Synthetic Biology and the Future of Man

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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.”


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!

**Synthetic Biology is**
A) the design and construction of new biological parts, devices, and systems, and
B) the re-design of existing, natural biological systems for useful purposes.

It is an international effort
Creating Life

Venter created a new bacterium's genetic information. ... If you know how to write a code, you can make it do almost anything.

Living things don't get much more humble 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.
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 …
China again a later comer as it did in genomics and other fields
<table>
<thead>
<tr>
<th>Funding Agency</th>
<th>Project Title</th>
<th>Project Leader</th>
<th>Affiliation</th>
<th>Approved Sum</th>
<th>Executing Period</th>
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<tbody>
<tr>
<td>*NSFC</td>
<td>Minimal Genome Research Based on Comparative Genomics and Large-scale Deletion of Genome Fragments</td>
<td>Jing Wang</td>
<td>Institute of Psychology, Chinese Academy of Sciences</td>
<td>240,000 RMB</td>
<td>Jan 2008 to Dec 2010</td>
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<tr>
<td>NSFC</td>
<td>Synthetic Biology Research of Control Units of Cell Concentration</td>
<td>BoShan Fang</td>
<td>HuaQiao University</td>
<td>300,000 RMB</td>
<td>Jan 2008 to Dec 2010</td>
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<td>NSFC</td>
<td>Cooperative Research of Biosafety and Risk Assessment of Synthetic Biology Between China and Austria</td>
<td>Wei Wei</td>
<td>Institute of Botany, Chinese Academy of Sciences</td>
<td>400,000 RMB</td>
<td>Jan 2009 to Dec 2011</td>
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*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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<td>PROGRAMMABLE BACTERIAL CATALYSTS (PROBACTYS)</td>
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<td>• Establishing computational and experimental frameworks</td>
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<td>• Tobin – the local platform/database for metabolic network reconstruction, simulation and data analysis</td>
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<td>• Production of added value synthons from halogenated aromatics</td>
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The first review on SynBio in China

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，也展现出了其在新能源、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*, LEO 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

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…”

> 130 Sanger sequencers
50 Mb/day
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

Gb

week

0 50 100 150 200 250 300 350 400 450 500

BGI - Sequencing

SOLiD

454

Solexa

Gb
BGI - Bioinformatics

CPUs: 368 in supercomputers
800 in CP clusters
Memory: 721 G
Storage: 75 T
BGI - Bioinformatics

CPUs: 1992
Memory: 4 T
Storage: 1500 T (1.5P)
Speed: 24T Flop (->100T)

New supercomputer at BGI, Shenzhen
The SOAP Family 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-seq methylation profiling

- 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)
Introduction

On October 11th, 2007, Beijing Genomics Institute at Shenzhen announced the completion of first diploid genome sequence representative of Asian population. The genome, named as YanHuang Project, which aims to sequence 100 Chinese indi

We set up this 'YH database' to present the entire DNA sequenced on 3.3 billion reads (117.7Gbp raw data) generated by Illumi.

total of 102.9Gbp nucleotides were mapped onto the NCBI h1
(BUILD 36) by self-developed software SOAP (Short Oligonucleotide Program), and 3.07 million SNPs were identified.

We illustrated the personal genome data in a MapView, which is powered by GBrowse. A new module was developed to browse large-scale short reads alignment. This module enabled users track detailed divergences between consensus and sequencing reads. In total of 53,643 HGMD records were used to screen YH SNPs to retrieve phenotype related information, to superficially explain the donor's genome. Blast service to align query sequences against YH genome consensus was also

de novo re-assembled genome sequence
Exomic sequencing

1000 patients
1000 controls
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
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.
“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
Engineering a mevalonate pathway in *Escherichia coli* for production of terpenoids

Vincent JJ Martin¹,²,³, Douglas J Pitera¹,³, Sydnor T Withers¹, Jack D Newman¹ & Jay D Keasling¹
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”

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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
“I try to find a Chinese proverb to express more properly my feelings for all those who deserve sharing this honor ...
“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
谢谢！Thanks!