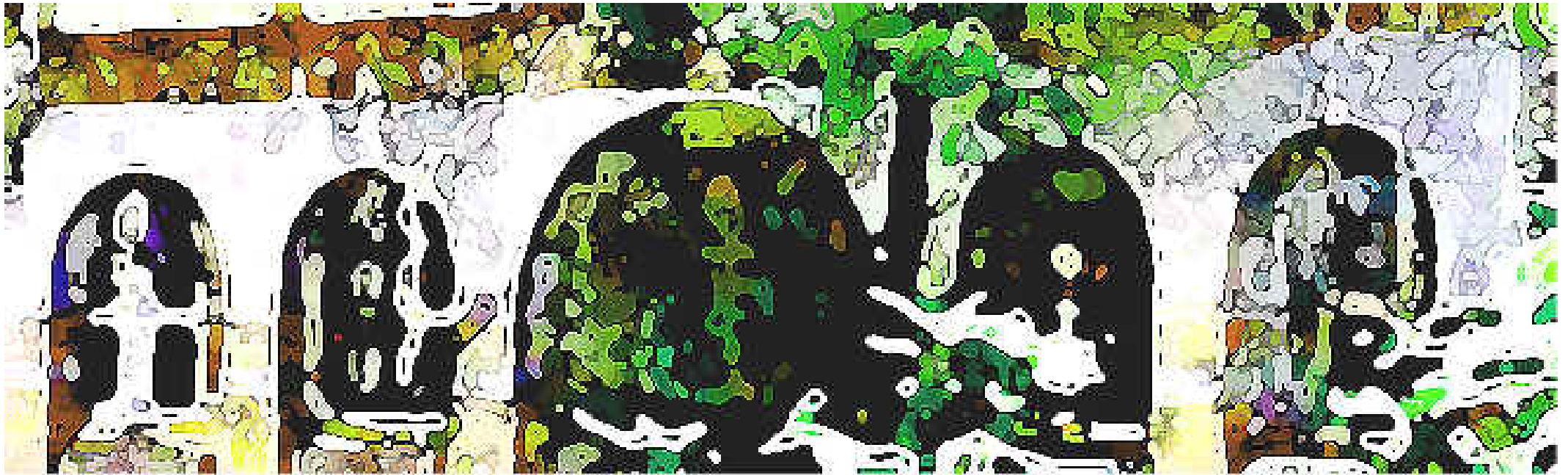


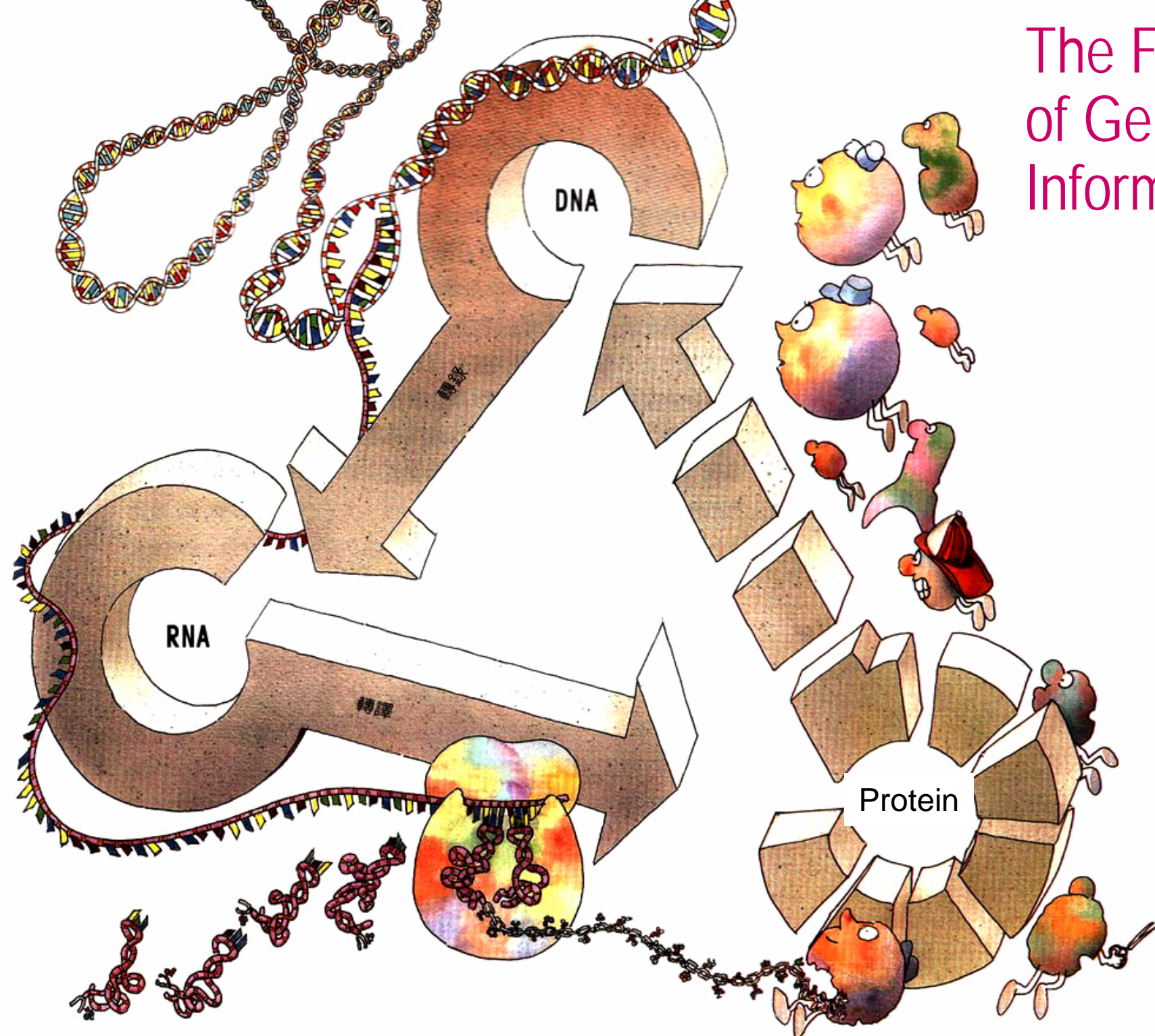
Life Story

How the molecules for life were created



Professor Rong-Huay Juang 莊榮輝
Department of Biochemical Science & Technology
National Taiwan University 國立臺灣大學

The Flow of Genetic Information





宇宙誕生

宇宙從「無」誕生。

大霹靂

成為高溫・高密度
的火球狀態。

密度的波動

隨著溫度的下降，
宇宙中的物質的密度會有
高低的不同。

Big Bang

宇宙的歷史

Big Bang

Cosmic Inflation

Matter formation
(Recombination)

Today

Model of the universe

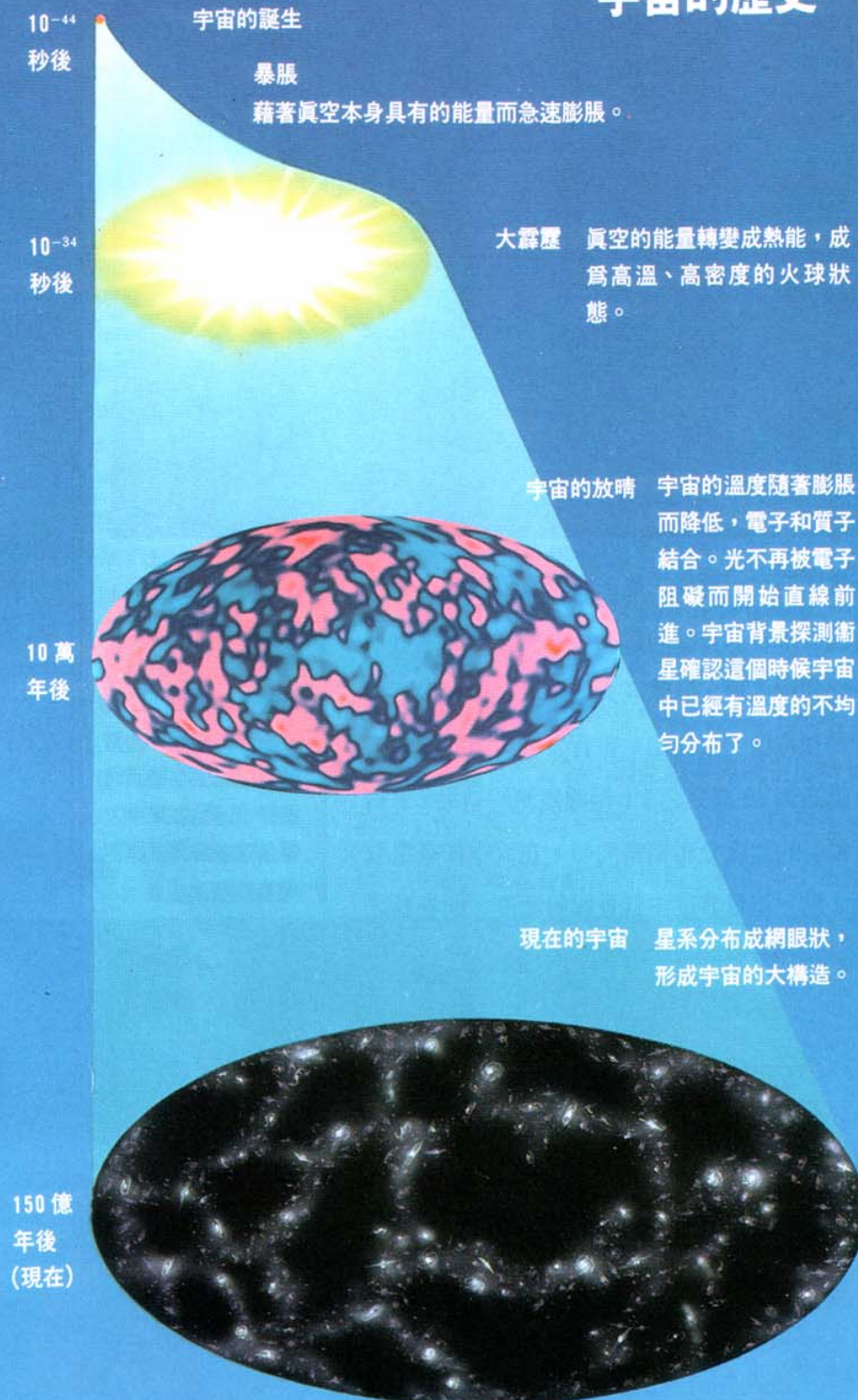
牛頓雜誌 (1994) 第 129 期, p.116

10^{-43} sec

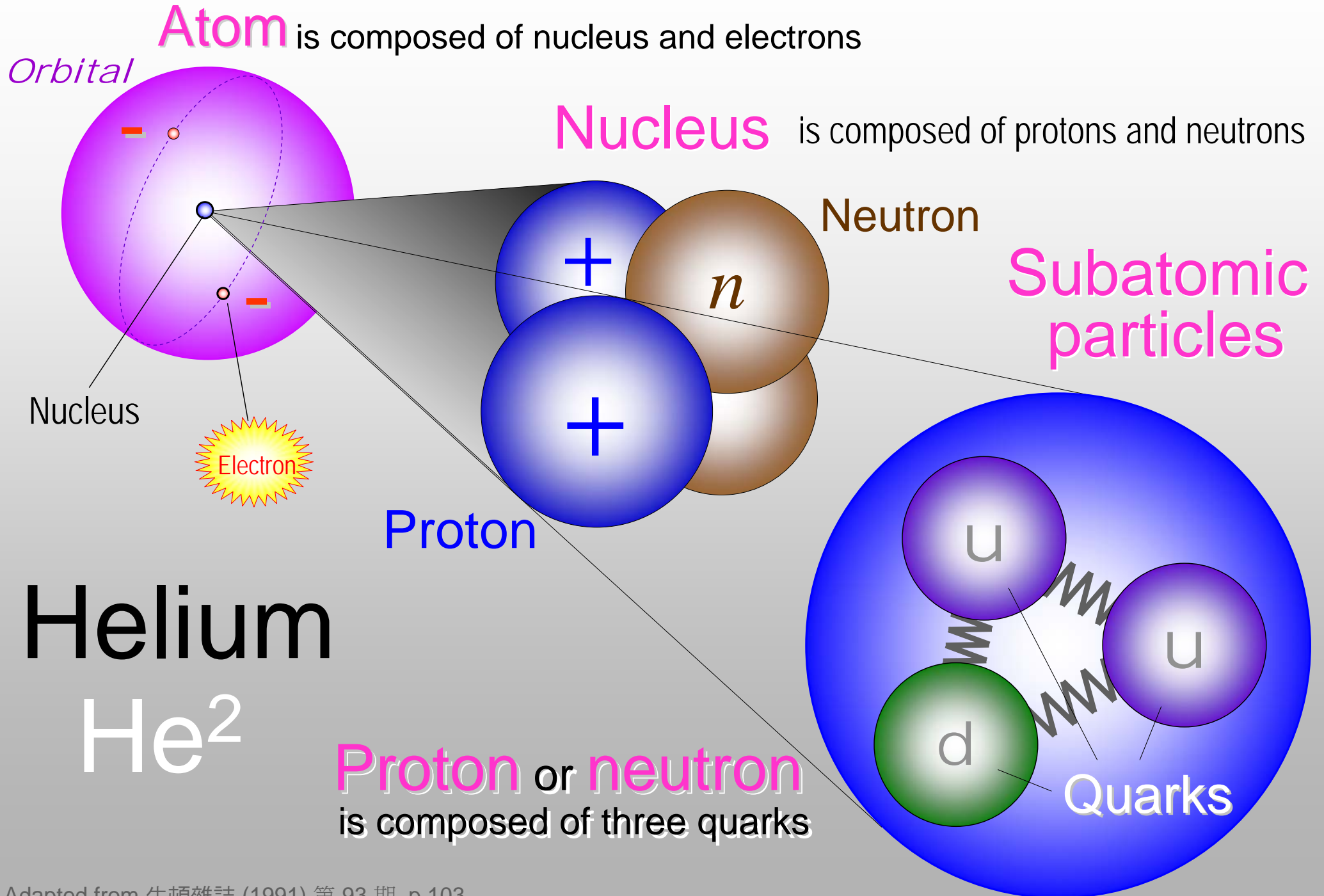
10^{-33} sec

70,000 yr
to
380,000 yr

13,700,000,000
yr

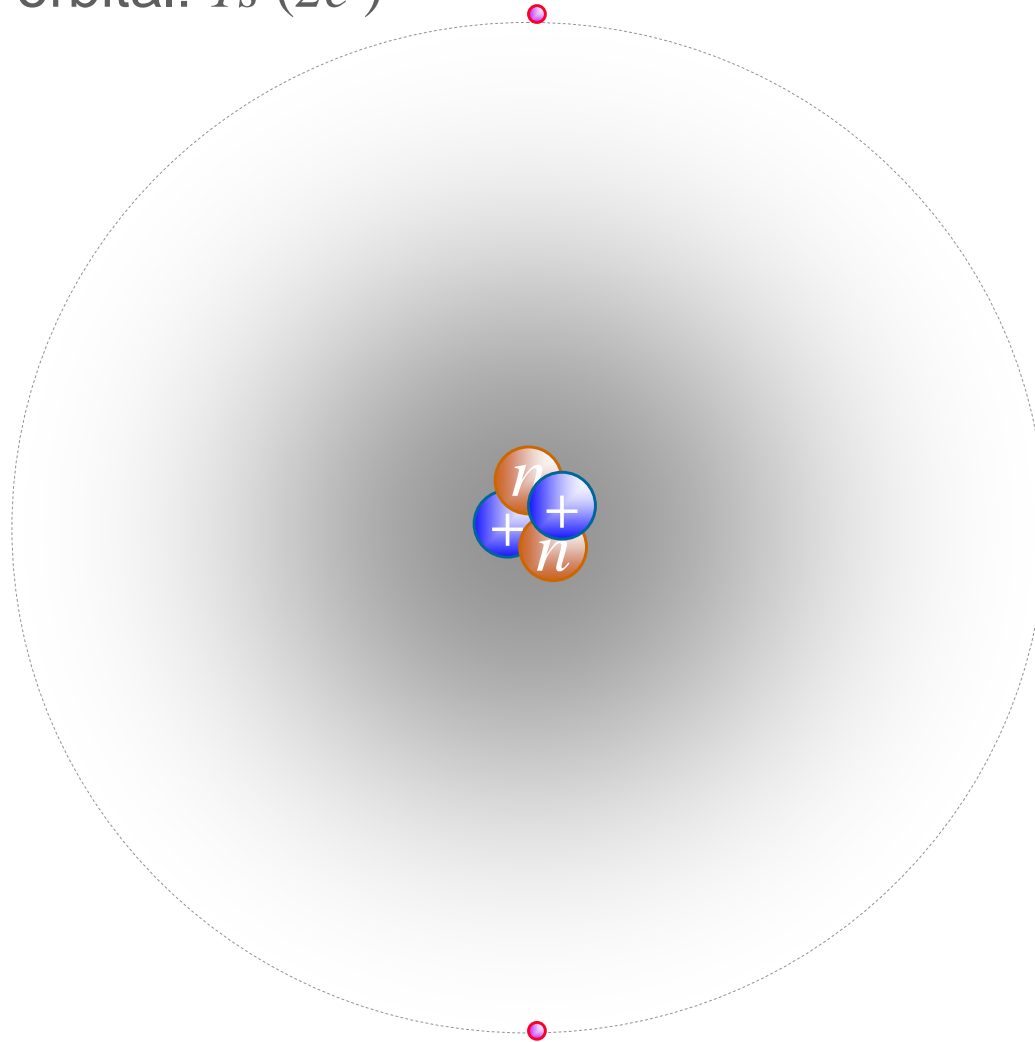


From elementary particles to atom



Helium He²

The smallest orbital: $1s$ ($2e^-$)



Hydrogen H¹

H CNO

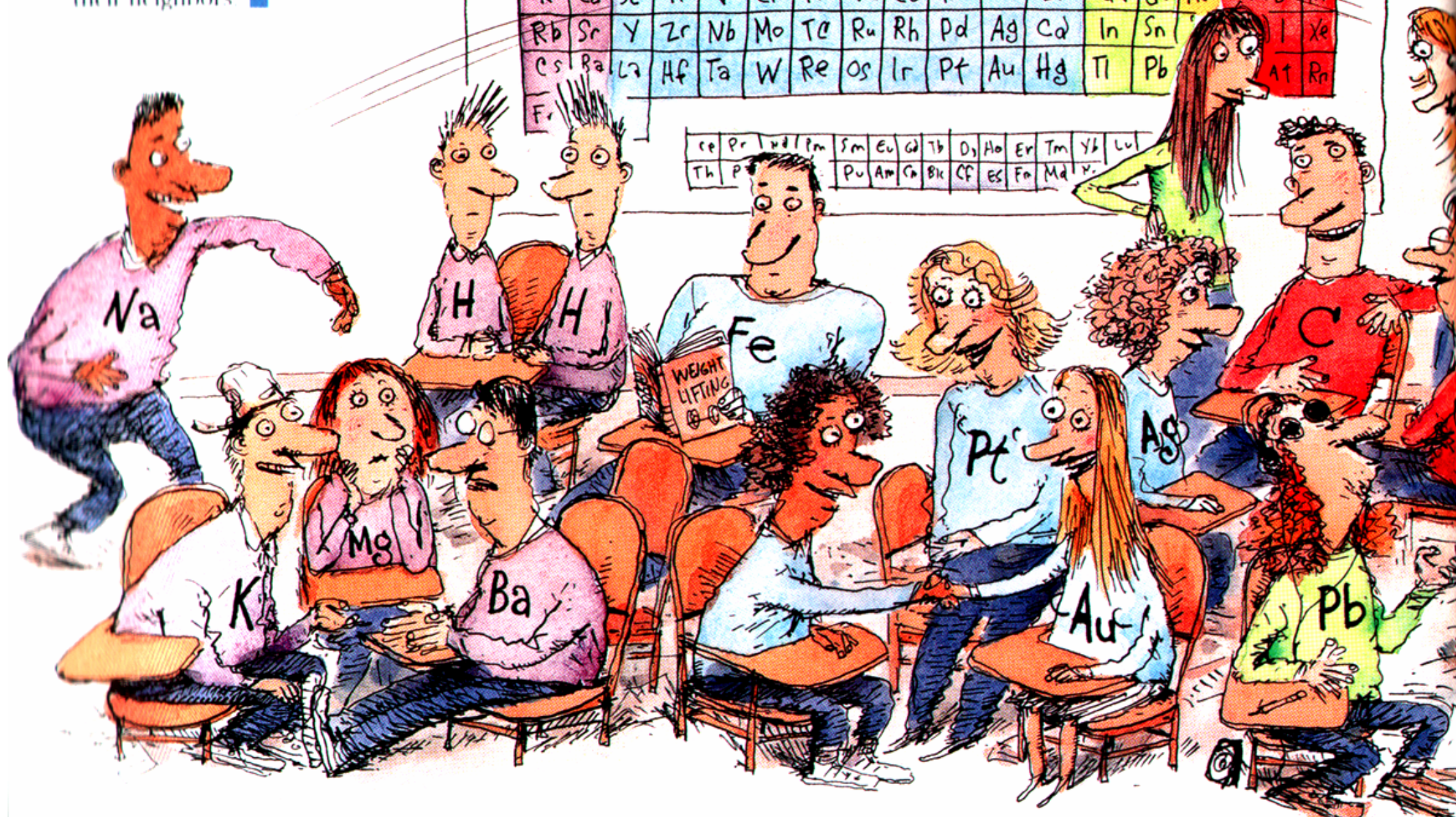
1 3 4 5 6 7 8 2

the PERIODIC TABLE OF ELEMENTS

H																		He
Li	Be											B	C	N	O	F	Ne	
Na	Mg											Al	Si	P	S	Cl	Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
Fr																		

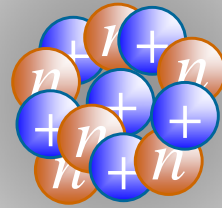
Lanthanides and Actinides:

ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr



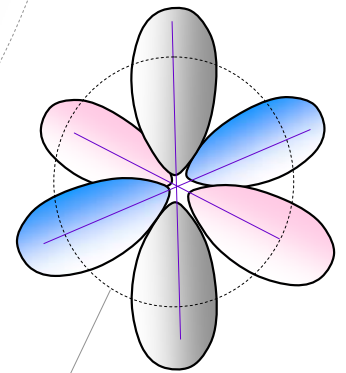
6 protons, 6 neutrons
and 6 electrons

The innermost shell: $1s$ ($2e^-$)



Carbon C^6

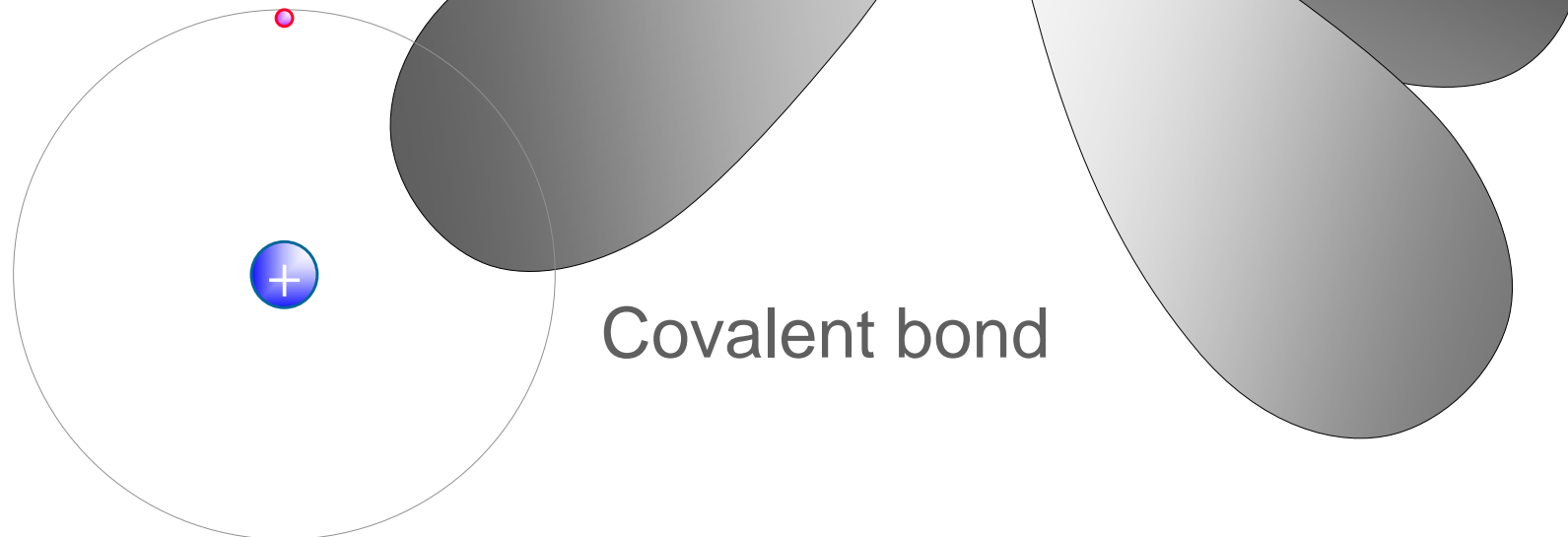
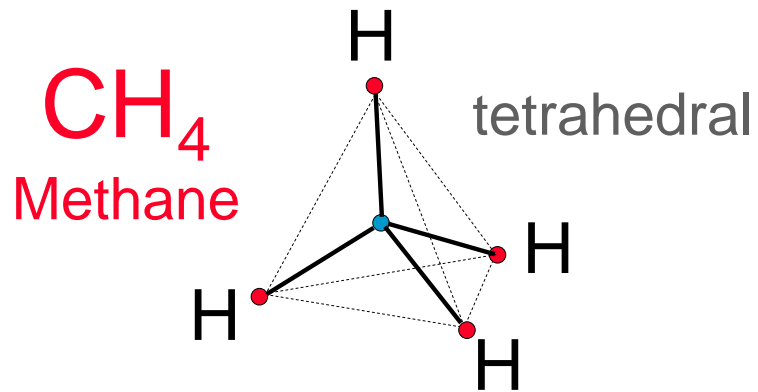
The second shell: $2s$ $2p^{x,y,z}$ ($4e^-$)



Hybrid orbital sp^3

C⁶

(2 inner electrons and
4 outer electrons)



Covalent bond

Steps for developing the Earth environment

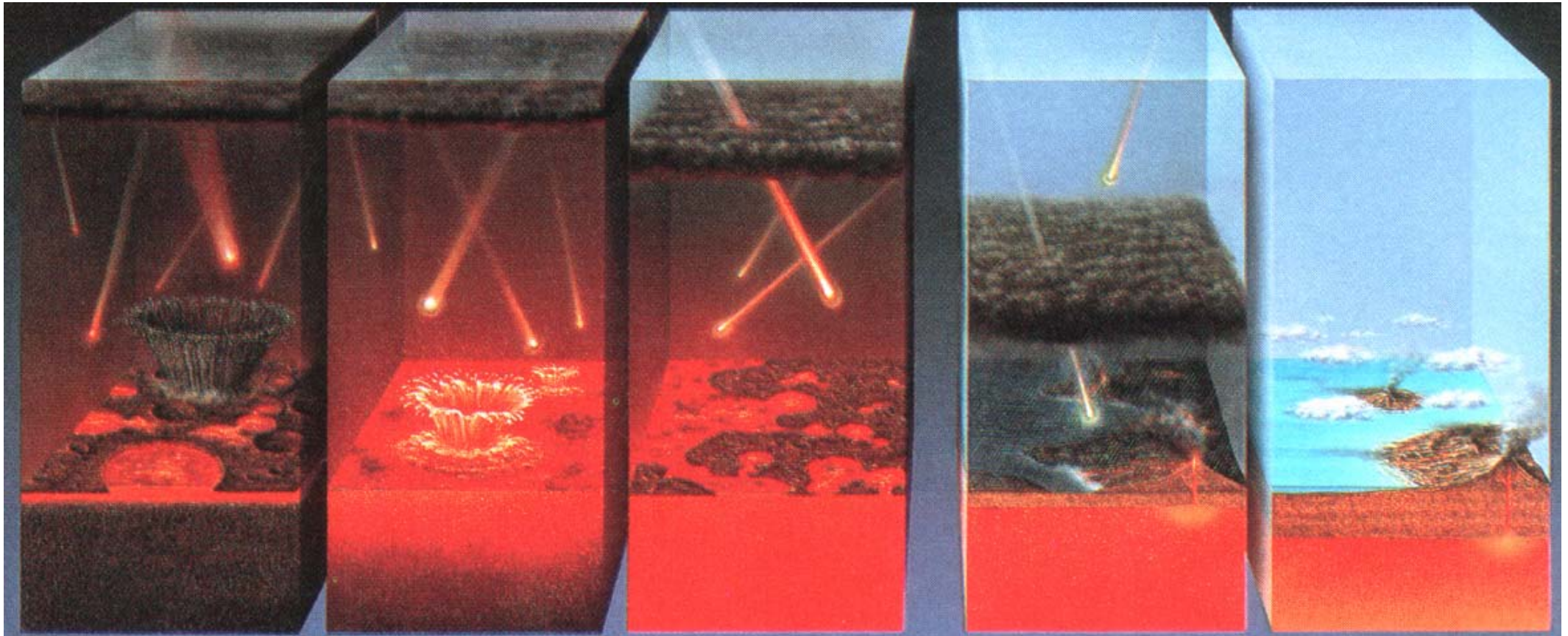
The core of the Earth is hot melted heavy metals

Meteorites
bombardment

Earth melted
Heavy cloud
accumulated

First rain

Sky cleared

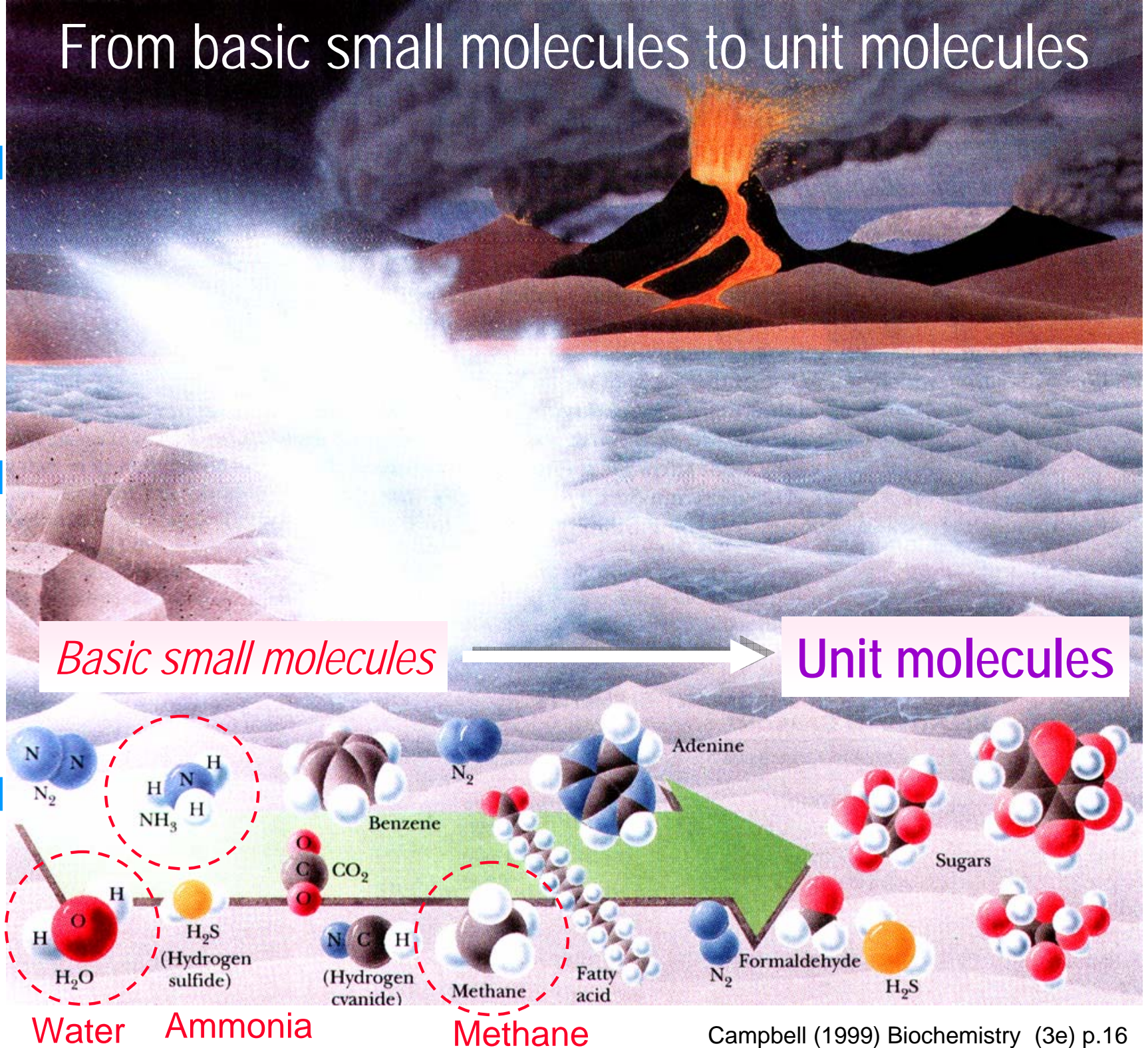
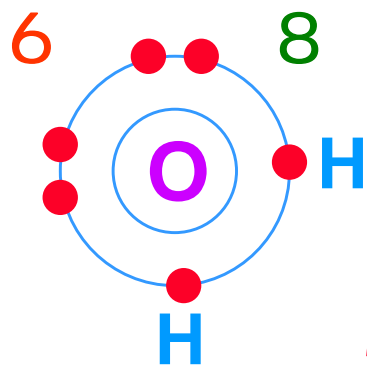
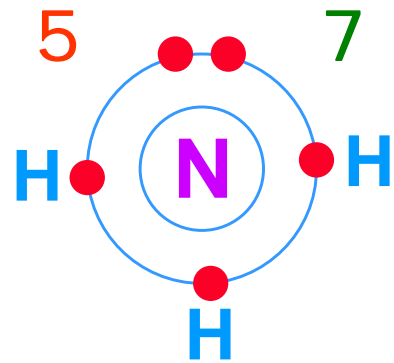
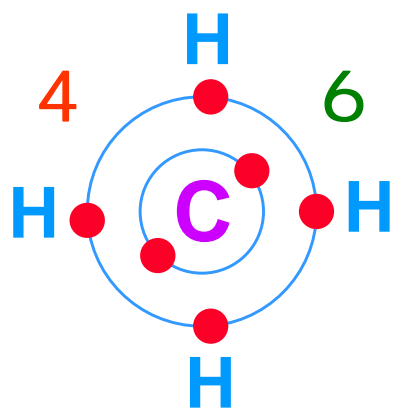


4.6 billion yr ago

3.8 billion yr ago

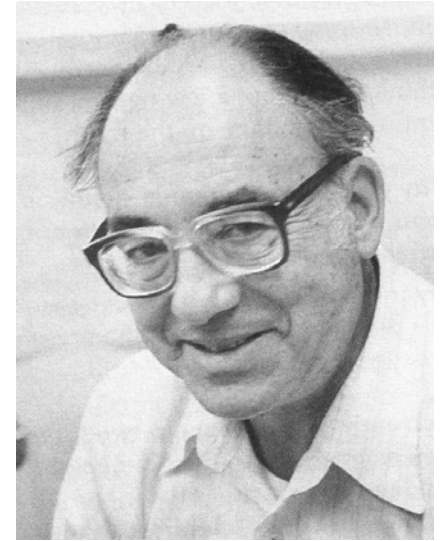
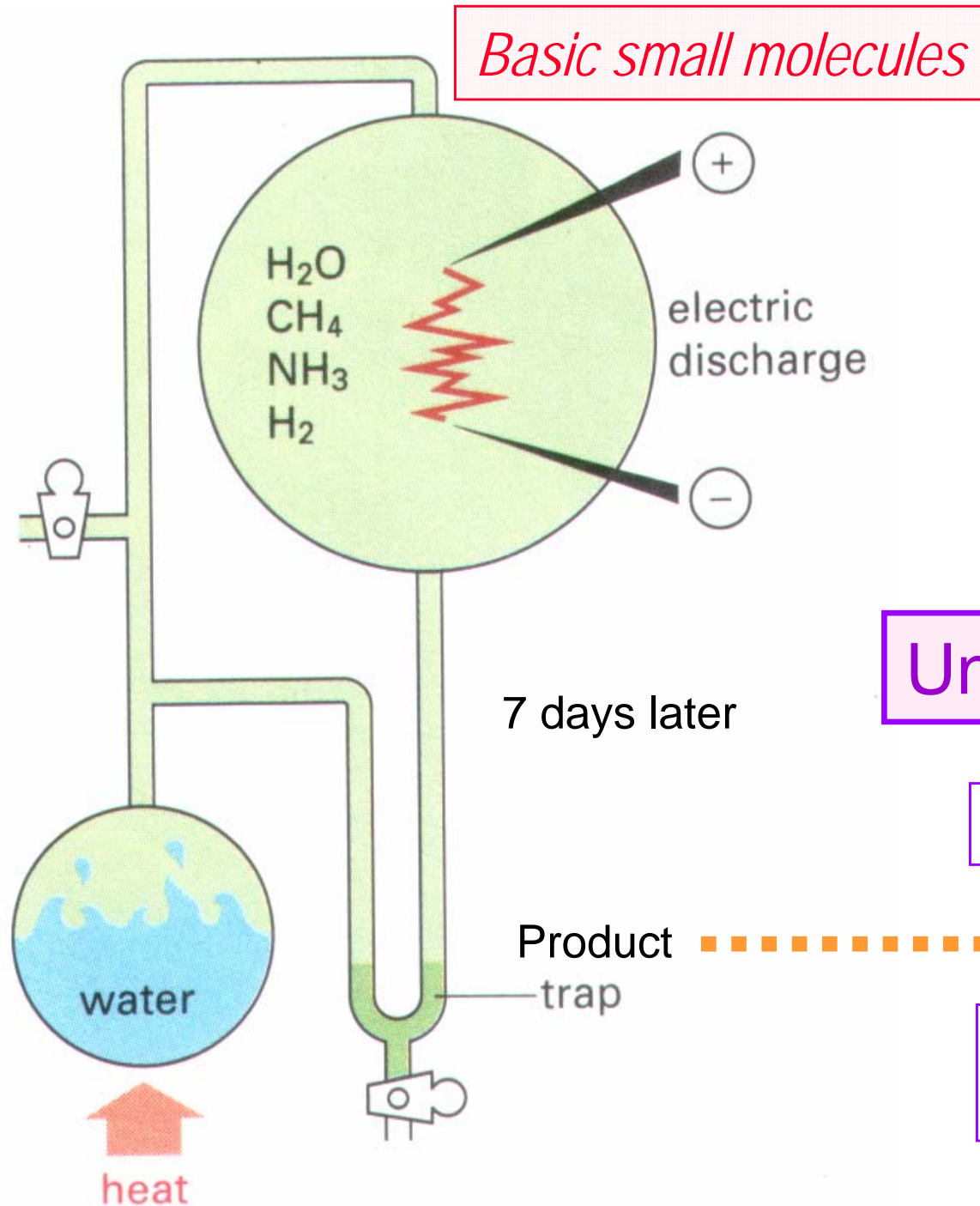
Water on the Earth was brought by meteorites from outer space

From basic small molecules to unit molecules



Unit molecules can be produced in test tube

Alberts et al (1994) Molecular Biology of the Cell (3e) p.4

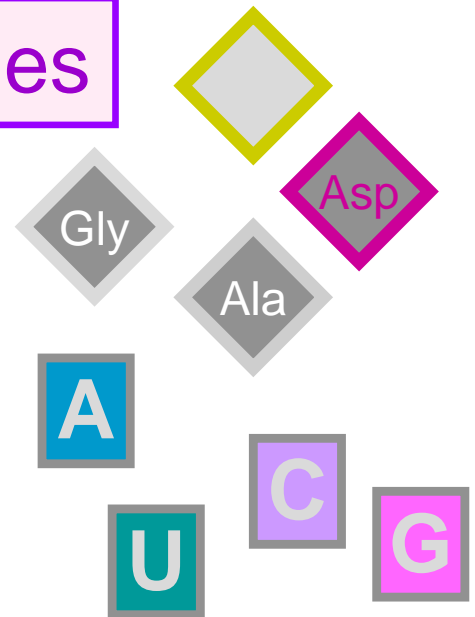


Stanley Miller

Unit molecules

Amino acids

Nucleic acid bases

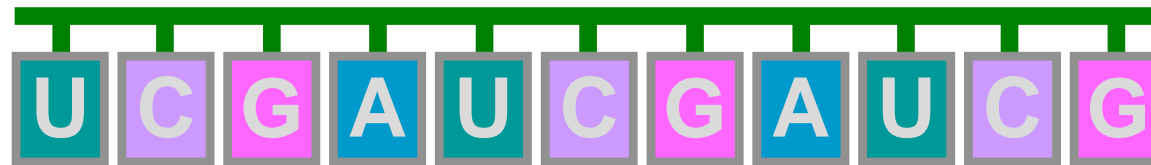


Replication mechanism of nucleic acid

A U C G

Ligation

dehydration

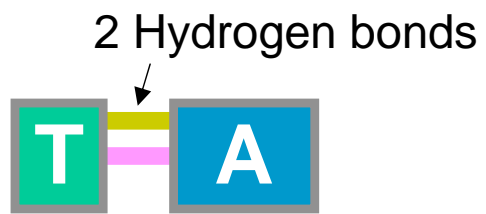


Trick

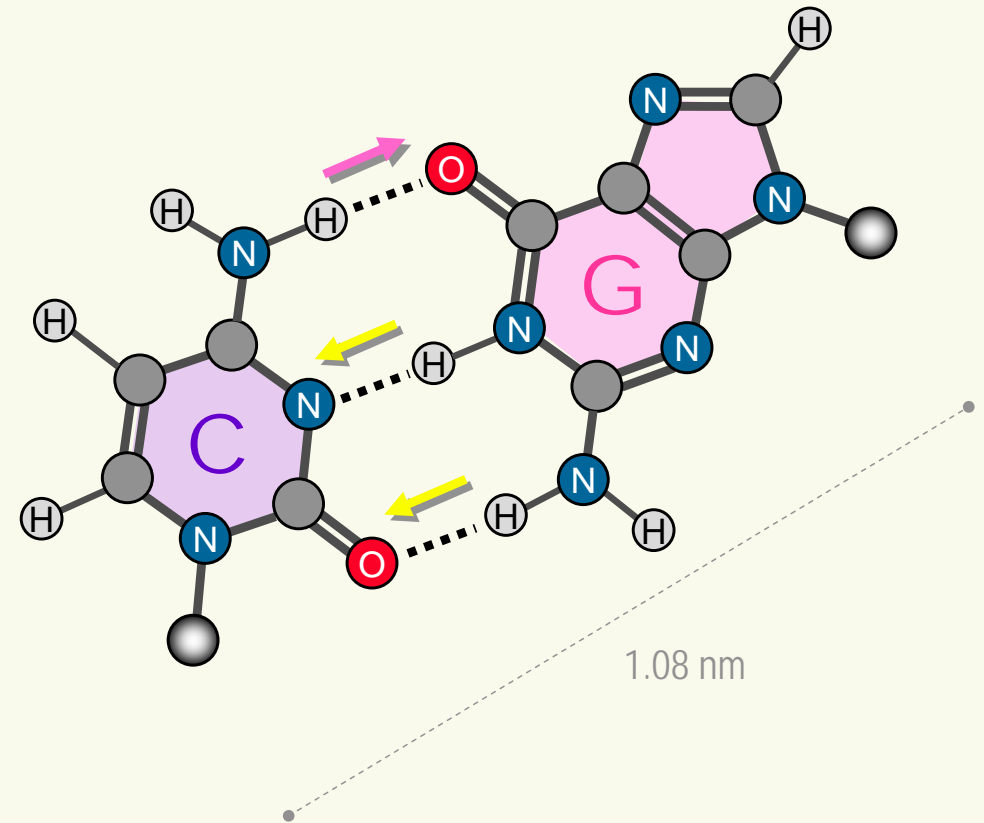
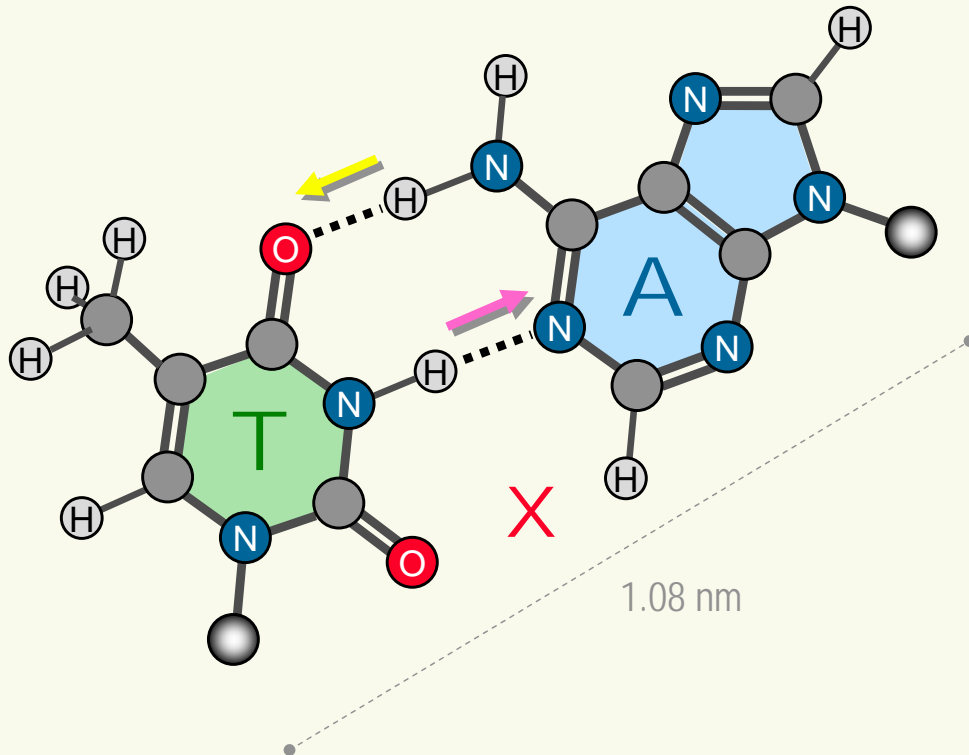
1

How to make copies from single molecule?

Trick
2



Pairing
DNA



RNA



Make template from the original molecule

Trick

1



Original

2



Pairing

U C G A U C G A U C G

Original

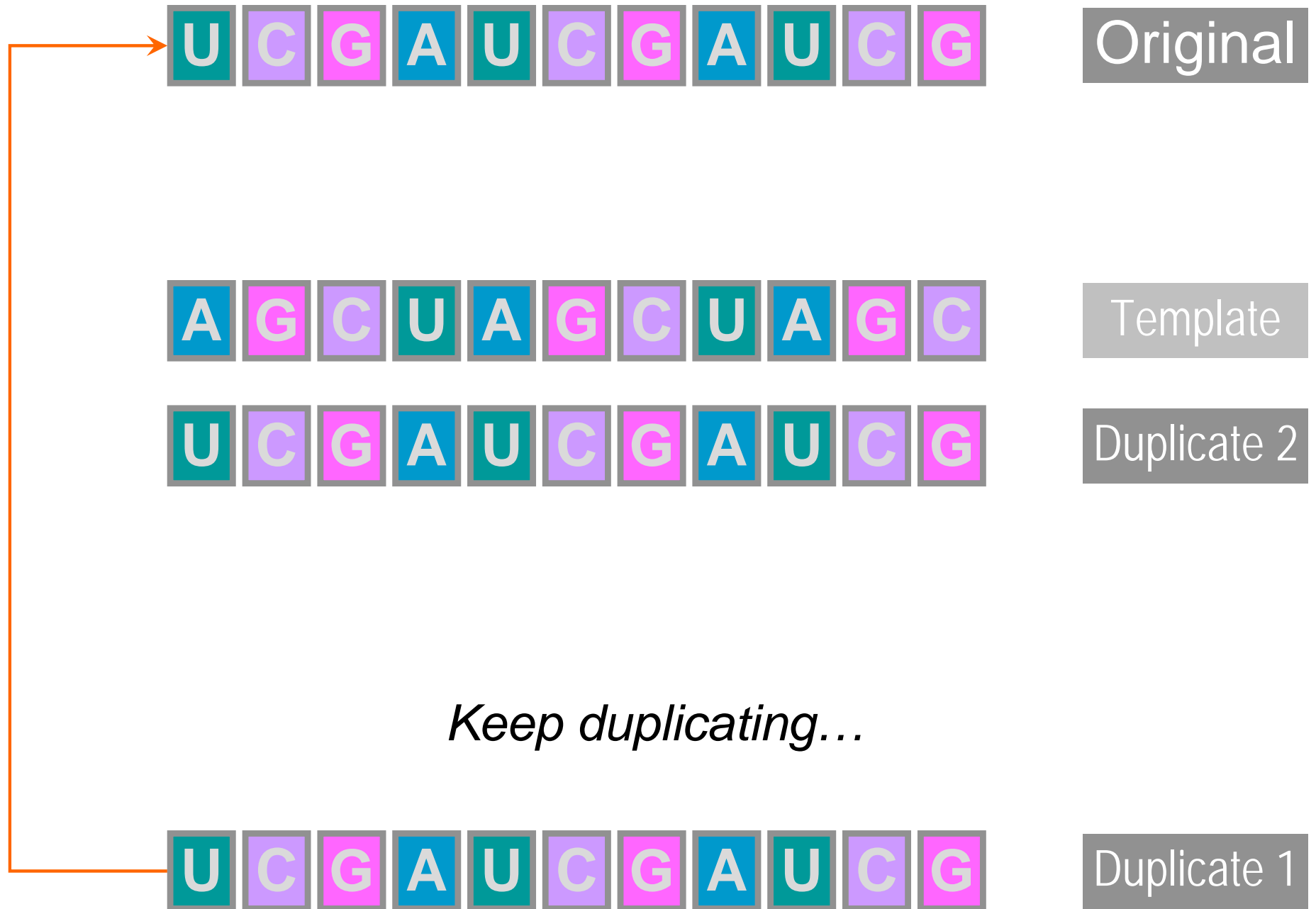
A G C U A G C U A G C

Template

U C G A U C G A U C G

Duplicate 1

Now make more copies from the template



U C G A U C G A U C G

Original

A G C U A G C U A G C

Template

U C G A U C G A U C G

Duplicate 3

U C G A U C G A U C G

Duplicate 2

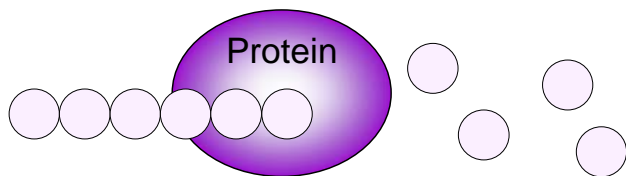
U C G A U C G A U C G

Duplicate 1

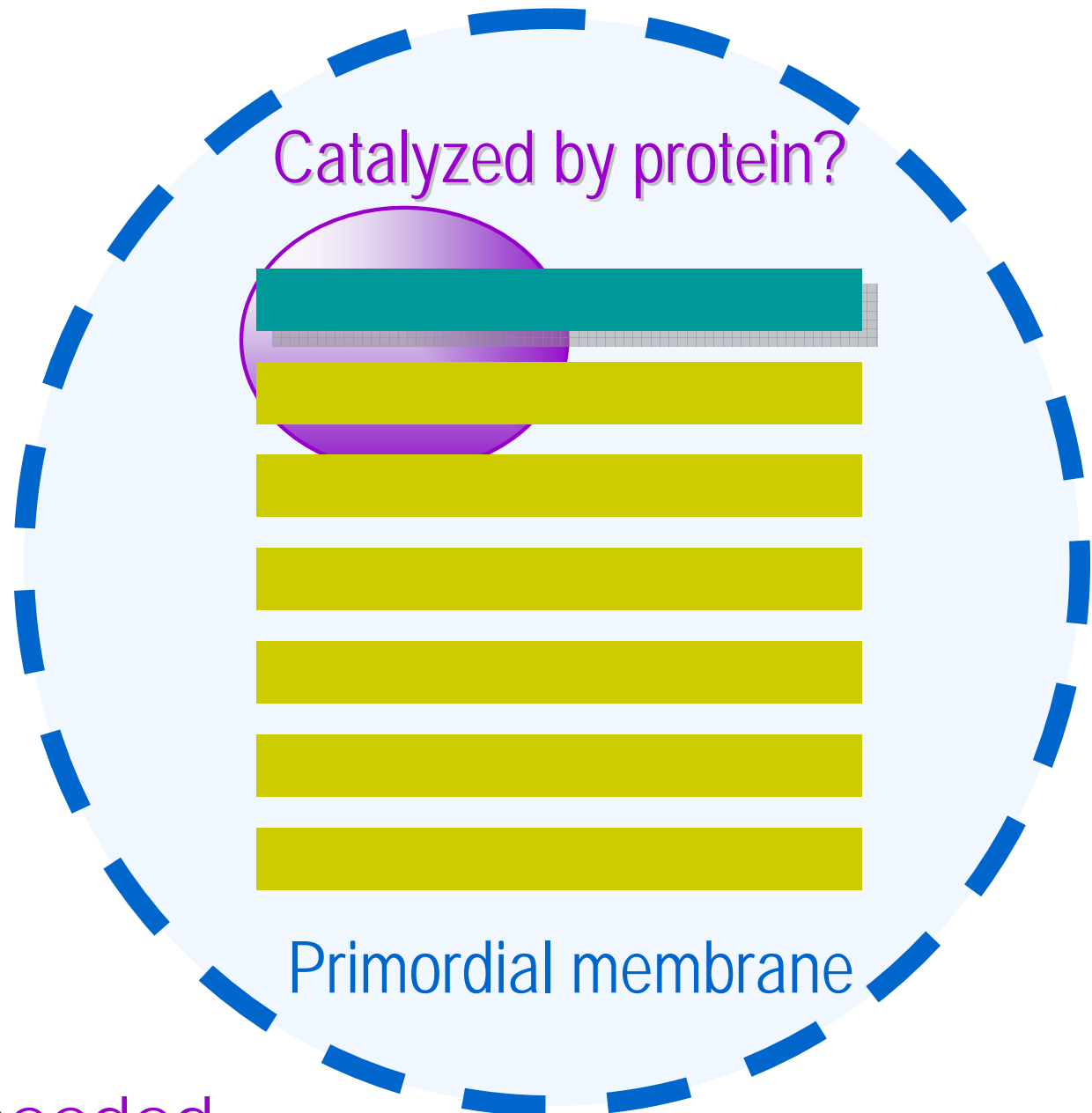
Catalytic proteins and membrane boundary



When the resource was limiting, the duplication was getting difficult



New strategy was needed...

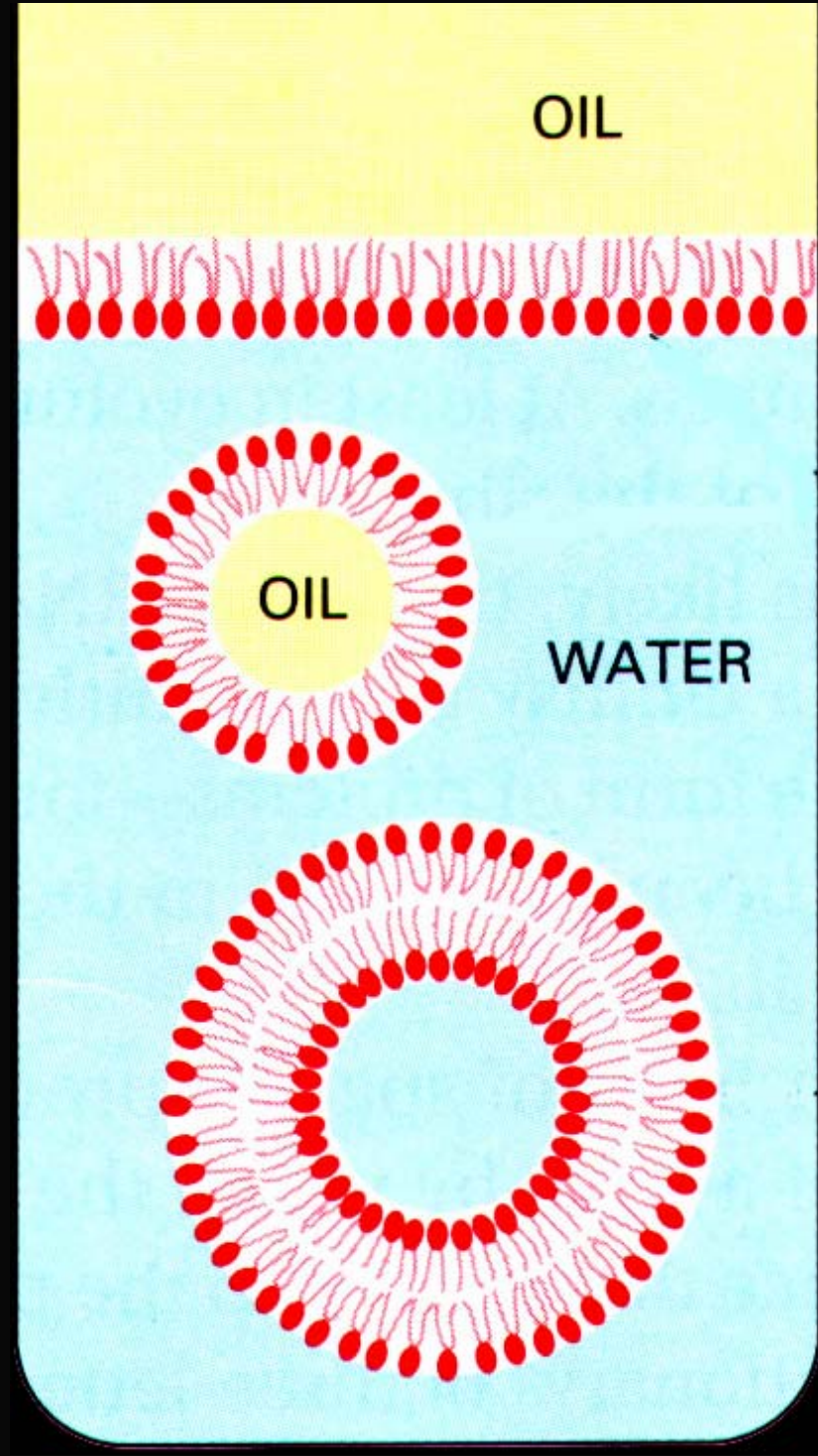


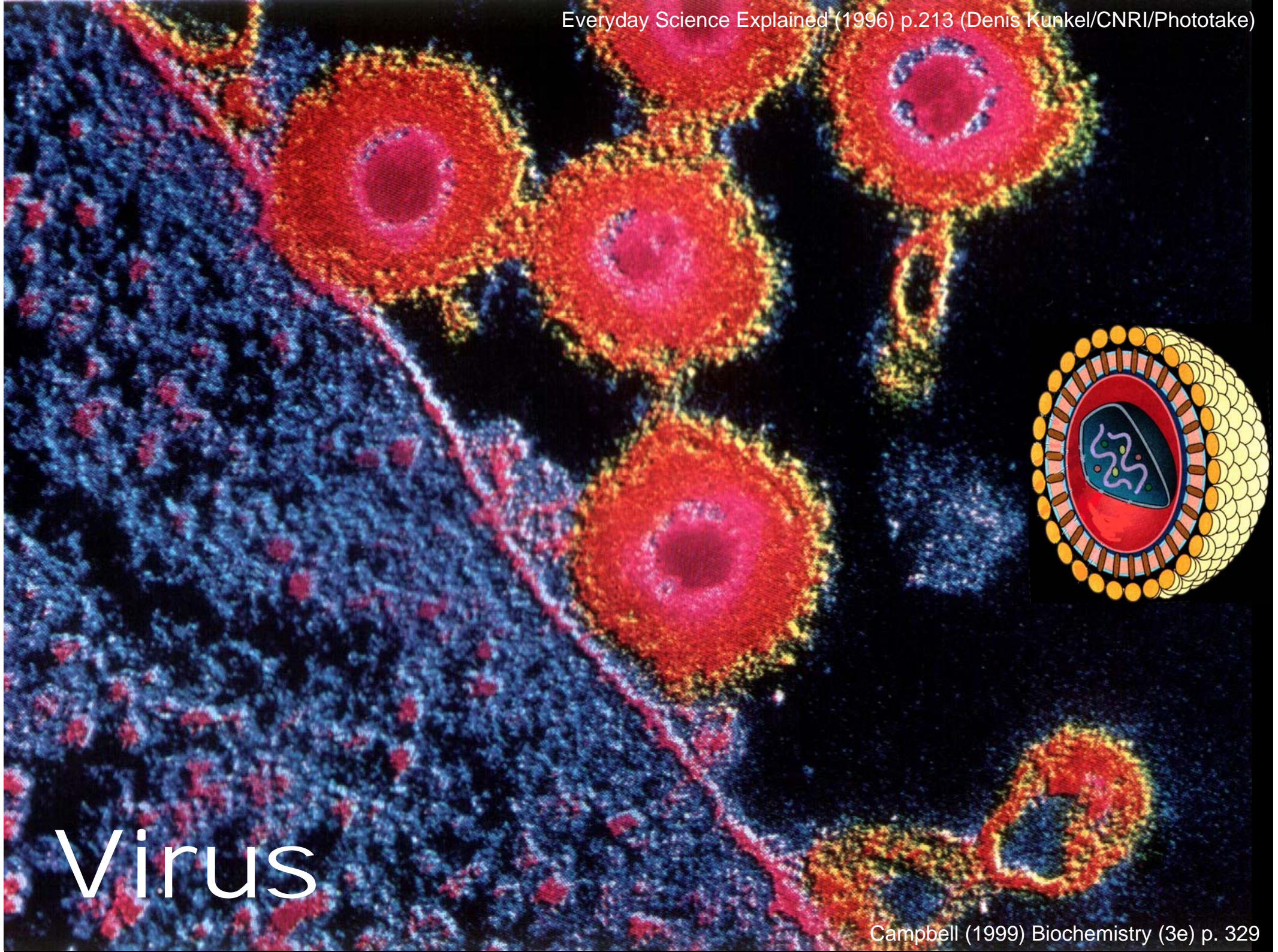
It was easy to make a membrane

Single layer membrane

Oil drop

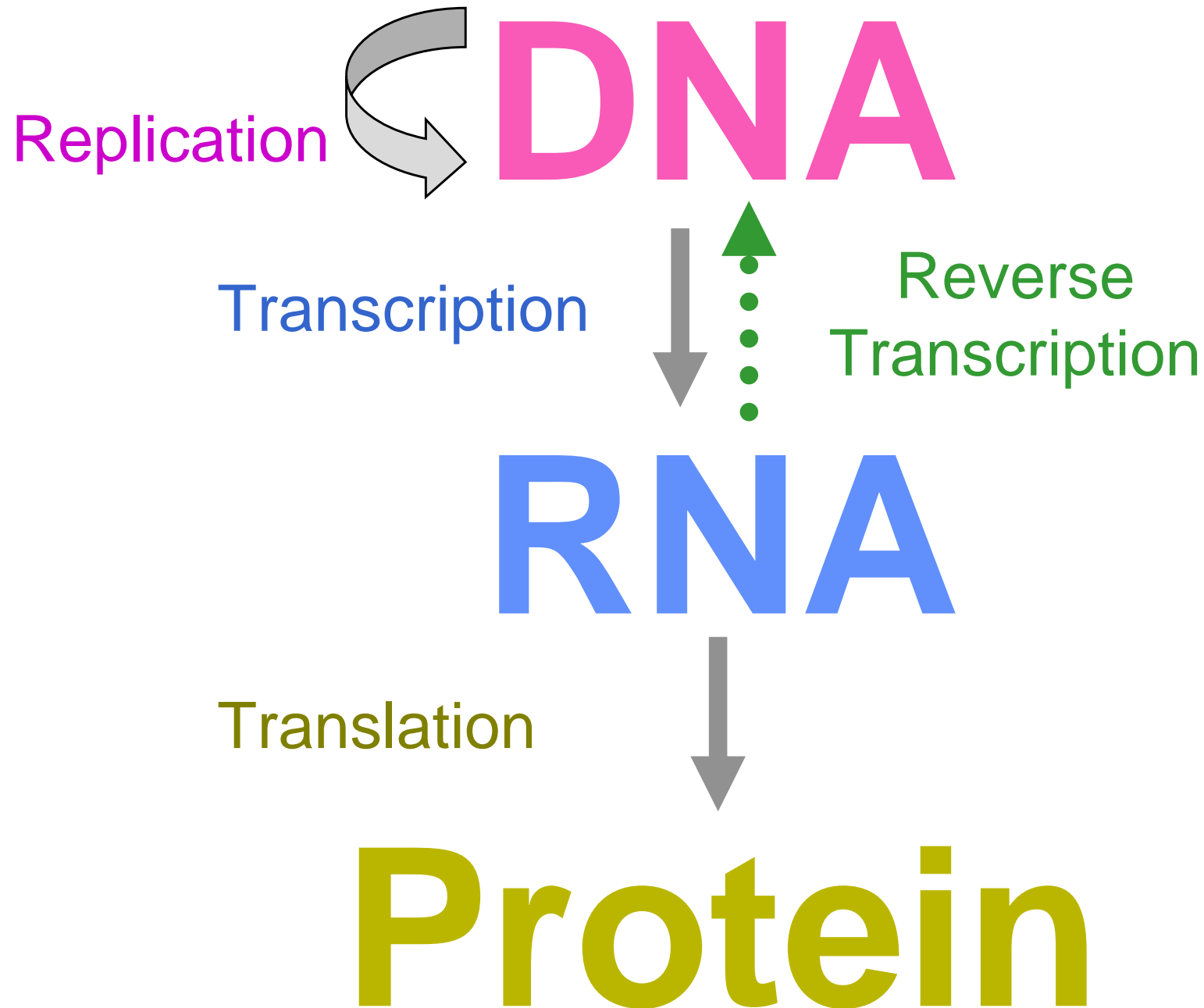
Bilayer liposome





Virus

Central Dogma



T A C A T C G A T C G

DNA

A U G U A G C U A G C

RNA

Transcription

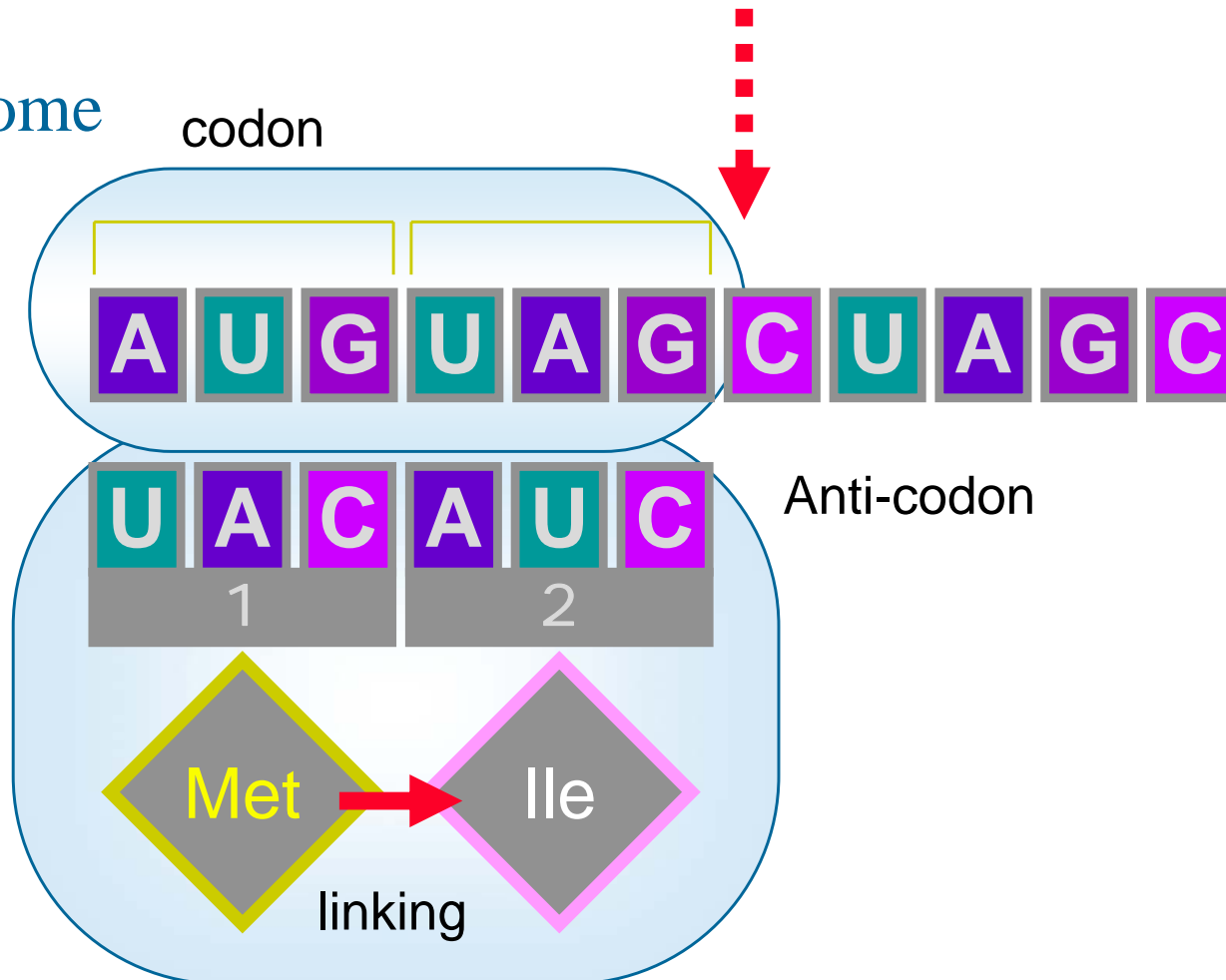
Amplification of DNA message

T A C A T C G A T C G

DNA

Ribosome

codon



messenger

mRNA

tRNA

transfer

Translation

T A C A T C G A T C G

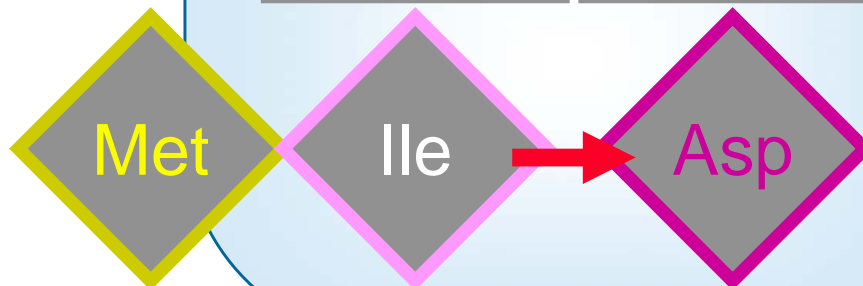
DNA

A U G U A G C U A G C

mRNA

A U C G A U
2 3

tRNA



Stop codons: UGA, UAG, UAA

T A C A T C G A T C G

DNA

A U G U A G C U A G C

mRNA

Met Ile Asp

Protein



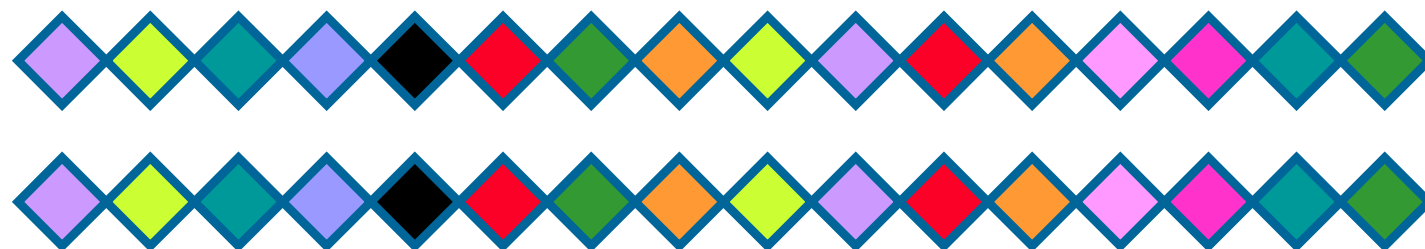
T A C A T C G A T C G

DNA

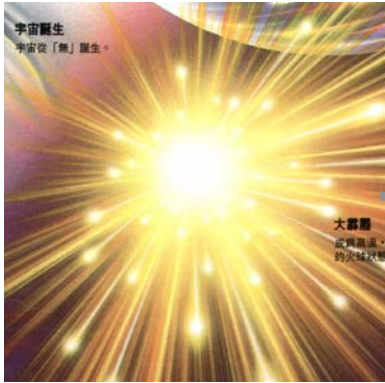
A U G C A C
U G A U G

mRNA

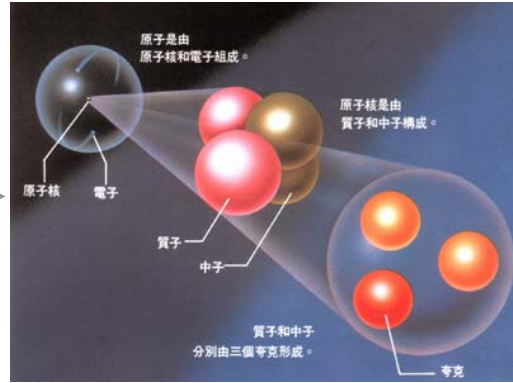
Destroyed



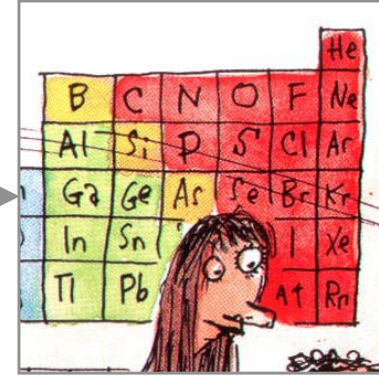
Big bang



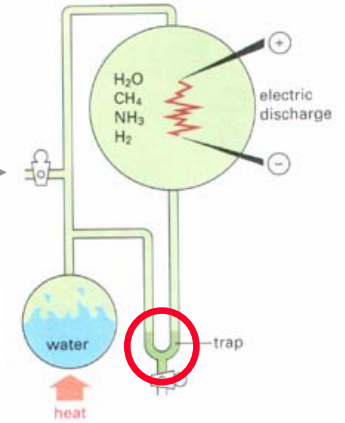
Elementary elements



Atom

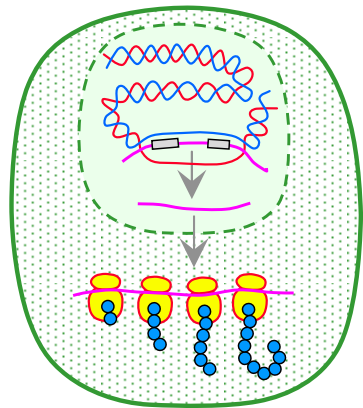


Basic molecules



COMBINATION

Nucleic acid Replication & Message

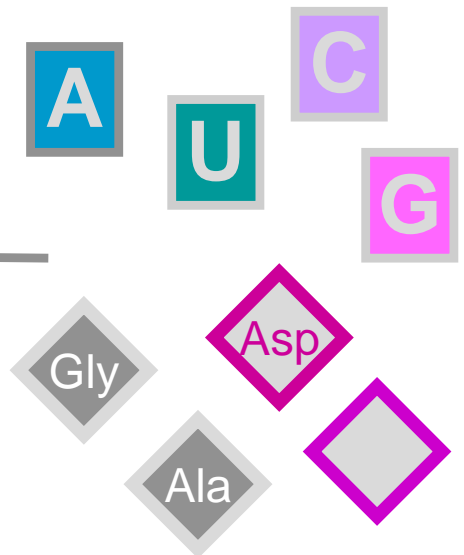


Central Dogma

Protein Catalysis & Function



Macromolecules



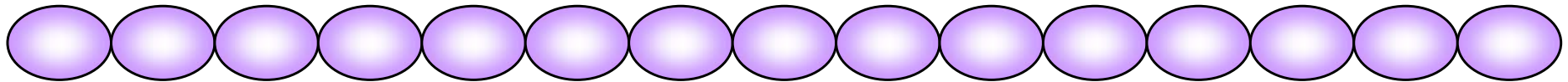
Unit molecules

Three major macromolecules in the cell

Nucleic
acid

Genetic message
Protein synthesis

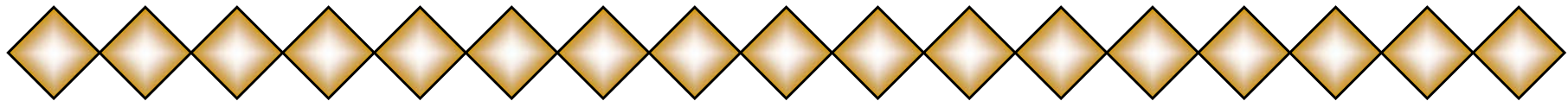
DNA
RNA



Protein

Cell structure
Cell functions

Muscle
Enzyme



Carbohydrate

Cell structure
Energy

Cell wall
Starch



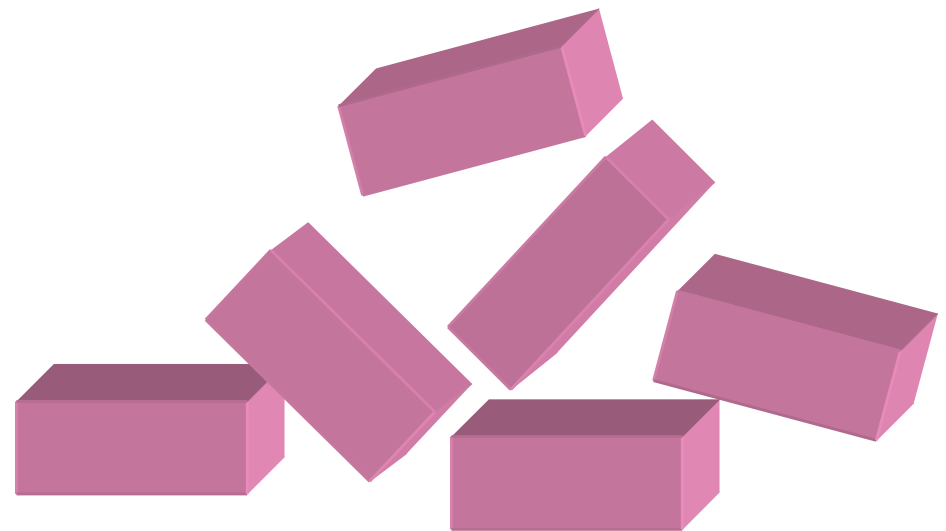
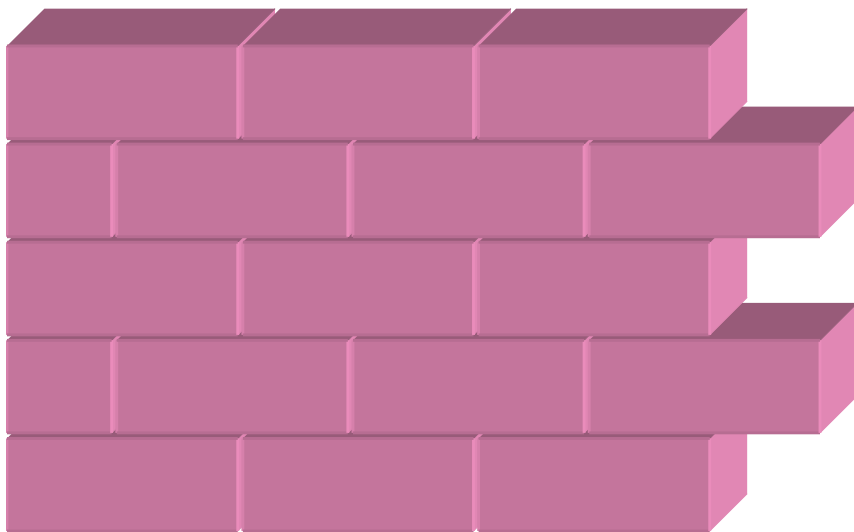
The sequence is critical important

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

J H T R
Z Y N D
B F I Q V
U A S
P E M O
W G L X C
K

M M P
E A A
S S S
S S S
A A A
G G G
E E E
S S S

English words

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

Deoxyribonucleic acid (DNA)

Phe Tyr Thr
Gly Asn Gln
Lys Asp Met
Val Ala Ser
Ile Leu His
Pro Trp Cys
Gly Arg Asp
Val Gly Gly
Asp Pro Pro
Ser Leu Leu
Phe Lys Gly
Arg Asn Lys
Glu Phe Trp
Ala Glu Cys

Protein

—A—C—T—C—G—A—C—G—A—
(DNA)



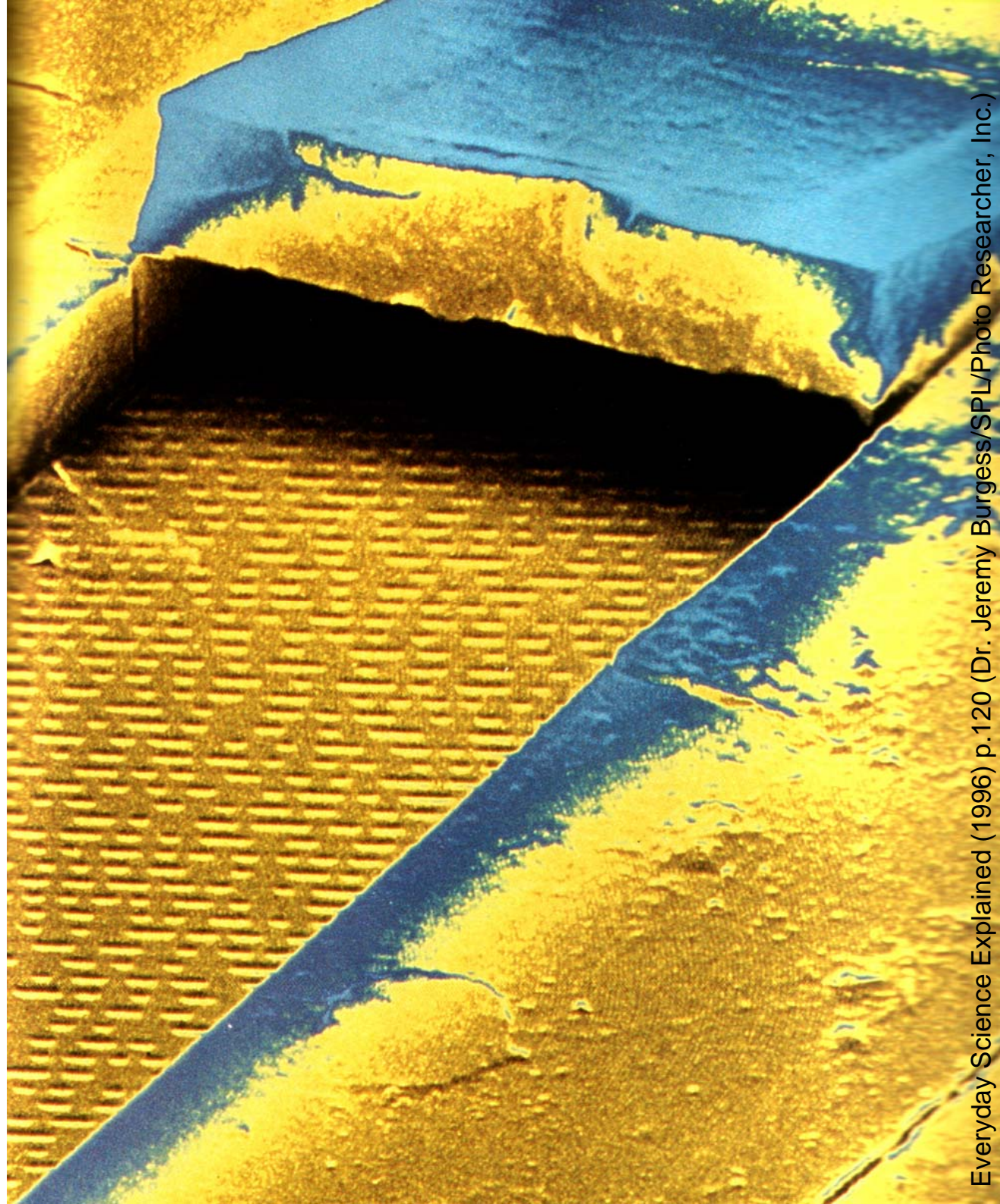
Glc — Glc — Glc — Glc — Glc —
(cellulose)

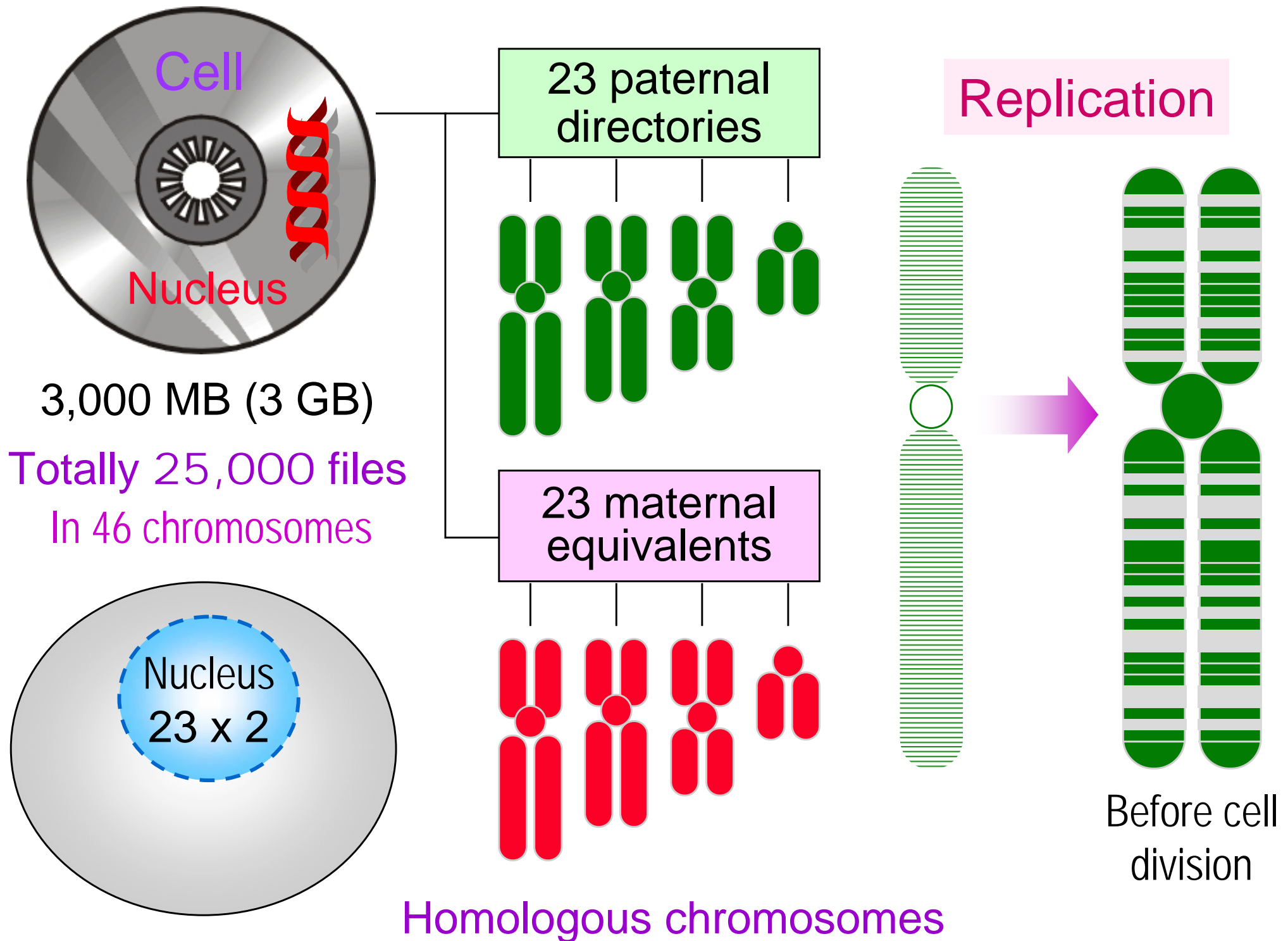


Significant message shows complex patterns



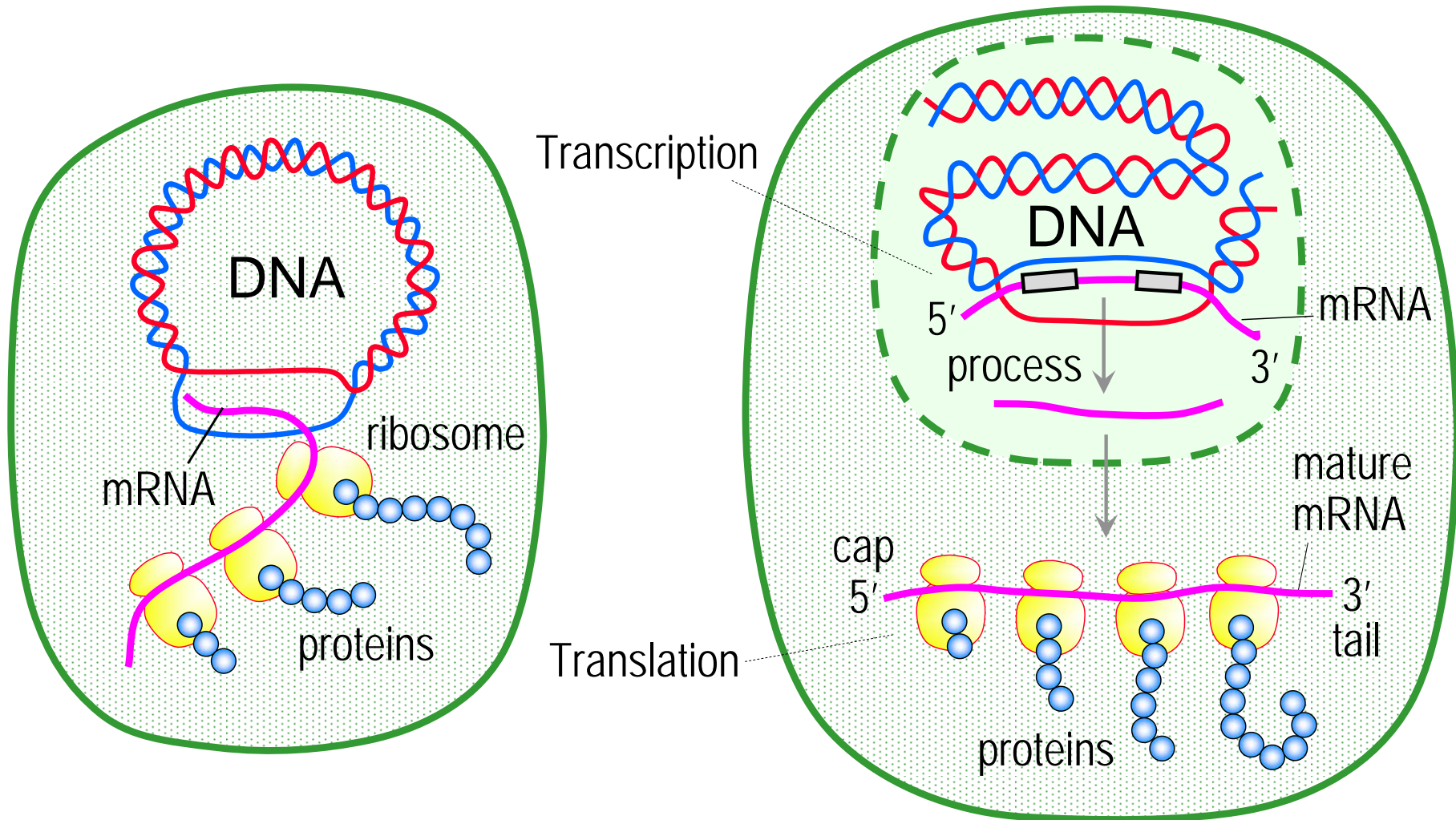
Arabidopsis genome decoded





Final version of cellular genetic mechanism

DNA replaced RNA and became the major genetic material
RNA shifted its role to protein biosynthesis



Prokaryote

Student dormitory

Eukaryote

Furnished apartment or house

Question

(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?

Juang Web

2006/07/31 minor revision



Search "JuangWeb"

[NTU Google search](#)

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

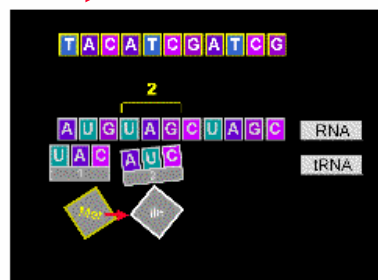
[Chinese Home](#)

Personal	Teaching	Research	Biochem Group	Linkings
Non-Official Records	Biochemistry Basics	Starch Phosphorylase	Introduction	National Taiwan University
I Think, I Write	Purification & Analysis	Heavy Metal Stress	Public Facilities	College of Life Science
Cartoons	Biotech Core Tech (BCT)	Lab 520 Alumni	Protein Sequencing	Dept Biochem Sci Tech (BST)
Art of Scientific Investigation	PROTEIN (short course)	Monoclonal Ab	Lab O-2D/3B	Inst Microbiol Biochem (mbc)
JYC's Oil Painting	Monoclonal Antibody Lab	Biotechnology	Lab for Ab Tools	Center for Biotechnology

- 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.

→ **Life Story**



From DNA to protein

- About Taiwan -

[Taiwan Profile](#) (BBC)

[Taiwan Festivals](#) (GIO)

[National Palace Museum](#)

[Taipei \(weather\)](#) | [Taiwan \(Wikipedia\)](#)

[JYC's Oil Painting Exhibition On-line](#)

→ [More animations in PowerPoint format](#)

If you have any question, please [e-mail to Juang](#)

How to teach your PC reading Chinese characters: