Life Story

How the molecules for life were created

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The Flow of Genetic Information

Central dogma for life

All stories on the earth began at this point … 13.7 billion years ago.

Big Bang
10^{-43} \text{ sec}

10^{-33} \text{ sec}

70,000 \text{ yr}
to
380,000 \text{ yr}

13,700,000,000 \text{ yr}

Big Bang

Cosmic Inflation

Matter formation (Recombination)

Today

Model of the universe

牛頓雜誌 (1994) 第 129 期, p.116
From elementary particles to atom

Atom is composed of nucleus and electrons

Nucleus is composed of protons and neutrons

Neutron

Proton or neutron is composed of three quarks

Helium

$\text{He}^2$

Proton or neutron is composed of three quarks

Adapted from 牛頓雜誌 (1991) 第 93 期, p.103
The smallest orbital: $1s \ (2e^-)$
more likely it is to shed or grab electrons — and the more reactive it is. Those with complete shells, such as helium atoms, almost never interact with their neighbors.
Carbon C\textsuperscript{6}

The innermost shell: 1s (2e⁻)

The second shell: 2s 2p \textit{x,y,z} (4e⁻)

6 protons, 6 neutrons and 6 electrons

Hybrid orbital $sp^3$

CH$_4$

Methane

tetrahedral

Covalent bond

Steps for developing the Earth environment

The core of the Earth is hot melted heavy metals

Meteorites bombardment  Earth melted  Heavy cloud accumulated  First rain  Sky cleared

Water on the Earth was brought by meteorites from outer space

4.6 billion yr ago  3.8 billion yr ago

牛頓雜誌 (1994) 第 132 期, p.37
From basic small molecules to unit molecules

Basic small molecules
- Water (H₂O)
- Ammonia (NH₃)
- Methane (CH₄)

Unit molecules
- Water (H₂O)
- Ammonia (NH₃)
- Methane (CH₄)

Campbell (1999) Biochemistry (3e) p.16
Unit molecules can be produced in test tube

Basic small molecules

7 days later

Product

Amino acids

Nucleic acid bases

Stanley Miller

Alberts et al (1994) Molecular Biology of the Cell (3e) p.4
Campbell (1990) Biology p.17
Replication mechanism of nucleic acid

How to make copies from single molecule?

Juang RH (2006) BCbasics
Trick 2

2 Hydrogen bonds

Pairing

3 Hydrogen bonds

Juang RH (2006) BCbasics
Make template from the original molecule

Trick

1  UCGAUUCGAUGC

2  AGCUUAGCUUAGC

Original

Pairing

Juang RH (2006) BCbasics
Now make more copies from the template

Juang RH (2006) BCbasics
Keep duplicating…
Juang RH (2006) BCbasics
When the resource was limiting, the duplication was getting difficult.

New strategy was needed...

Catalytic proteins and membrane boundary

Catalyzed by protein?

Primordial membrane

Juang RH (2006) BCbasics
Single layer membrane

Oil drop

Bilayer liposome

It was easy to make a membrane

Central Dogma

- DNA
  - Replication
  - Transcription
  - Reverse Transcription
- RNA
  - Translation
- Protein

Juang RH (2006) BCbasics
Transcription

Amplification of DNA message
Translation

Ribosome

DNA

mRNA

tRNA

Translation

Ribosome

codon

AUG UAG GCU UAG C

Anticodon

UAC AUC C

1

2

Met

Ile

linking

Juang RH (2006) BC basics
Stop codons: UGA, UAG, UAA
DNA

mRNA

Protein

Juang RH (2006) BCbasics
DNA

mRNA

Destroyed

Juang RH (2006) BCbasics
Big bang

Elementary elements

Combination

Nucleic acid
Replication & Message

Central Dogma

Protein
Catalysis & Function

Macromolecules

Unit molecules

Juang RH (2006) BCbasics
### Three major macromolecules in the cell

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Juang RH (2006) BCbasics
The sequence is critical important

A pile of disorderly bricks is not a house
A mess of aimless alphabets is not a word nor sentence
A string of random nucleotides is not a useful gene
A string of random amino acids is not a functional protein
Macromolecules ...

(1) Composed of small unit molecules
(2) Its sequence is important
(3) Combination has several levels
(4) Higher level, higher complexity

Alphabets – Words – Sentences – Paragraphs – Chapters - Books

DNA:
-A-C-T-C-G-A-C-G-A-

(cellulose):
Glc-Glc-Glc-Glc-Glc-

Significant message shows complex patterns

Lehninger Principles of Biochemistry (3e) p.5, 70
Bioinformatics

Arabidopsis genome decoded
3,000 MB (3 GB)
Totally **25,000** files
In 46 chromosomes

Replication

Before cell division

Juang RH (2006) BCbasics
DNA replaced RNA and became the major genetic material. RNA shifted its role to protein biosynthesis.
(1) How was this universe formed by combination?

(2) Is the whole universe composed of elements exclusively from the Periodical Table?

(3) How is protein translated from gene sequence?

(4) Why the sequence of a macromolecule in the cell is critical important to the life?

(5) How was a living cell developed from non-living substances?
Search “JuangWeb”

Key board of PC Boy links to an English index table for this web site →

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- About English Pages -

Basically this web site is compiled in Chinese. To help the access of information by computer which can not read Chinese characters, this English Home Page is created. Besides, an index table in English is used to help surfing this web site.

From DNA to protein

More animations in PowerPoint format

- About Taiwan -

Taiwan Profile (BBC)
Taiwan Festivals (CNN)
National Palace Museum
Taipei (weather) | Taiwan (Wikipedia)
FYC's Oil Painting Exhibition On-line

If you have any question, please e-mail to Juang

How to teach your PC reading Chinese characters: