

Principles of Evolution

Principles of Evolution -The Origin of Life

‘Creation v. Biology’

Creationists

- each species was divinely created by a superior being
- theory is outside the scope of science since it is impossible to test

Biologists

- process by which biomolecules, subcellular structures and living cells have come into existence
- primitive cell then evolved

Principles of Evolution -The Origin of Life

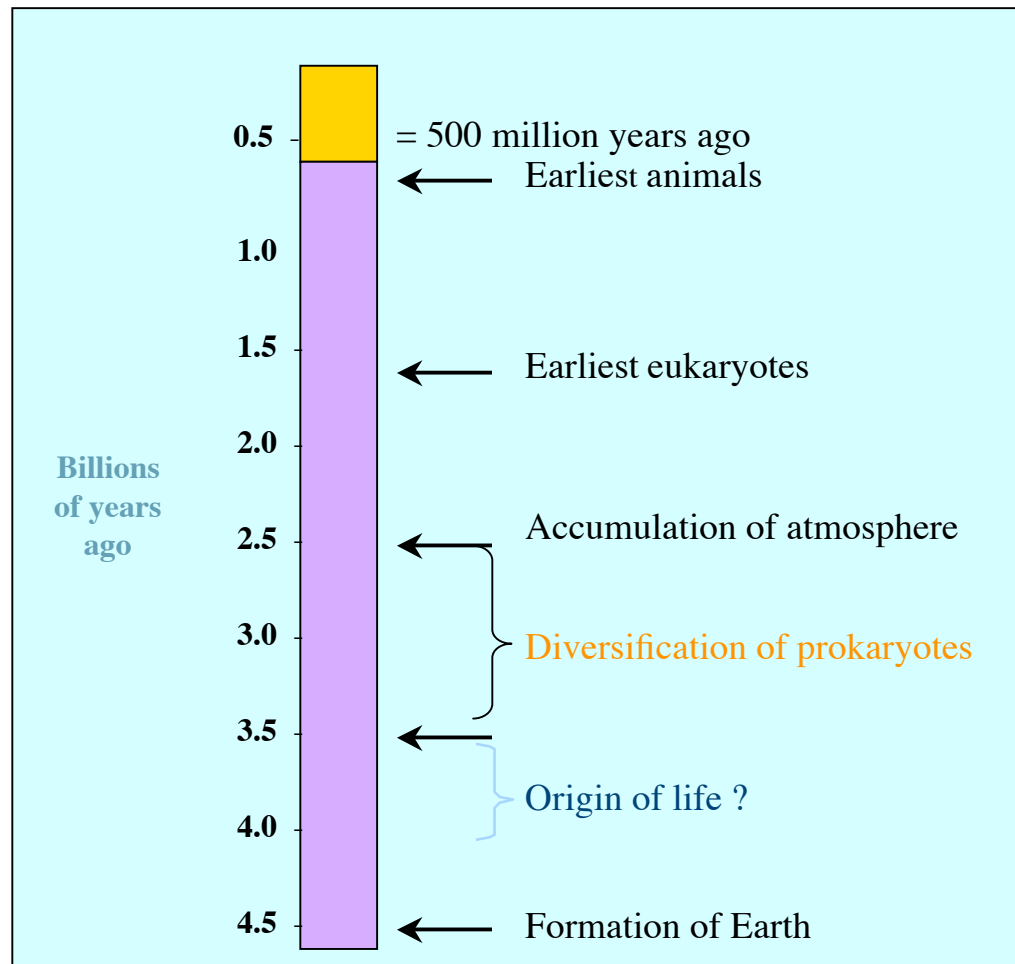
Abiogenesis (spontaneous generation)

- living organisms from non-living material
example:
spoiled meat produces maggots

Biogenesis

- 'life from life'
- species give rise only to similar forms
- derived from parents that are similar

Principles of Evolution -The Origin of Life



Principles of Evolution -The Origin of Life

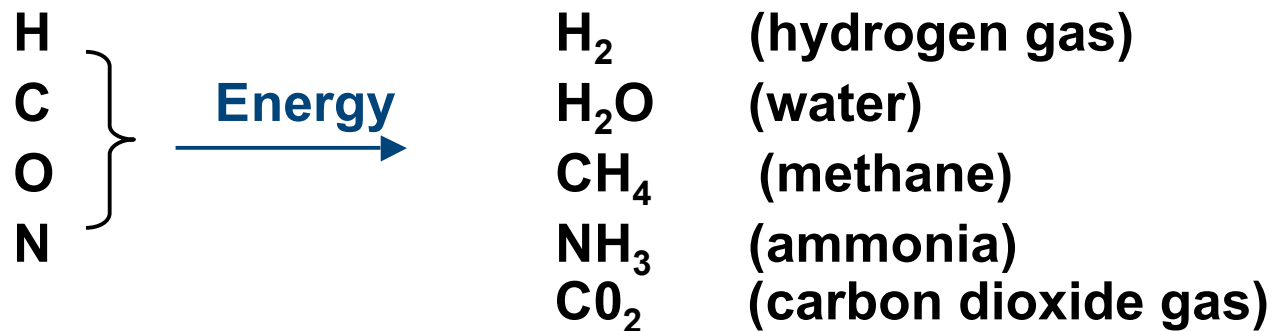
Chemical evolution (synthesis of reactions)

- starts with gaseous raw materials from Earth's early atmosphere
- synthesized in the oceans



Principles of Evolution - Origin of Life (Hypothesis)

STEP 1: Abiotic synthesis of monomers (simple molecules)



Miller / Urey (1953):



Principles of Evolution - Origin of Life (Hypothesis)

STEP 2: Abiotic synthesis of polymers (more complex molecules)

- occurring in sand pockets along the shore
- evaporation of water (ingredients become concentrated)

sugars	+	sugars	--->	polysaccharides
fatty acids	+	glycerin	--->	fats
amino acids	+	amino acids	--->	proteins
nitrogen bases	+	sugars + phosphates	--->	nucleotides
nucleotides	+	nucleotides	--->	nucleic acids

--> after this origin of the first living units, they were washed out to sea where further evolution occurred

Principles of Evolution - Origin of Life (Hypothesis)

STEP 3: Self-replicating molecules

- life is partially defined by **inheritance**
(obtaining characteristics by transfer of genetic material)
- now occurs with DNA
(primitive method previously existed)
- the first genes were short strands of RNA that replicated without the existence of enzymes (RNA genes)

Principles of Evolution - Origin of Life (Hypothesis)

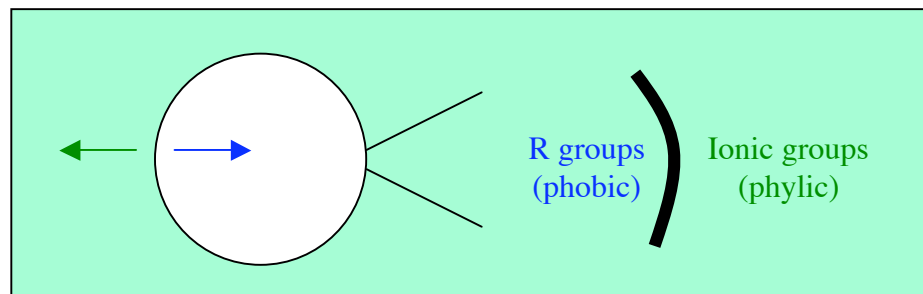
STEP 4: Formation of Pre-cells

- packaging of these materials and molecules into membrane-bound pre-cells (not cells)
- Coacervates v. Proteinoids

Principles of Evolution - Origin of Life (Hypothesis)

Coacervate Theory - "Hot Thin Soup"

- formation of mixed colloidal units called **coacervates**
- colloids can be a protein, lipid, or nucleic acid



- although not living, molecules behave like biological systems
 - coacervates reproduce by fragmentation
 - take a long time to evolve

Principles of Evolution - Origin of Life (Hypothesis)

"Dry Heat Theory"

- polymerization of amino acids under hypohydrous conditions and very high temperatures (180°C) to form **proteinoids** (straight chain proteins)

CH_4 , NH_3 , water vapor -----> 14 amino acids

- proteinoids aggregate to form **microspheres** displaying some characteristics of life
 - cell membrane is selective permeable
 - easily formed, trapping chemicals
 - stable
 - enzymatic properties
- short time to evolve

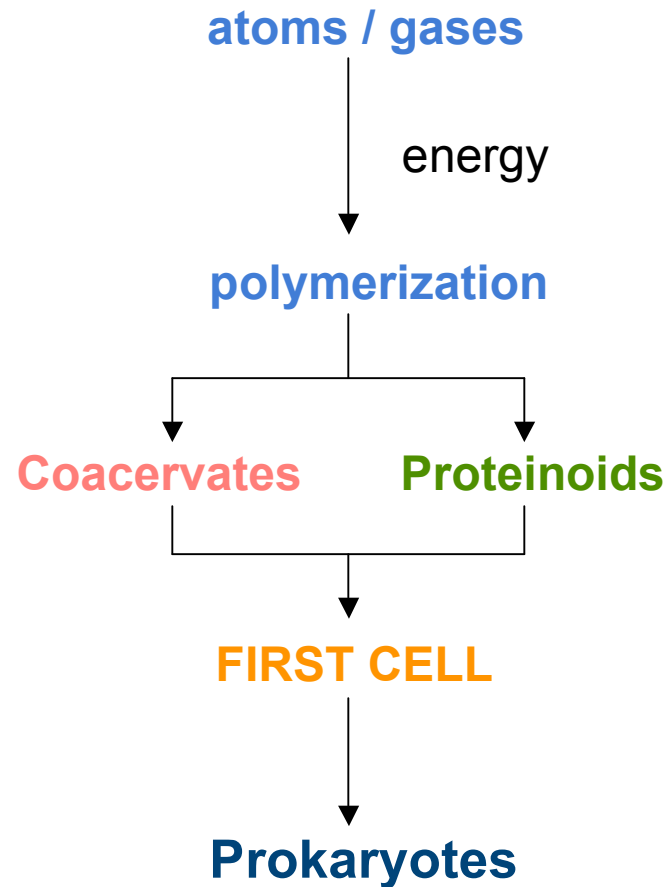
Principles of Evolution - Origin of Life (Hypothesis)

Primitive atmosphere:

**Chemical
Evolution**



**Biological
Evolution**



Principles of Evolution - Origin of Life (Hypothesis)

**Biological
Evolution**



FIRST CELL



Prokaryotic Cells



Nutrition:
chemo/photo autotrophs
and heterotrophs

Monera (bacteria / archaea)
Virus

*** Endosymbiont Theory ***



Eukaryotic Cells

Principles of Evolution - Origin of Eukaryotic Cells

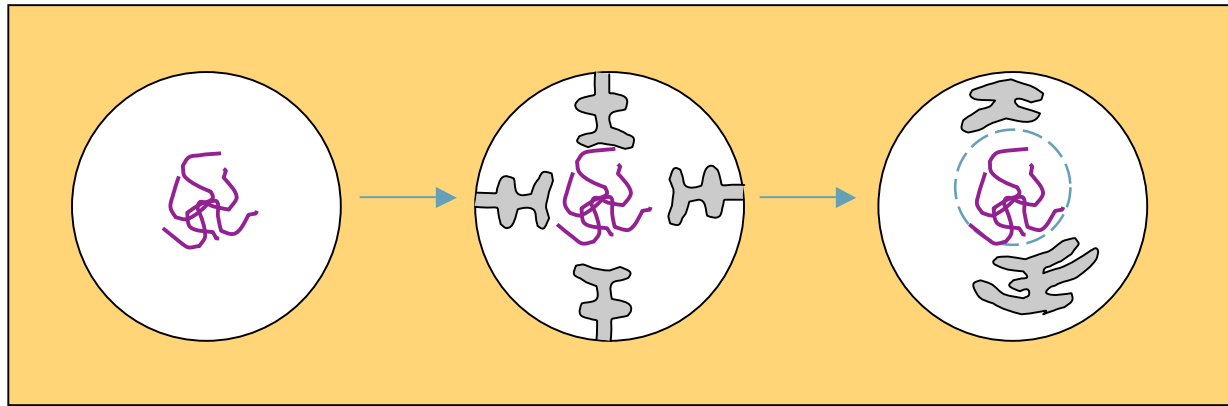
Prokaryotes	Eukaryotes
No true nucleus	Nucleus with nuclear membrane
Single chromosome made up of nucleic acid	Several chromosomes with nucleic acid complexed with protein
Cell organelles absent	Golgi apparatus, endoplasmic reticulum, lysosomes, mitochondria present
If present, chlorophyll not in chloroplasts	If present, chlorophyll in chloroplasts
Flagella lack 9 + 2 structure	Flagella with 9 + 2 structure
Cell division by binary fission	Cell division by mitosis and meiosis

Question: How did the membrane-bound organelles in eukaryotes form?

Principles of Evolution - Origin of Eukaryotic Cells

Eukaryotic cells evolved through a combination of two processes:

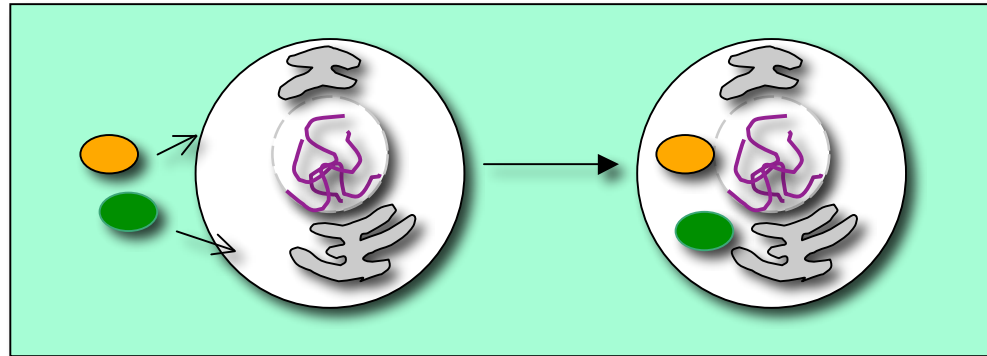
FIRST: prokaryotic plasma membrane formed inward folds
--> creating a endomembrane system



Principles of Evolution - Origin of Eukaryotic Cells

SECOND: **endosymbiosis** generated mitochondria and chloroplasts (one species living inside of another)

- mitochondria and chloroplasts evolved from small symbiotic prokaryotes
- aerobic heterotrophic prokaryote --> **mitochondria**
photosynthetic prokaryote --> **chloroplast**



Principles of Evolution - Origin of Life (Hypothesis)

Biological Evolution



Evolution / Time

--> sexual reproduction }
--> mutations }

Nutrition: parasitism
saprophytism
holophytism
chemosynthesis
photosynthesis

Eukaryotic Cells

Protists

(protozoans/slime molds/
unicellular algae)

natural
selection



Principles of Evolution - Origin of Life (Hypothesis)

Biological
Evolution



Eukaryotic Cells



Oxygen revolution:

O_2 + methane --> CO_2

O_2 + ammonia --> N_2

O_2 + oxygen --> O_3 (ozone)

O_2 + metals --> ores, rocks

O_2 + organisms --> aerobic respiration



Multicellular organisms

Principles of Evolution - Origin of Life (Hypothesis)

Summary: Evolution of Eukaryotes

1. cell membrane encapsulates genetic DNA
 - ... development of nucleus - internalized genome
2. loss of a rigid cell wall
 - ... cells developed ability of phagocytosis - engulfing foods
 - ... allows clumping of cells --> multicellularity --> tissues
3. evolve a selectively permeable membrane
 - ... protection, gas & nutrients exchange with environment

Principles of Evolution - Origin of Life (Hypothesis)

4. evolve a cytoskeleton

... provides framework - cell growth, movement, & metabolism

5. evolve aerobic respiration

... more efficient energy transformation

6. develop various organelles (endosymbiosis)

... a sub-cell part specific for a metabolic function

The evolution of eukaryotes was the single most important step in evolution of multicellular life forms & was a key step that lead to plant & animal life.

Principles of Evolution - Origin of Life (Hypothesis)

**Biological
Evolution**



Multicellular organisms

cellularization

colony forms

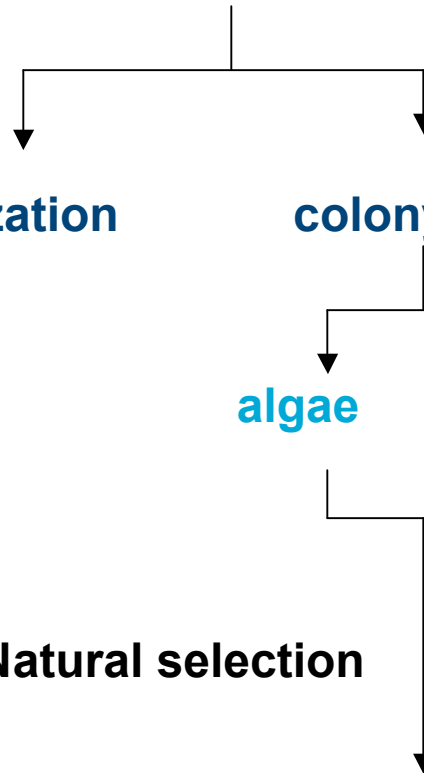
algae

slime mold

Natural selection

Sexual Mutations

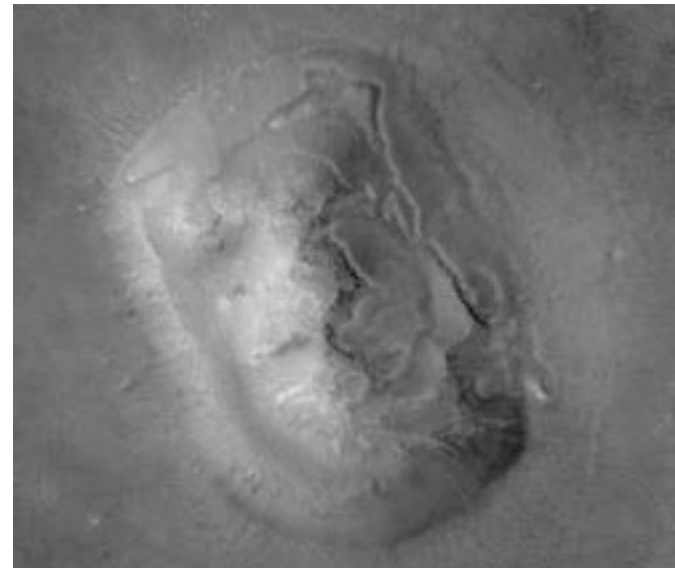
Origin of Species



Principles of Evolution - Exobiology

Exobiology

- the study of life beyond Earth



Principles of Evolution - Exobiology

Finding life elsewhere.

Life as we know it ...

- certain type of chemistry (carbon atoms, liquid water)
- requires a certain range of temperatures
- it alters its own environment in certain characteristic ways

Life as we don't know it ...

- based on unknown chemistry (silicon atoms?)
- lives under unknown conditions
- leaves an unknown mark on the world around it

Principles of Evolution - Exobiology

How can we search for something like that?

Learning about

“black smoke

ch ultra-hot

- survival in
(no light s
- $> 100^{\circ}\text{C}$ w
- surrounded by living creatures
(tube worms, sightless fish, blind crabs)



Principles of Evolution - Exobiology

Finding life elsewhere.

- animals survive on bacteria that thrive off the super-heated materials
- **chemosynthetic** (converting chemicals into useful energy)

“extremophiles” - bacteria that thrive on extremely hot, high-pressure conditions

conventionally defined habitable zone
(surface-dwelling, photosynthetic organisms)

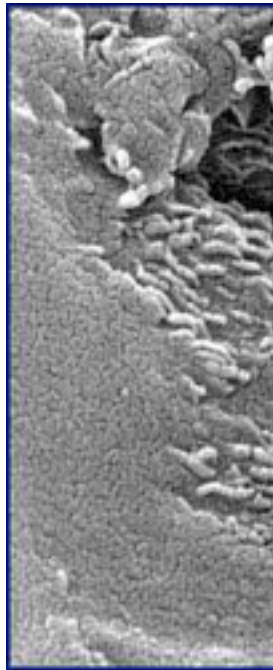


a lot more places where life might be happening

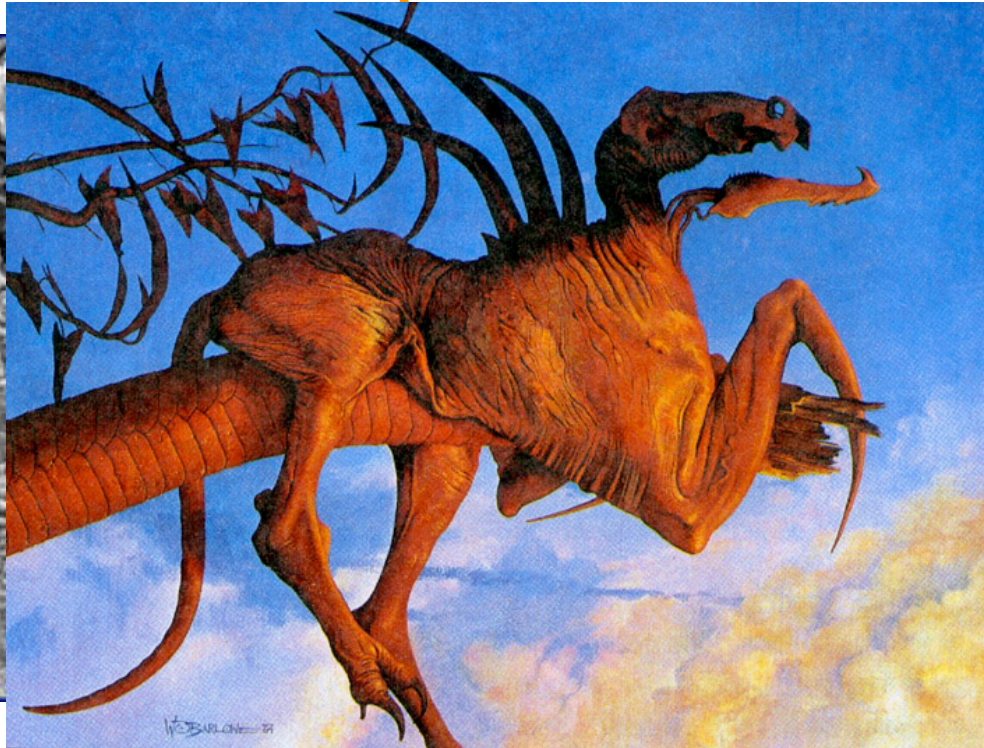
Principles of Evolution - Exobiology

Finding life elsewhere.

Mars ...



Europa ...



Enceladus ...

