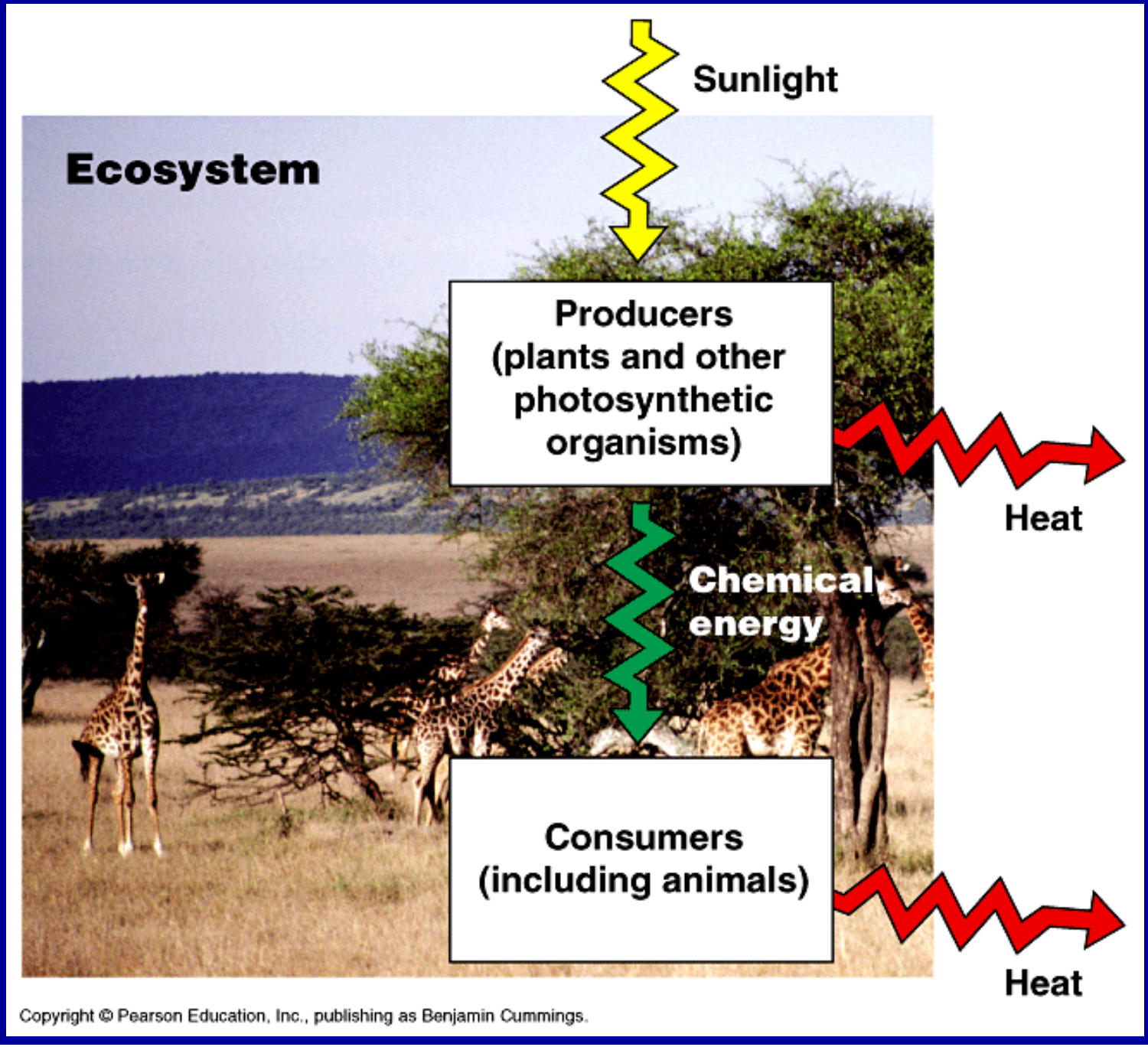
Lecture Series 1

Introduction to Cellular and Molecular Biology 205

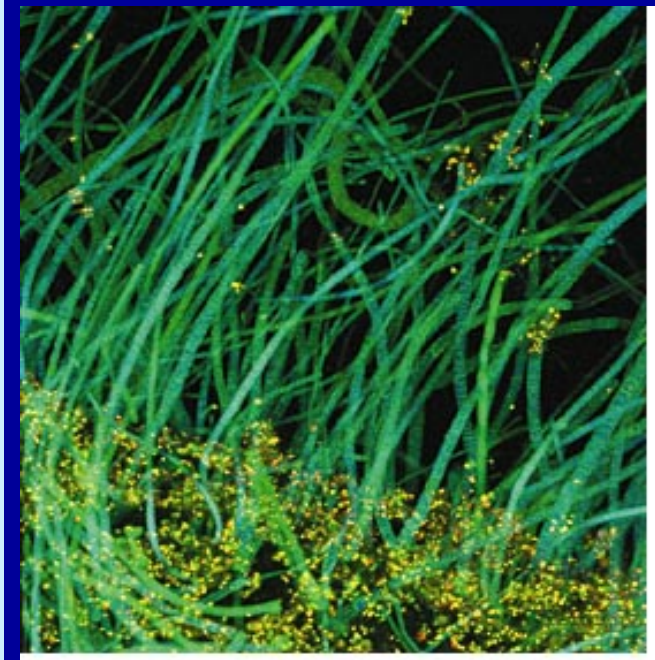
A. Evolutionary Milestones

- A major theme in evolution is increasingly diverse ways of capturing external energy for biologically useful reactions.

An introduction to energy flow and energy transformation in an ecosystem



Chemosynthesis: Hydrothermal Vents

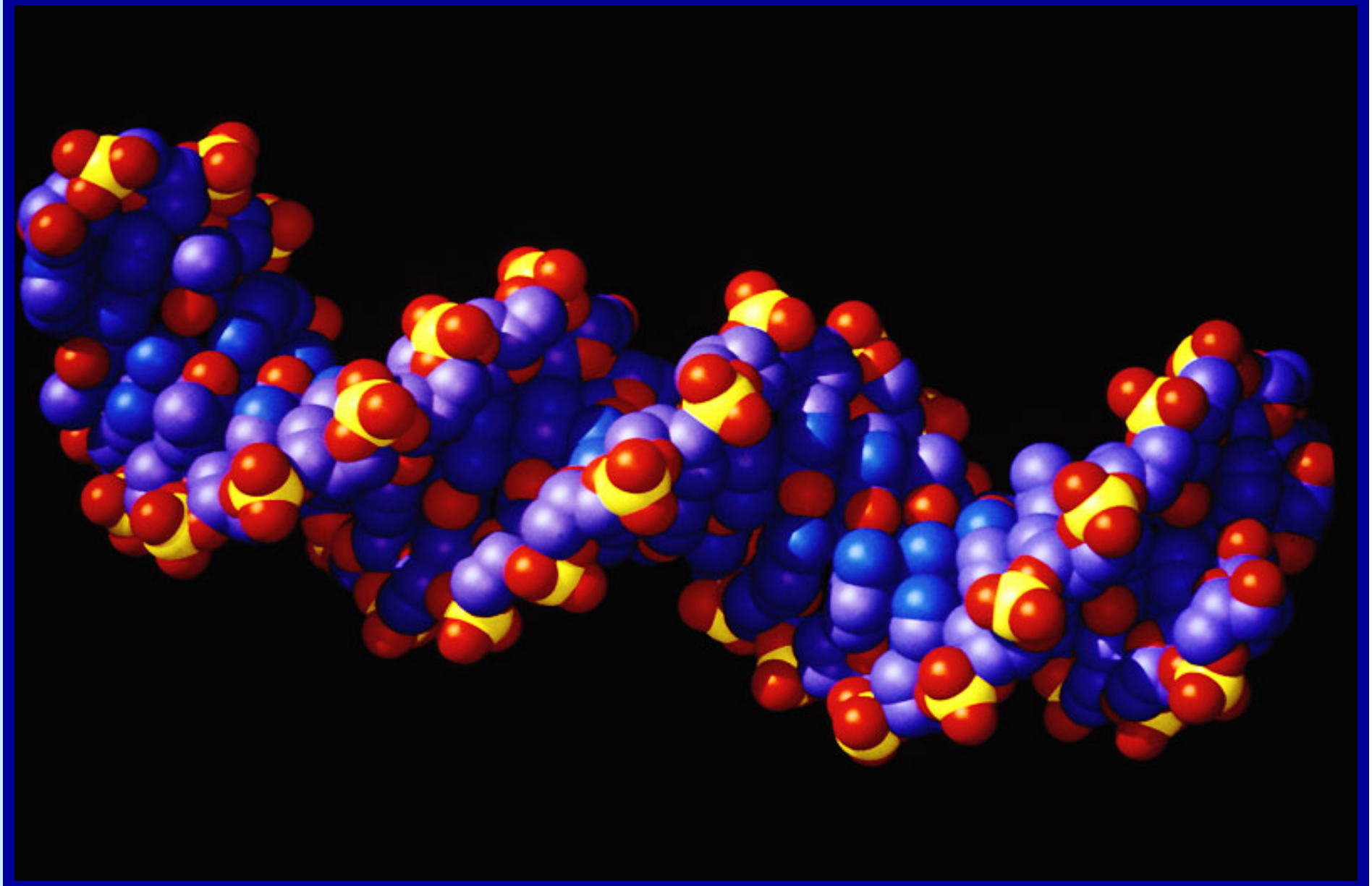


Magnified view of bacteria that inhabit vents.

A. Evolutionary Milestones

- All living organisms contain the large molecules—carbohydrates, lipids, proteins, and nucleic acids.
- Ordered “bags of biochemistry” insulated from the chaos of the environment. Not a closed system.
- Storage, transfer and expression of genetic information.

DNA



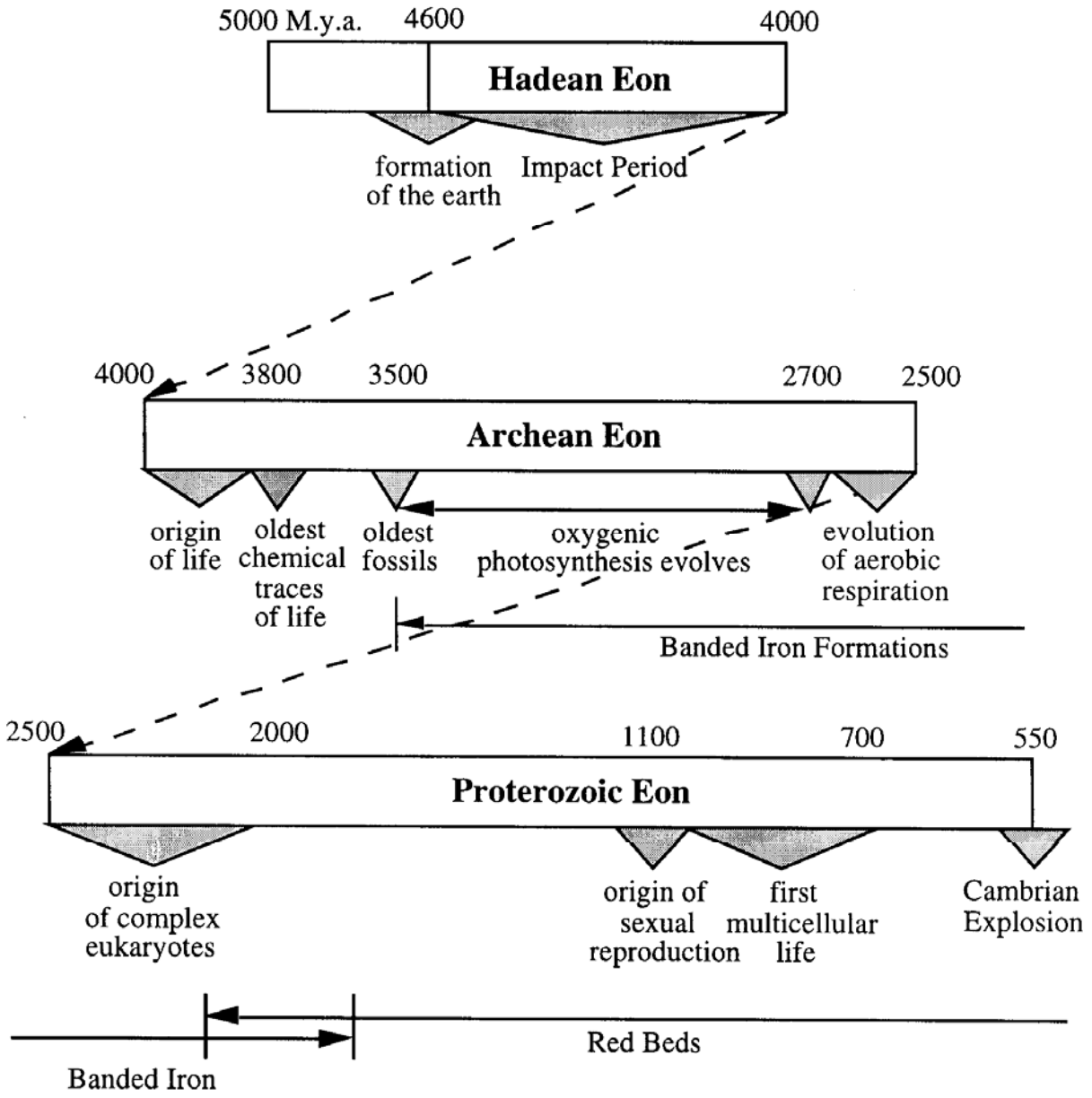
A. Evolutionary Milestones

- Life arose from nonlife about 3.8 to 4.0 billion years ago.
- This process occurred over only a couple hundred million years! Not 2 billion.
- Now all cells come from cells.....why?

A. Evolutionary Milestones

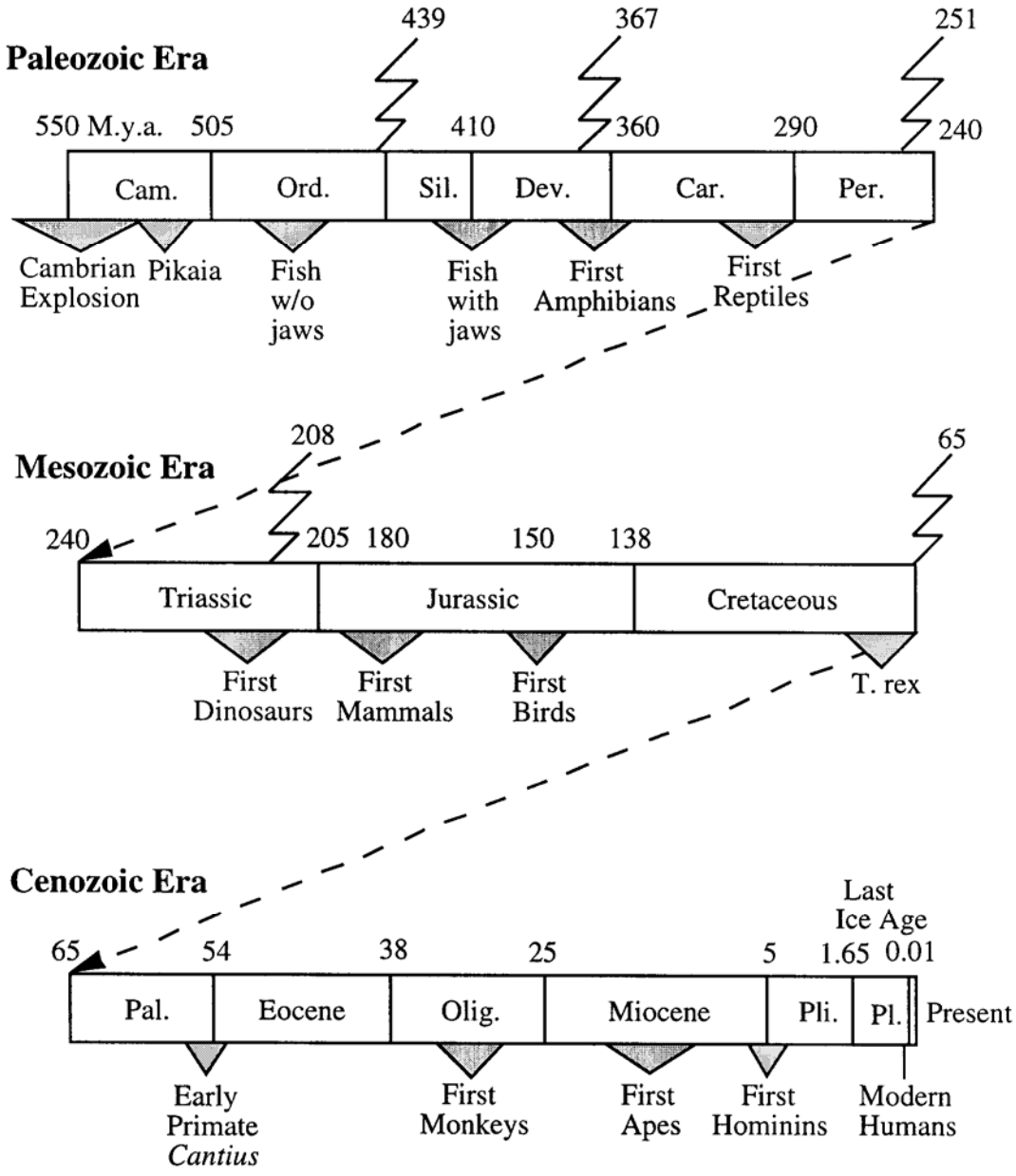
- Photosynthetic single-celled organisms released oxygen, allowing oxygen-based metabolism of large cells and eventually multicellular organisms.
- Oxygen began getting released very early on, but only accumulated in atmosphere after “Rust the Crust” and movement onto land only after Ozone shield.

The Precambrian



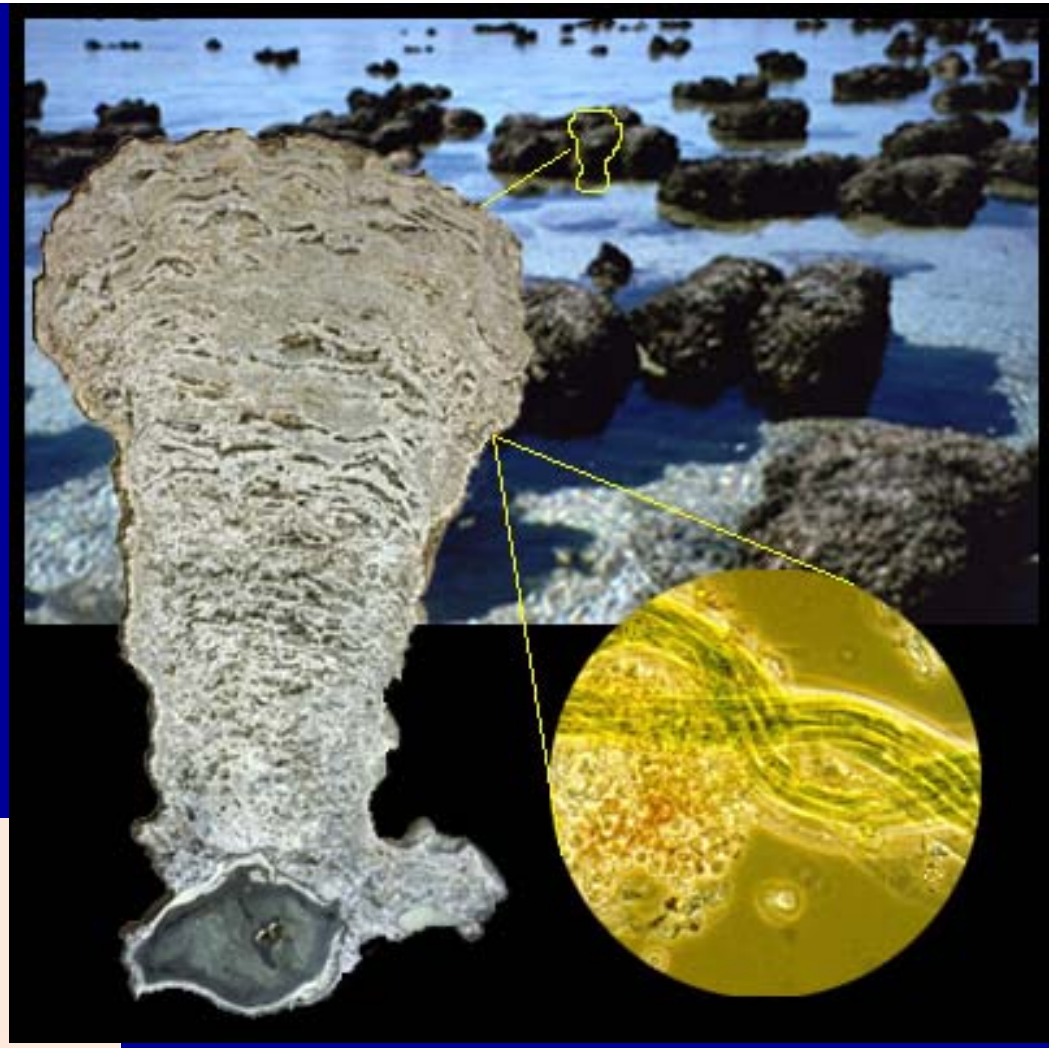
All dates are in millions of years ago, M.y.a.

The Phanerozoic Eon



All dates are in millions of years ago, M.y.a.

Stromatolites

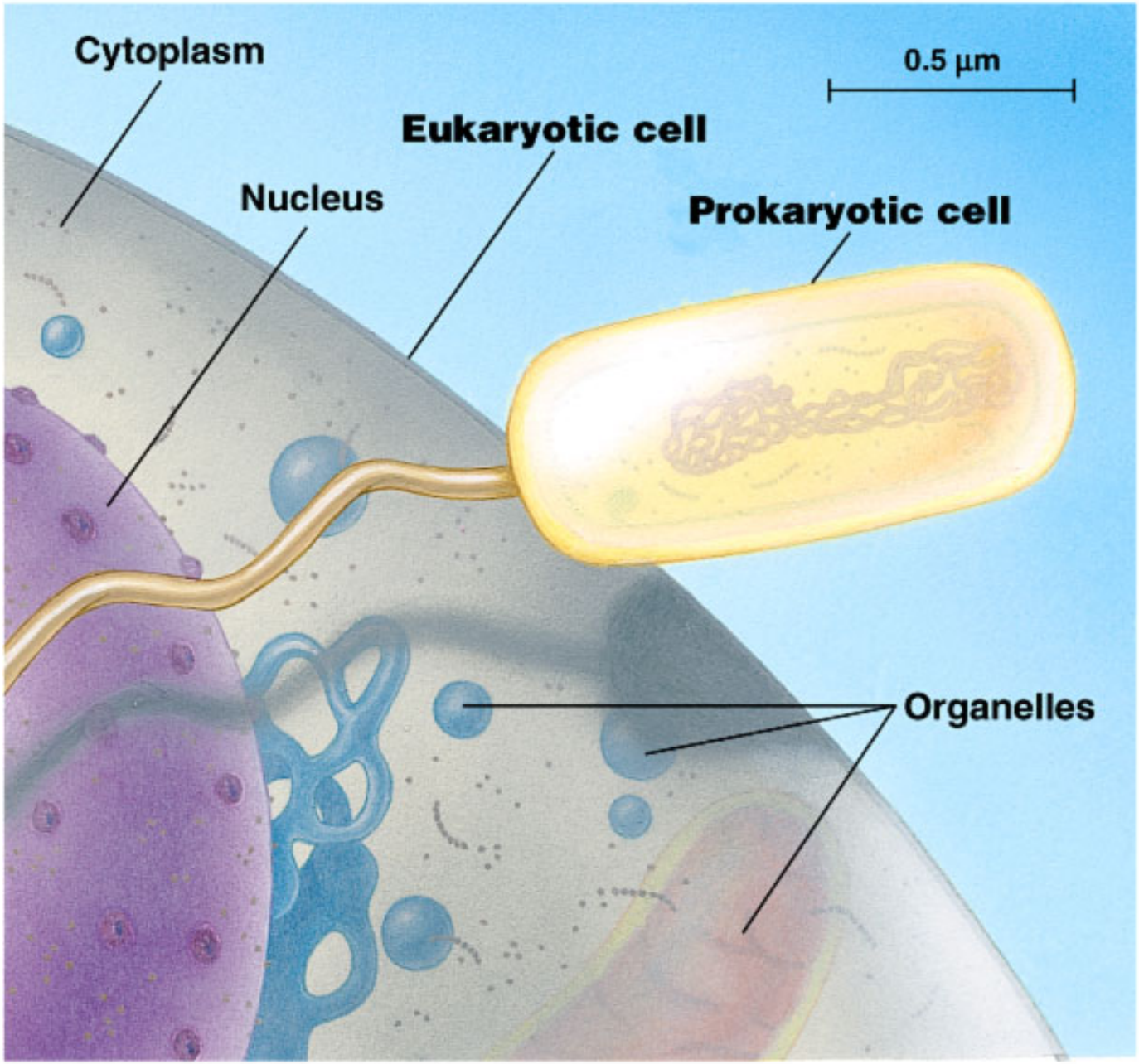


BIFs aka Banded Iron Formations

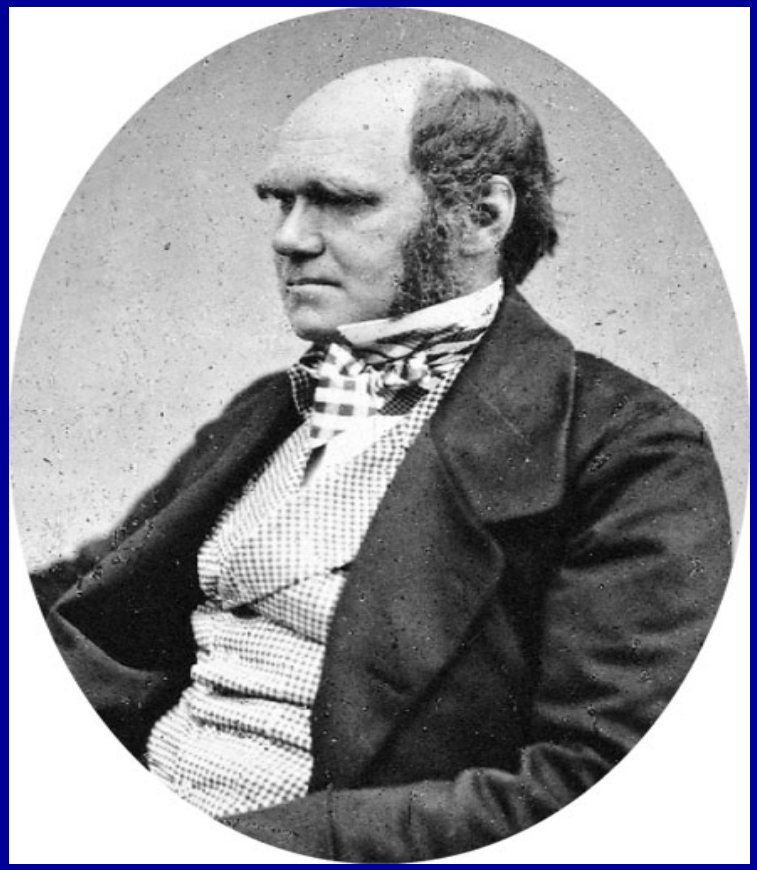
A. Evolutionary Milestones

- Complex eukaryotic cells evolved from prokaryotic cells. Eukaryotic cells developed into multicellular organisms whose cells became modified for specific functions.
- The evolution of sexual reproduction enhanced the ability of organisms to adapt to changing environments.
- Adaptation to environmental change is the result of evolution by natural selection, the filter for innate variability.

Structural organization of Eukaryotic and Prokaryotic cells

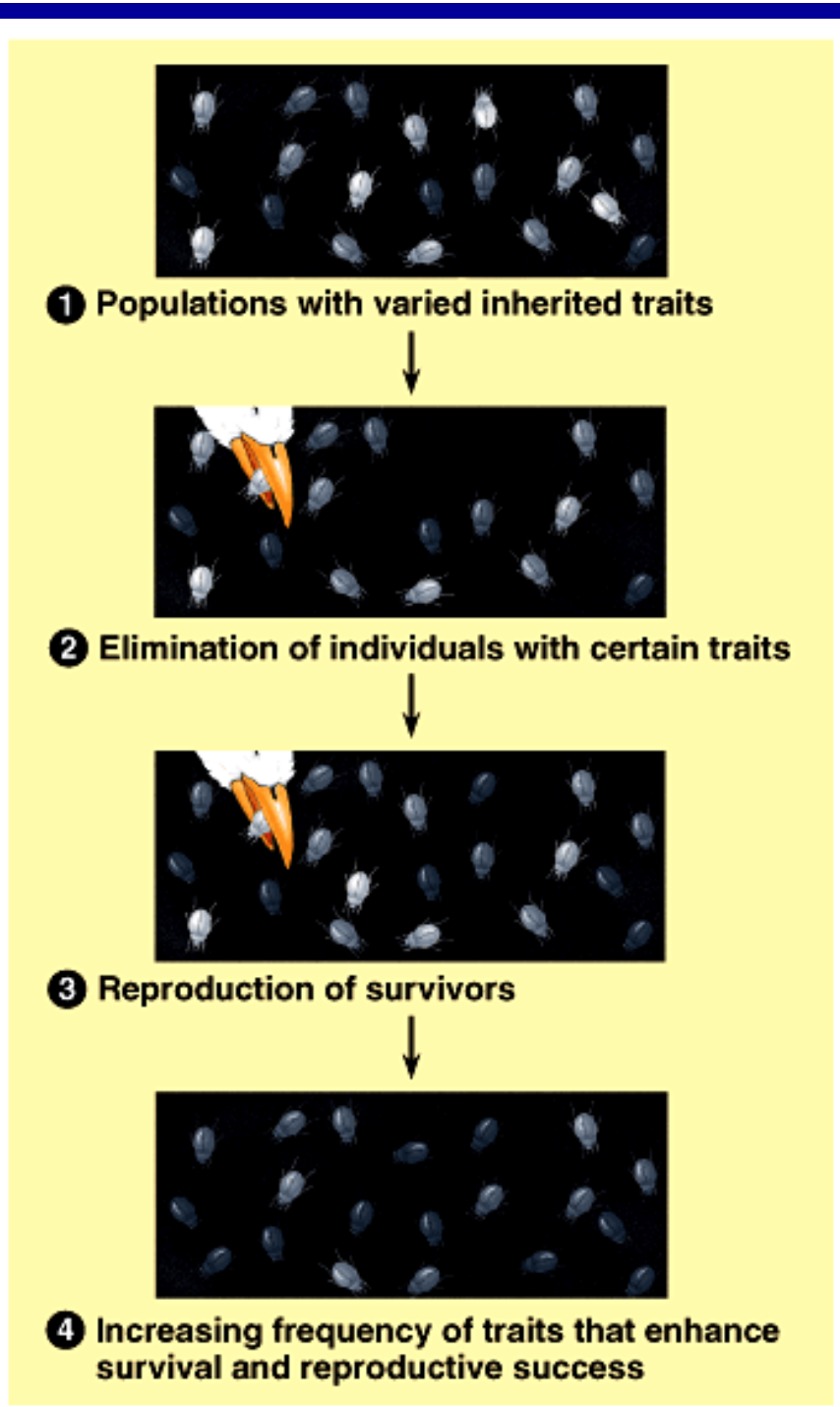


- The evolutionary view of life came into sharp focus in 1859 when Charles Darwin published *On the Origin of Species by Natural Selection*

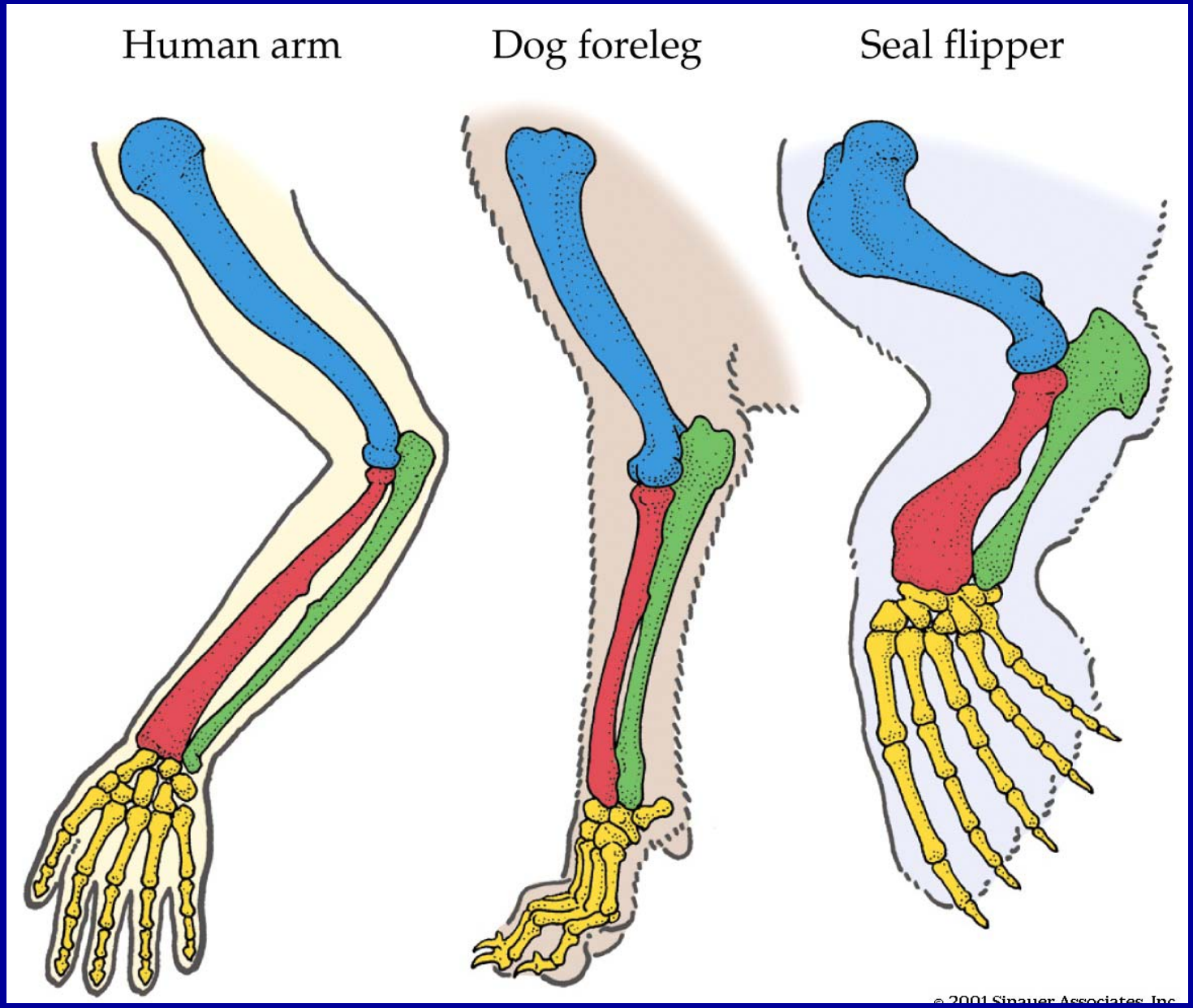


- *The Origin of Species* articulated two main points
  - Descent with modification
  - Natural selection

Natural selection

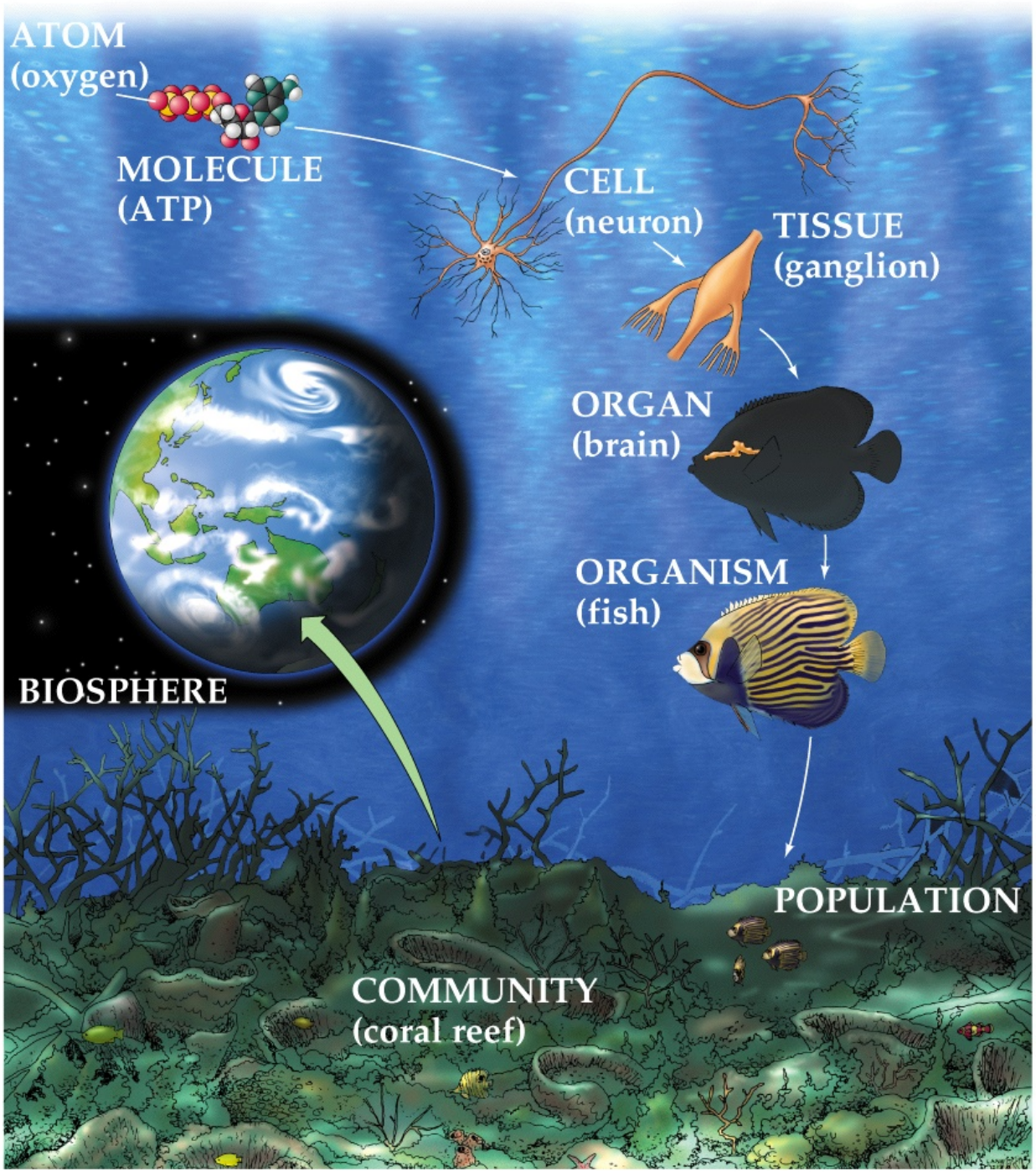


Descent with modification

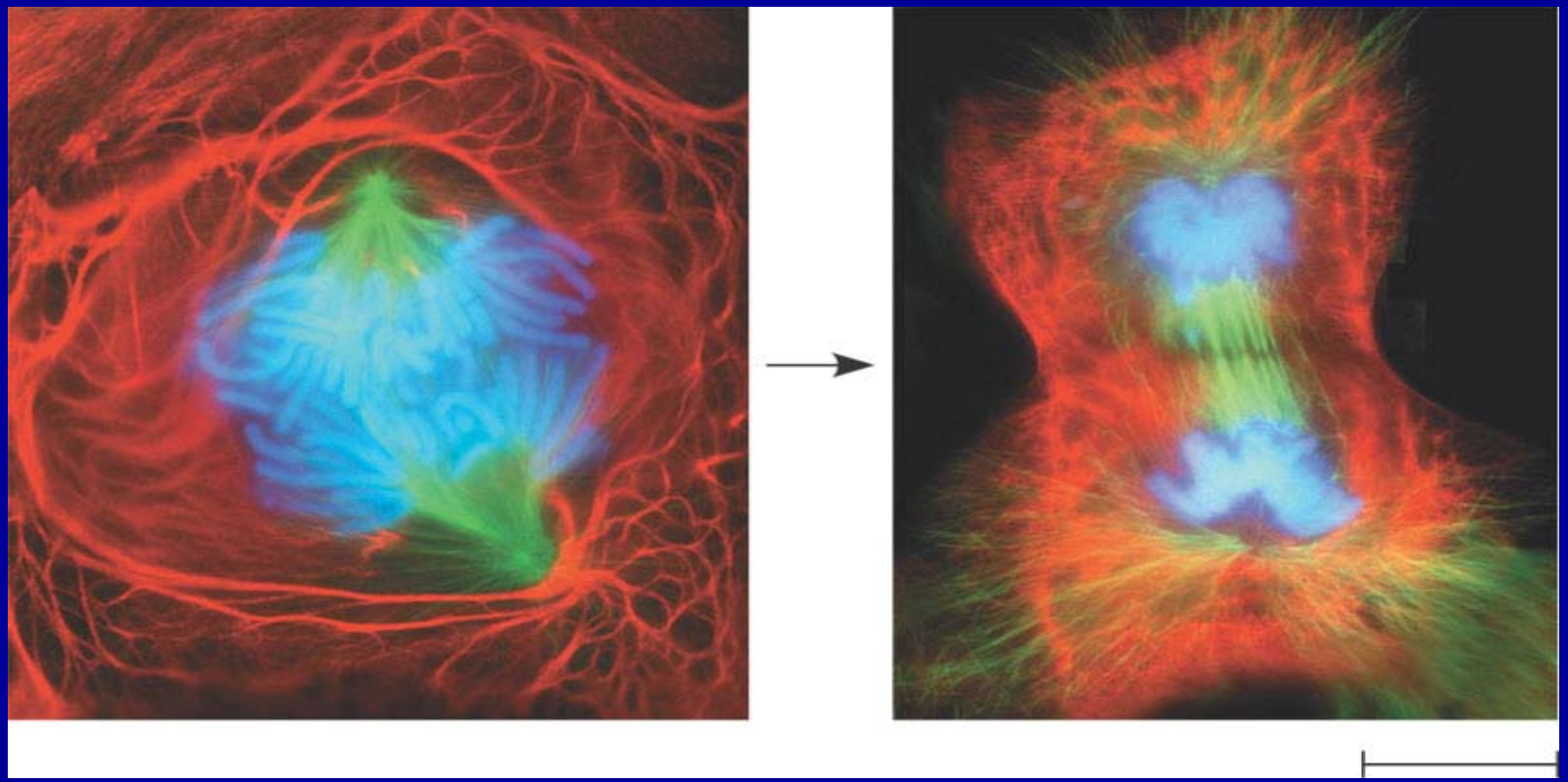


B. The Hierarchy of Life

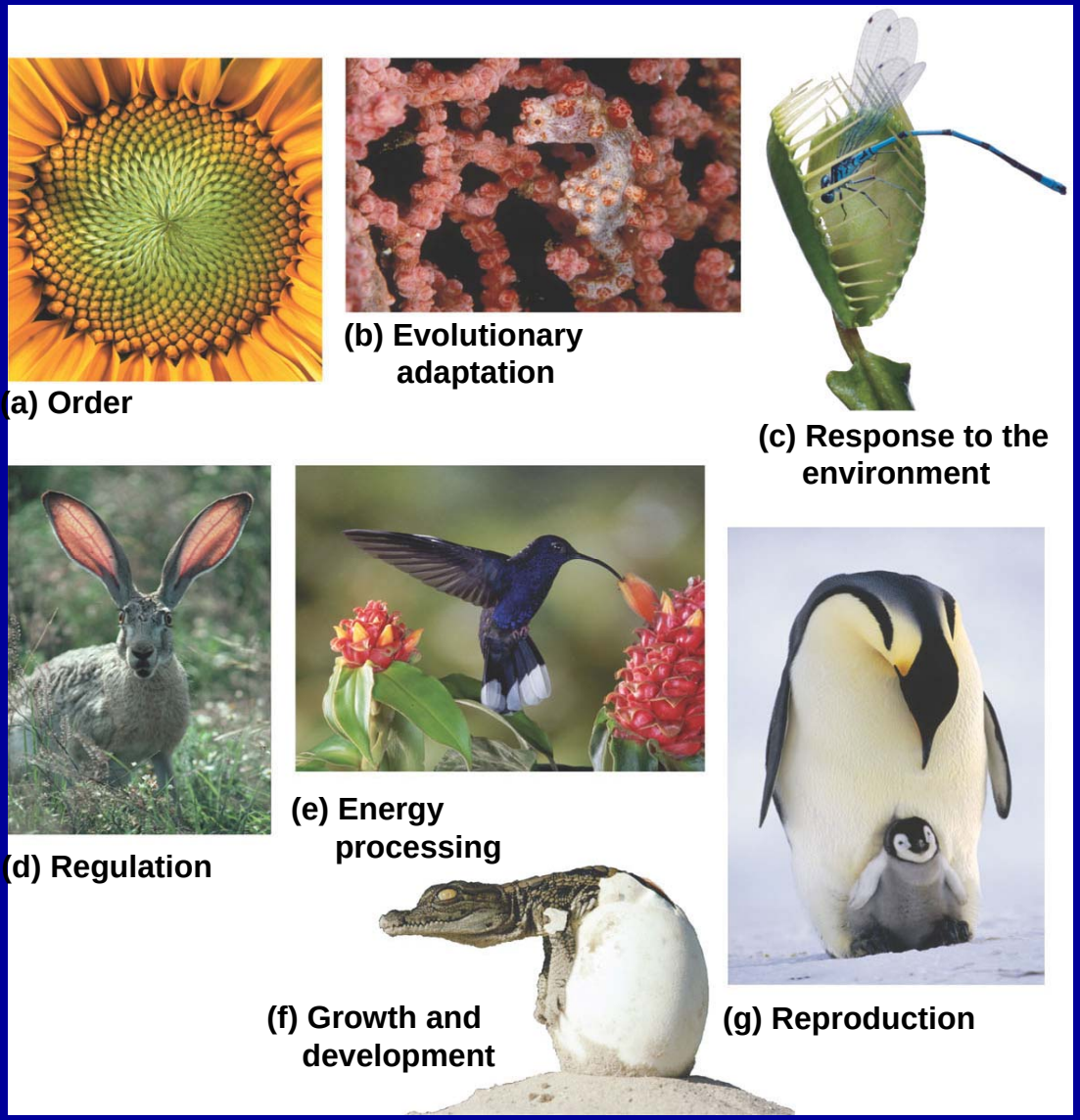
- Biology is organized into a hierarchy of levels. Each has “emergent properties” not found at lower levels.
- Emergent properties are where the sum is greater than the parts.
- Basic unit of biology is the cell, we go up or down from there.


ATOM
(oxygen)
MOLECULE
(ATP)
CELL
(neuron)
TISSUE
(ganglion)
ORGAN
(brain)
ORGANISM
(fish)
POPULATION
COMMUNITY
(coral reef)
BIOSPHERE

- The cell is the lowest level of organization that can perform *all* activities required for life



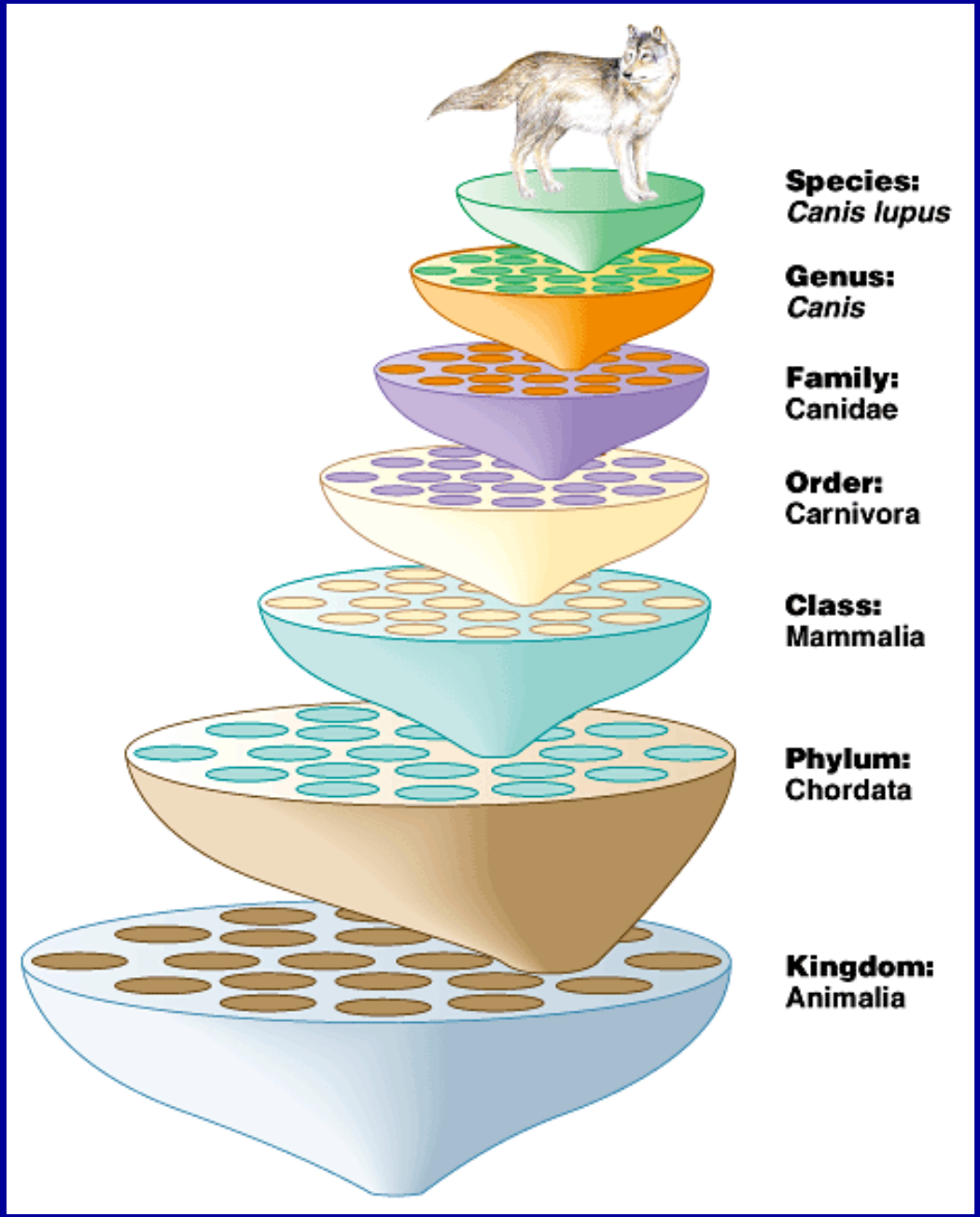
- Some emergent properties of life

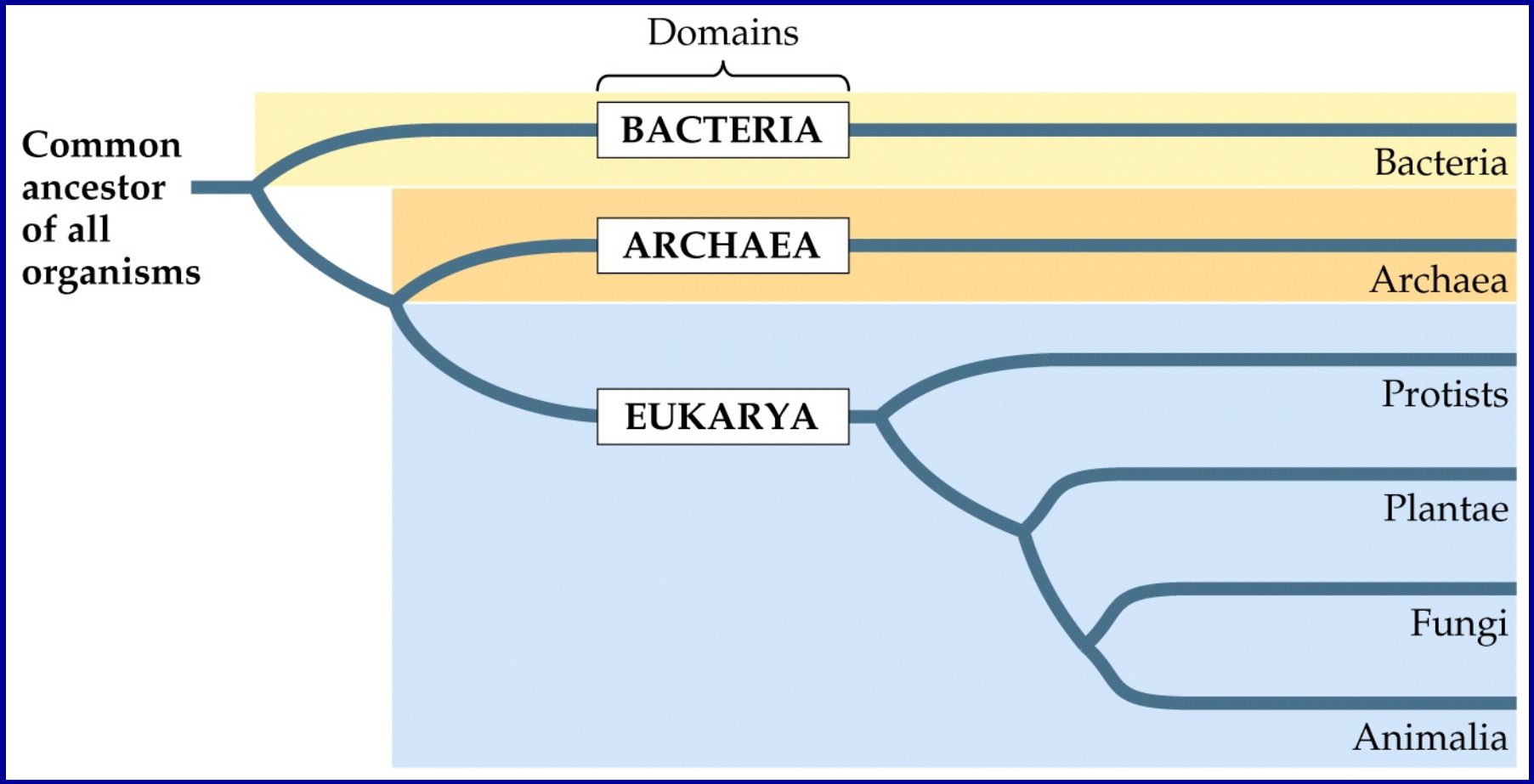


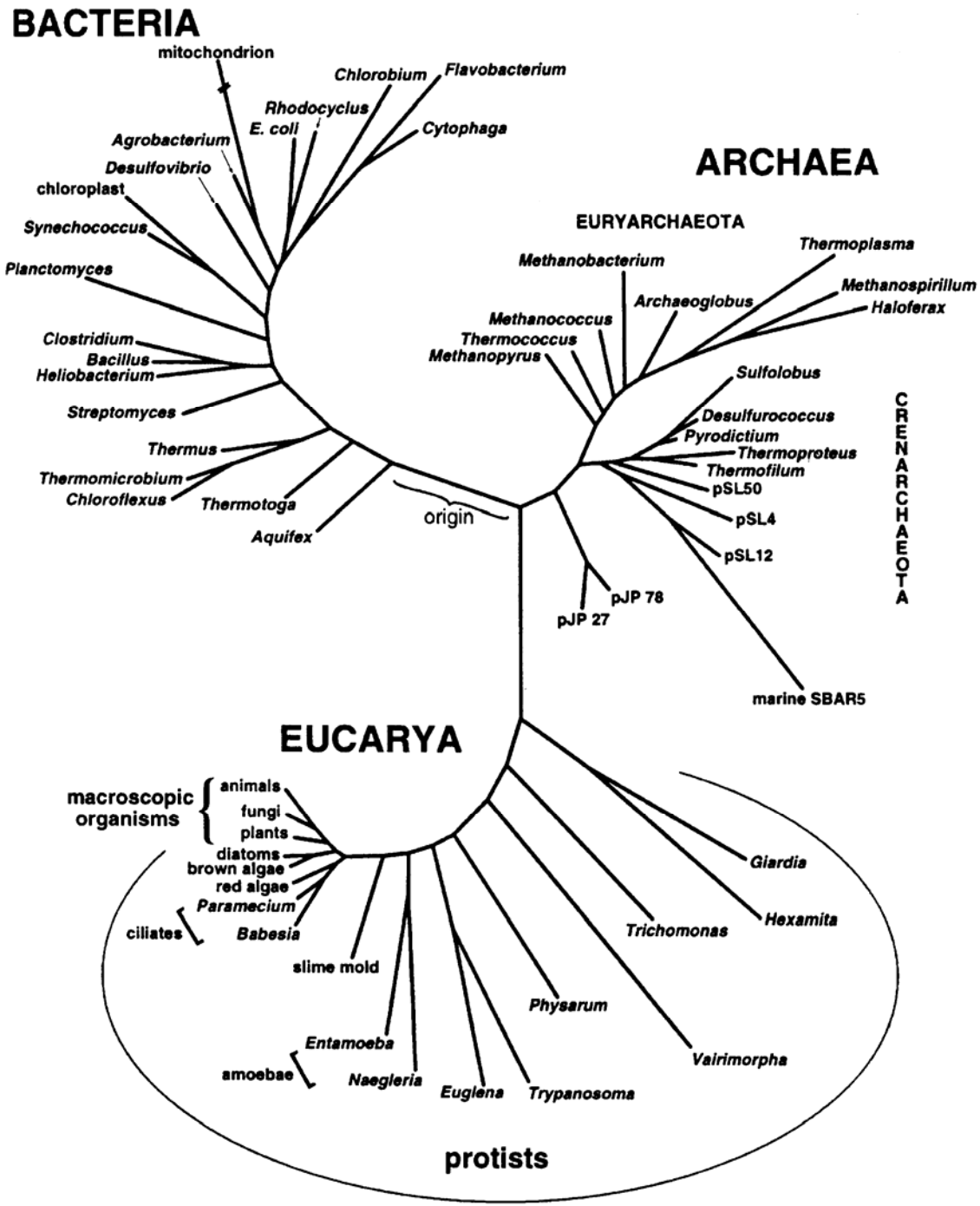
B. The Hierarchy of Life

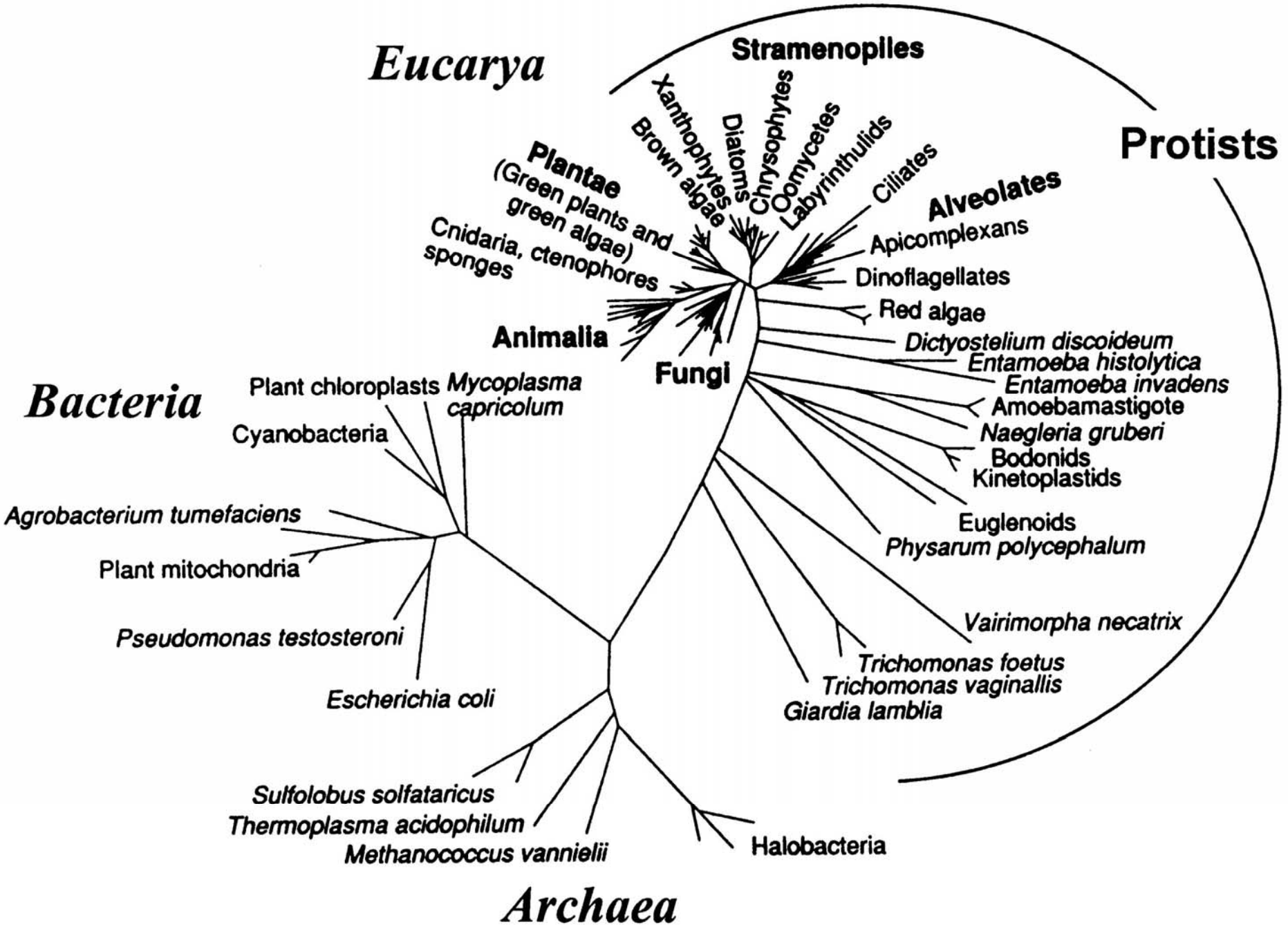
- Domains vs Kingdoms...etc.
- Species are classified into domains Archaea, Bacteria, and Eukarya. Archaea and Bacteria consist of prokaryotic cells. Eukarya contain the protists and the kingdoms Plantae, Fungi, and Animalia.
- Crown Groups all require endosymbiosis!

Classifying life




Domains
Common ancestor of all organisms
BACTERIA
ARCHAEA
EUKARYA
Bacteria
Archaea
Protists
Plantae
Fungi
Animalia


BACTERIA
mitochondrion
Chlorobium
Flavobacterium
Rhodocyclus
E. coli
Cytophaga
Agrobacterium
Desulfovibrio
chloroplast
Synechococcus
Planctomyces
Clostridium
Bacillus
Heliobacterium
Streptomyces
Thermus
Thermomicrobium
Chloroflexus
Thermotoga
Aquifex
origin
ARCHAEA
EURYARCHAEOTA
Thermoplasma
Methanobacterium
Methanospirillum
Archaeoglobus
Haloferax
Methanococcus
Thermococcus
Methanopyrus
Sulfolobus
Desulfurococcus
Pyrodictium
Thermoproteus
Thermofilum
pSL50
pSL4
pSL12
pJP 78
pJP 27
marine SBAR5
CRENARCHAEOTA
EUCARYA
macroscopic organisms
animals
fungi
plants
diatoms
brown algae
red algae
ciliates
Paramecium
Babesia
slime mold
Entamoeba
amoebae
Naegleria
Euglena
Trypanosoma
Physarum
Vairimorpha
Trichomonas
Giardia
Hexamita
protists


Eucarya
Stramenopiles
Xanthophytes
Brown algae
Diatoms
Chrysophytes
Oomycetes
Labyrinthulids
Ciliates
Protists
Plantae
(Green plants and
green algae)
Cnidaria, ctenophores
sponges
Alveolates
Apicomplexans
Dinoflagellates
Red algae
Animalia
Fungi
Dictyostelium discoideum
Entamoeba histolytica
Entamoeba invadens
Amoebamastigote
Naegleria gruberi
Bodonids
Kinetoplastids
Euglenoids
Physarum polycephalum
Vairimorpha necatrix
Trichomonas foetus
Trichomonas vaginallis
Giardia lamblia
Bacteria
Plant chloroplasts
Mycoplasma
capricolum
Cyanobacteria
Agrobacterium tumefaciens
Plant mitochondria
Pseudomonas testosteroni
Escherichia coli
Sulfolobus solfataricus
Thermoplasma acidophilum
Methanococcus vannielii
Halobacteria
Archaea

Examples of the three Domains of life

Bacteria

Archaea

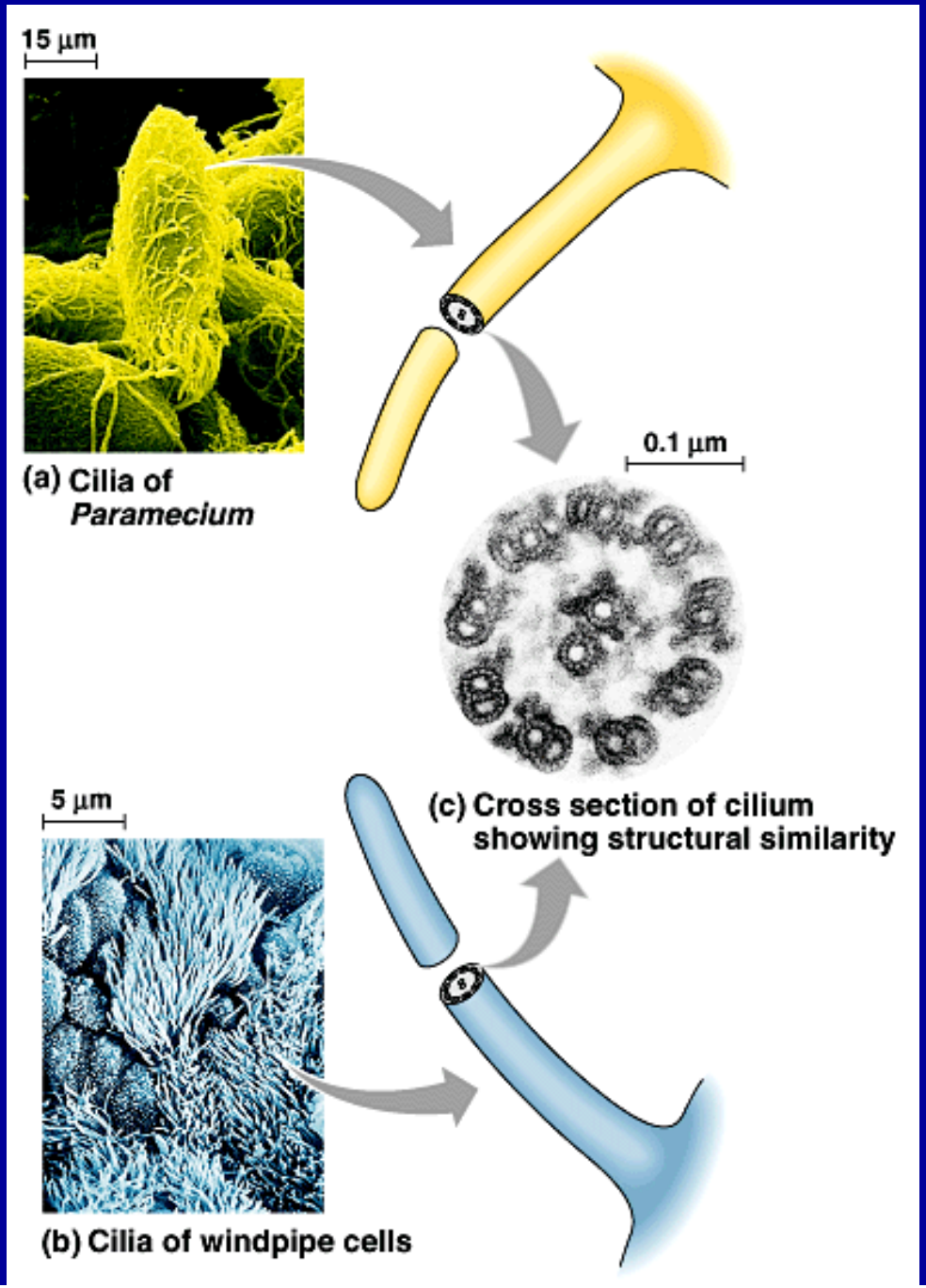
Protista

Plantae

Fungi

Animalia

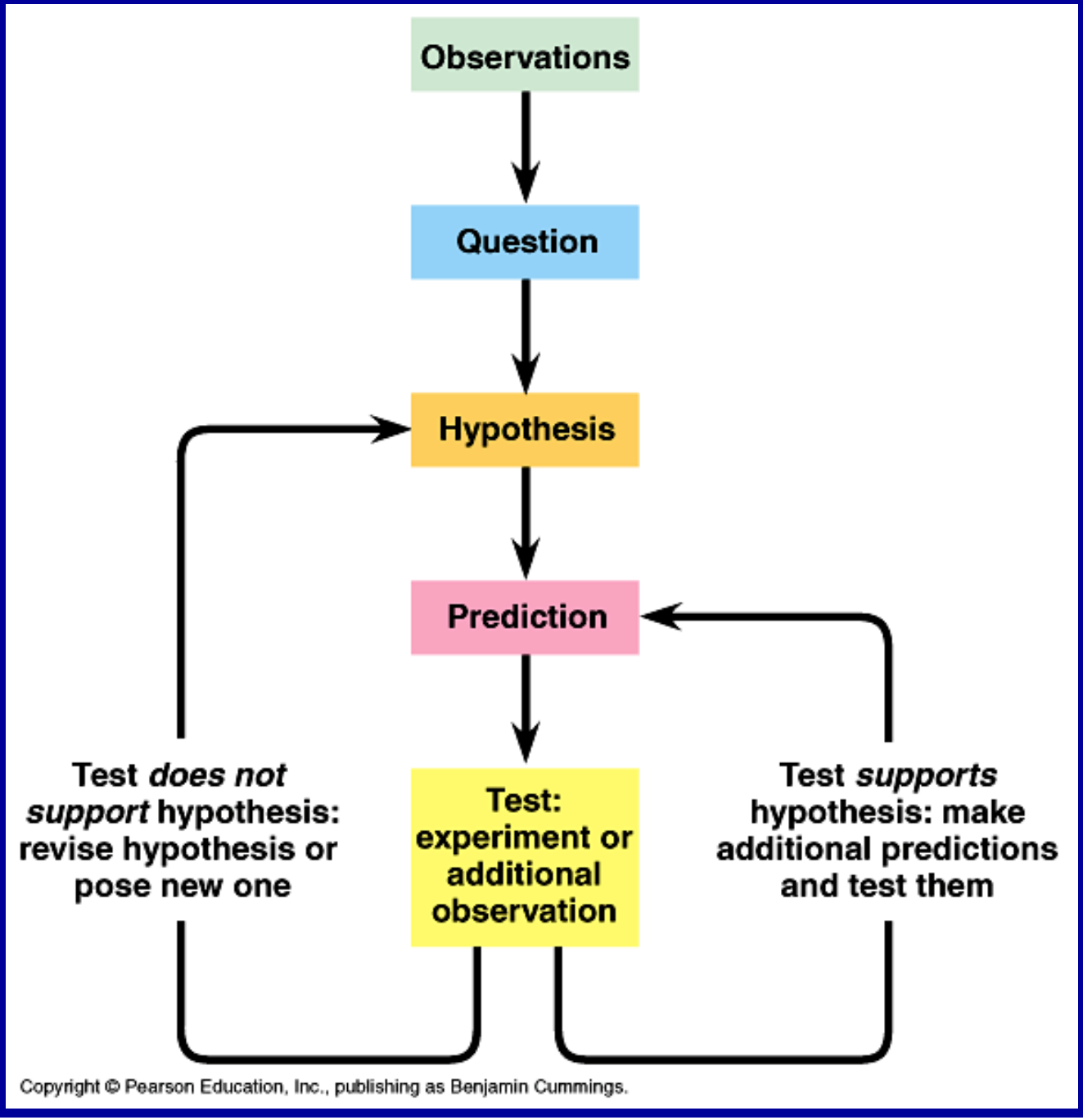
Unity underlying the diversity of life: the architecture of Eukaryotic cilia

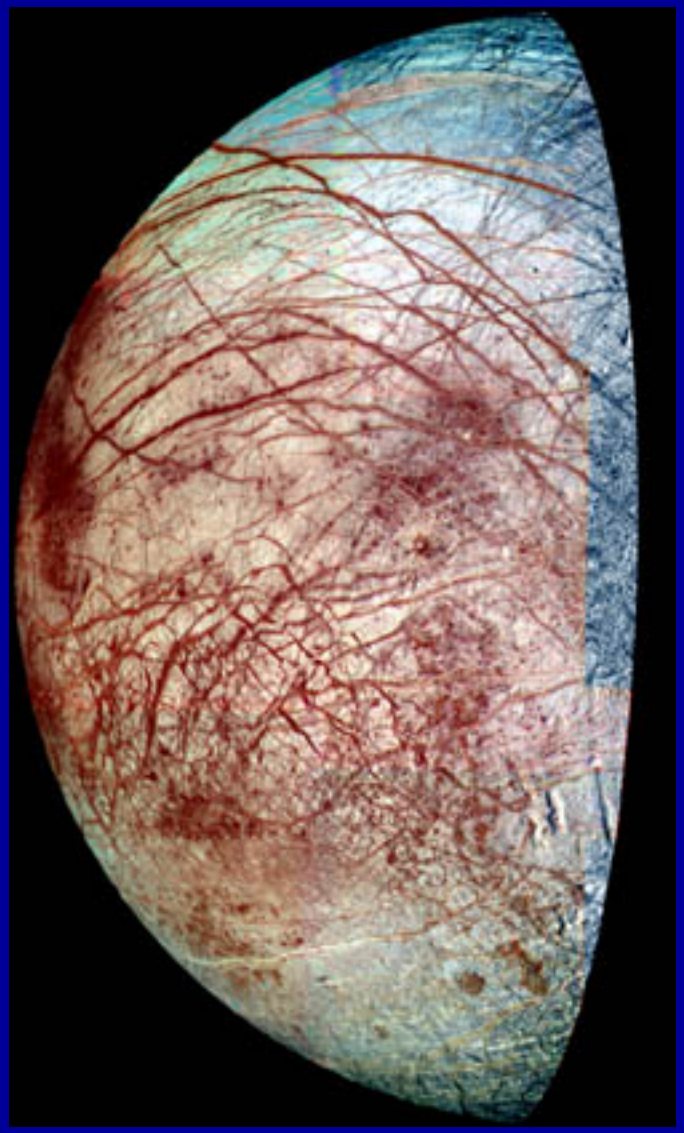


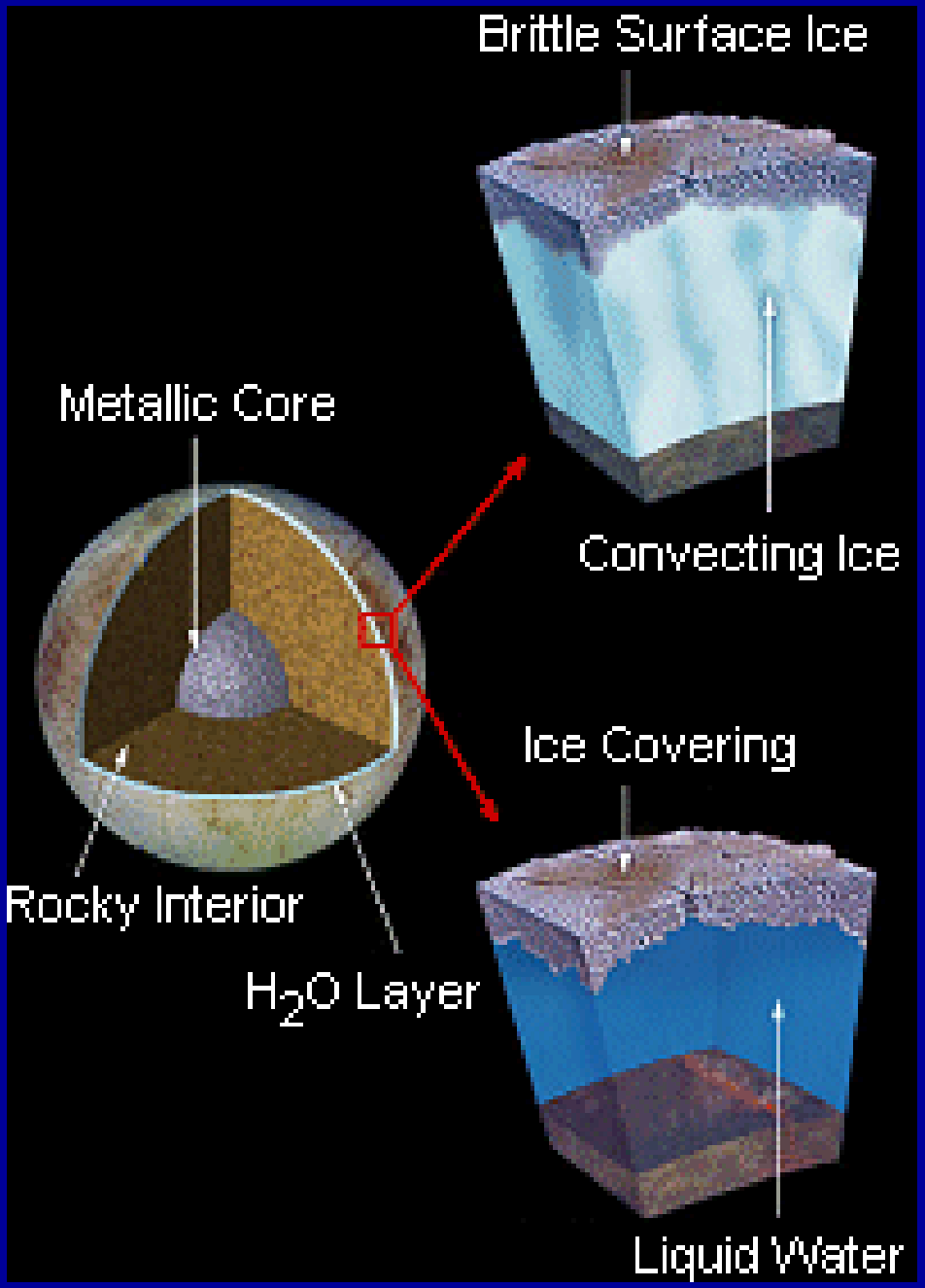
C. Fundamental Concepts Used Throughout Biology

- Evolution unites all of biology. It's mechanism is Natural Selection.
- Emergent Properties
- Hierarchical Organization
- Hypothesis Testing/Deductive Reasoning

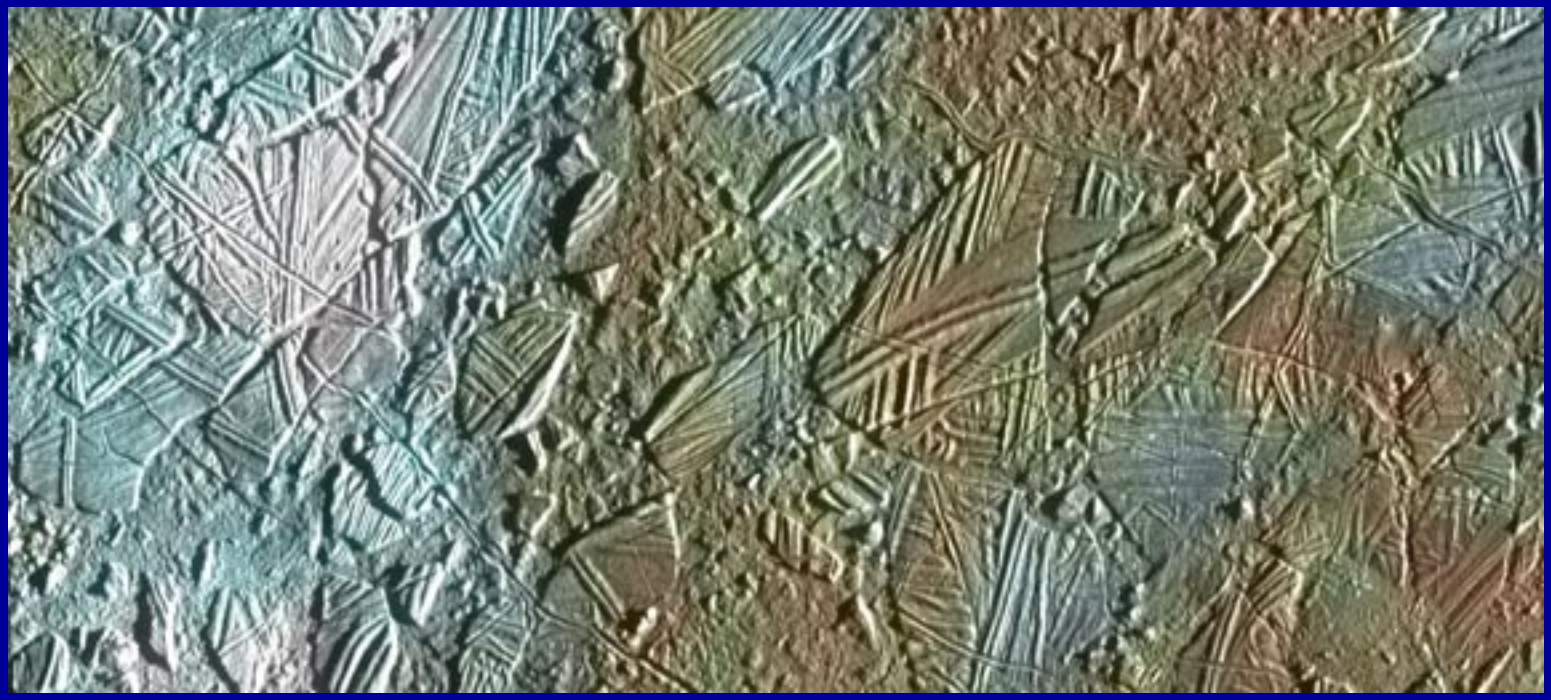
Idealized version of the scientific method







Life on Europa?




frozen water
cryo-volcanic
ridges