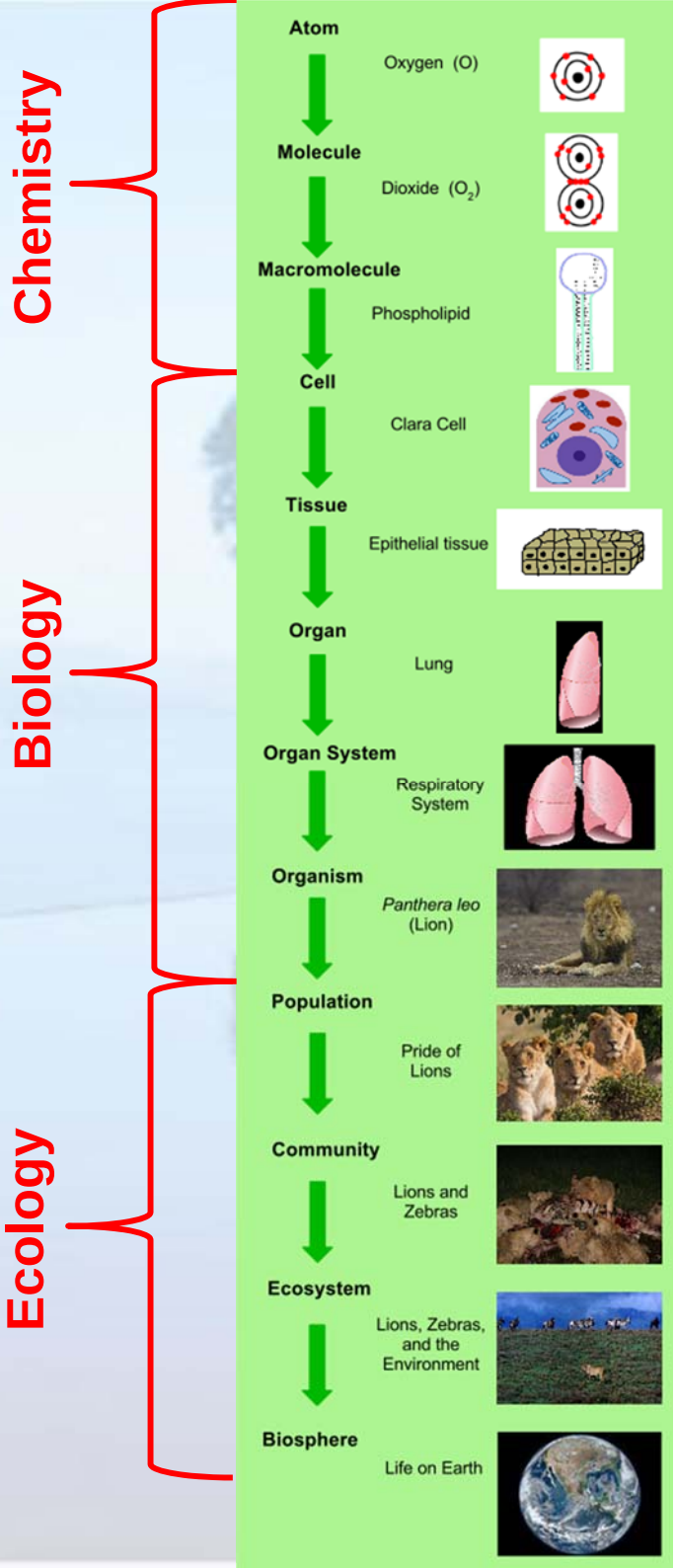
UGFN1000
In Dialogue with Nature
與自然對話

Supplementary lecture on Biology

Ecology, Biology and Chemistry

- Our world can be viewed as having a **hierarchy of complex structures**. This is especially true for life forms.

- Viewing our world at different scale becomes different field in science – e.g. **Chemistry**, **Biology** and **Ecology**.



http://en.wikipedia.org/wiki/Biological_organisation

Ecosystem (生態系統) and Biosphere (生物圈)

- **Ecosystems** are communities of organisms that interact with one another and with their physical environment, including sunlight, rainfall, and soil nutrients.

- Organisms within an ecosystem tend to **interact with one another** to a greater extent than do the organisms between ecosystems.

- Ecosystems can vary greatly in size. For example, a tidal pool of only about 2m in diameter could be considered an ecosystem. On the largest scale, our global **biosphere**, could be considered the "ultimate" Earthbound ecosystem.

- [Davis and Masten, Principles of Environmental Engineering and Science, Ch5]

Habitat (棲息地)

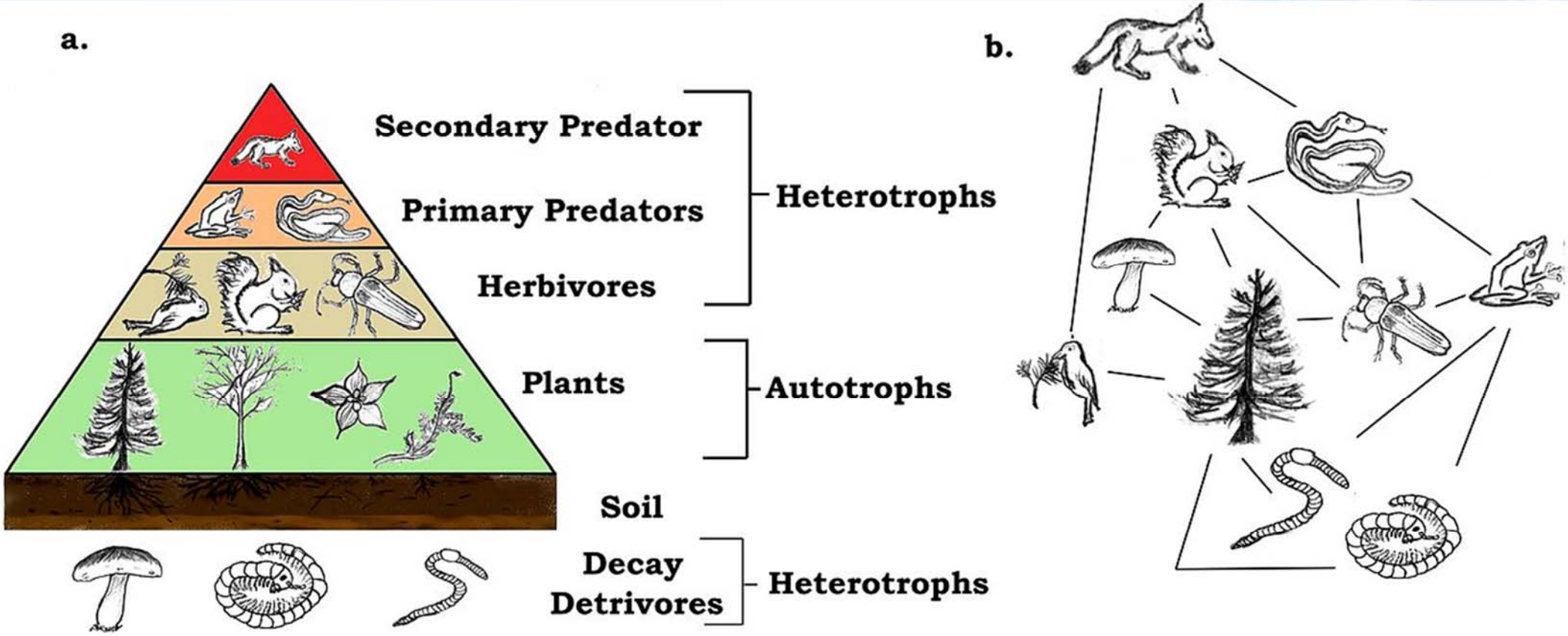
- A **habitat** is an environment inhabited by a **population** of organisms, and is made up of physical factors (e.g. soil, water, temperature, light) and biotic factors (e.g. food, predator).

Question

- Is a human body an habitat?
  - Yes
  - No

Food Web

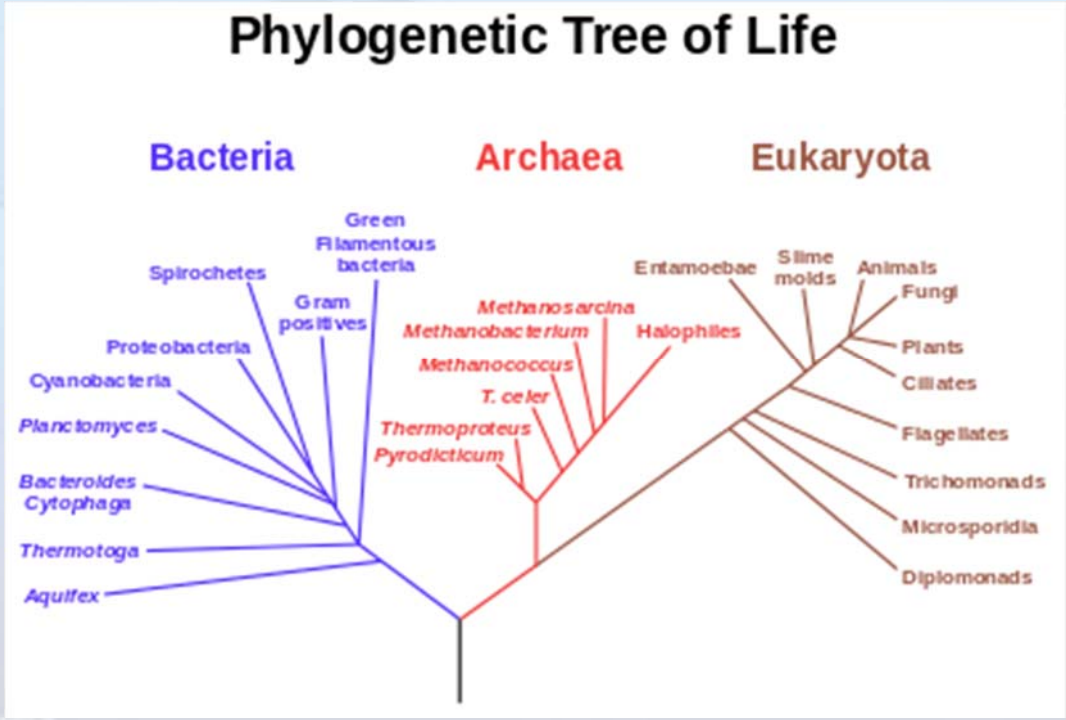
Food web is a description of the complex relationship between organisms in an ecosystem.



The three domains

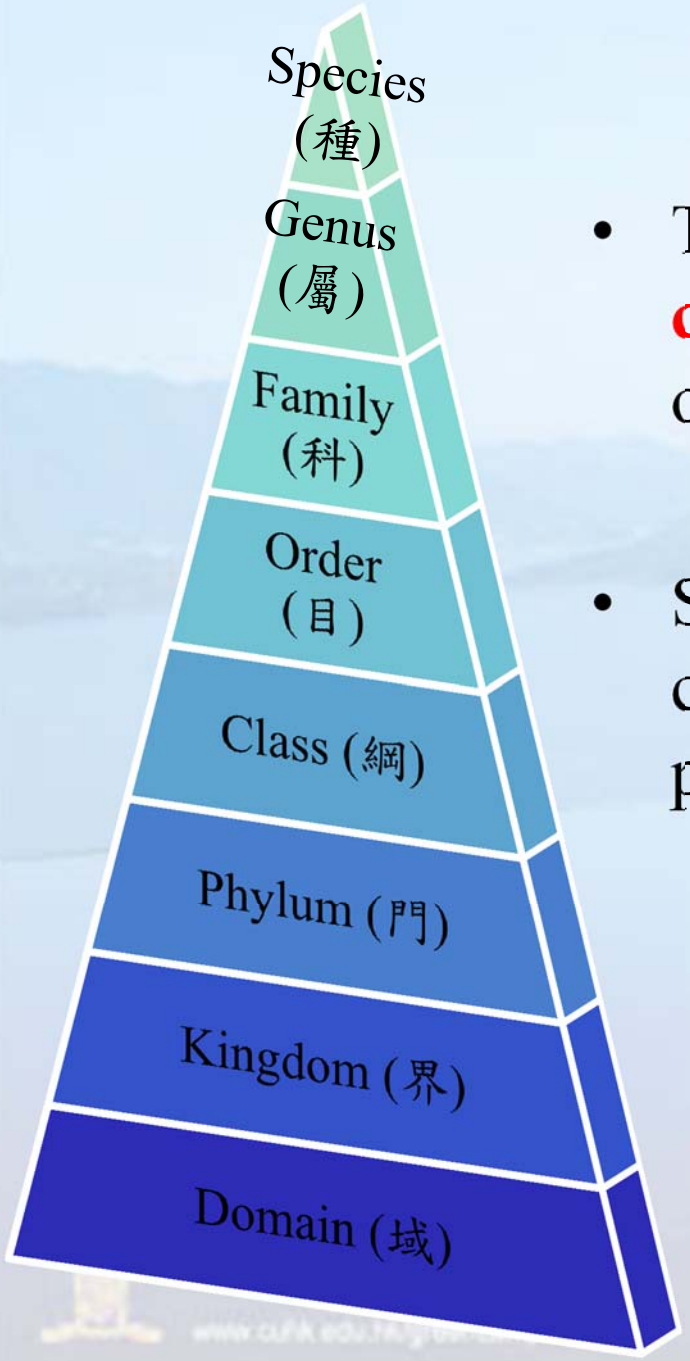
- The **three-domain system** is a biological classification that divides cellular life forms into three domains:
  - **Bacteria (細菌), Archaea (古菌), and Eukaryote (真核生物)**

- Both Bacteria and Archaea are **Prokaryotes (原核生物)** and are mostly single-celled organisms.

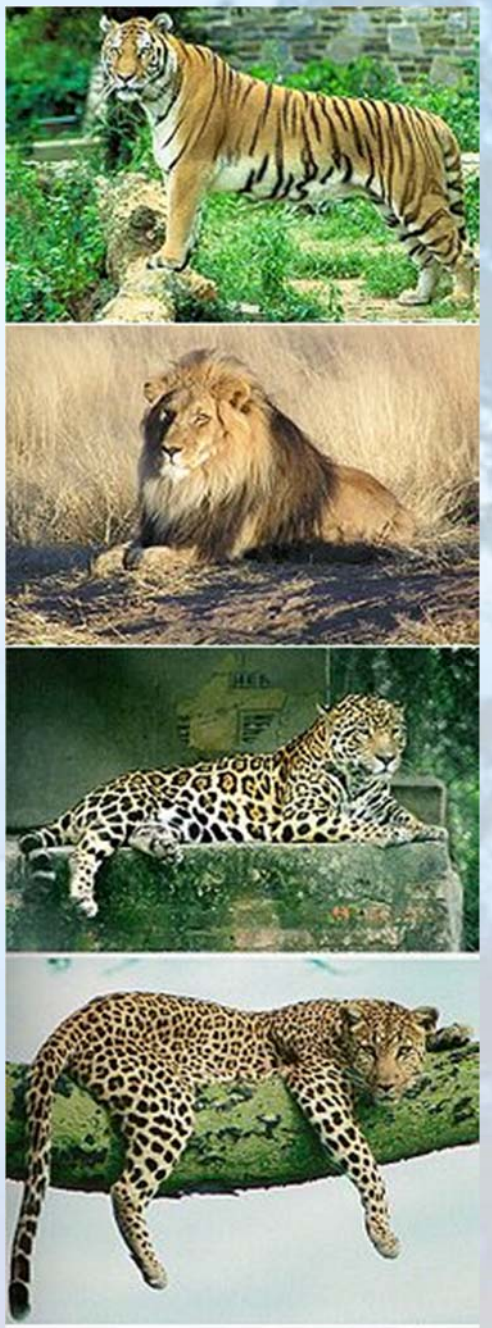


http://en.wikipedia.org/wiki/Three-domain_system

Species (物種)



- There is a **hierarchy of classification** of all living organisms on Earth.
- Species: a group of organisms capable of **interbreeding** and producing **fertile offspring.**



Panthera 豹屬

http://sco.wikipedia.org/wiki/File:4panthera2.0.png

Example: Human is…

Domain Eukarya	真核域
Kingdom Animal	動物界
Phylum Chordata	脊索動物門
Class Mammalia	哺乳動物綱
Order Primates	靈長目
Family Homindae	人科
Genus *Homo*	人屬
Species *Sapiens*	智人種

Question

- Are white people and black people two separate species?
  - Yes
  - No

Biodiversity (生物多樣性)

- **Biodiversity** is the degree of variation of life.
  - Species biodiversity: number of species in an area
  - Genetic biodiversity: variations in genes in a single species (e.g. Chinese vs. British)
  - Ecological biodiversity: varieties of ways that species interact with each other and the environment (e.g. A panda at Ocean Park vs. A panda in the wild)

Reference: http://www.nwf.org/Wildlife/Wildlife-Conservation/Biodiversity.aspx

Organism (生物)

- An **Organism** is any contiguous living system, such as an insect, animal, plant or bacterium.

- There is no unequivocal definition of life, but usually is considered to have most of the following traits:
  - Homeostasis（體內平衡）
  - Organization（組織性）
  - Metabolism（新陳代謝）
  - Growth（生長）
  - Adaptation（適應）
  - Response to stimuli（對刺激作出反應）
  - Reproduction（繁殖）

- But note that there are exceptions. E.g. Mule (騾)

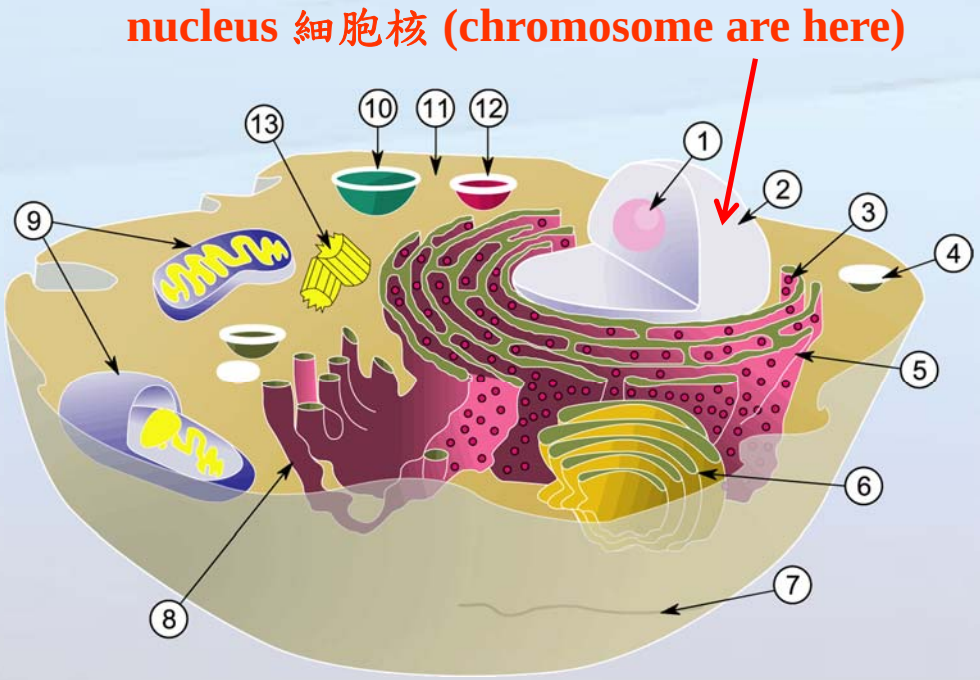
Question

- Are DNA and RNA molecules considered as organisms?
  - Yes
  - No

Cell (細胞)

- An organism consists of one or more cells. Humans are **multicellular organisms** composed of many trillions of cells grouped into specialized tissues and organs.

- A cell is the basic structural, functional and biological unit of all known living organisms.

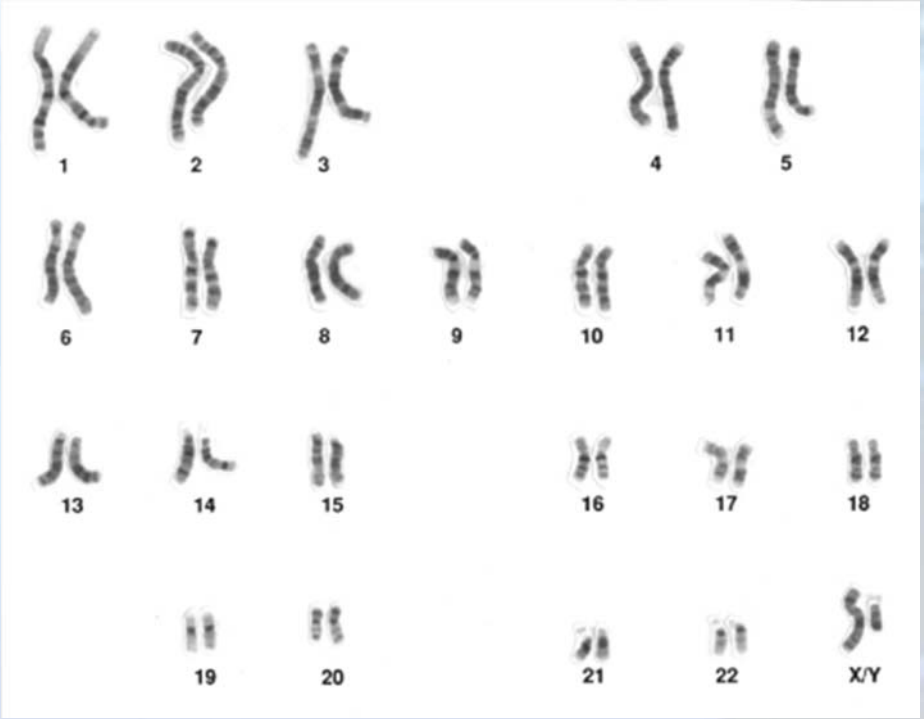


http://commons.wikimedia.org/wiki/File:Biological_cell.svg

Chromosomes (染色體)

- Each human cell contains **23 pairs of chromosomes** (22 pairs of autosomes and one pair of sex chromosomes), giving a total of 46 per cell.

- The **human genome** is the complete set of **genetic information** for humans. This information is encoded as DNA sequences within the 23 chromosome pairs.



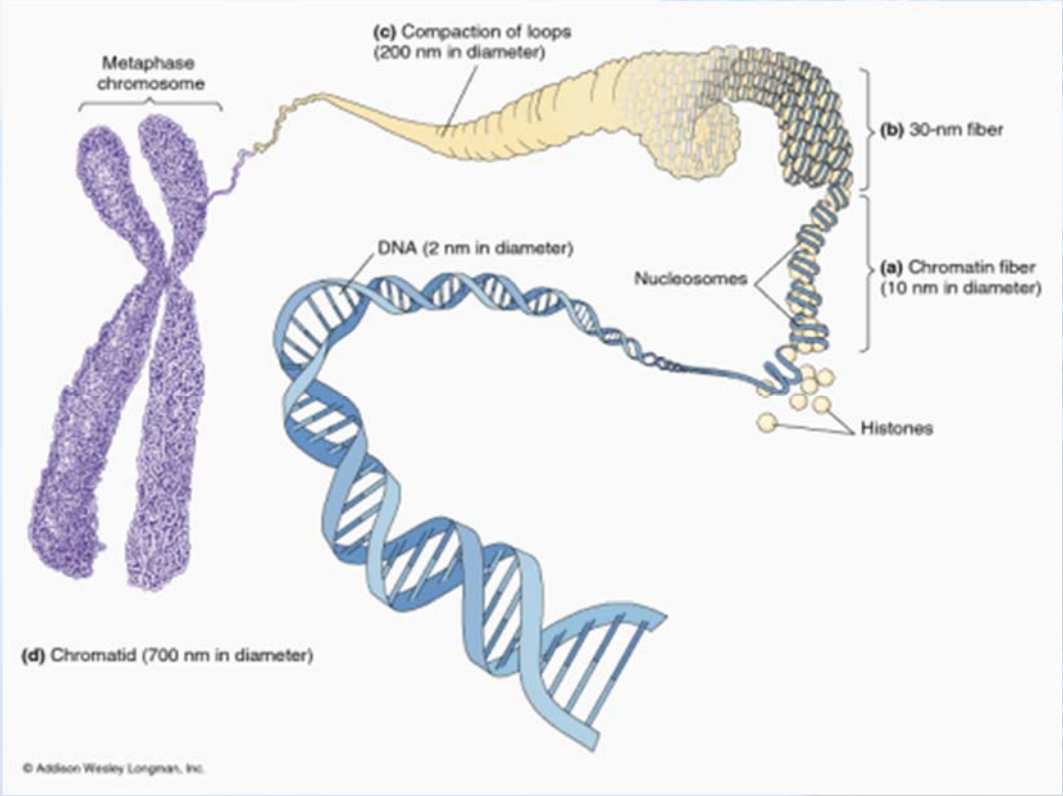
http://en.wikipedia.org/wiki/File:NHGRI_human_male_karyotype.png

DNA

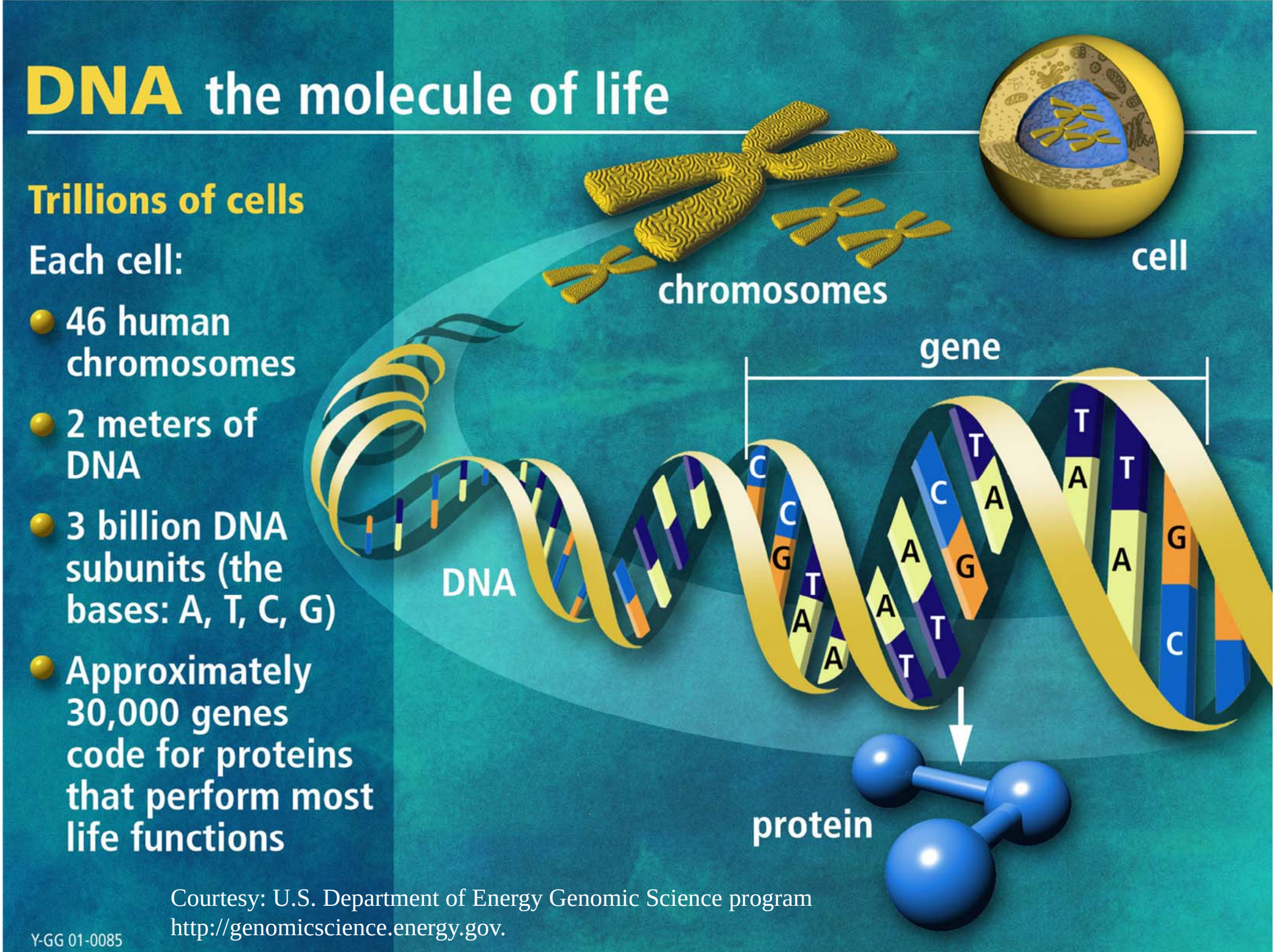
- A chromosome is itself a complex structure consisting of a **single piece of coiled double-stranded DNA**, **Protein** and **RNA**.

- The DNA molecule can be considered as a long chain of **4 kinds of basic units (nucleotides)**, denoted by **A, T, C, G**.

- (we shall talk about this more in the supplementary lecture for Chemistry).



http://rupoyr12biol.wikispaces.com/Unit+4+-+Chapter+9+-+Genes,+Chromosomes+%26+Patterns+of+Inheritance


DNA the molecule of life
Trillions of cells
Each cell:
46 human chromosomes
2 meters of DNA
3 billion DNA subunits (the bases: A, T, C, G)
Approximately 30,000 genes code for proteins that perform most life functions
chromosomes
cell
gene
DNA
protein
Courtesy: U.S. Department of Energy Genomic Science program
http://genomicscience.energy.gov.
Y-GG 01-0085

Question

- Which of the following is biggest in size?
  a) Chromosomes
  b) Gene
  c) Nucleotide

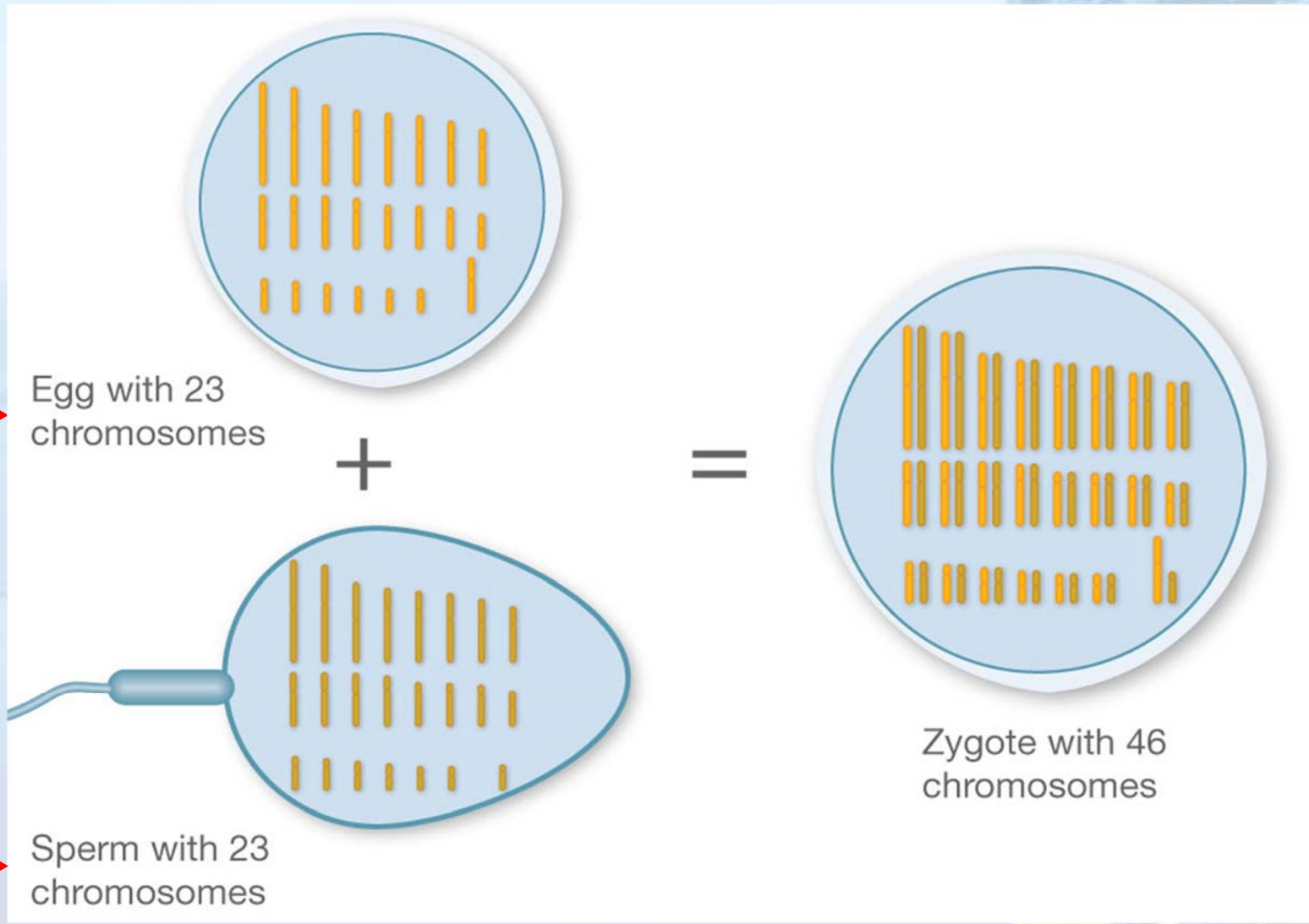
Question

- What is the form that chromosome exist most of the time?
  a) Very messy, without any specific form
  b) As a X shaped form
  c) As a I shaped form

Reproduction of Human

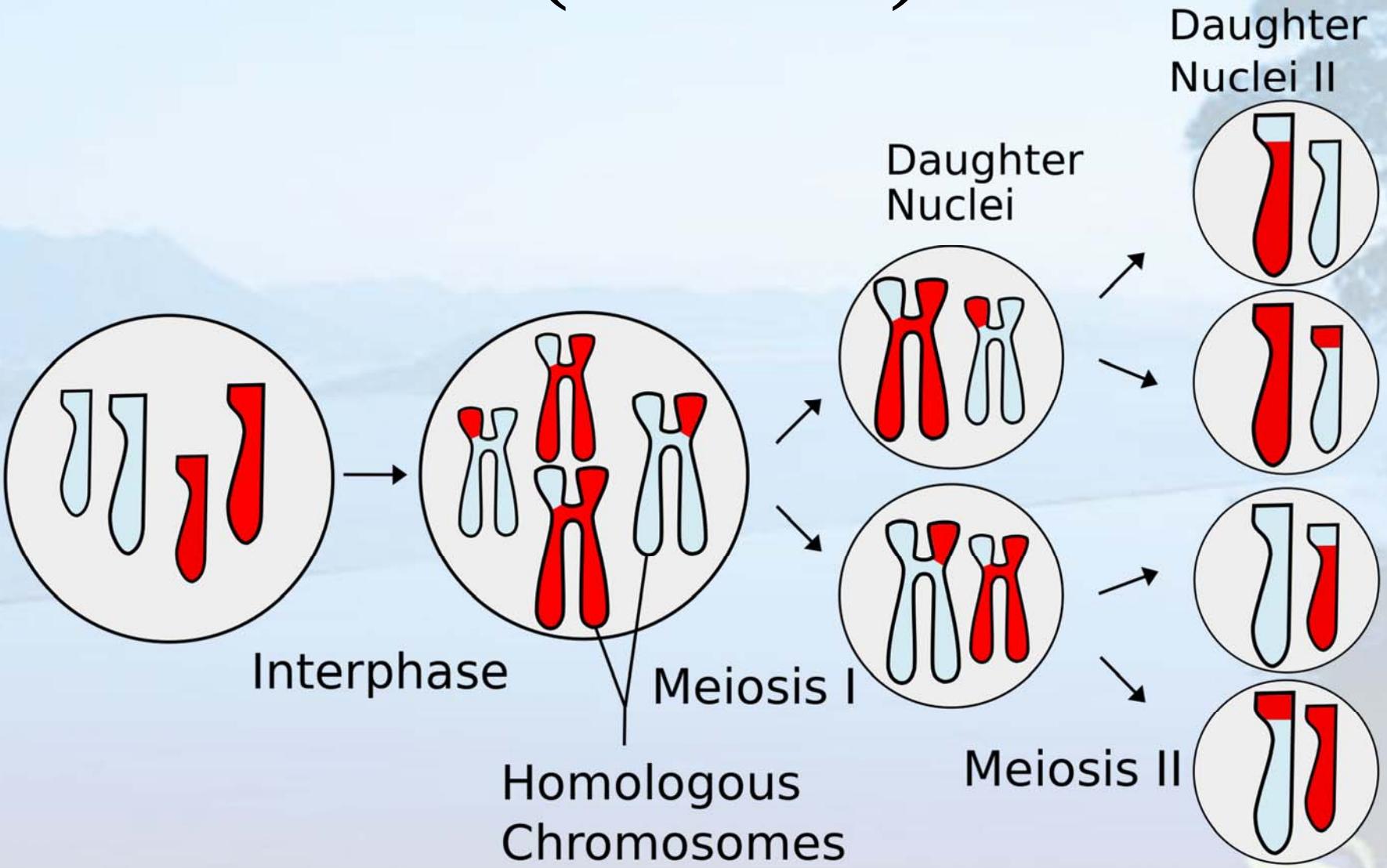
With an X chromosome and 22 autosomes

With either an X or Y chromosome and 22 autosomes



http://learn.genetics.utah.edu/content/chromosomes/diagnose/images/fertilization.jpg

Reproduction - cell division (Meiosis)



http://en.wikipedia.org/wiki/Meiosis

Question

- Each of us has a pair of sex chromosomes, For male, this pair is X and Y. For female, the pair is:
  a) Y and X
  b) X and X
  c) Y and Y

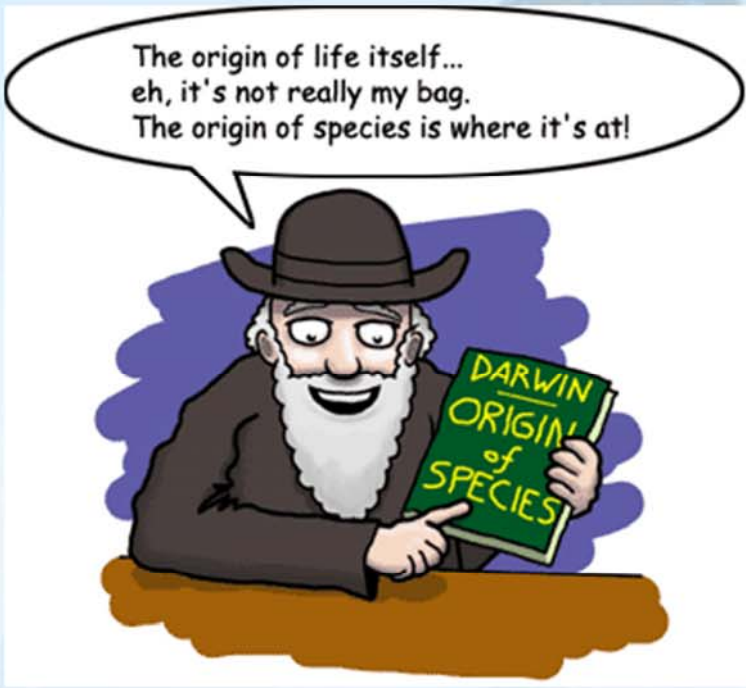
Question

- How does a Y chromosome look like during cell division?
  a) X or Y Shaped
  b) I or Y Shaped
  c) I or X Shaped

How did the world of life became what it is now?

ANS: Modern evolutionary theory

Modern evolutionary theory: Beginning of Life

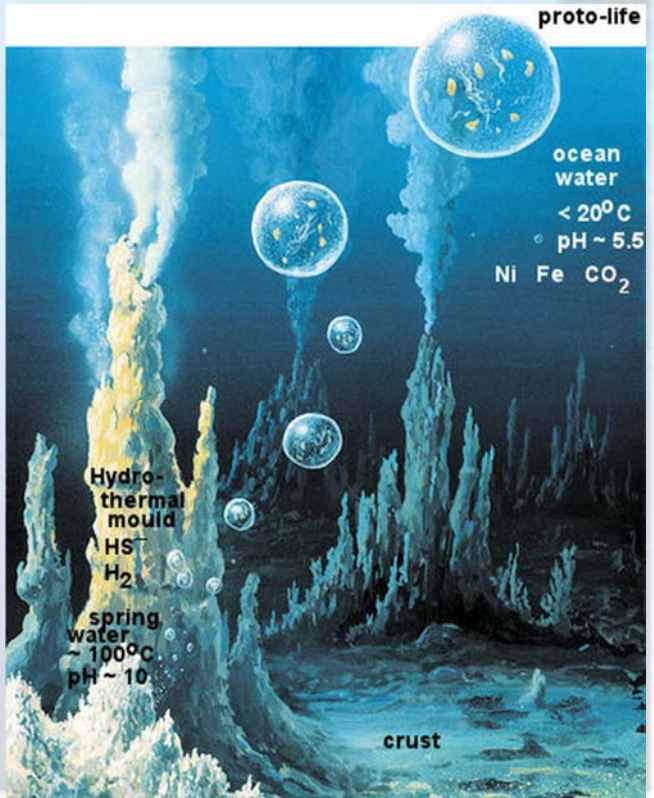


http://morriscourse.com/myths_of_evolution/myths_of_evolution.htm

- Contrary to common misconception, **the beginning of Life is NOT a question addressed by Darwin**. It remains to be highly controversial now.

- Several hypothesis include:
  - **Panspermia (泛種論)**: life distributed by comets, meteroids, etc. [Some said the comets brought organic molecules rather than life.]

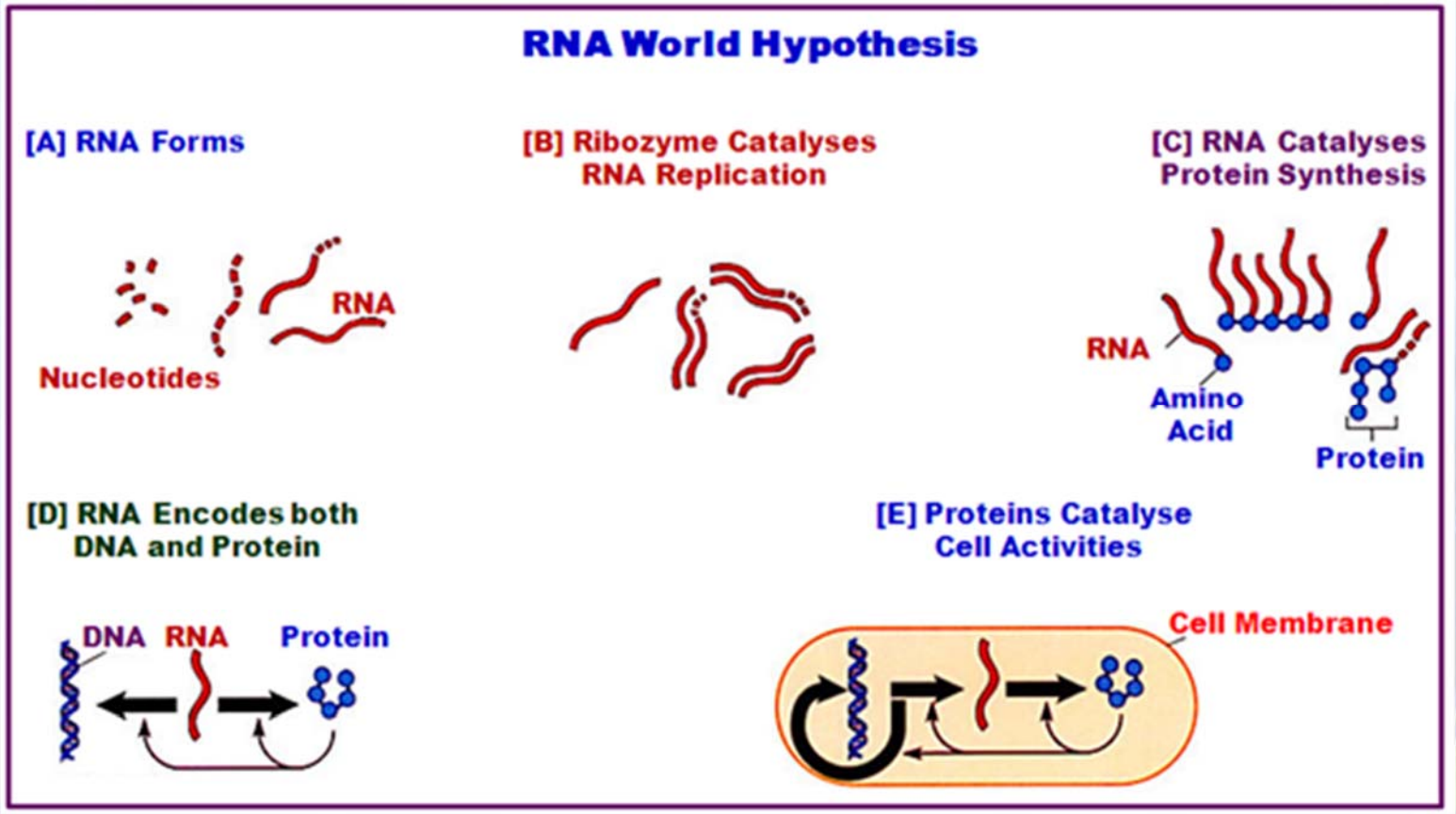
  - **Deep sea vent hypothesis (深海熱泉論)**: proto-life developed from the alkaline fluid in deep sea.



http://universe-review.ca/I11-02-hydrothermal.jpg

Modern evolutionary theory: RNA World

- Self-replicating RNA as precursor of all lives on Earth.



http://biologicalexceptions.blogspot.hk/2013/09/rna-takes-first-place.html

Modern evolutionary theory: Last Universal Common Ancestor (3.5-3.8 billion years ago)

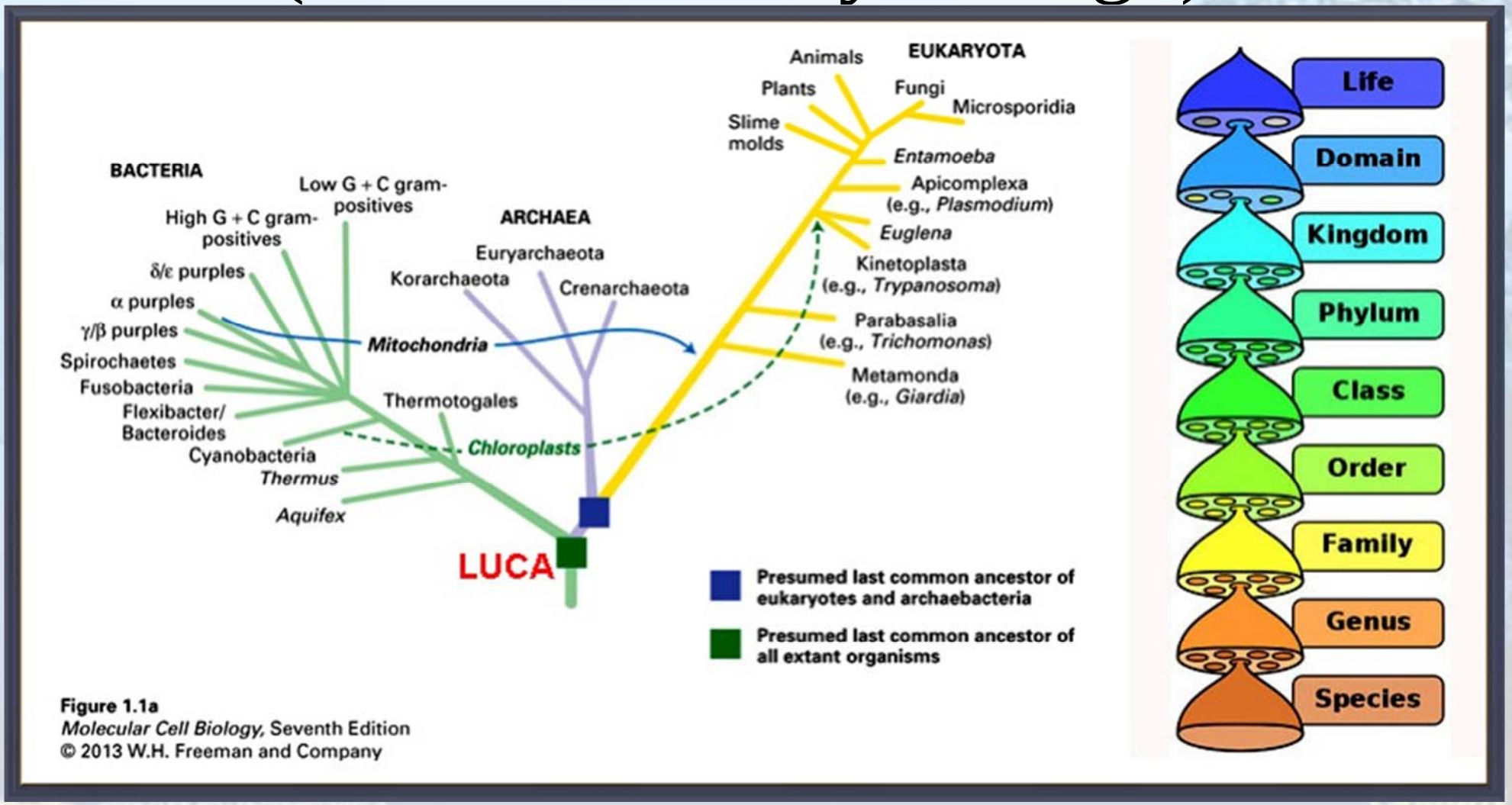
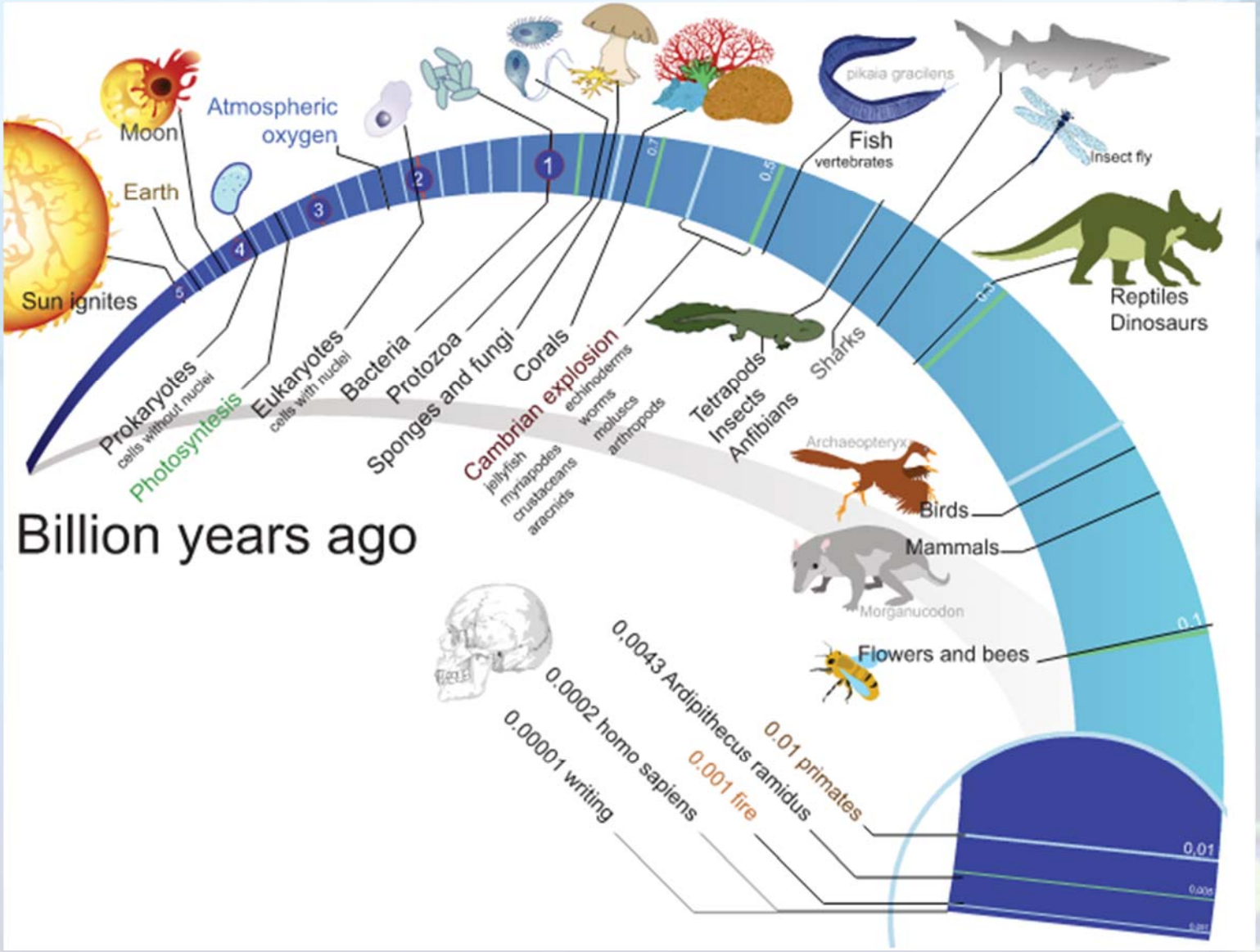


Figure 1.1a
Molecular Cell Biology, Seventh Edition

http://www.bio.miami.edu/~cmallery/255/255hist/mcb1.3.jpg

Timeline of evolution



http://upload.wikimedia.org/wikipedia/commons/e/eb/Timeline_evolution_of_life.svg

Question

- Is modern evolutionary theory still agree with Darwin's evolutionary theory?
  - Yes
  - No

The causes of evolution

- In Darwin's theory, evolution is a result of natural selection, which is caused by **variations** between organisms within a species.
- But what is the **cause** of this variations?

Fig. 24.—Skulls of Pigeons viewed laterally, of natural size. A. Wild Rock-pigeon, *Columba livia*. B. Short-faced Tumbler. C. English Carrier. D. Bagadotten Carrier.

Drawn by Darwin - http://darwin-online.org.uk/

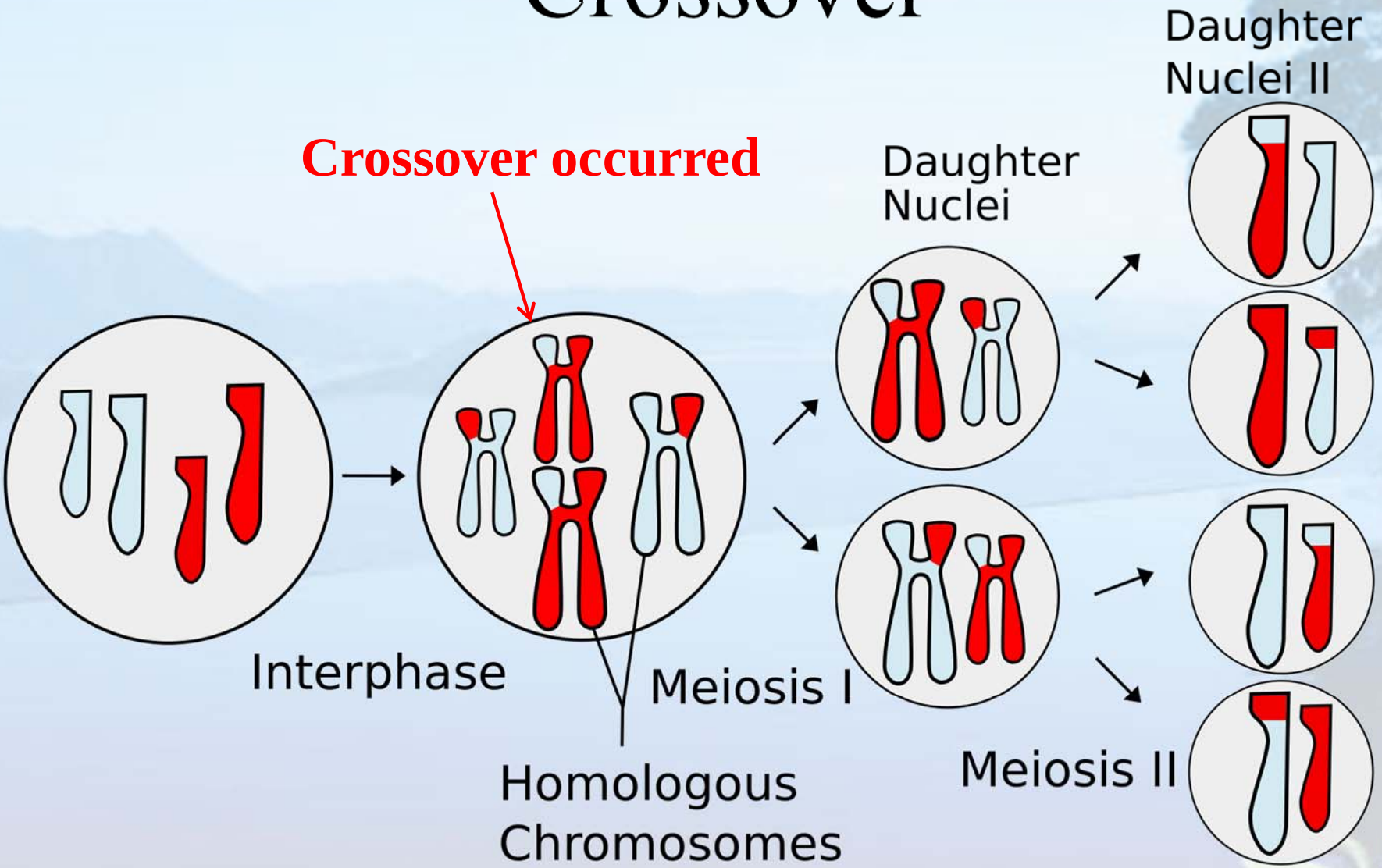
Current understanding of variations: Caused by DNA Mutations

- **Mutation** is a change in the DNA sequence
  - Due to error in DNA replication, chemical-induced mutation, etc.

- MCR-1 gene in chromosome 16:
  - …ATCGACCCC…
  - …ATC**C**ACCCC…
  - Asp ⇨ His (at amino acid 294 of the protein)
  - Mutation leads to variations: **Black** hair to **Red** hair!!!

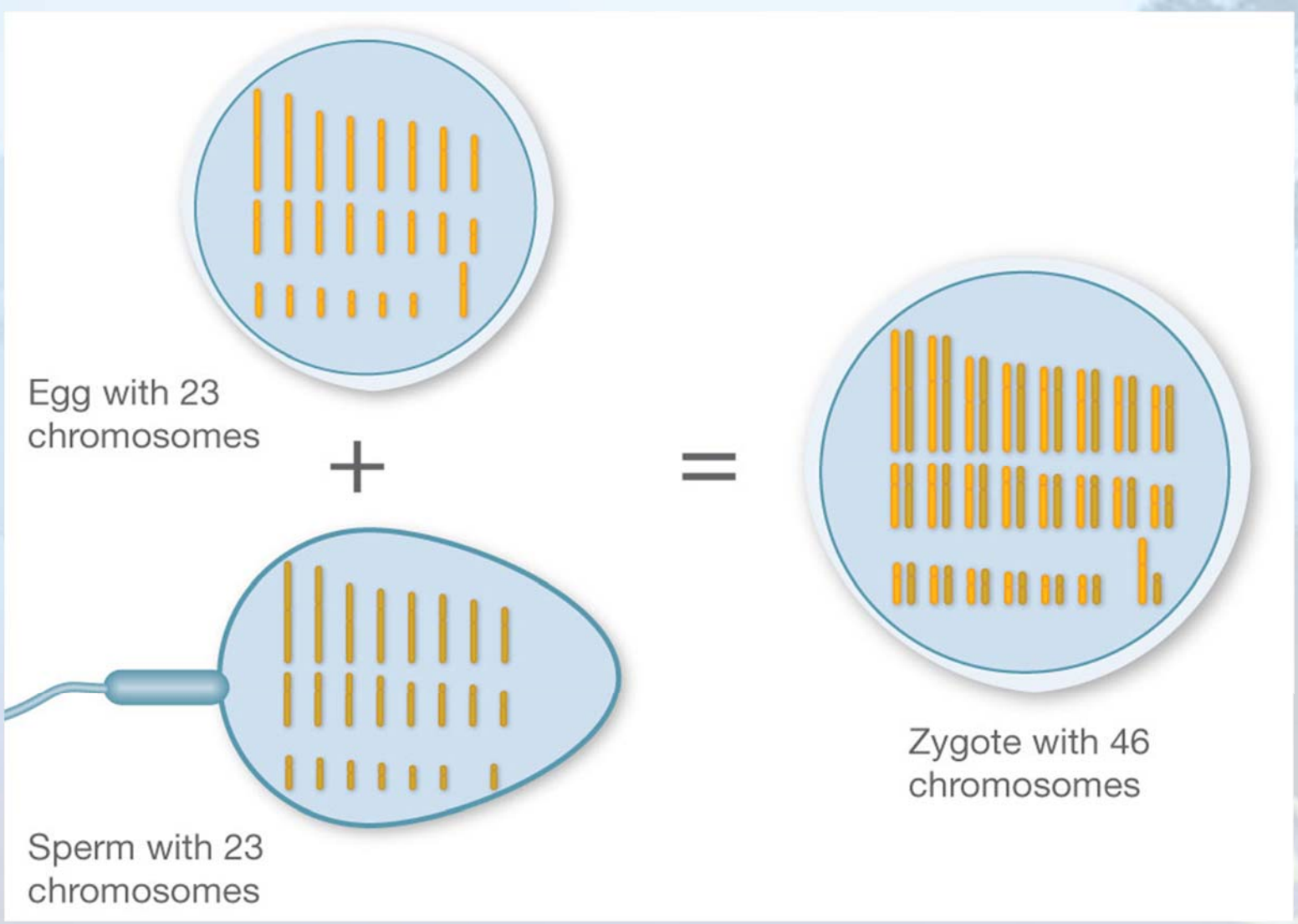
http://en.wikipedia.org/wiki/File:Woman_redhead_natural_portrait_1.jpg

Another source of variation: Crossover



http://en.wikipedia.org/wiki/Meiosis

Another source of variation: Fertilization (受精)



http://learn.genetics.utah.edu/content/chromosomes/diagnose/images/fertilization.jpg

Question

- Consider that if you and your brother, one being very active in sport and developed strong muscles while the other did not, would that be consider as another source of variation?
  - Yes
  - No