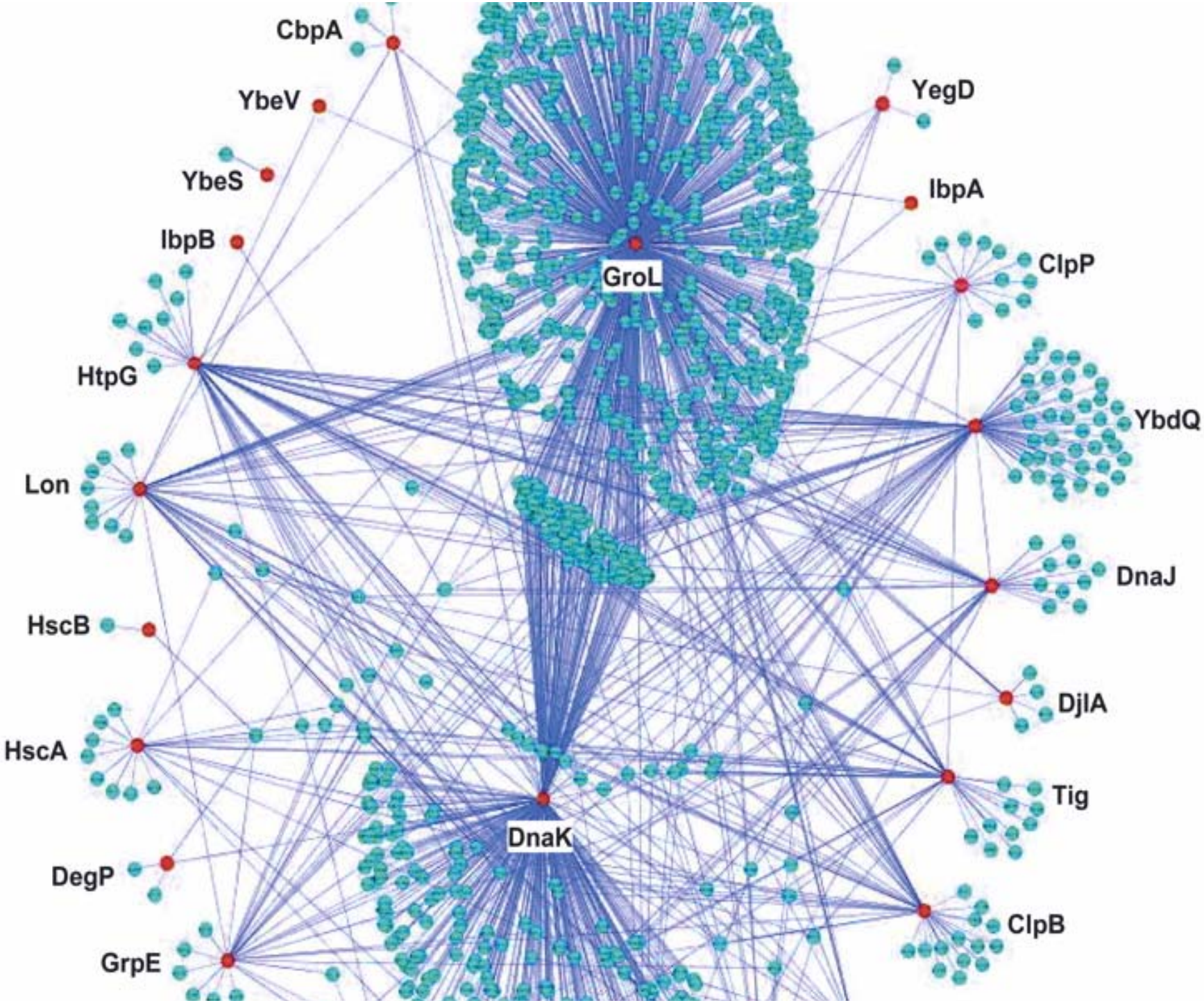






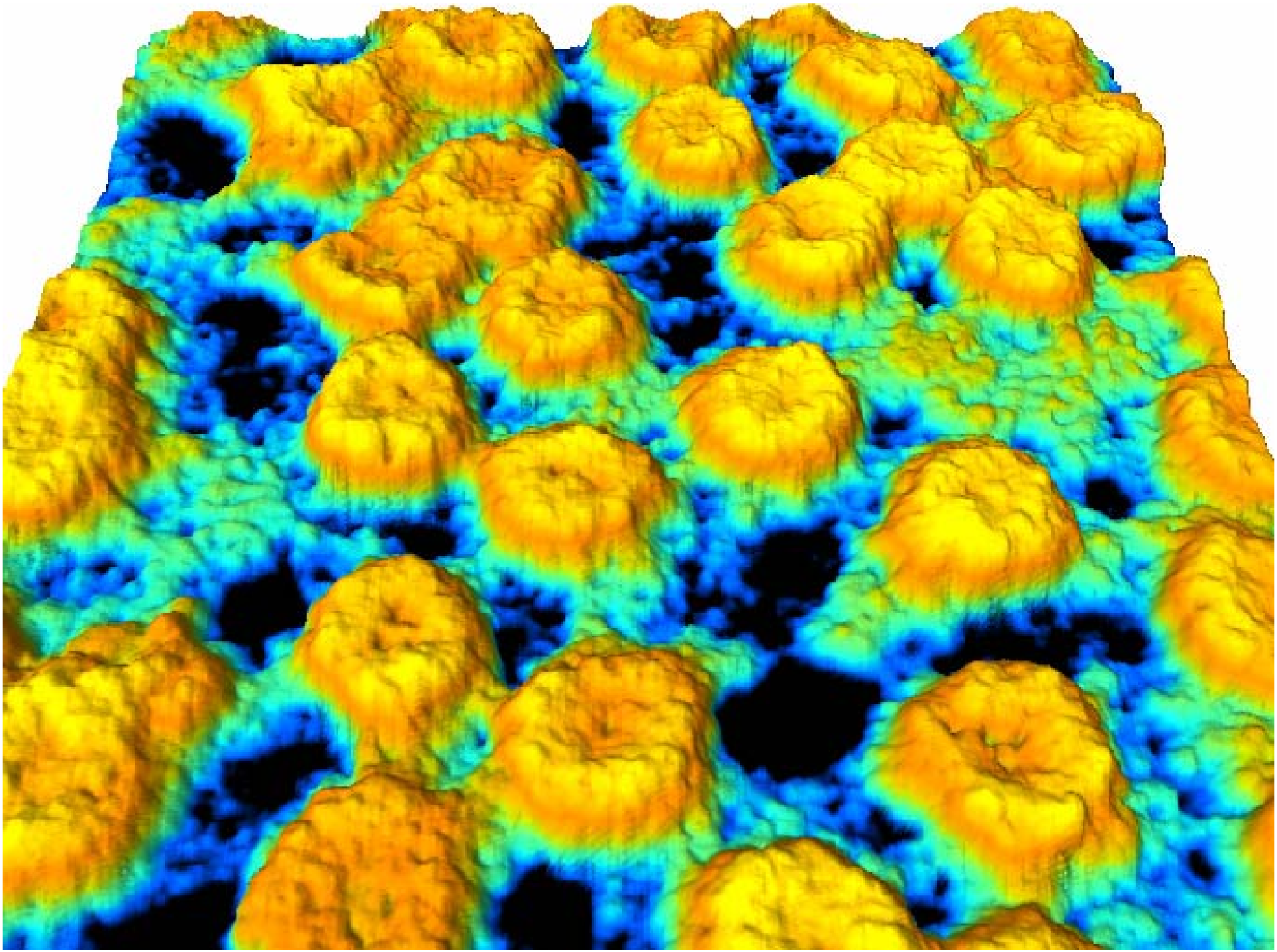

http://wishart.biology.ualberta.ca - CGView map - Mozilla
E coli K12 complete genome
4500 kbp
500 kbp
4000 kbp
1000 kbp
3500 kbp
1500 kbp
3000 kbp
2000 kbp
2500 kbp
BASys
Genes encoding proteins
Forward strand
Reverse strand
Genes encoding functional RNA
Forward strand
Reverse strand
COG functional categories
Information storage and processing
Translation, ribosomal structure and biogenesis
Transcription
DNA replication, recombination and repair
Cellular processes
Cell division and chromosome partitioning
Posttranslational modification, protein turnover, chaperones
Cell envelope biogenesis, outer membrane
Cell motility and secretion
Inorganic ion transport and metabolism
Signal transduction mechanisms
Metabolism
Energy production and conversion
Carbohydrate transport and metabolism
Amino acid transport and metabolism
Nucleotide transport and metabolism
Coenzyme metabolism
Lipid metabolism
Secondary metabolites biosynthesis, transport and catabolism
Poorly characterized
General function prediction only
Function unknown
BASys: Friday April 15 09:42:20 2005
Length: 4,639,675 bp; Genes: 4,254
Expand -
Expand +
Full view
Rotate -
Rotate +
?
Click tick marks to expand the view.
Valid XHTML 1.0; Valid CSS.
Displayed PNG file size: 188 kb.
Centered on base 1; Zoom = 1.

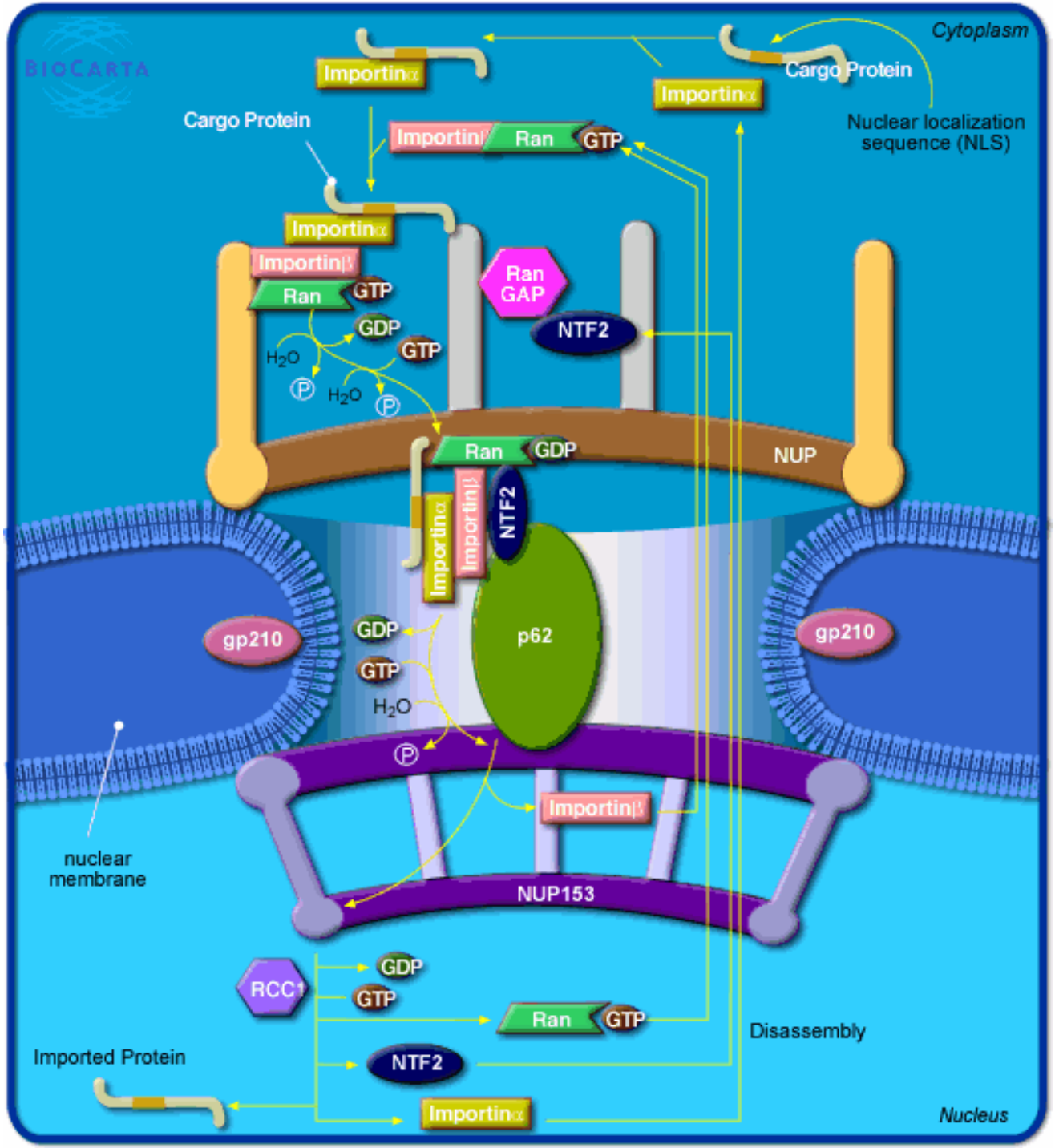

http://wishart.biology.ualberta.ca - CGView map - Mozilla
E coli K12 complete genome
mdlB [S]
mdlA [S]
glnK [S]
amtB [S]
ybaY [S]
ybaA [S]
acrR [S]
kefA [S]
ybaN [S]
apt [S]
recR [S]
ybaB [S]
dnaX [S]
htpG [S]
adk [S]
hemH [S]
gsk [S]
ushA [S]
ybaQ [H]
ybaS [S]
ybaT [S]
ybbL [S]
cueR [S]
ybbM [H]
ybbA [S]
ybbP [S]
rhsD [S]
470 kbp
480 kbp
490 kbp
500 kbp
510 kbp
520 kbp
530 kbp
ylaC [S]
maa [S]
hha [S]
ybaJ [S]
acrB [S]
acrA [S]
ybaM [S]
priC [S]
aes [S]
ybaL [S]
fsr [S]
ybaK [S]
ybaP [S]
copA [S]
yblJ [S]
ybbK [S]
ybbN [H]
ybbO [S]
tesA [S]
b0502; [C]
BASys
Genes encoding proteins
Forward strand
Reverse strand
Genes encoding functional RNA
Forward strand
Reverse strand
COG functional categories
Information storage and processing
Translation, ribosomal structure and biogenesis
Transcription
DNA replication, recombination and repair
Cellular processes
Cell division and chromosome partitioning
Posttranslational modification, protein turnover, chaperones
Cell envelope biogenesis, outer membrane
Cell motility and secretion
Inorganic ion transport and metabolism
Signal transduction mechanisms
Metabolism
Energy production and conversion
Carbohydrate transport and metabolism
Amino acid transport and metabolism
Nucleotide transport and metabolism
Coenzyme metabolism
Lipid metabolism
Secondary metabolites biosynthesis, transport and catabolism
Poorly characterized
General function prediction only
Function unknown
BASys: Friday April 15 09:42:20 2005
Length: 4,639,675 bp; Genes: 4,254
Expand -
Expand +
Full view
Rotate -
Rotate +
?
This is a fully expanded view.
Valid XHTML 1.0; Valid CSS.
Displayed PNG file size: 79 kb.
Centered on base 500,000; Zoom = 36.

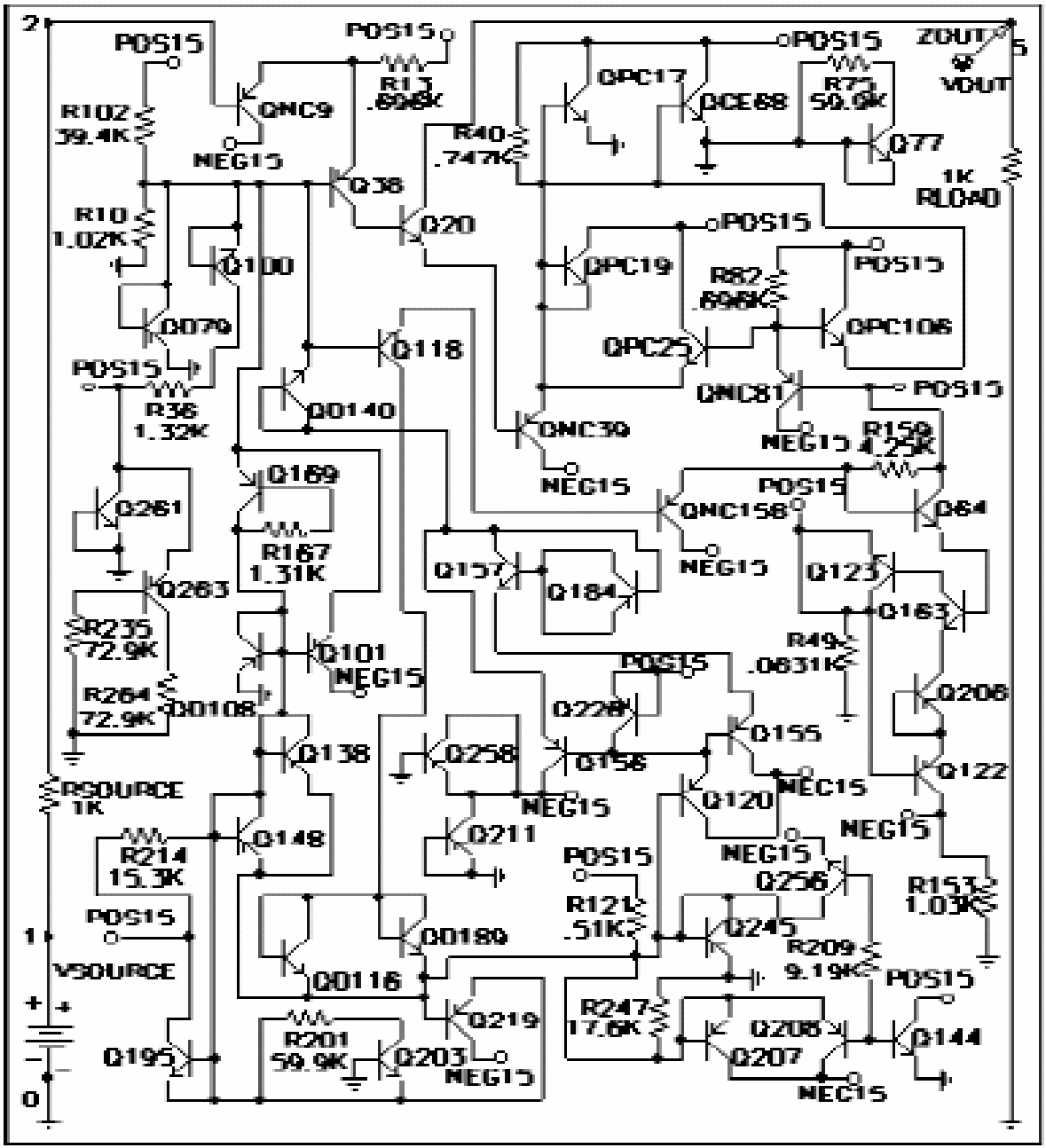

CbpA
YbeV
YbeS
IbpB
HtpG
Lon
HscB
HscA
DegP
GrpE
GroL
DnaK
YegD
IbpA
ClpP
YbdQ
DnaJ
DjlA
Tig
ClpB

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

596 TFLOPS (trillion floating point operations per second)




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



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

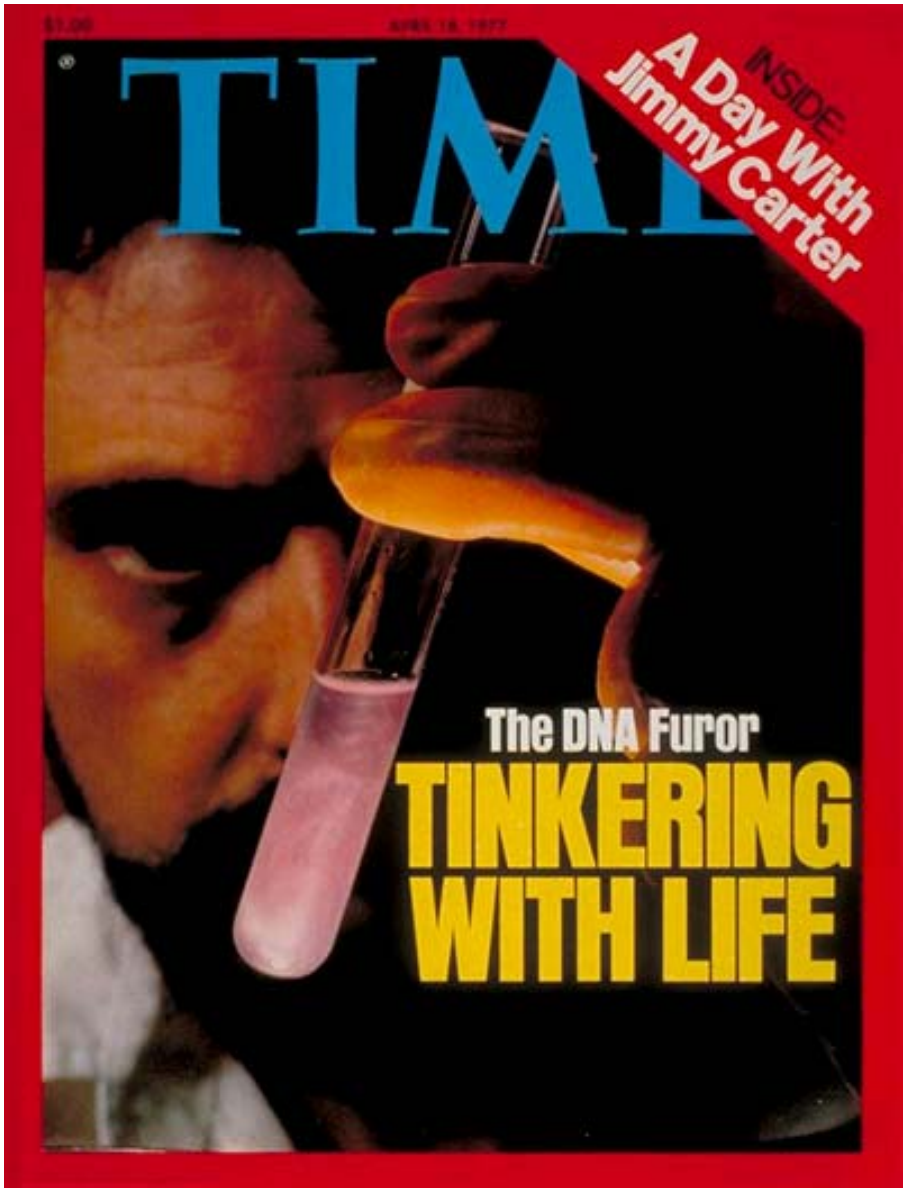
http://www.genetic-programming.com/jkpdf/acdm1998.pdf

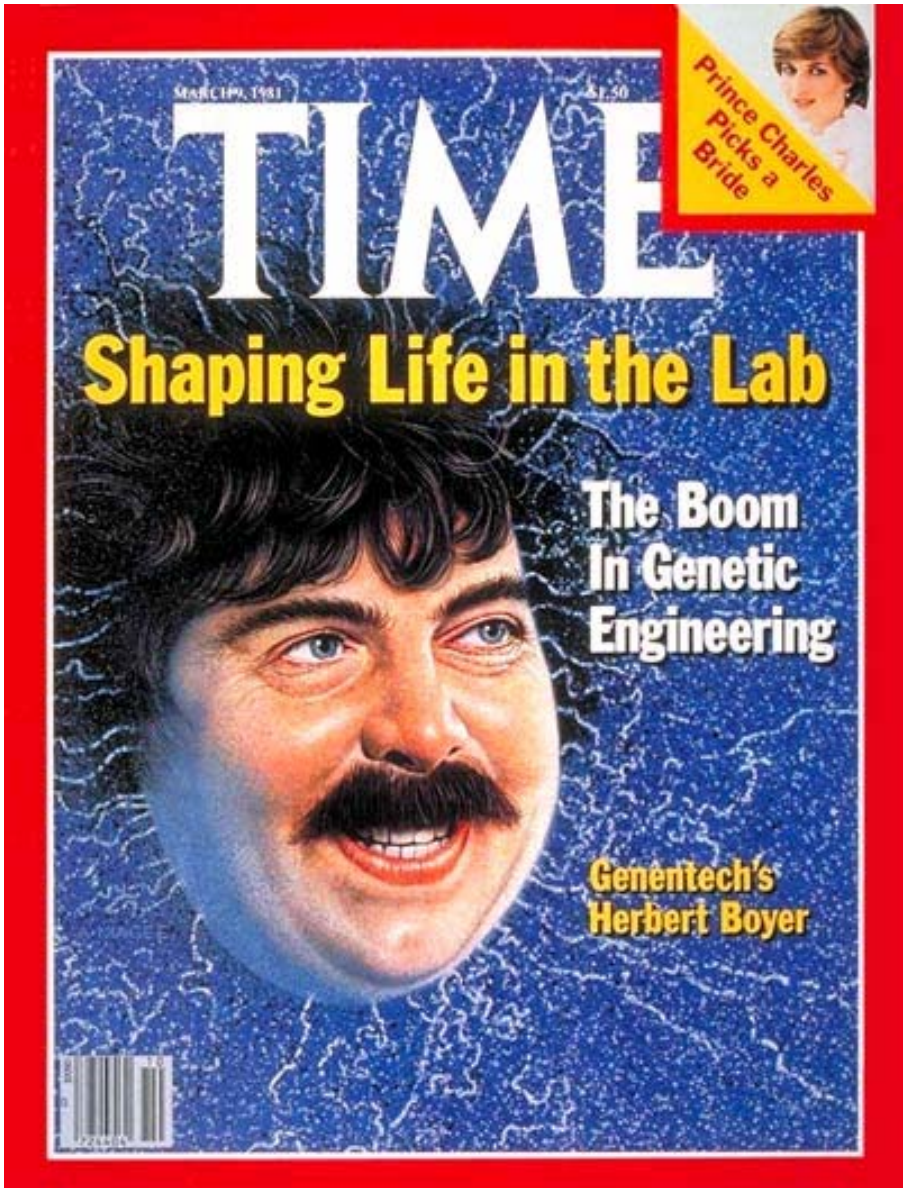
REDUCTION | COMPLEXITY

If we didn’t build it, we may not be able to fully understand it.

Genetic “Engineering”

Writing code


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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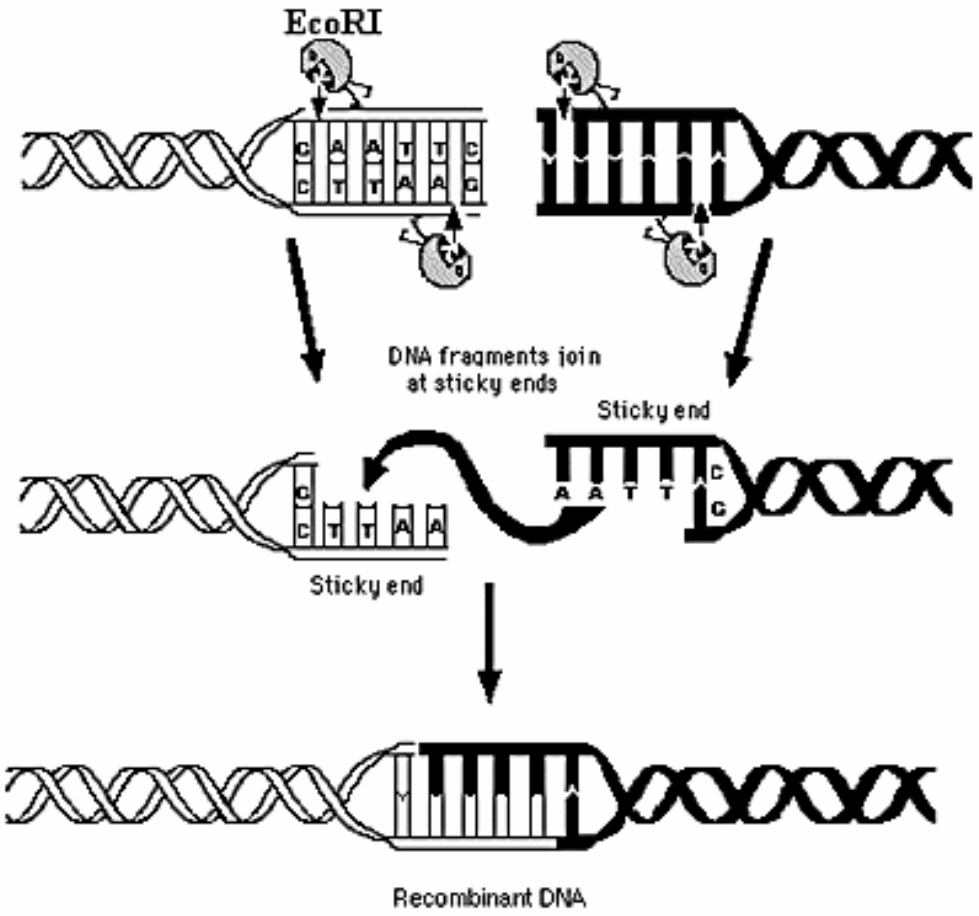
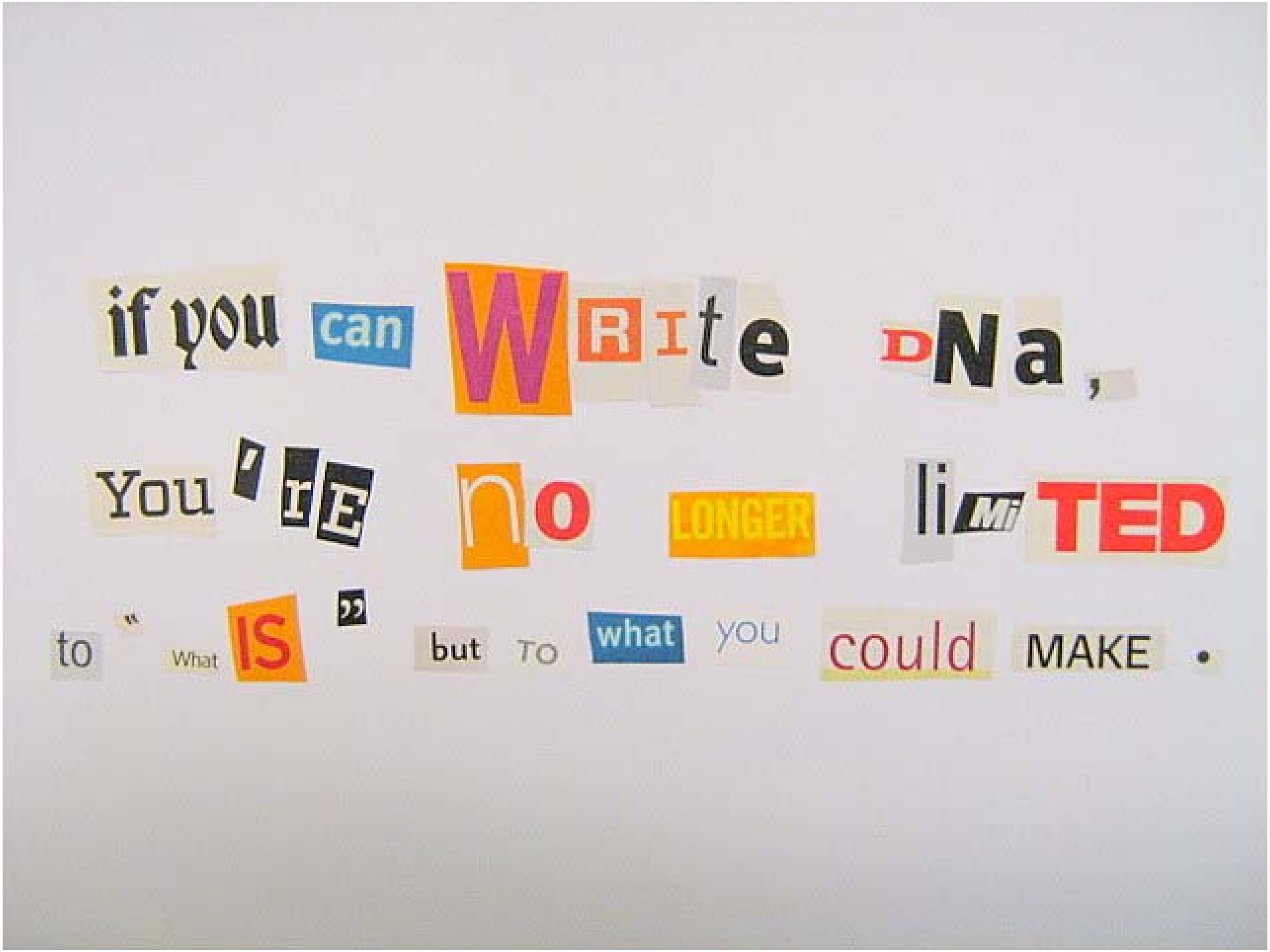


Restriction Enzyme Action of EcoRI

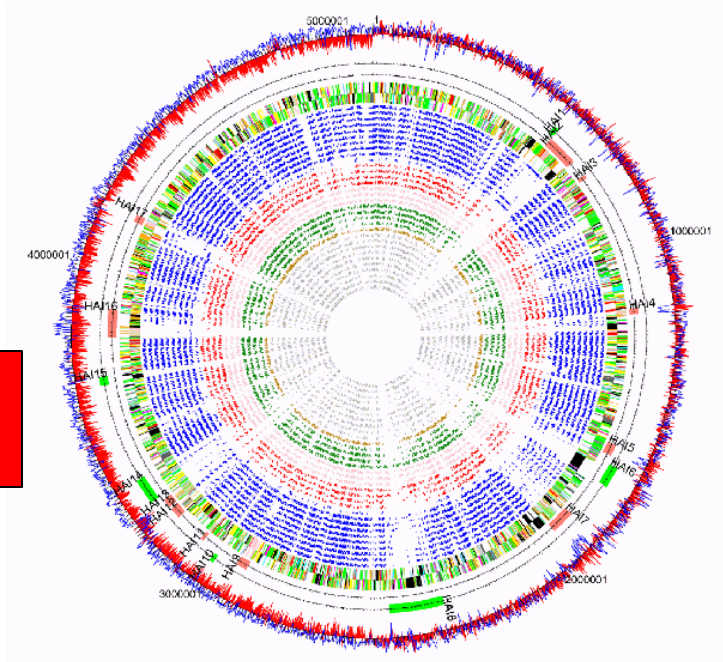

if you can WRIte DNa,
You 're no LONGER liMiTED
to " What IS " but TO what you could MAKE .

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

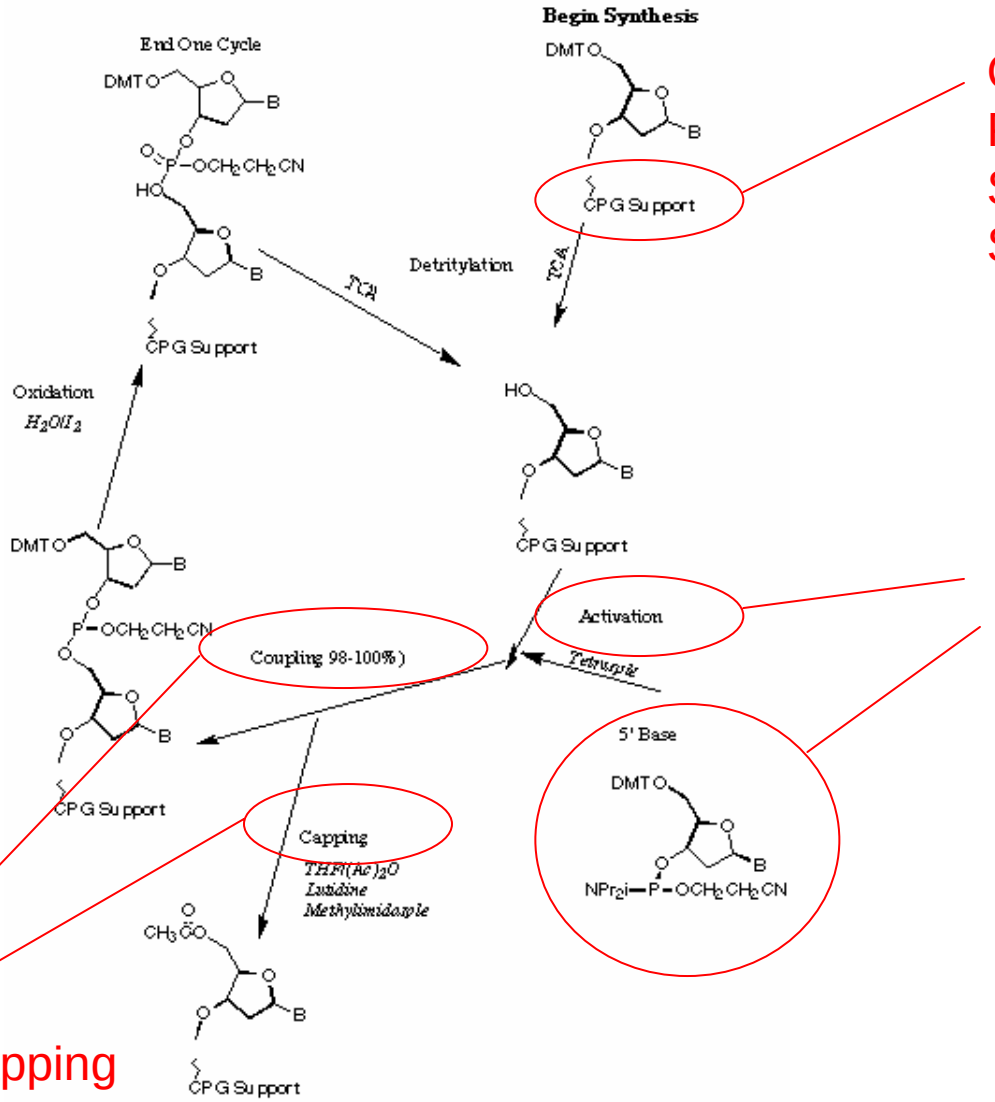

WARNING

Physical DNA

sequencing



Digital DNA

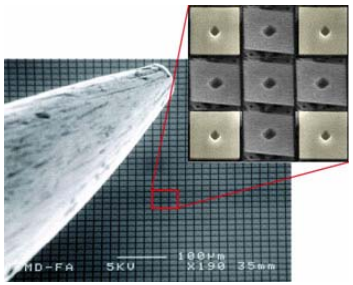


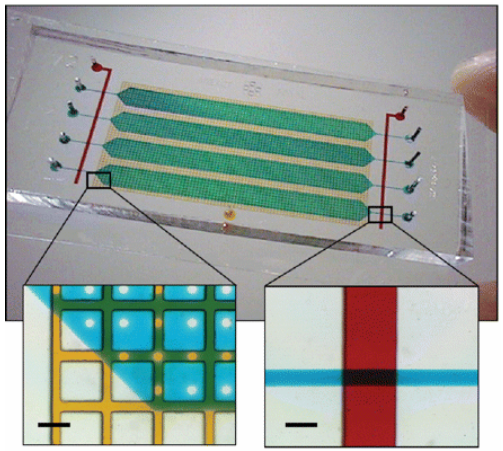
Controlled Pore Glass Solid Support

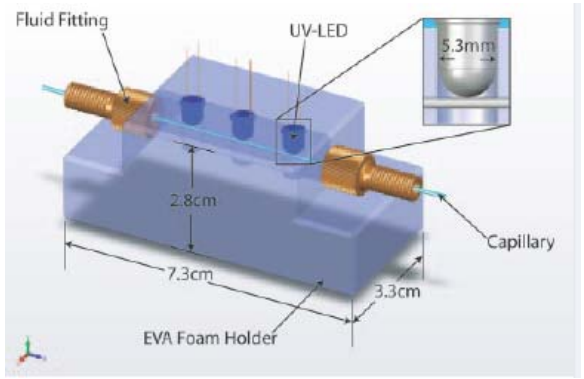
Activation (acid) and new base addition

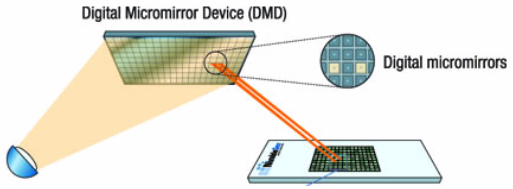
Coupling and Capping


BECKMAN






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


Digital Micromirror Device (DMD)
Digital micromirrors

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Codon Devices for your gene
synthesis solutions. Build With Us!
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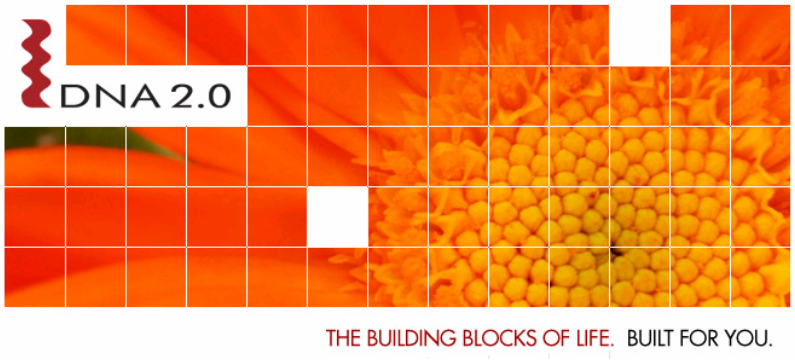

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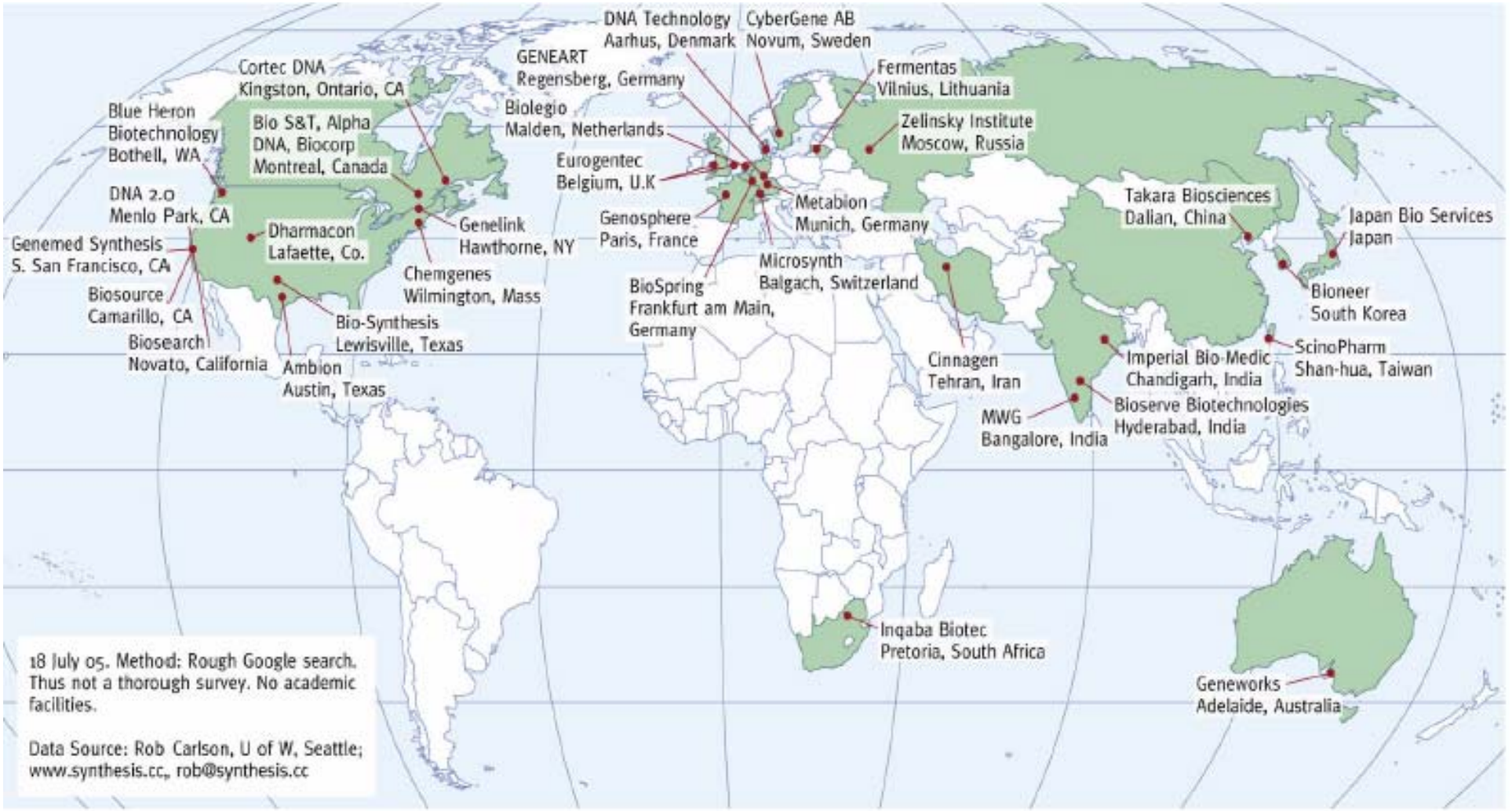


Sources: Source: R. Carlson, G. Epstein, A. Yu (2005)

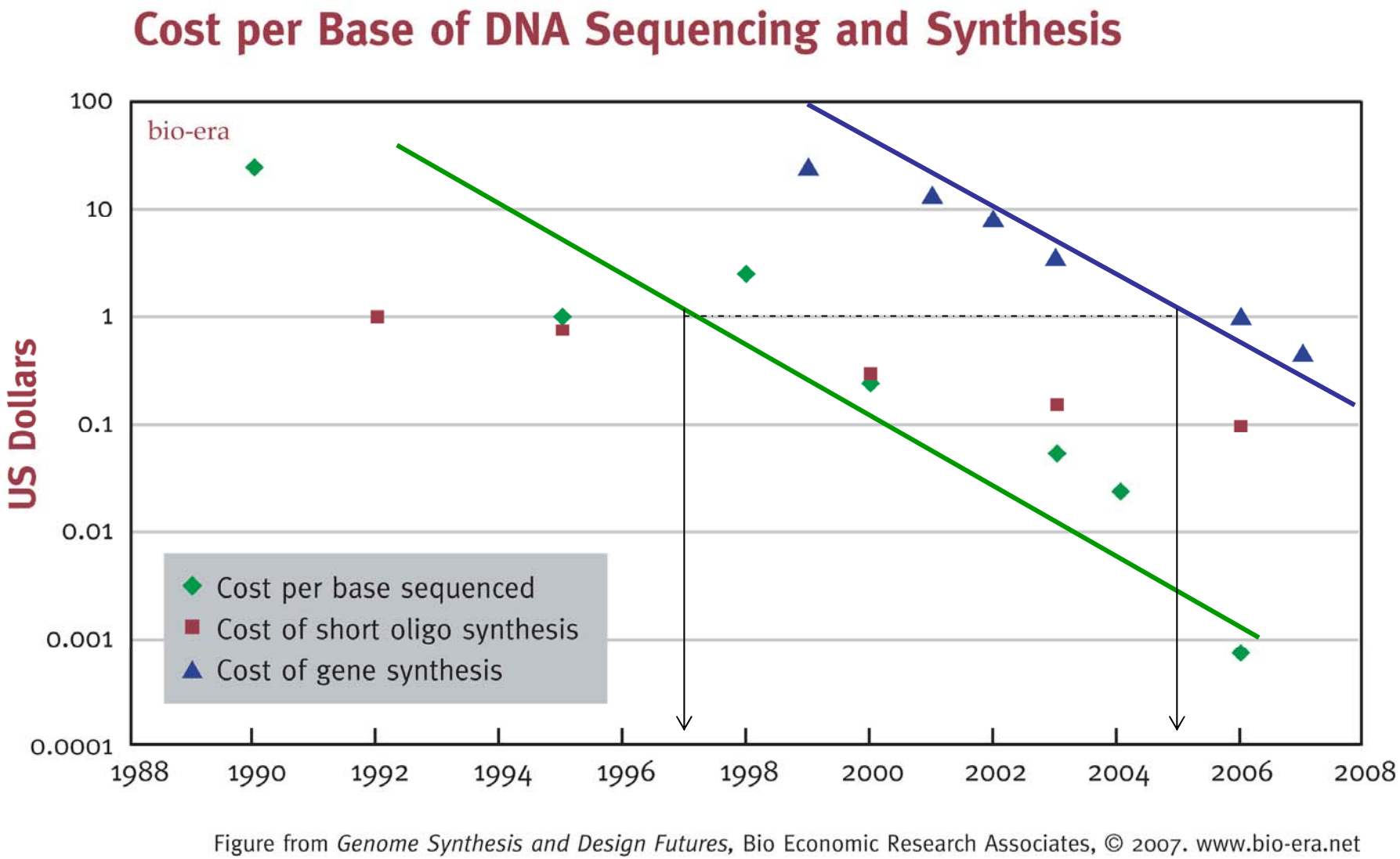


Figure from *Genome Synthesis and Design Futures*, Bio Economic Research Associates, © 2007. www.bio-era.net

Synthetic trend lags by about 8 years

MILLIGEN BIOSEARCH Cyclone Plus DNA Synthesizer

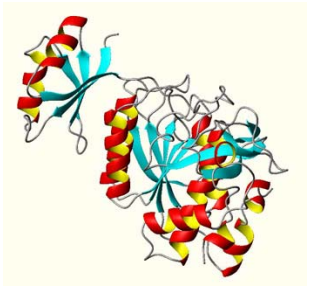
Seller of this item? Sign in for your status

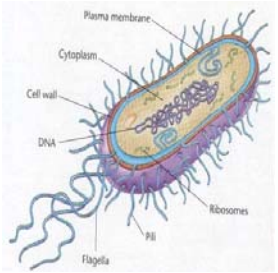
1 of 4

View larger picture

Starting bid:	**US $59.99**
Your maximum bid:	**US $** [ ] Place Bid >
	(Enter US $59.99 or more)
Buy It Now price:	**US $129.99** Buy It Now >
End time:	**Apr-16-08 17:00:00 PDT** (2 days 21 hours)
Shipping costs:	**US $55.00** Standard Flat Rate Shipping Service Service to United States (more services)
Ships to:	United States
Item location:	Texas, United States
History:	0 bids
You can also:	Watch This Item
	Get mobile or IM alerts | Email to a friend

Applications dependent on synthetic capabilities and $





single genes

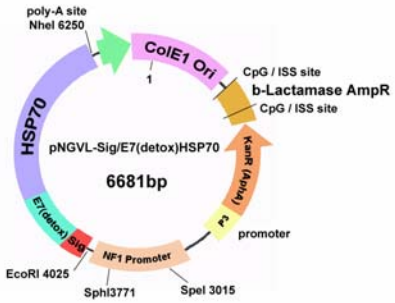
minimal life

base pairs

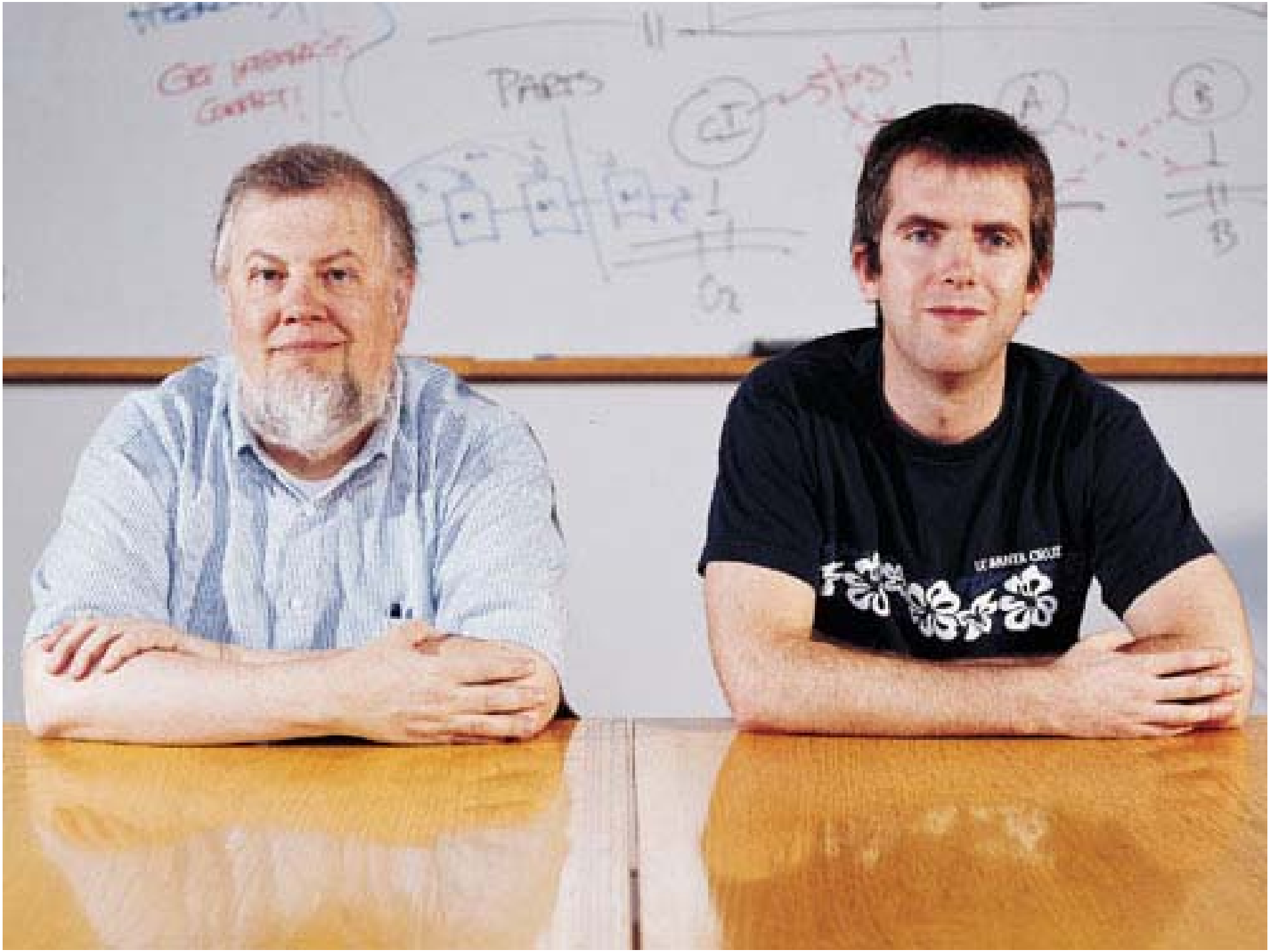
10^2 10^3 10^4 10^5 10^6 10^7

genetic circuits, viruses, GEMs

Engineered organisms




TED


PARTS

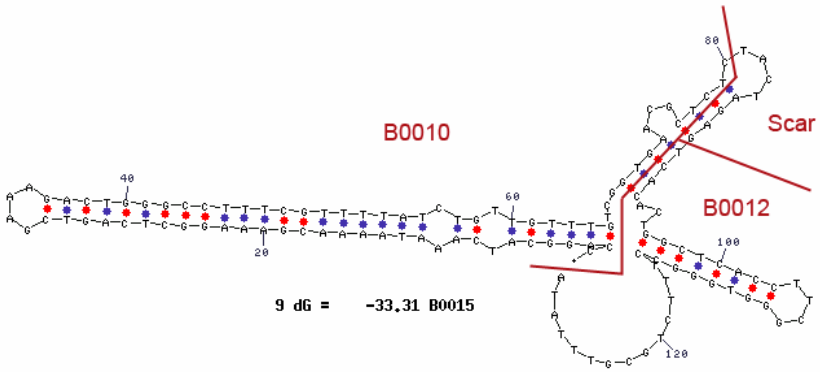
F1760

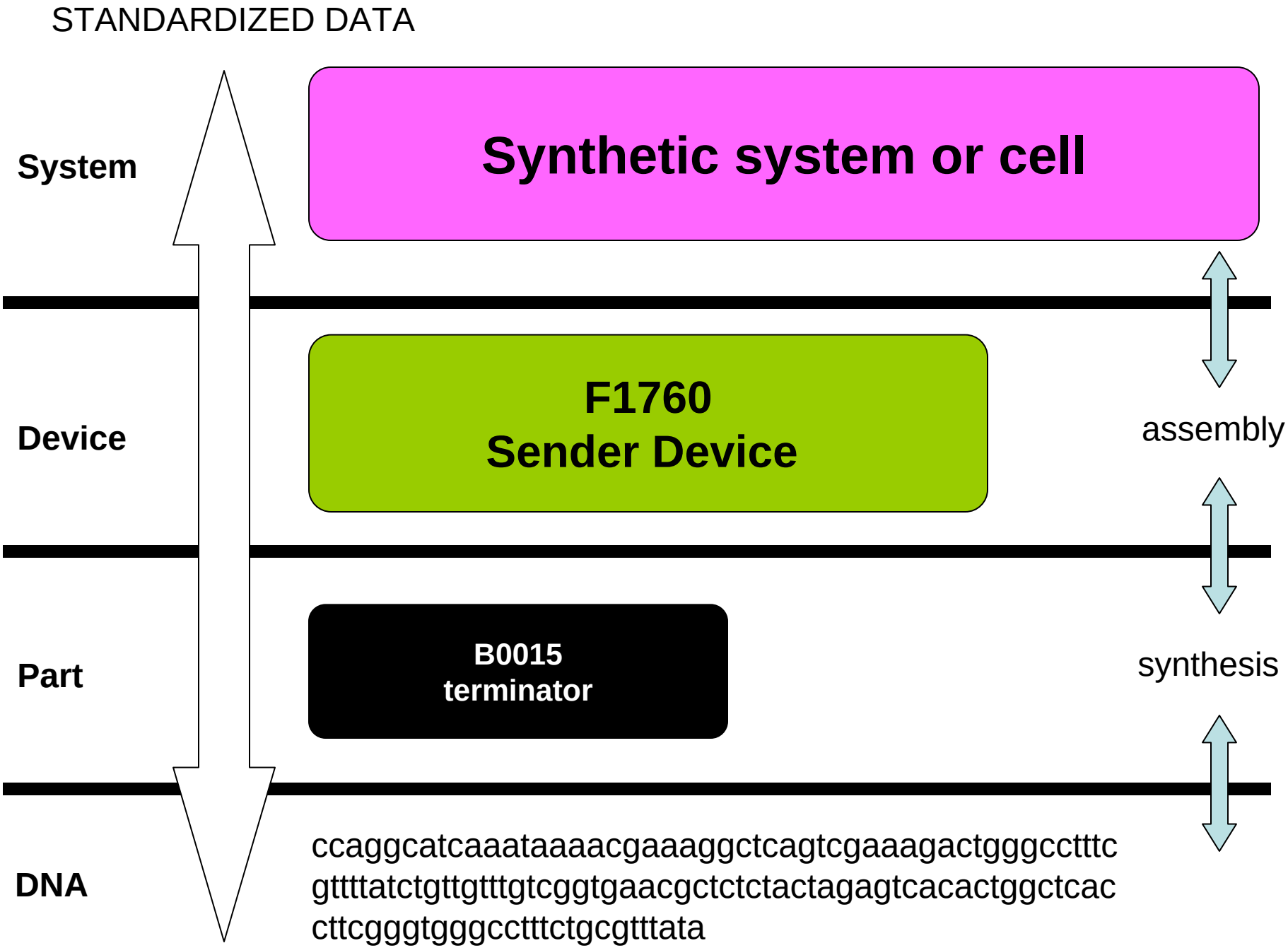
Sender Device

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
- Part Searches
- DNA Repositories
- 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.

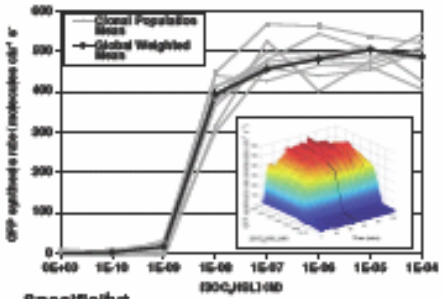
Characteristics

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

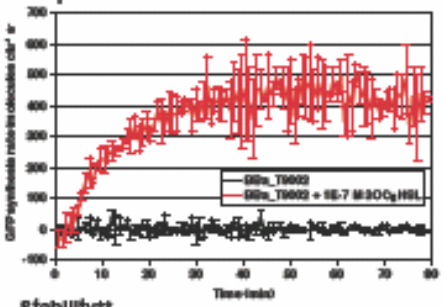
Key Parts

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

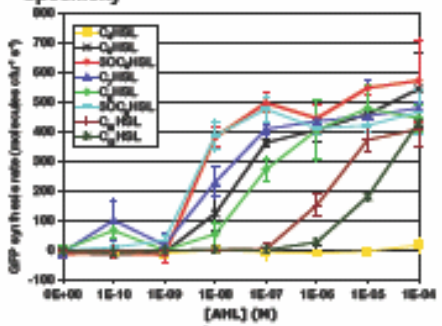
Transfer Function*



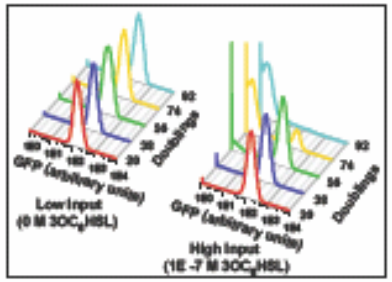
Response Time*



Specificity*



Stability**



Demand (low/high input)

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

Stability (low/high input)

Genetic: **>32/74** replication events**
Performance: **>32/74** replication events**

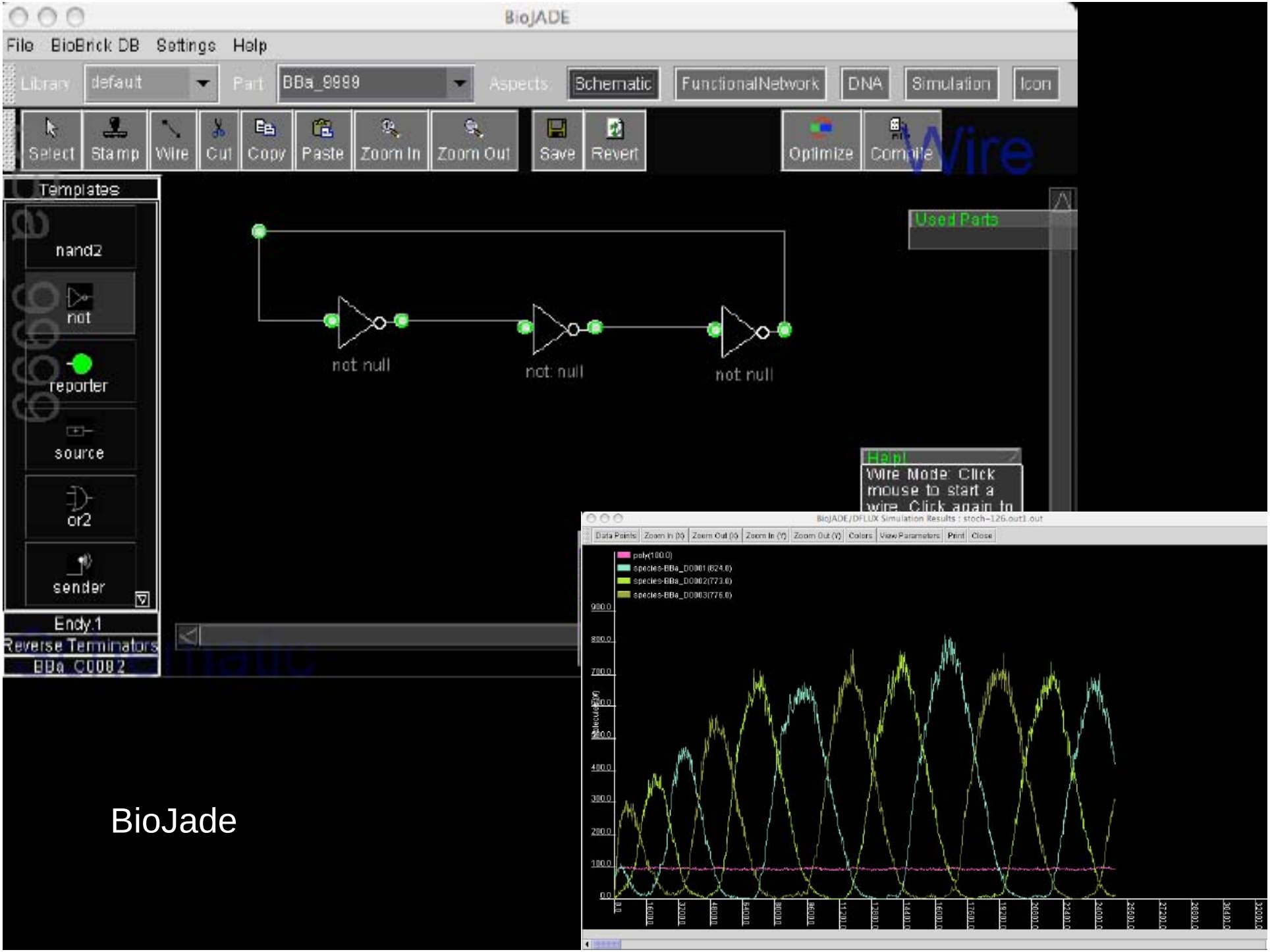
Compatibility

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(624.0)
species-BBa_D0002(773.0)
species-BBa_D0003(776.0)
BioJade

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

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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

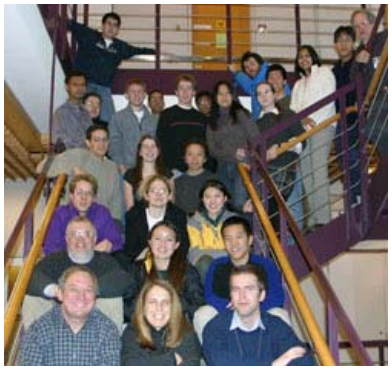
sat & sun, nov 3-4

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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Davidson/Missouri
Bay Area RSI
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Berkeley UC
UCSF
Caltech
Mississippi
Rice
Prairie View
Mexico
Minnesota
Colombia
Wisconsin
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Virginia Tech
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Turkey
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Valencia
Bologna
Naples
Melbourne

Open source biology …

BIO BRICKS foundation

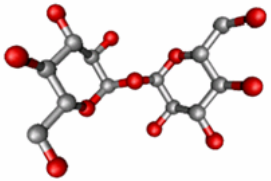
- Maximizes innovation
- Empowers communities
- Generates expertise
- Legal and technical standards

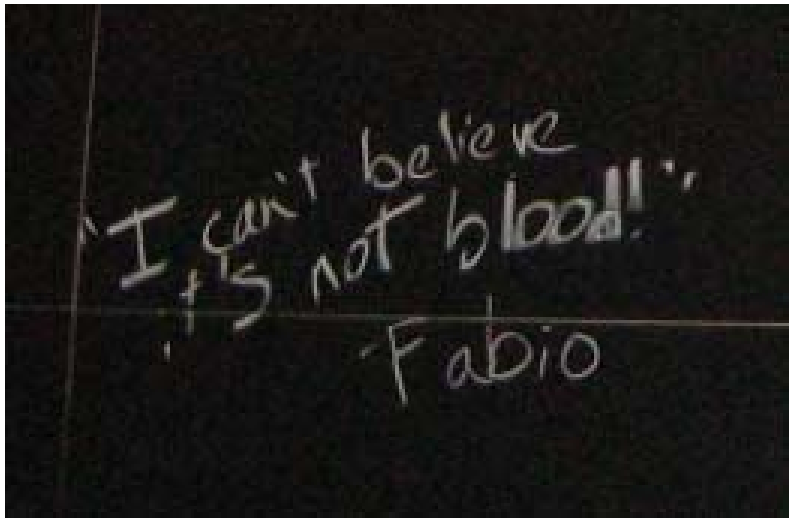
BACTOBLOOD

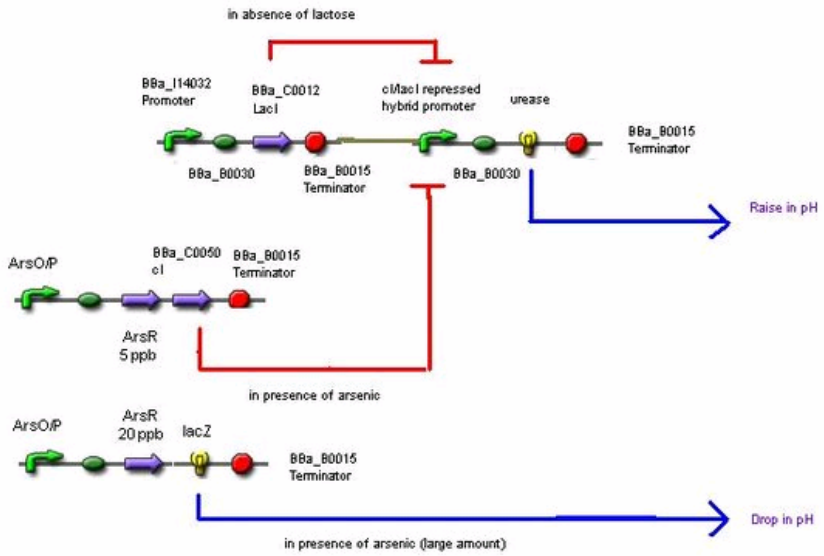
UC BERKELEY

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.

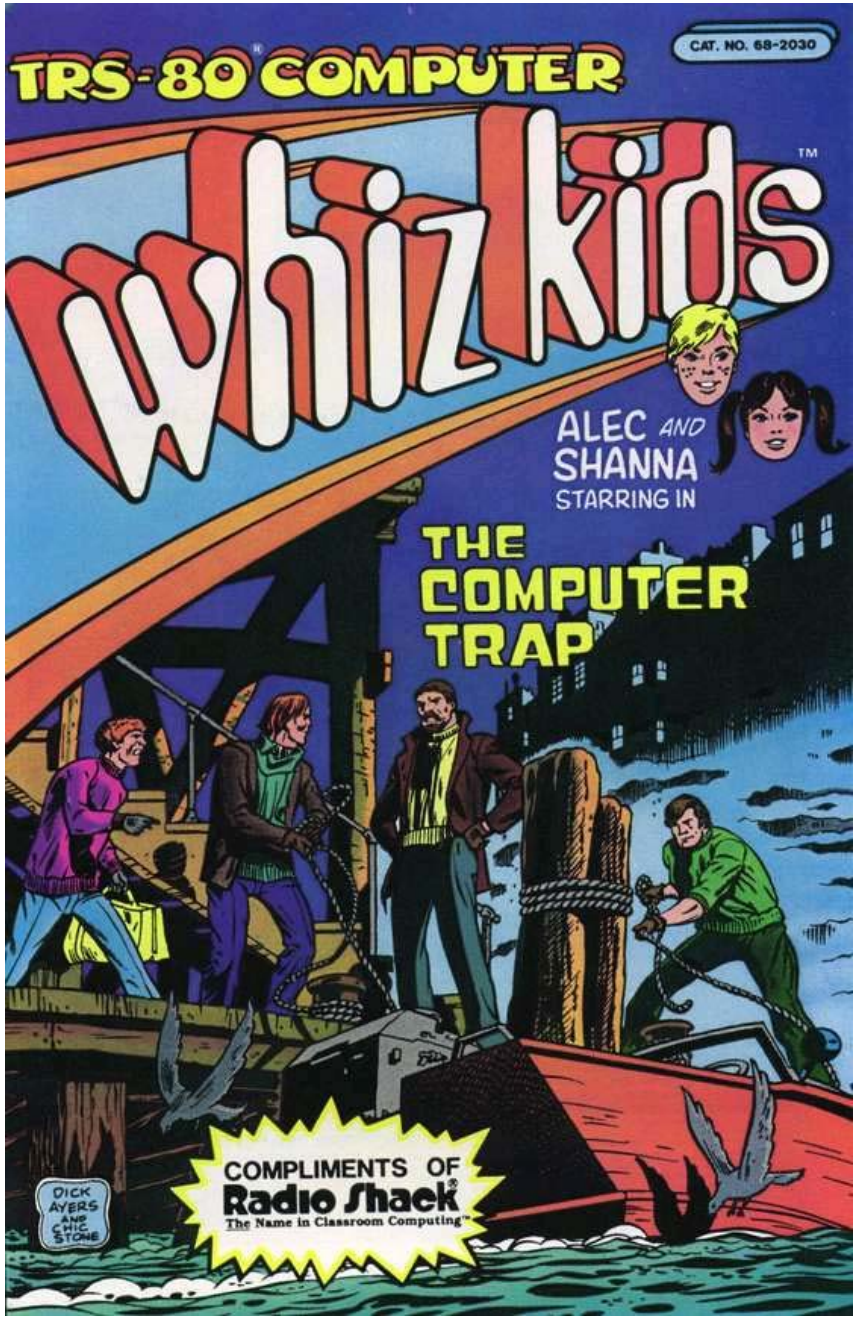
The New York Times

English, Algebra, Phys Ed ... and Biotech

Jim Wilson/The New York Times

George Cachianes, left, formerly of Genentech, teaches biotechnology at Lincoln High School in San Francisco.


MAY 3, 1982
$1.50
TIME
-.3%
INFLATION VANISHES!
At Least for A Month
COMPUTER GENERATION
A New Breed of Whiz Kids


TRS-80® COMPUTER
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COMPLIMENTS OF
Radio Shack®
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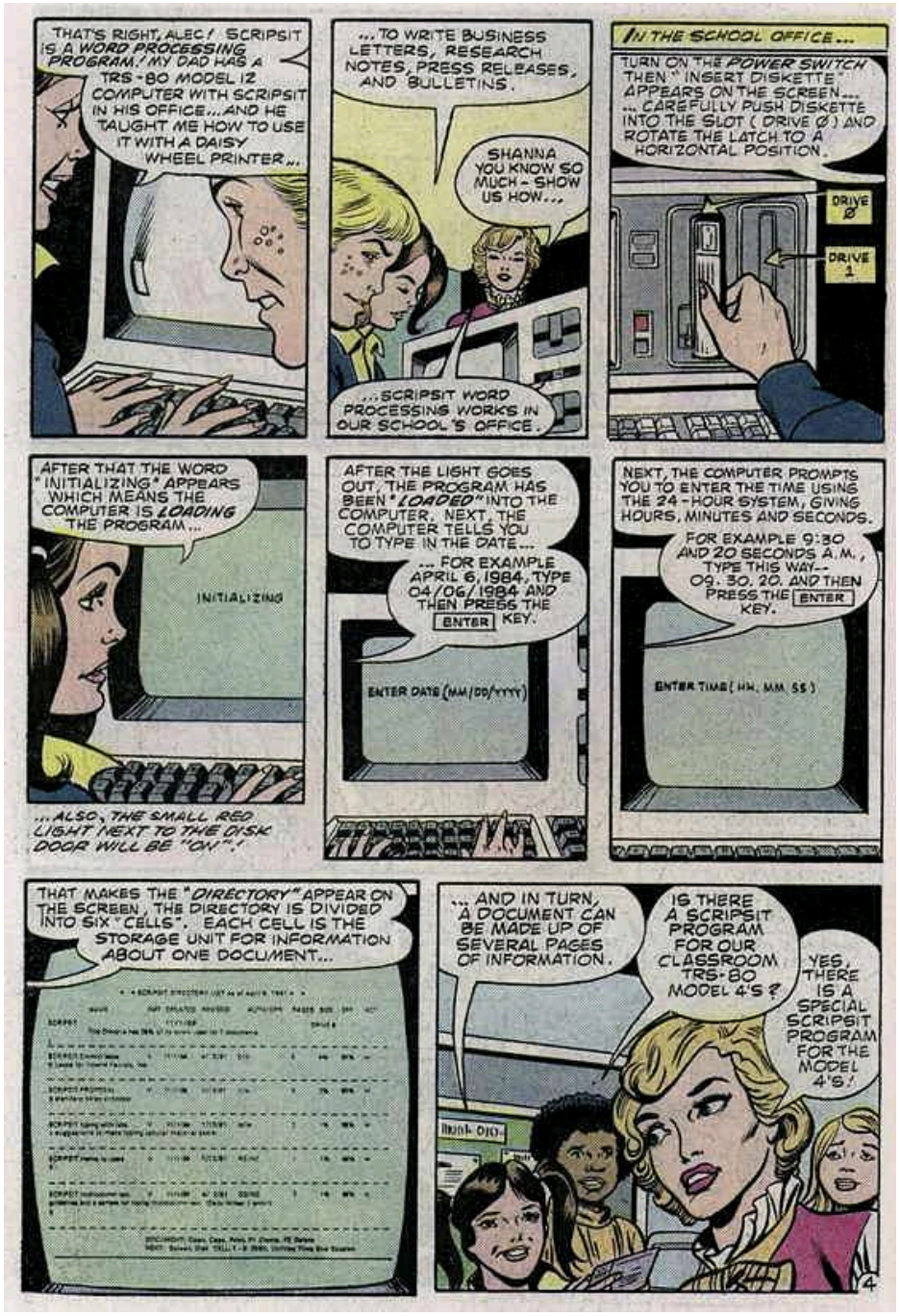
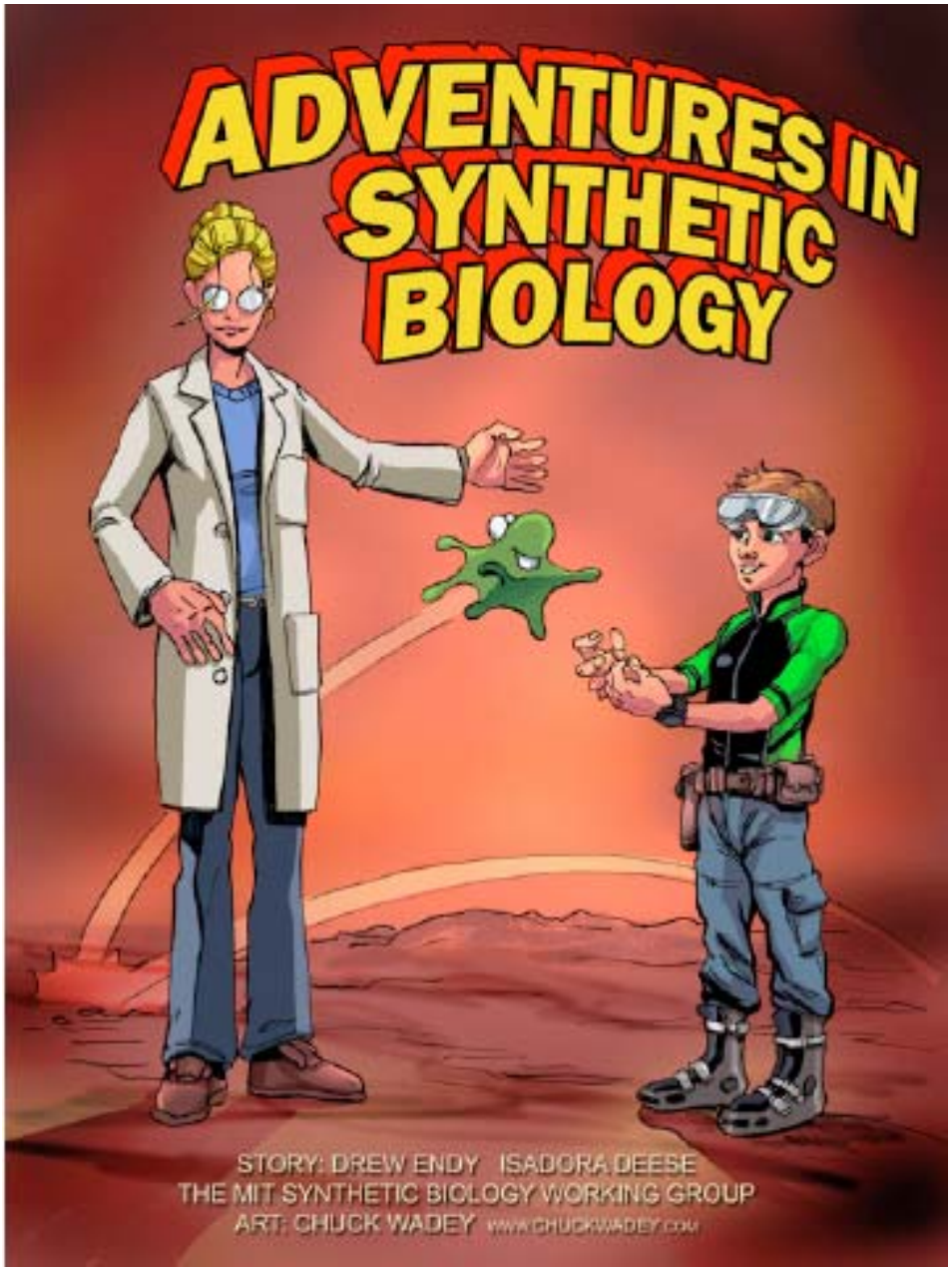
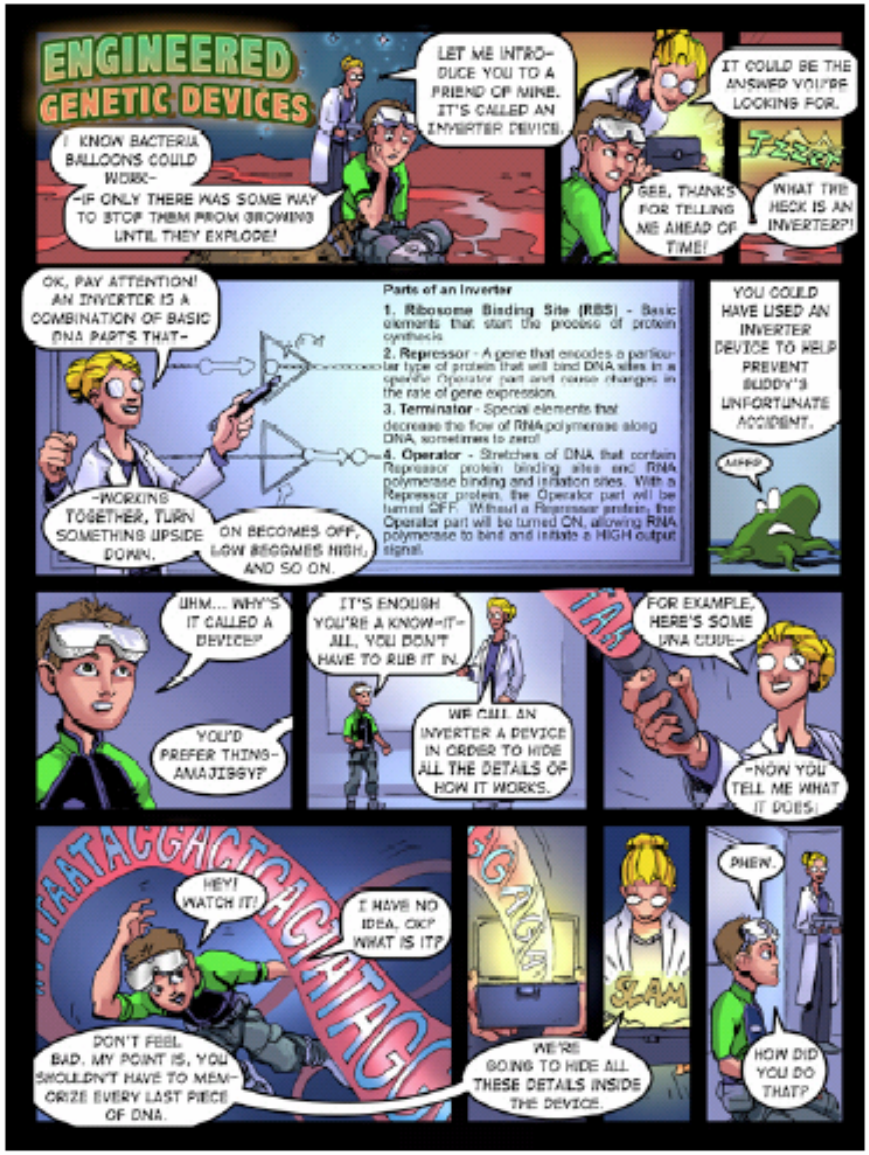
DICK AYERS AND CHIC STONE


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.
GEE, THANKS FOR TELLING ME AHEAD OF TIME!
IT COULD BE THE ANSWER YOU'RE LOOKING FOR.
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.
MMMP
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.
TAATACGACTCACTATAGG
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.
TGAGA
SNAM
WE'RE GOING TO HIDE ALL THESE DETAILS INSIDE THE DEVICE.
PHEW.
HOW DID YOU DO THAT?

Maxitronix™

ELECTRONIC LAB

130 in 1

THE FUN WAY TO LEARN ABOUT ELECTRONICS AND STUDY THE WONDERS OF SCIENCE

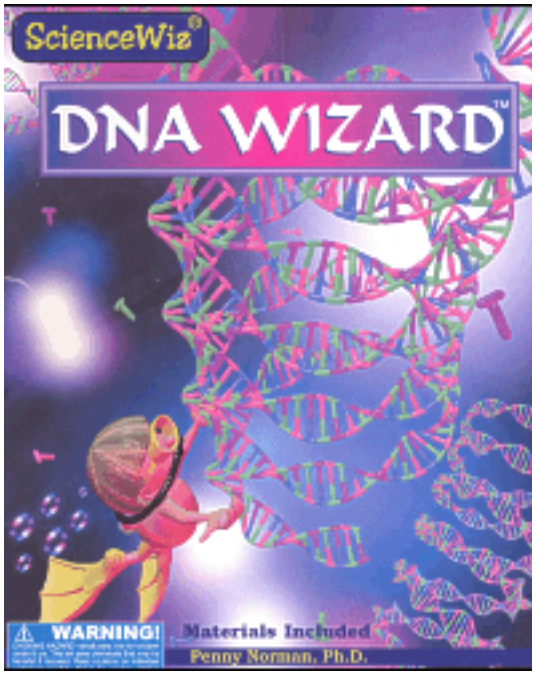
- Start a great hobby in electronics
- No prior knowledge needed to assemble
- Spring-coil connections make it safe and easy for anyone to use
- Includes detailed step-by-step illustrated manual for easy project construction
- Build a radio, AM broadcast station, electronic organ, kitchen timer, logic circuits and more
- Comes with built-in speaker, 7-segment LED display, two fully integrated circuits and rotary controls

ELECTRONIC 130 in 1 LAB

ITEM NO. MX906

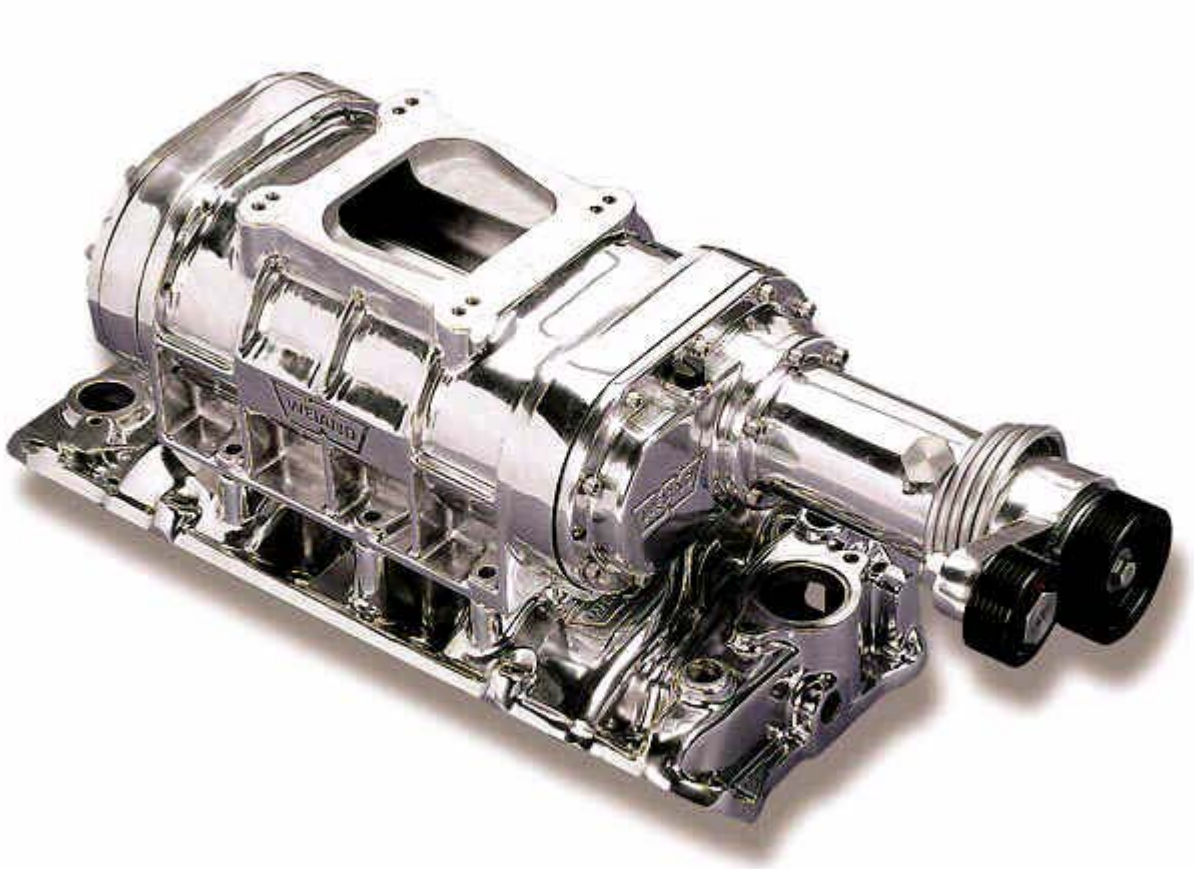
Requires 6 "AA" batteries (Not included)

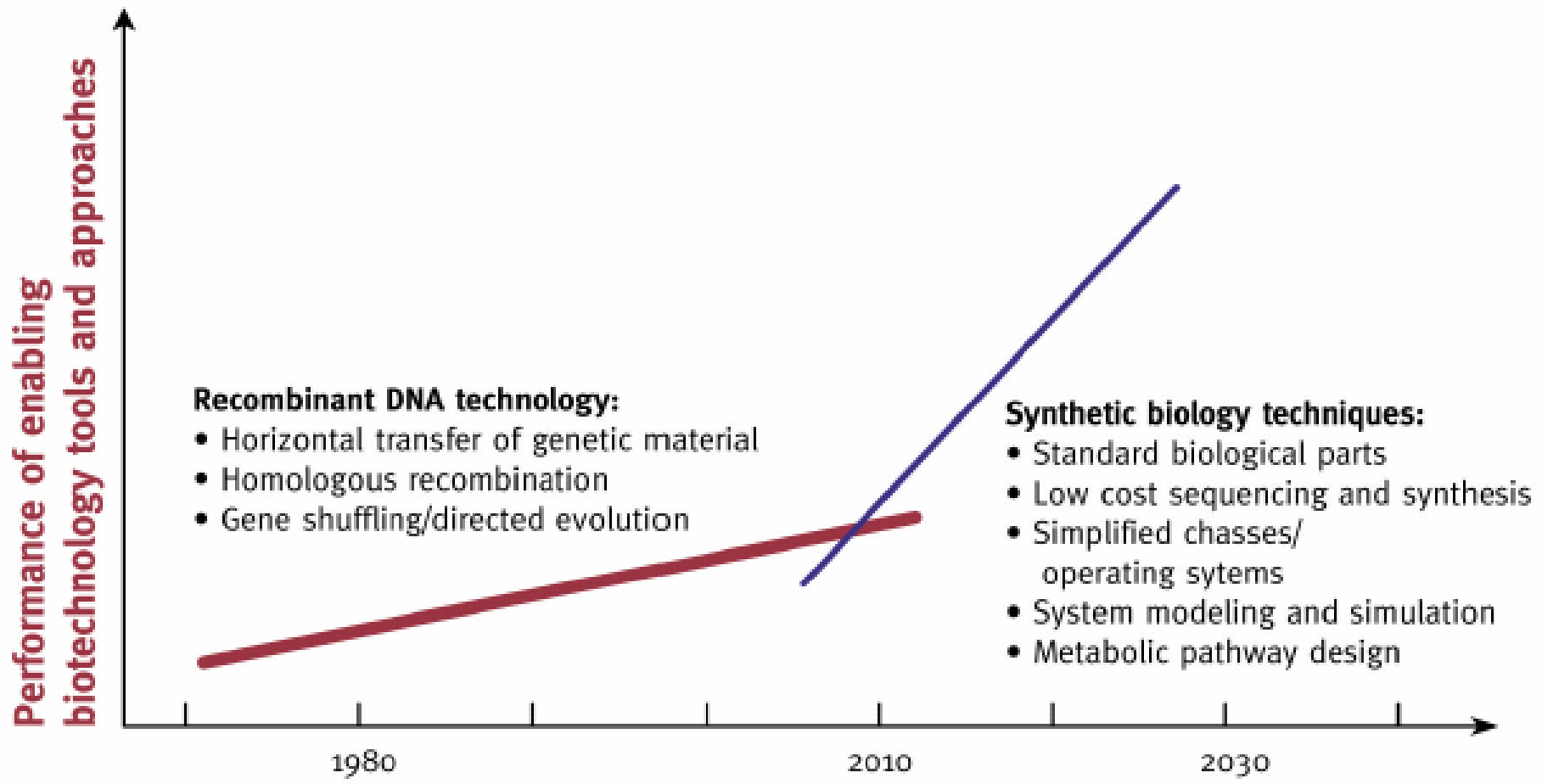
For ages 10 and up



http://www.electrowiz.com/

Next generation biotechnology





Source: Bio era


AMGEN
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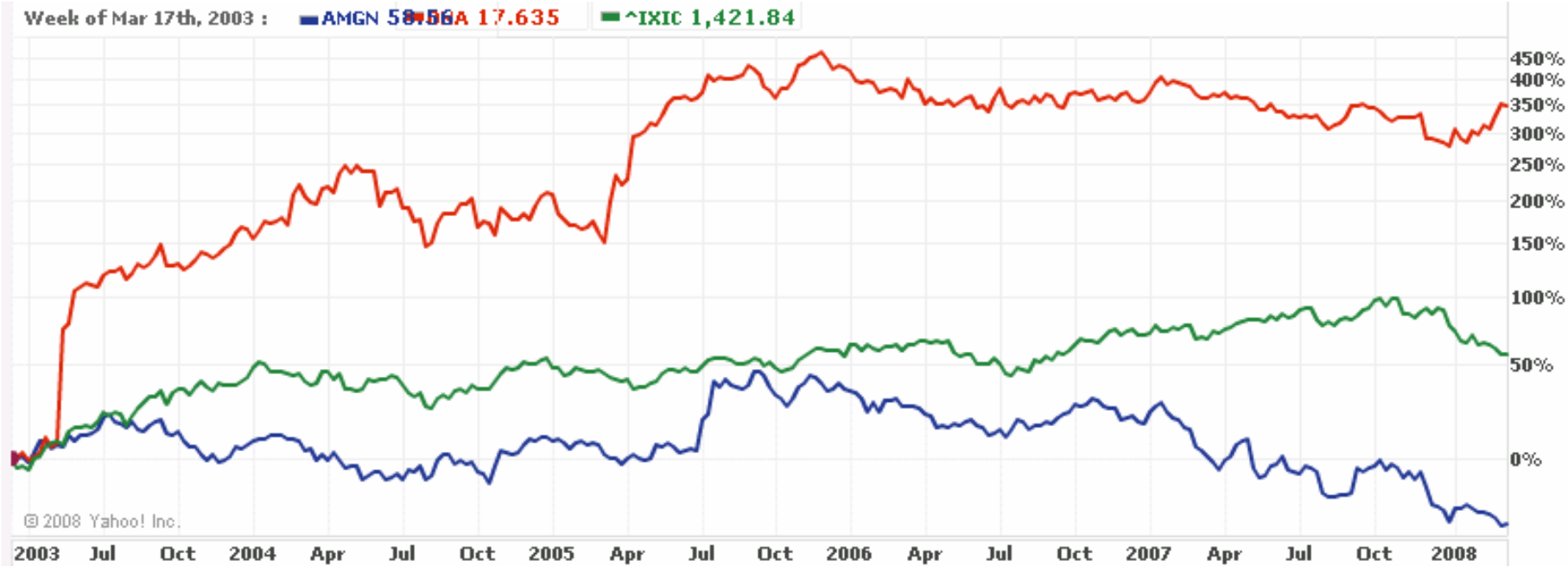
Medical Professionals
Partners
Investors
Careers
Media
Home > Patients > Overview


Week of Mar 17th, 2003 :
AMGN 58.56
^IXIC 1,421.84
450%
400%
350%
300%
250%
200%
150%
100%
50%
0%
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2003 Jul Oct 2004 Apr Jul Oct 2005 Apr Jul Oct 2006 Apr Jul Oct 2007 Apr Jul Oct 2008


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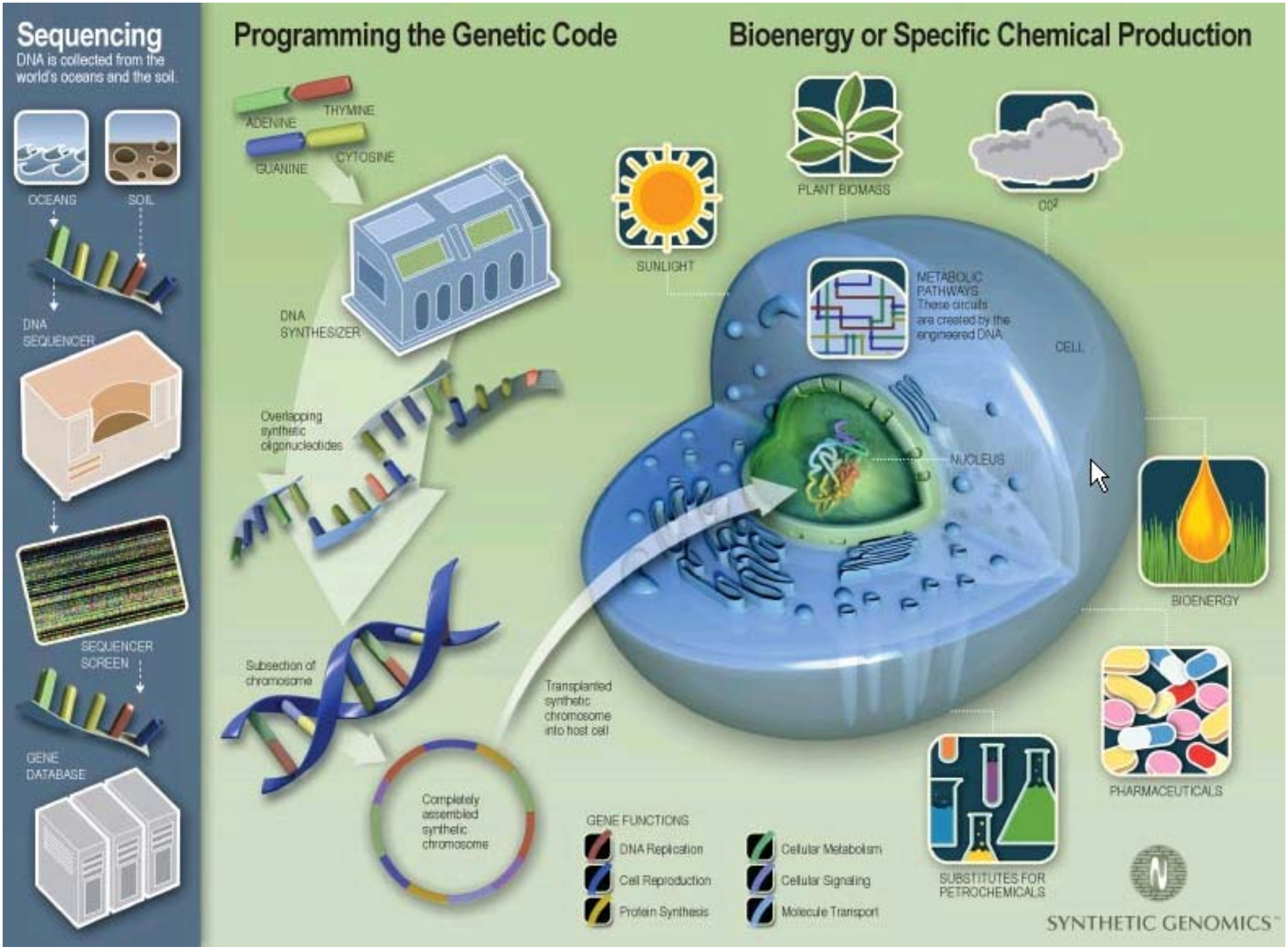
Genomic Engineering


Sequencing
DNA is collected from the world's oceans and the soil.
OCEANS
SOIL
DNA SEQUENCER
SEQUENCER SCREEN
GENE DATABASE
Programming the Genetic Code
ADENINE
THYMINE
GUANINE
CYTOSINE
DNA SYNTHESIZER
Overlapping synthetic oligonucleotides
Subsection of chromosome
Completely assembled synthetic chromosome
Transplanted synthetic chromosome into host cell
Bioenergy or Specific Chemical Production
SUNLIGHT
PLANT BIOMASS
CO2
METABOLIC PATHWAYS
These circuits are created by the engineered DNA.
CELL
NUCLEUS
BIOENERGY
PHARMACEUTICALS
SUBSTITUTES FOR PETROCHEMICALS
GENE FUNCTIONS
DNA Replication
Cell Reproduction
Protein Synthesis
Cellular Metabolism
Cellular Signaling
Molecule Transport
SYNTHETIC GENOMICS™

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.

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.

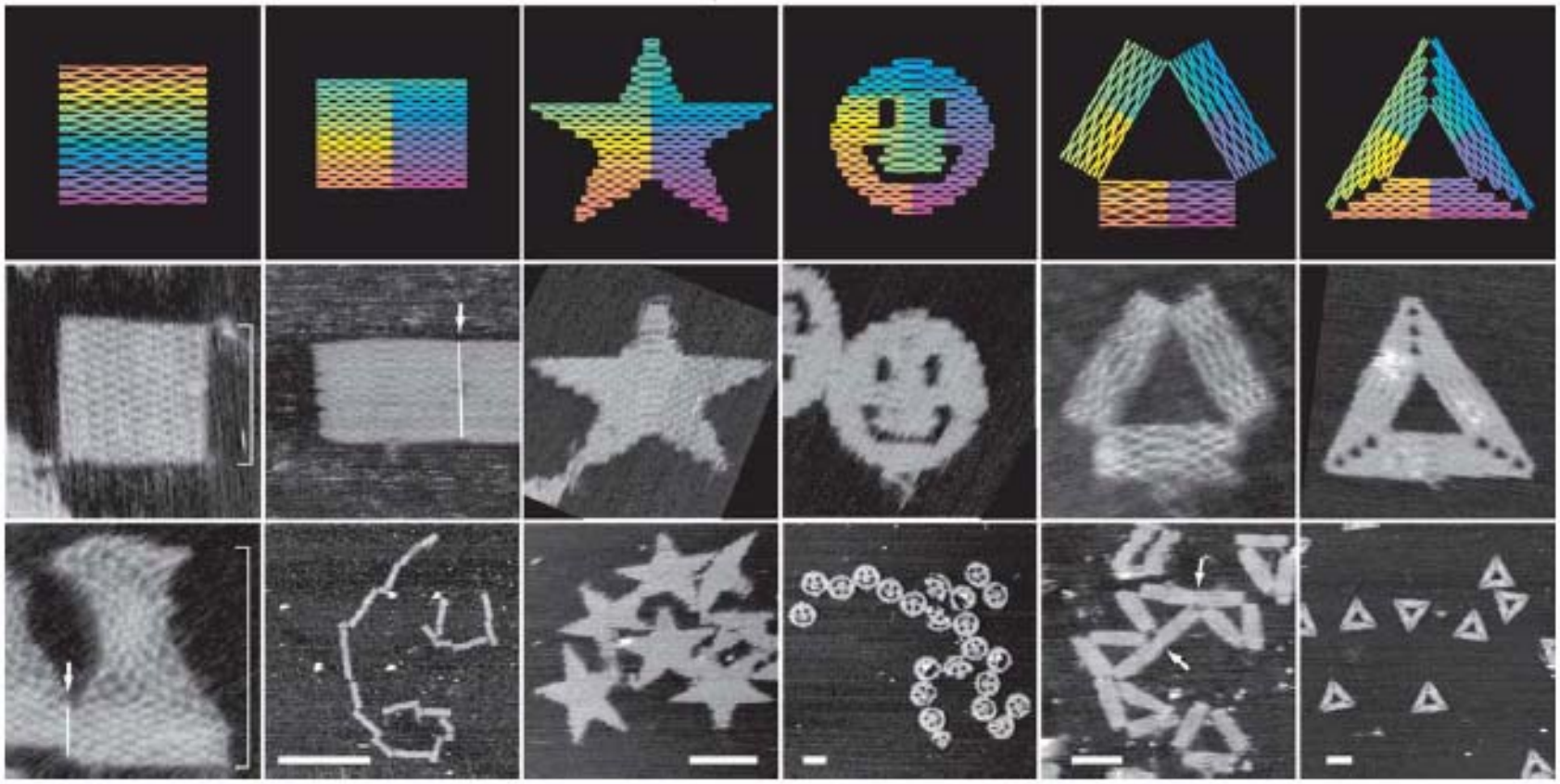
The Series A round ($52M, completed 3Q 2002) included lead investors Atlas Venture, Prospect Venture Partners and SV Life Sciences. Other investors included Rho Ventures, Care Capital, MDS Capital, POSCO BioVentures, and US Trust Private Equity.

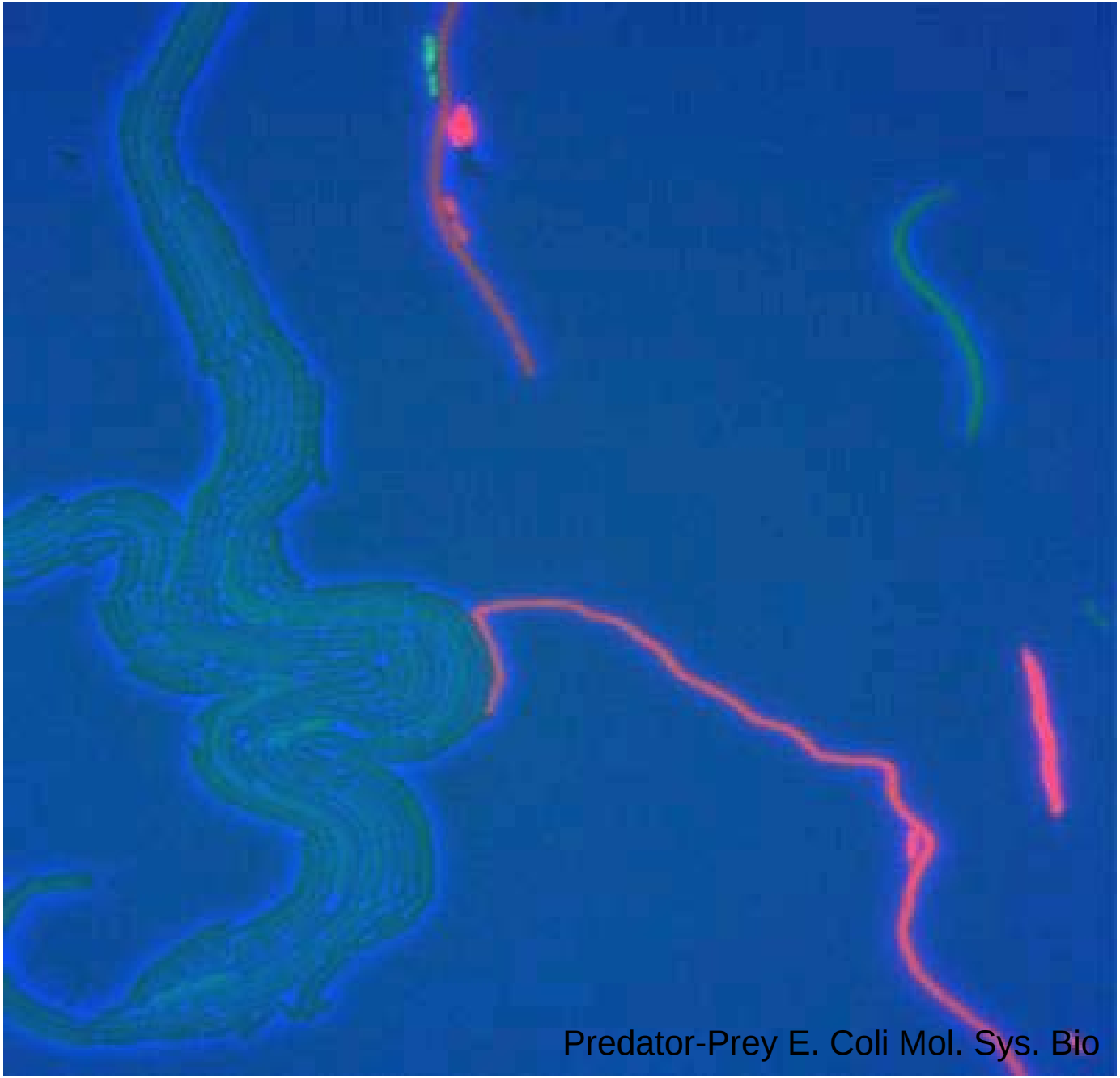
Archemix and Merck KGaA Sign Strategic Alliance

Collaboration to Focus Primarily on Cancer Therapeutics Using Novel Aptamer Technology

Folding DNA to create nanoscale shapes and patterns

Paul W. K. Rothemund[1]




Predator-Prey E. Coli Mol. Sys. Bio

Within 10 years, if present trends continue…

- Synthesis and boot-up will become integrated and practical on the desktop
- 10 MB of DNA synthesis will cost <$10K
- Drag and drop metabolic design software, and parts libraries, will be open sourced
- A substantially different academic and industry than landscape than exists today

Summary

- Synthetic biology transforming life science into an information science
- Multidisciplinary
- Accelerating technology development and globally fueling innovation and competition
- IT industry-type dynamics, but greater ramifications for society
- Open source may play a crucial role

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