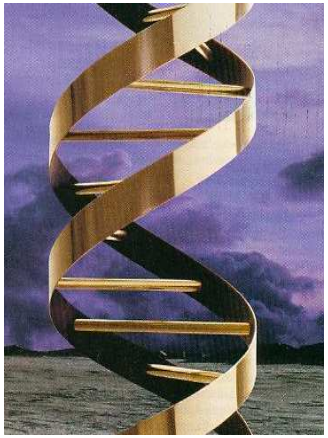
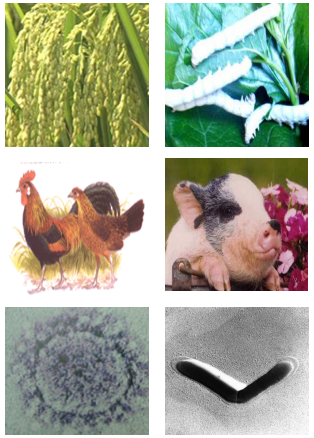
Synthetic Biology and the Future of Man





Huanming Yang Ph.D.
Beijing Genomics Institute (BGI), China

1. An independent researcher
2. Head of BGI
3. Chief Scientist of “Omics” Project

   (High-Tech Programs, “863”, of China)

4. Co-Vice Chairman of EAGLES

   (European Actions on Global Life Sciences)

“**To raise the banners of Science and Humanity**”!

“It is science that brings us here”

An Opportunity

To meet old friends, to make new friends

To collaborate on another important project

Why Synthetic Biology?

“Synthesis defines an ambitious ‘put-a-man-on-the-moon’ goal.”

Benner & Sismour. *Nat Rev Genet*, 6:533-43, 2005

Conventional Biology：

“Life is what we are curious of”

Synthetic Biology:

“Life is what we make it”

Synthetic Biology

It is a science changing the world and the future of man.

SynBio: A big breakthrough

Global civilization, social progress and scientific development depend on technological breakthroughs.

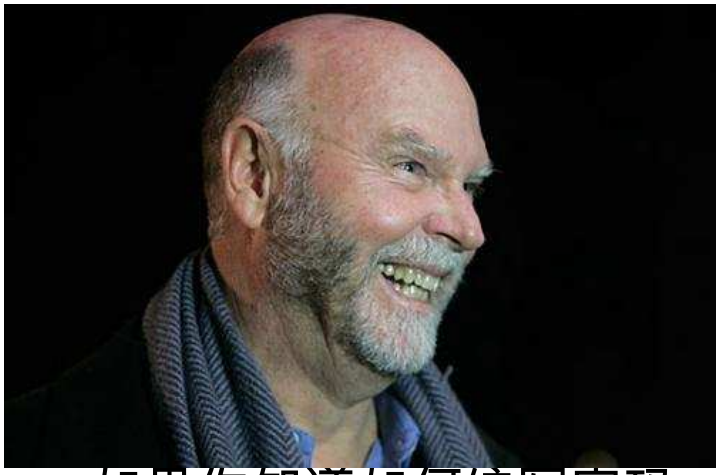
SynBio will have its significant impacts on our life and society, our environment and the world

Congratulations on the birth and achievements of synthetic biology!

《时代》周刊2008年十大科学发现

The Top 10 Scientific Discoveries of 2008

TIME



3. 科学家创造生命

Creating Life

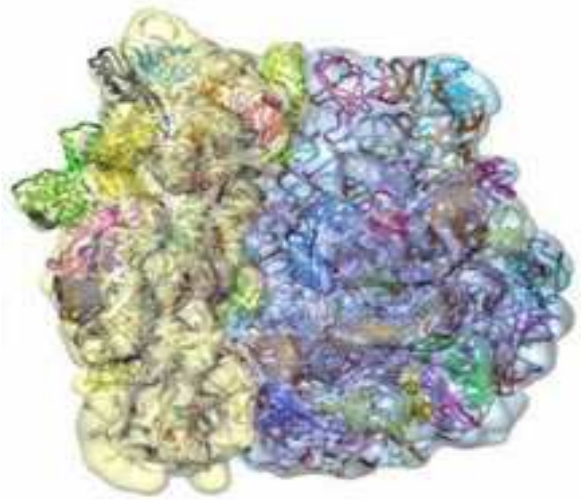
Venter 创造了一个全新细菌的基因信息。...如果你知道如何编写密码，你就能让它做几乎任何事情Living things don't get a whole lot humbler than a bacterium, with its few hundred thousand genetic base pairs and its stripped-down physical design. Still, you try inventing one. That's what geneticist J. Craig Venter — one of the two men credited with mapping the human genome — managed to do. Venter stitched together the 582,000 base pairs necessary to invent the genetic information for a whole new bacterium. Step two is to boot up that DNA programming in a living bacterium to see if it takes charge of the organism. That's next on Venter's agenda — and he has little doubt it will work. As any software designer will tell you, once you know how to write the code, you can make it do almost anything.

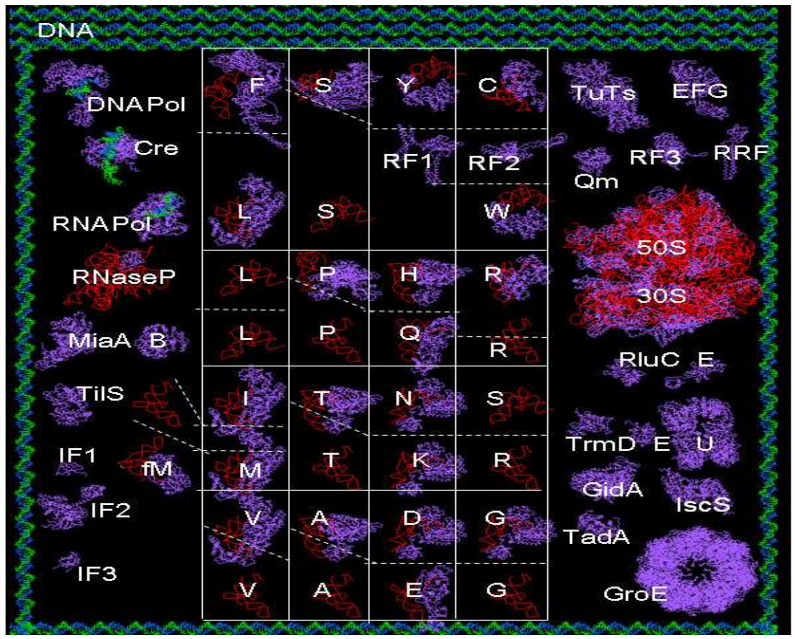
Technology
PUBLISHED BY MIT Review

Creating Cell Parts from Scratch

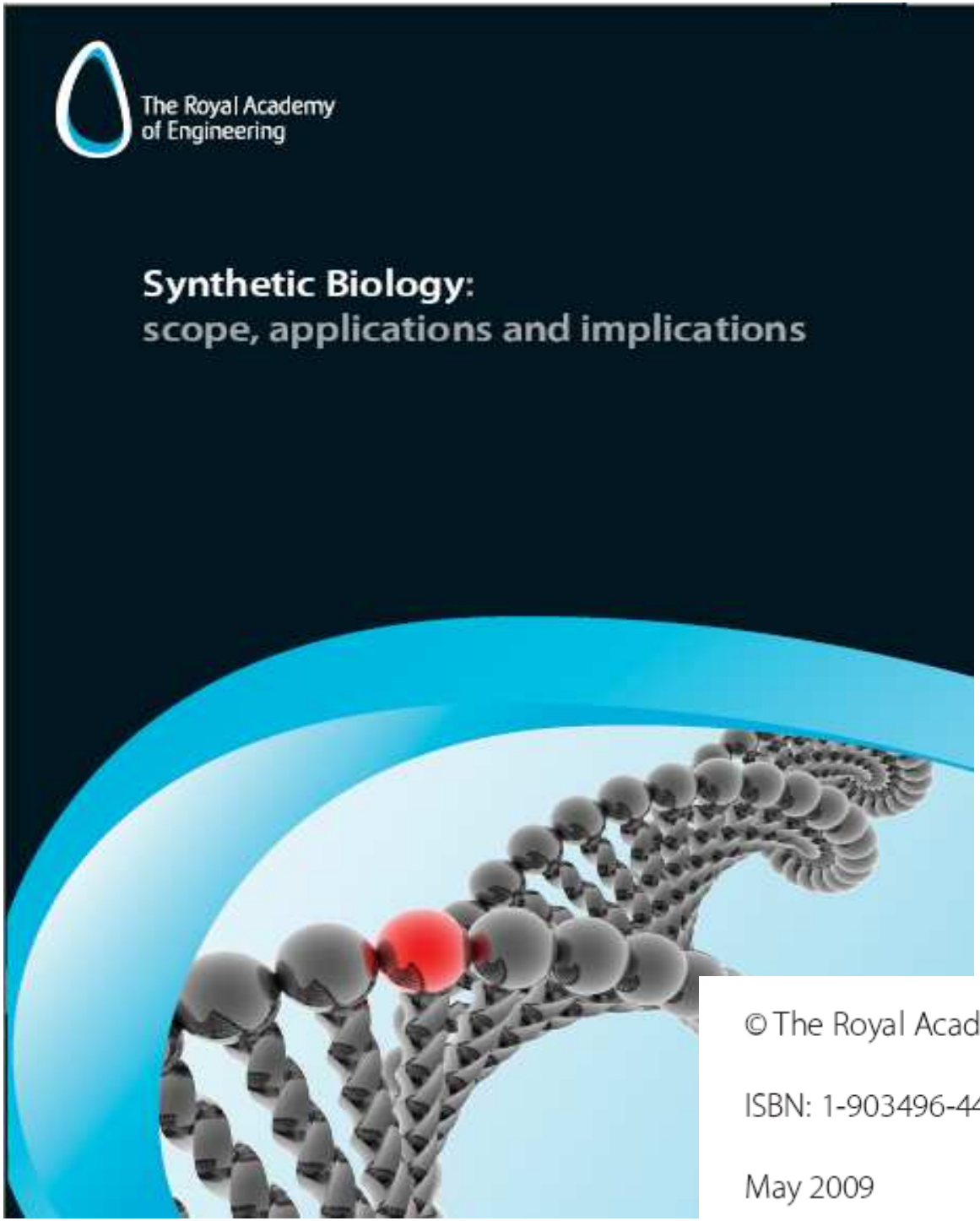
A newly made synthetic ribosome is an important step in the quest to create artificial life forms.

Tuesday, March 10, 2009 By Emily Singer





Researchers at Harvard University have built a functional ribosome--the cell's protein-making machine--from scratch, molecule by molecule. The creation represents a significant step toward making artificial life …



ISBN: 1-903496-44-6

May 2009

China

again a later comer as it did in genomics and other fields

Synbio-related projects funded in China

Funding Agency	Project Title	Project Leader	Affiliation	Approved Sum	Executing Period
EU-FP6	Programmable Bacteria Catalyzing Research (PROBACTYS) 可编程的细菌催化研究	Huanming Yang /Jing Wang	Beijing Genomics Institute/Institute of Psychology, Chinese Academy of Sciences	195,000 Euro	Oct 2006 to Sept 2009
*NSFC	Minimal Genome Research Based on Comparative Genomics and Large-scale Deletion of Genome Fragments 基于比较基因组学与大规模基因组片段删除技术的基因组最小化研究	Jing Wang	Institute of Psychology, Chinese Academy of Sciences	240,000 RMB	Jan 2008 to Dec 2010
NSFC	Synthetic Biology Research of Control Units of Cell Concentration 细胞浓度控制元件德合成生物学研究	BoShan Fang	HuaQiao University	300,000 RMB	Jan 2008 to Dec 2010
NSFC	Cooperative Research of Biosafety and Risk Assessment of Synthetic Biology Between China and Austria 中国和奥地利合成生物学生物安全和风险评价的合作研究	Wei Wei	Insitute of Botany, Chinese Academy of Sciences	400,000 RMB	Jan 2009 to Dec 2011

*NSFC: National Natural Science Foundation of China

**Search for “synthetic biology” in the public databases of all Chinese funding agencies

Synbio-related projects funded in China

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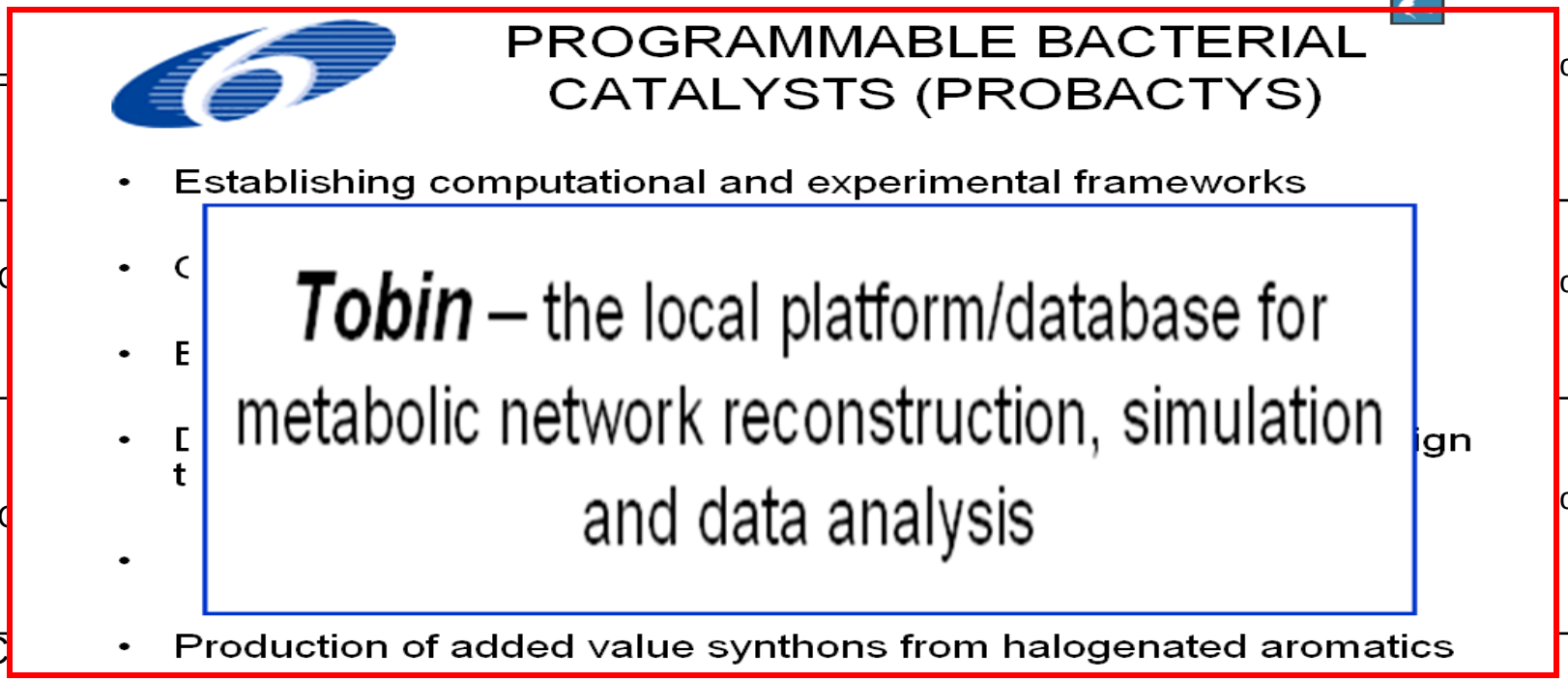
*NSF	Minimal Genome Research				o Dec
NSFC					o Dec
NSFC					o Dec



*NSFC

**Search for “synthetic biology” in the public databases of all Chinese funding agencies

The first review on SynBio in China

国际遗传学杂志 2008 年 8 月 15 日第 31 卷 第 4 期 Int J Genet Aug. 15,2008,Vol. 31,No. 4

合成生物学进展与应用

朱新星 罗永伦 王 晶 杨焕明

【摘要】 合成生物学是一门新兴的建立在生物信息学、DNA 化学合成技术、遗传学和系统生物学之上的交叉学科。近十年来,该学科在病毒全基因组合成、标准化遗传回路和最小基因组研究中取得了巨大的突破,也展现了其在新能源、新药物开发、疾病治疗和环境污染治理中应用的美好前景。本文主要从最新进展和应用前景两方面对合成生物学作简要的综述。

【关键词】 合成生物学;人造生命;最小基因组

Synthetic Biology-Progress and Application *ZHU Xin-xing*, LUO Yong-lun, WANG Jing, YANG Huan-ming. (* Behavioral Genetics Research Center, Institute of Psychology, Chinese Academy of Sciences, Beijing* 100101, *China.*)

Corresponding author: WANG Jing. Email: wangjing@psych.ac.cn;
YANG Huan-ming. E-mail: yanghm@genomics.org.cn

【**Abstract**】 Synthetic biology is an emerging cross-disciplinary science based on the integration of bioinformatics, automated DNA synthesis technology, genetics, and systems biology. It has achieved enormous breakthroughs in the reconstruction of complete virus genome, standardized genetic circuits and minimal genome studies. Meanwhile, synthetic biology shows a great promising future for its potential application in the development of new energy and pharmaceuticals, diseases therapy and treatment of environment pollutions. This review briefly introduces the recent progress and application in prospect of synthetic biology.

【**Key words**】 Synthetic biology; Artificial life; Minimal genome

Synbio-related Publications in China

- Search for “synthetic biology” and “China” in PubMed (July 7, 2009)
- 14 items/articles found (since 2007)
- 5 groups
  Shanghai, Tianjin (2), Chengdu
  Taipei
  (All governmental laboratories)
  (All related to metabolic pathway analysis)

China

in return for your help, is contributing more to international genomics

The 1000 Genomes Project

			X	CEU	TSI	UK	Finn	Span	YRI	LWK	CHB	JPT	CHS	DAI	ASW	MXL	Total
Summary of full-scale project, including pilot 1 and additional samples for full project	Sanger	Solexa	4	26.5	95	47	51	2	23.0	33	13	39	0	0	0	0	329.5
	Beijing	Solexa	4	0.0	0	0	0	0	0.0	0	60	0	80	80	0	0	220.0
	Beijing	SOLiD	4	0.0	0	0	5	0	0	0	0	0	20	20	0	0	45.0
	Broad	Solexa	4	19.0	0	31	30	1	32.5	10	10	34	0	0	24	30	221.5
	WashU	Solexa	4	5.5	0	4	0	1	24.0	10	0	8	0	0	26	28	106.5
	WashU	454	4	1.0	0	0	0	0	1.5	0	0	2	0	0	0	0	4.5
	Illumina	Solexa	4	5.0	0	0	0	0	0.0	30	0	0	0	0	0	0	35.0
	MaxPlanck	Solexa	4	15.0	5	0	0	0	3.0	0	0	0	0	0	0	0	23.0
	MaxPlanck	SOLiD	4	0.0	0	10	4	0	4.0	2	2	2	0	0	4	4	32.0
	Baylor	SOLiD	4	12.0	0	8	10	0	12.0	15	15	15	0	0	7	8	102.0
	Baylor	454	4	6.0	0	0	0	0	0.0	0	0	0	0	0	0	0	6.0
Proportion 454				0.12	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.01

BGI has been an integrated part of the international genomics community

China: a later comer in genomics

Far Eastern Economic Review 03/22/2001 by David Murphy

"So what has China achieved in the life sciences so far? A good place to begin answering that question is the

Beijing Genomics Institute…"

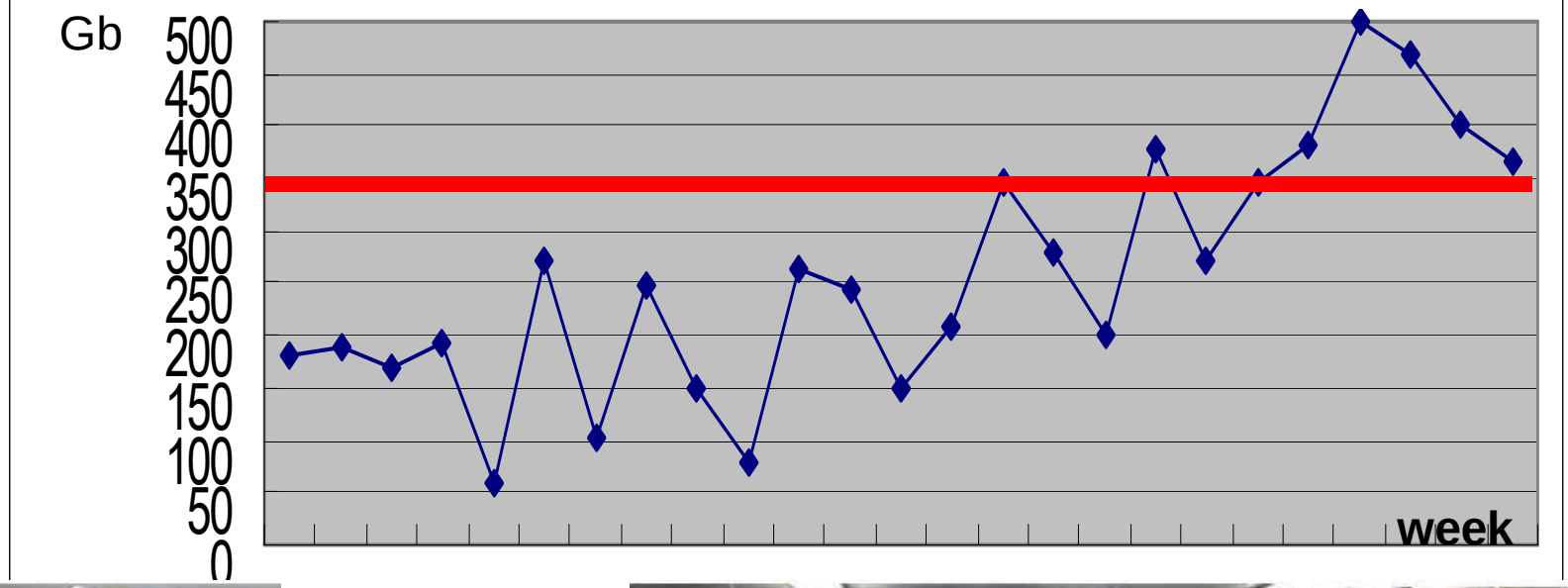
“BGI to Ramp Up Sequencing Abilities”

NEW YORK March 26, 2008 (GenomeWeb News) – Beijing Genomics Institute is dramatically expanding its DNA sequencing capacity by adding fourteen new next-generation sequencers, … to bring BGI's raw-sequencing data output to up to 20 Gbps per day or more, ranking the 3rd biggest center in the world concerning its capacity.

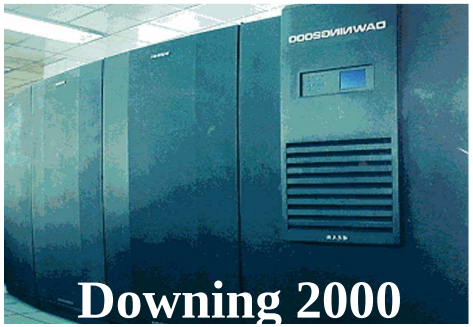
BGI - Sequencing

> 50 Gb / Day

Solexa GAIIx	30
SOLiD 3	2
454 GS FLX	1



BGI - Bioinformatics



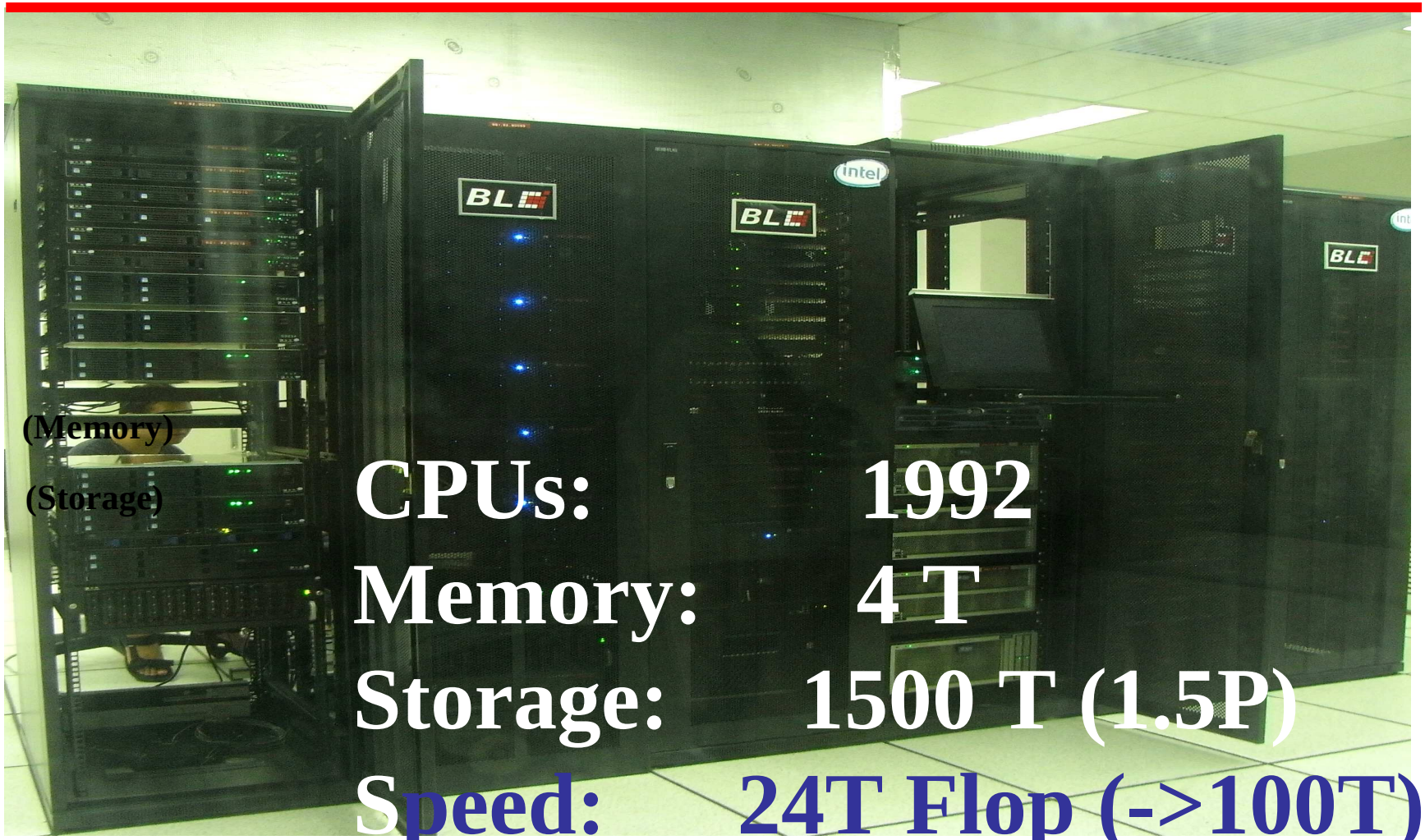
CPUs: 368 in supercomputers

800 in CP clusters

Memory: 721 G

Storage: 75 T

BGI - Bioinformatics



New supercomputer at BGI, Shenzhen

The SOAP Familiy by BGI

- **SOAPaligner**
- **SOAPsnp**
- **SOAPindel**
- **SOAPsv**
- **SOAPmultisnp**

- **SOAPnovo**
- **SOAPnovosv**

(Short Oligonucleotide Analysis Package)

SOAP: RNA-seq solutions

- SOAPrna
  - Transcriptome re-sequencing
  - Transcriptome*de novo* assembly
- SOAPdgep
  - digital gene expression profiling
- SOAPmir
  - microRNA identification

SOAP: Epigenome solutions

- SOAPmedip
  - Chip-seqmethylationprofilling
- SOAPes
  - Whole genome treatment and sequencing
  - Unbiased methylation profiling
  - Solve imprinted differentially methylated regions

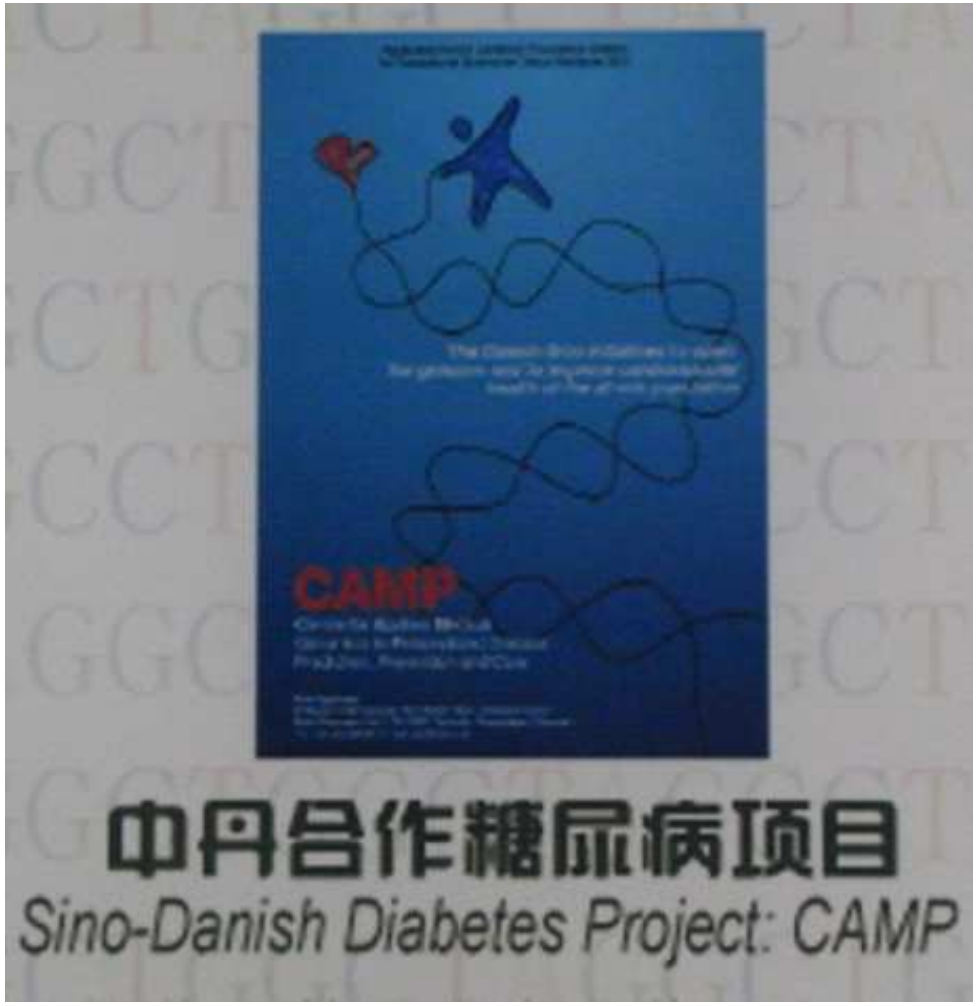
SOAP: Metagenomics solutions

- SOAPmeta
- 2-fold output of identified genes comparing to previous approach (Sanger, 454, etc.)

SOAP cited at least 24 times within 1 year (ranking No. 1 in scholar.google.com)

Database of the 1st Asian Genome

de novo re-assembled genome sequence



1000 patients
1000 controls

Exomic sequencing

De novo sequencing projects

Giant Panda Genome Project

- Genome size: ~3Gb
- Data production:
  - 50X Solexa (35~75bp; paired-end insert size: 200bp, 500bp, 2Kb,5Kb)
- Assembly:
  - Scaffold N50: 330K
  - Coverage: ~90%

De novo sequencing projects

Cucumber Genome Project

- **Assembly:**
  - **Scaffold N50: 1.14Mb**
  - **Coverage: ~99%**
- **Annotation**
  - **30% satellite sequence (Centeromere & Telomere)**
  - **24% transposons**
  - **26,682 genes**

Other sequencing projects

MetaHIT (metagenomics):

> 200 meta-samples of human intestine tracts

***Yersinia pestis (genome diversity of microbes)*:**

> 200 pathogenic and non-pathogenic strains

The 1,000 Plant Genomes Project

EDMONTON (Nov.14, 2008) — The Alberta government is investing in a new international plant-genome project.

Worldwide, the DNA of only about 100 plant species have been analyzed.

The plant-genome project is supported by international partners, including China's **Beijing Genomics Institute**. The institute, which was a key contributor to the Human Genome Project, is planning to donate services such as computer power and advanced equipment for gene Sequencing.

Dr. Gane Wong is seen among plants at the the University of Alberta Biosciences Building greenhouses in Edmonton, Thursday, Nov.13, 2008. THE CANADIAN PRESS/Edmonton Sun/HO-Government of Alberta

“To read more, to write more/better”

Discovery and elucidation of
more metabolic pathways,
signal transduction pathways, and
gene expression regulation networks

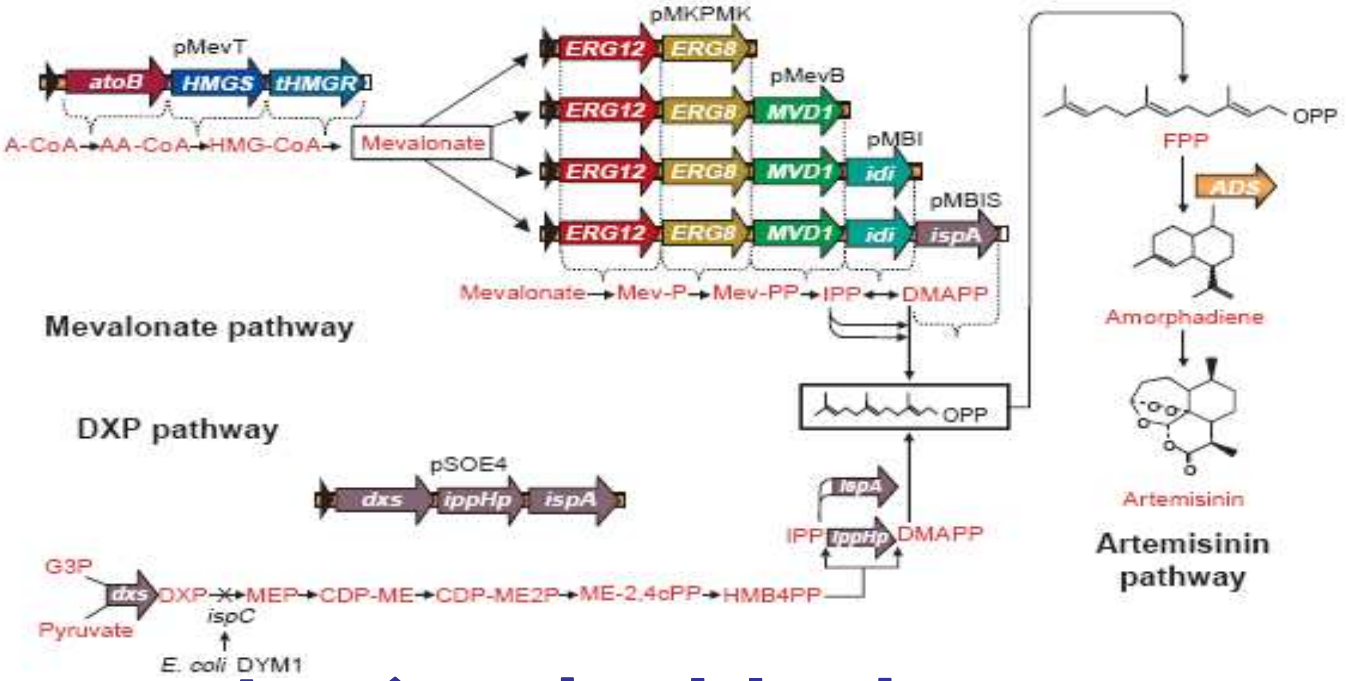
fundamental to SynBio

nature biotechnology

rebiotechnology

Engineering a mevalonate pathway in *Escherichia coli* for production of terpenoids

Vincent JJ Martin[1,2,3], Douglas J Pitera[1,3], Sydnor T Withers[1], Jack D Newman[1] & Jay D Keasling[1]



“人工”生产青蒿素

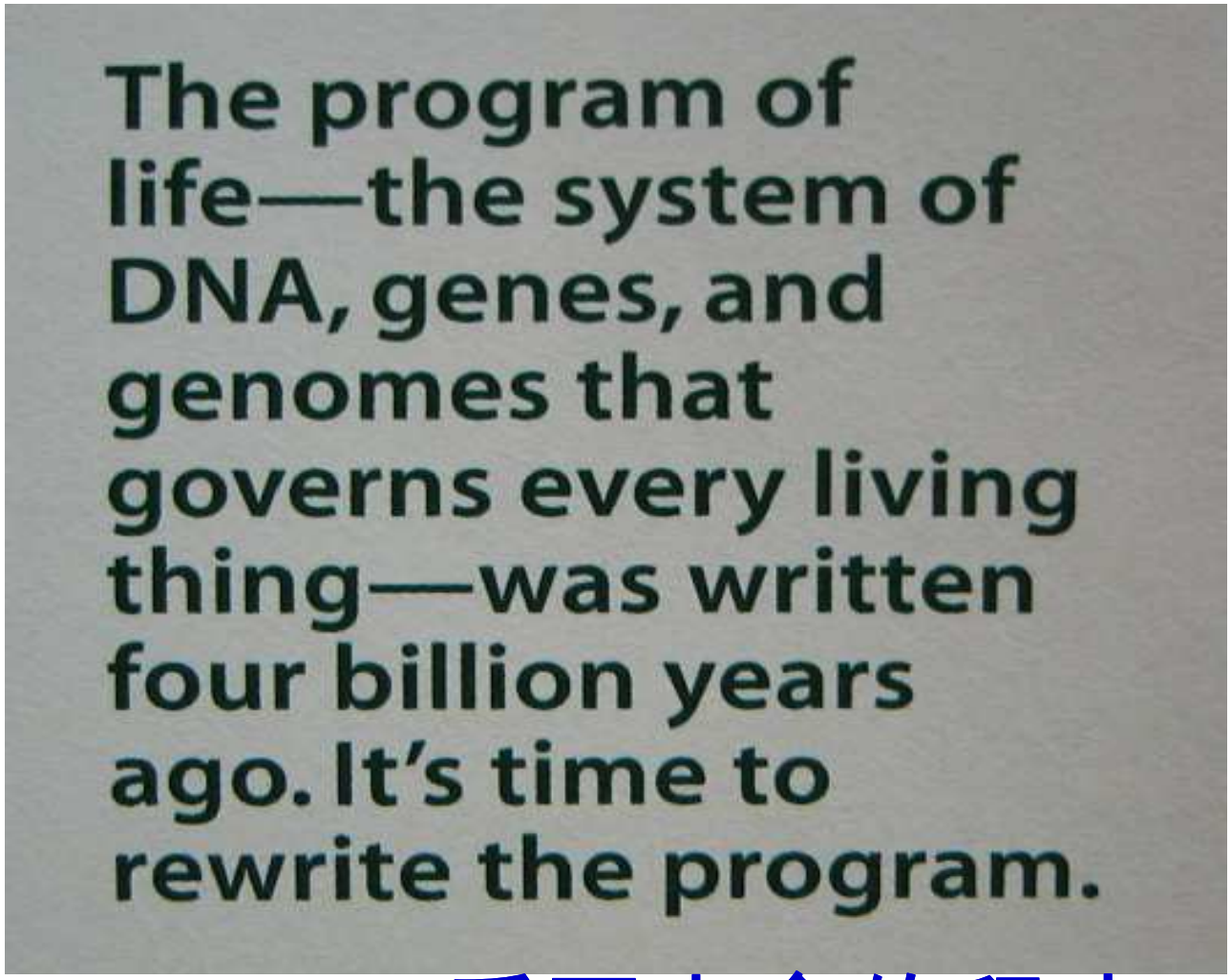
Genomics & SynBio

A natural and reasonable development/extension of genomics

A turning point in genomics

from *READING* to *WRITING* genome sequences

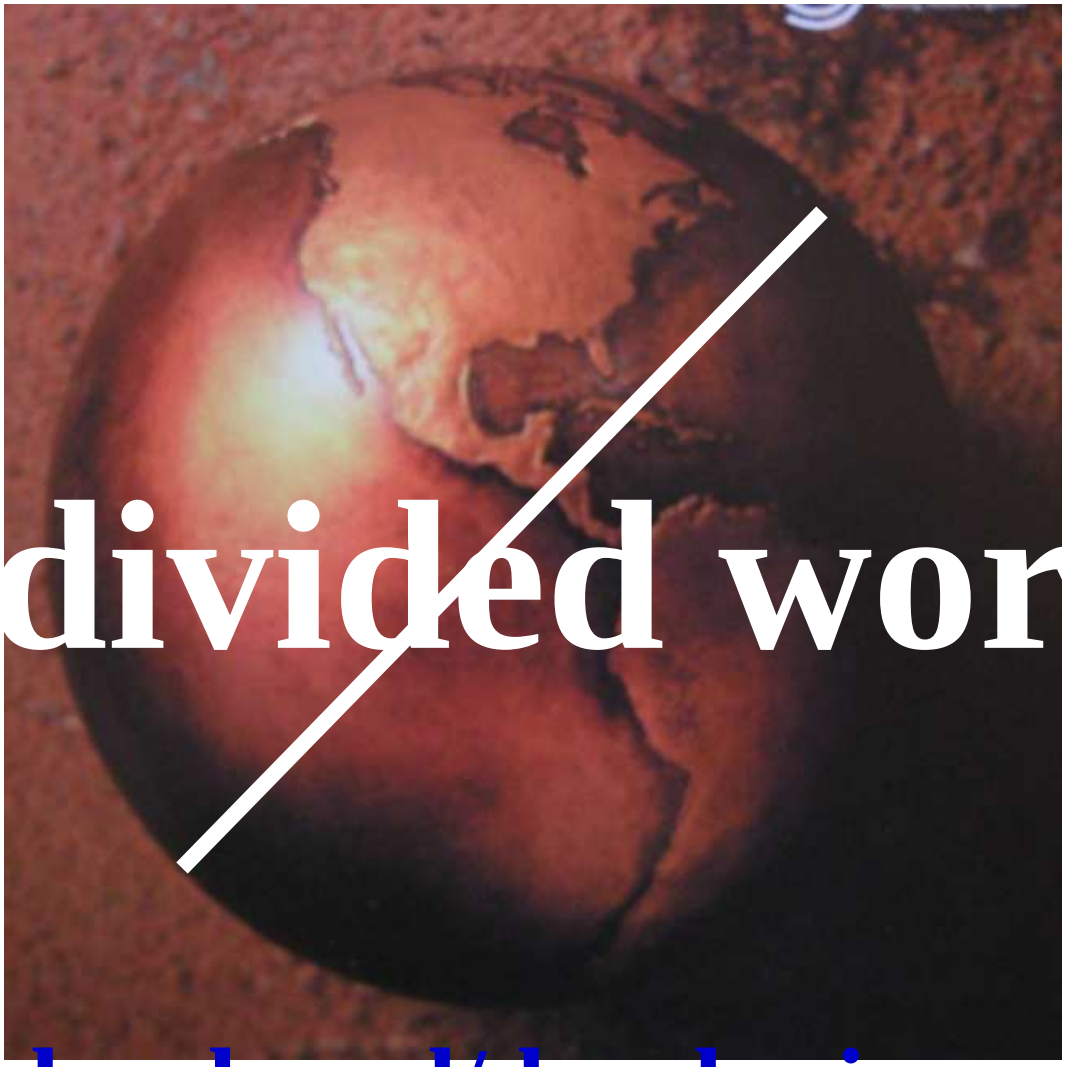
The summit stage and most brilliant outputs of GENOMICS


The program of life—the system of DNA, genes, and genomes that governs every living thing—was written four billion years ago. It's time to rewrite the program.

“重写生命的程序”

Science brings us knowledge & power

more food, better health, comfort, convenience, and makes the world smaller…



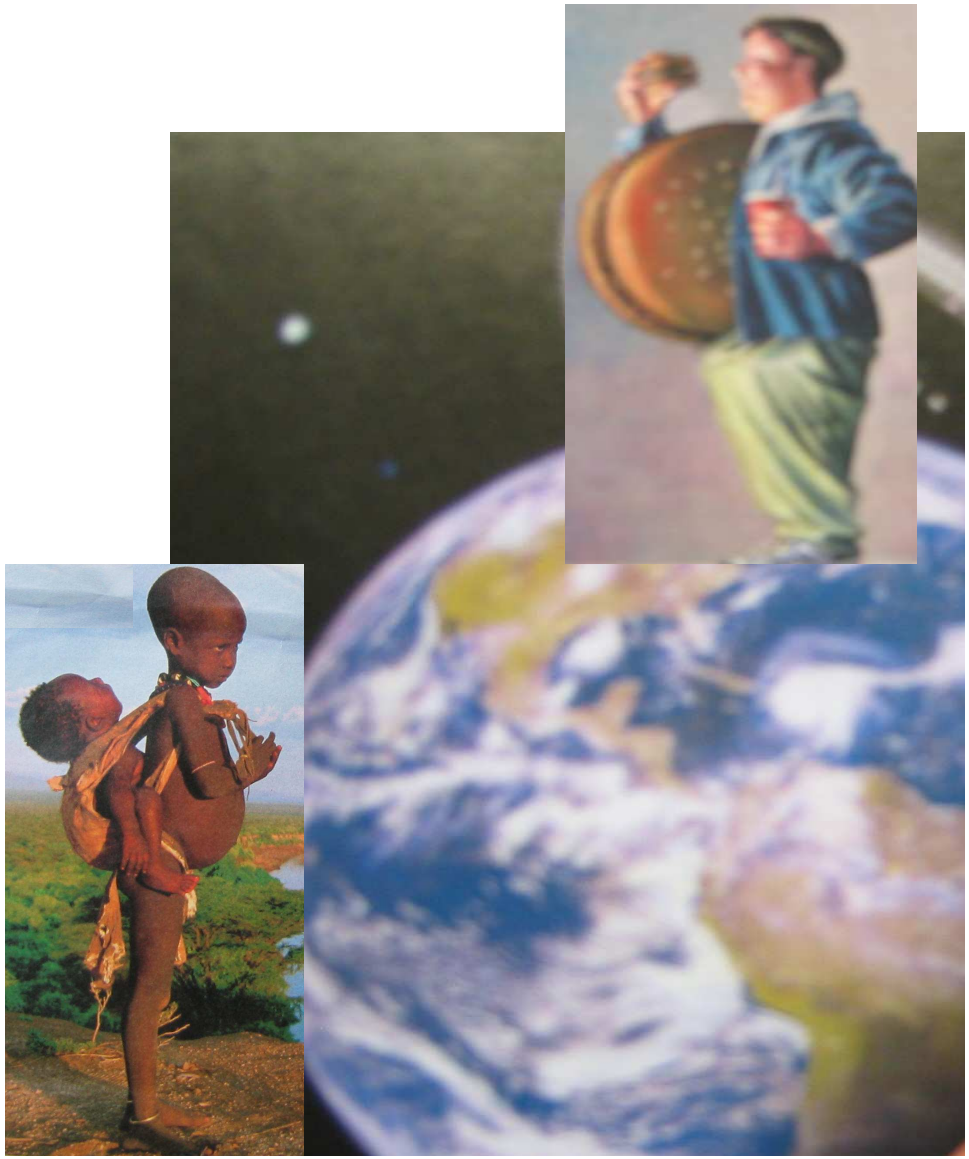
A divided world!

The “developed/developing world”

The “industrialized/less-fortunate” world

“The 3rd World”

An imbalanced world



A troubled world

communication and collaboration
mutual friendship, understanding, and trust
among scientists of various countries

more important

than ever before

The challenge is not only technology, but also humanity!

SynBio

Should not create more differences or to make the differences even bigger

Let science unify us!

1. Turn an institute's, or a country's, project to an internationally collaborative project

2. To call for more developing countries to join

“International SynBio Consortium”

1. Better communication & exchange
2. Possibly better coordination of effort and resource worldwide
3. Possibly coordinated data-release and data-sharing policies, e.g. IPR, etc.
4. Better response to the biosafety and bioethical challenges

Chinese SynBio Consortium

To coordinate

the effort and resource in China

To contribute to

the International SynBio community

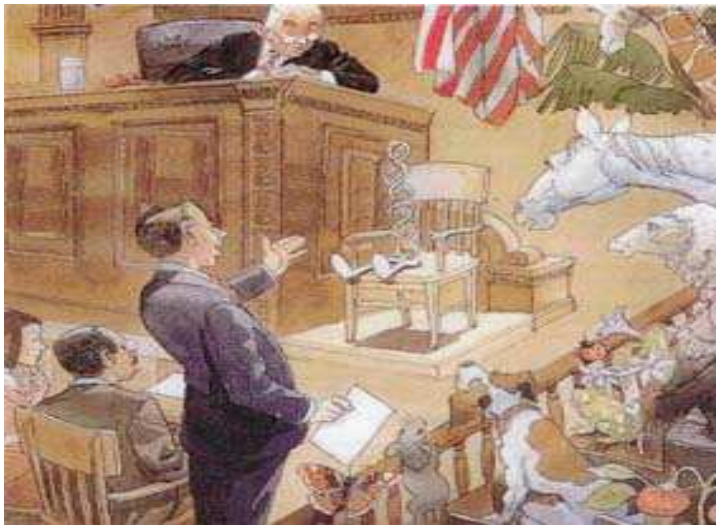
Bioethical Discussions: Ultimate obligation by scientists/researchers

"What we bring back should not only be the advanced technology, but also the internationally acknowledged ethical principles."

H. Yang, 1984

To make the world safer, cleaner, and more sustainable

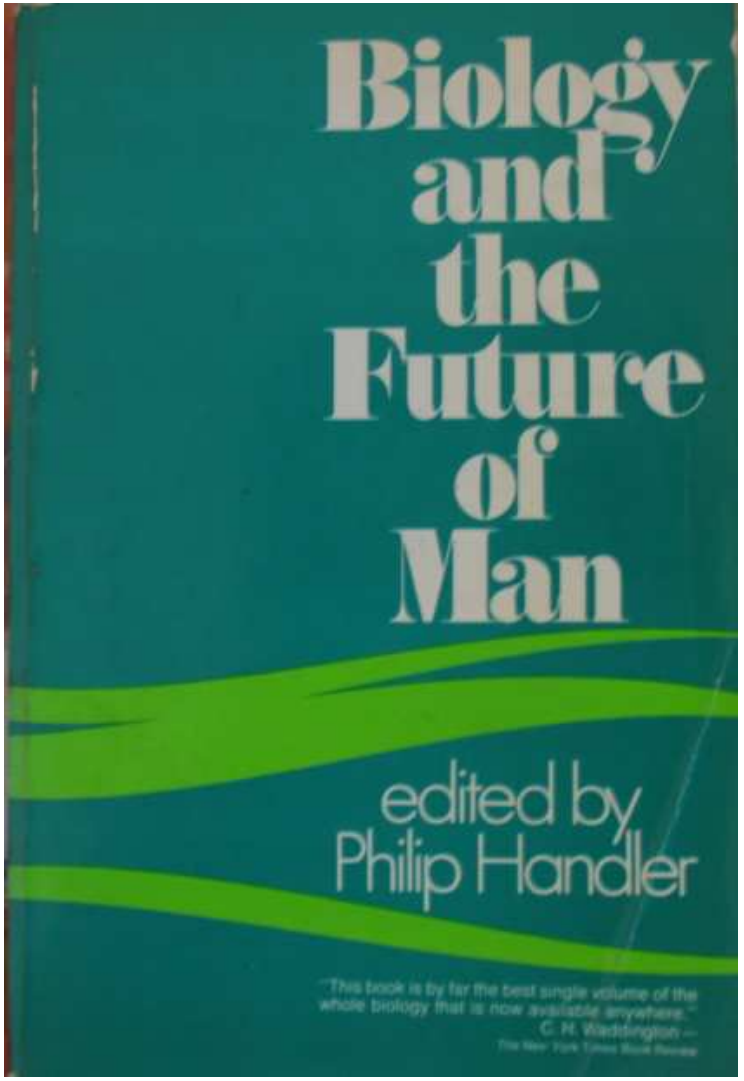
"I would be extremely ashamed as a scientist if what we have discussed could really take place."



A Workshop on Scientific and Technological Developments Relevant to Biological and Toxin Weapons Convention

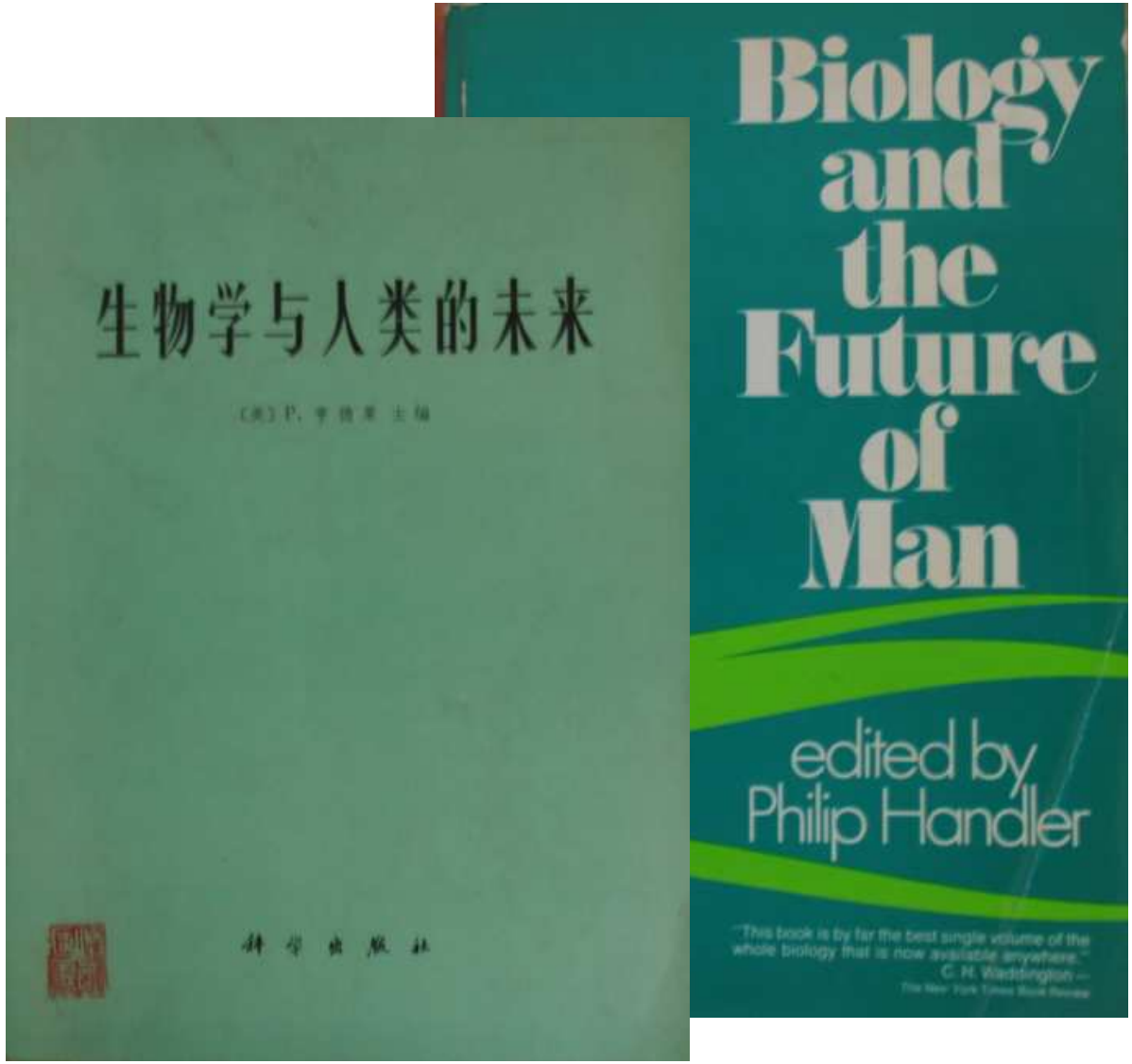
4 - 6 September 2006,

Biology and the Future of Man



1968

“Synthetic Biology and the Future of Man”



1977 (1974)

tion he is to strive.

Man's view of himself has undergone many changes. From a unique position in the universe, the Copernican revolution reduced him to an inhabitant of one of many planets. From a unique position among organisms, the Darwinian revolution assigned him a place among the millions of other species which evolved from one another. Yet, *Homo sapiens* has overcome the limitations of his origin. He controls the vast energies of the atomic nucleus, moves across his planet at speeds barely below escape velocity, and can escape when he so wills. He communicates with his fellows at the speed of light, extends the powers of his brain with those of the digital computer, and influences the numbers and genetic constitution of virtually all other living species. Now he can guide his own evolution. In him, Nature has reached beyond the hard regularities of physical phenomena. *Homo sapiens*, the creation of Nature, has transcended her. From a product of circumstances, he has risen to responsibility. At last, he is Man. May he behave so!

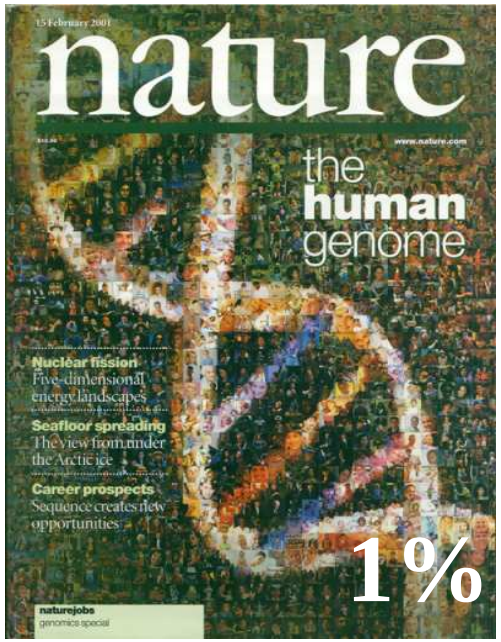
***Homo sapiens*, the creation of Nature, has transcended her. From a product of circumstances,**

***Homo sapiens*, the creation of Nature, has transcended her. From a product of circumstances, he has risen to responsibility.**

At last, he is Man.

At last, he is Man.
May he behave so!

Let science unify us!



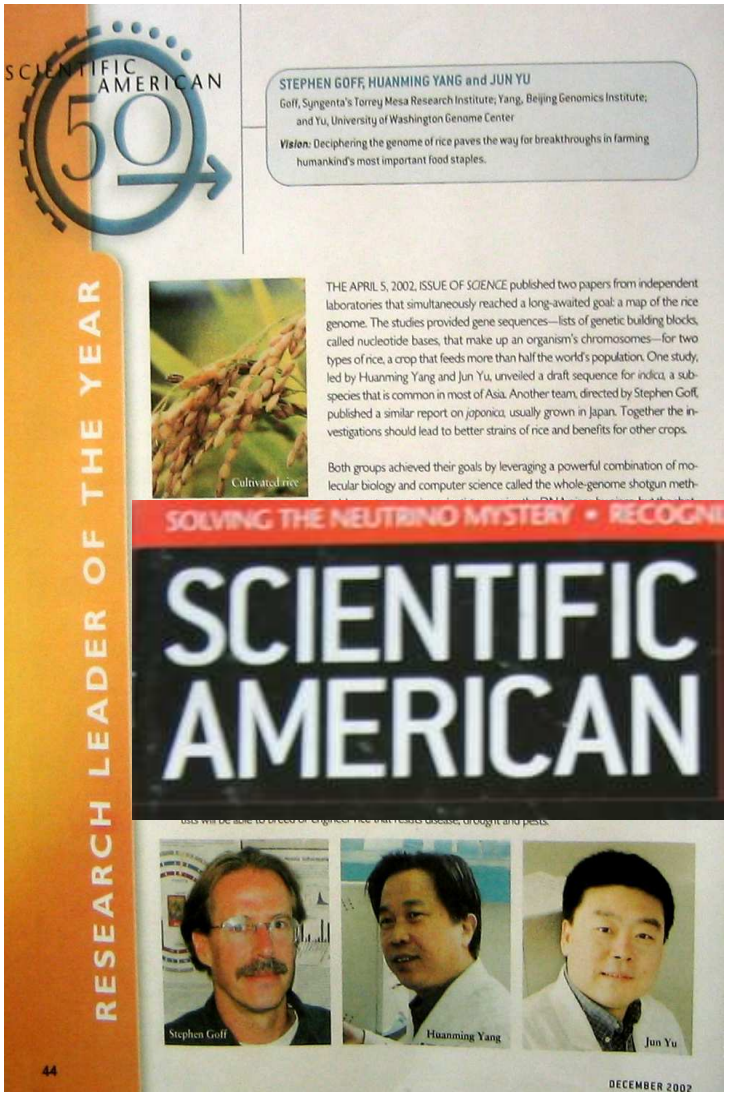
Nothing could be done by us without international collaboration

It is also the same case for SynBio

Scientific American: Research Leader of the Year (2002)

"I try to find a Chinese proverb to express more properly my feelings for all those who deserve sharing this honor …

That is:



Scientific American: Research Leader of the Year, 2002

"When you drink from the well, don't forget who helped dig it!"

"饮水思源"

"滴水之恩，也当涌泉相报!"

Gratitude speech at the reception by *Scientific American*


nature
human genome
Science
The RICE Genome
GENOME RESEARCH
Science
SILKWORM
nature
The chicken genome
PLoS BIOLOGY
nature
THE HAPMAP PROJECT
nature
BREAK GLASS WHEN READY
YOUR LIFE IN YOUR HANDS
Instructions for the personal genome age
Feb. 2001 (Nature)
Apr. 2002 (Science)
Jun. 2003 (Genome Research)
Dec. 2004 (Science)
Dec. 2004 (Nature)
Feb. 2005 (Plos Biology)
Oct. 2005 (Nature)
Nov.2008 Nature

谢 谢！ Thanks!