EARLY EARTH AND THE ORIGIN OF LIFE
(Ch. 26)

In the Big Bang Theory, the observable universe began with an instantaneously expanding point, roughly ten to twenty billion years ago. Since then, the universe has continued to expand, gradually increasing the distance between our Galaxy and external galaxies. The expansion of the universe "stretches" light rays converting blue light into red light and red light into infrared light. Thus, distant galaxies, which are rapidly moving away from us, appear redder. Gravity slows the expansion of the universe. If the universe is dense enough, the expansion of the universe will eventually reverse and the universe will collapse. If the density is not high enough, then the expansion will continue forever.

- How life began is unknown, current theories attempt to reconstruct conditions on primitive earth and provide models of possible evolution.
- Sun is approximately 5 b.y.o. (dust, H, He aggregate to form sphere. Thermonuclear reactions occur when H nuclei collide forming He)
- Planet formation thought to have occurred through accumulation of particles with an increasing gravitational attraction for other particles.
- Earth estimated to have formed 4.6 b.y.o.
- Recent journals suggest evidence for life forming at about 3.8 – 3.9 bya. If this is true, life appeared early in Earth's history.
- Stromatolites are fossilized layers of sediment thought to have been produced by ancient bacteria. Dating has placed them at 3.5 b.y.o.

Abiotic synthesis, Spontaneous Generation, and the Beginning of Life.
In order for life to form, complex organic molecules need to be synthesized from precursor molecules. This requires energy, simple molecules, and ***luck***! Chemical evolution depends on a primitive earth that is much different from today's earth. [Non-oxidizing atmosphere.]

1) The formation of living organisms requires:

a) Molecules and elements most form larger molecules to be monomers of more complex macromolecules (amino acids, nucleic acids)

i) Oparin/Haldane Hypothesis

(1) Proposed that a primitive reducing atmosphere (H_2, H_2O, CH_4, NH_3), and abundant supply of H, O, C, N were able to aggregate to from simple organic molecules.
(2) **Absence** (minimal) of O_2 prevents oxidation of newly formed molecules.
(3) Energy from volcanoes, UV light from sun could provided necessary energy to form bonds.

ii) Urey/Miller Experiment

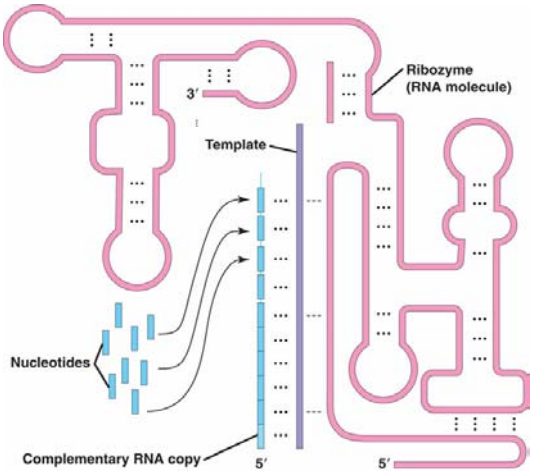
(1) Simulated conditions of early earth (gases present and energy from sparks)
(2) Synthesized 11/20 amino acids from differing gas combinations.
(3) Gases used in experiment have since been disputed.

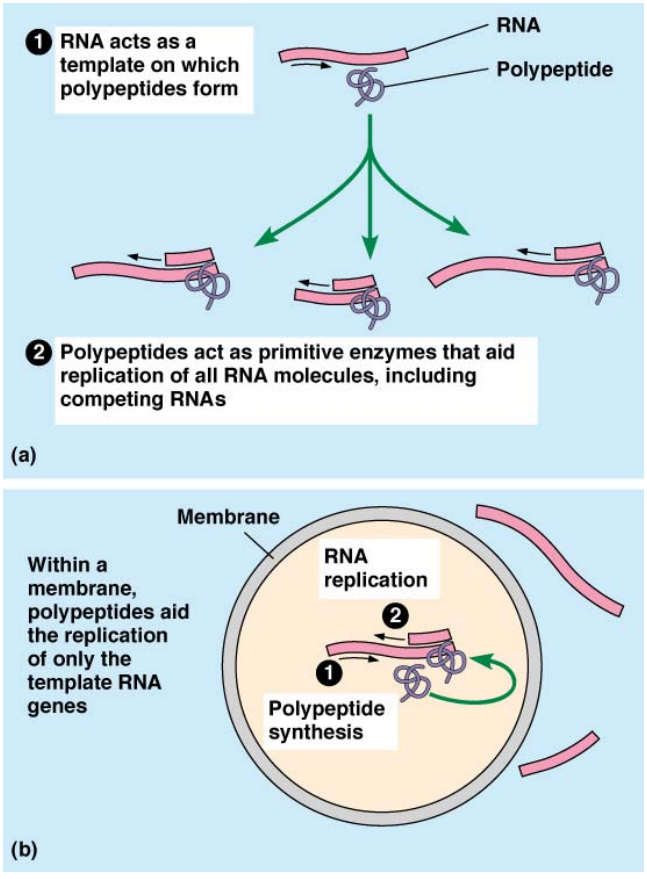
Composition of early atmosphere continues to be debated.
Free Oxygen can be created by photodissociation of water (present in volcanic emissions)

b) *Monomers must come together to form polymers.*
   i) Dehydration synthesis is required to combine monomers into polymers. Enzyme catalyzed today.
   ii) Studies simulating the conditions of earth have formed polymers using warm clay as a substrate for polymerization.
      (1) **Sydney Fox** (U. of Miami). Suggests process for the formation of proteinoids (polypeptides formed by abiotic means).

c) *Polymers form structures that are chemically distinct from their environment.*
   i) Protobionts are small "membrane-bound" structures that have an internal environment different from their surroundings.
      (1) *Microspheres*- protein spheres; selectively permeable; excitable.
      (2) *Liposomes*- lipid spheres. Internal environment differs. Fission produces smaller spheres.
      (3) *Coacervates*- polypeptides, nucleic acids, polysaccharide sphere.

d) *Chemically distinct structures must be able to replicate and pass on this primitive form.*
   i) In order for primitive cells to persist, they must be able to pass on ability to grow, develop, and metabolize. Require some type of hereditary material.
   ii) RNA is thought to have been the first genetic material because of its autocatalytic properties.
   iii) Ribozymes (RNA molecules with protein-like catalytic properties) can cause modification of pre-RNA (splicesome). Supports idea that RNA could self-replicate from an original strand with high degree of accuracy.





   iv) Replication and translation of genetic information requires cooperation between numerous molecules. This can allow for the use of material for metabolic processes from their surroundings. Protobionts that have this ability would have been selected for by natural selection.

These hypotheses suggest a mechanism for how chemical evolution may have occurred.
Do not answer the question.
Do the laws of probability hold?

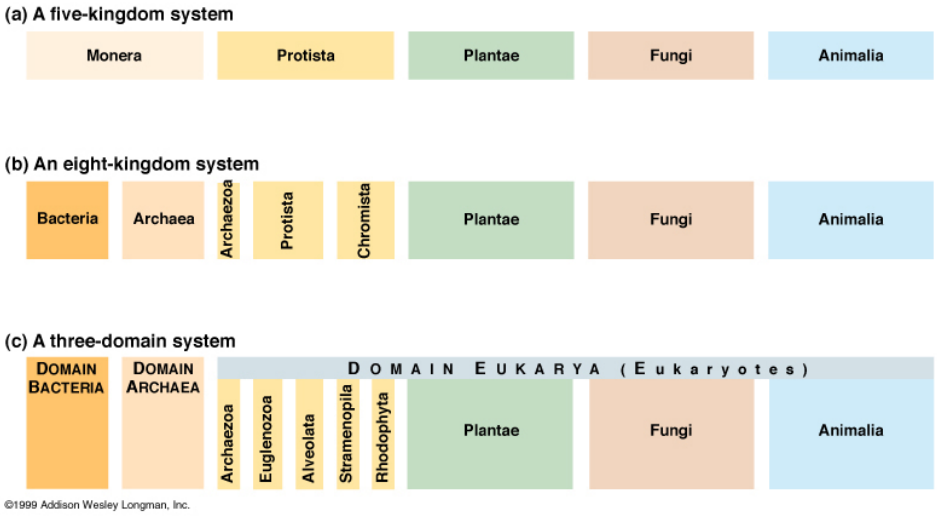
Classification and The Tree of Life. How new information changes our schemes.

- The abundance of Life of Earth lends itself to a classification system that assists in the grouping and naming of these organisms.
- The hierarchical system of classification system developed by Linnaeus has the Kingdom taxon as the most inclusive, largest category. Created to attempt to order life. Human construct.

1) Originally 2 Kingdom System
   a) Animalia (move, eat, determinate growth); protozoa and animals.
   b) Plantae (do not move, eat, indeterminate growth); fungi, algae, bacteria.

Observed differences between prokaryote and eukaryotes and biochemistry aided in the development of more kingdoms.

2) 5 Kingdom System
   a) Robert Whittaker (Cornell, 1969)
      i) Prokaryotes
         (1) Monera
      ii) Eukaryotes
         (1) Fungi
         (2) Plantae
         (3) Animalia
         (4) Protista



The Lumpers and Splitters

3) Current trends include dividing the prokaryotes into multiple kingdoms
   a) ***Eubacteria (commonly called Bacteria)*** "true". Structurally, biochemically, physiologically different from archaebacteria.
   b) ***Archaebacteria (referred to as Archaea)*** "ancient" substantially different. Inhabitant of extreme environments (halophilic, thermophilic)

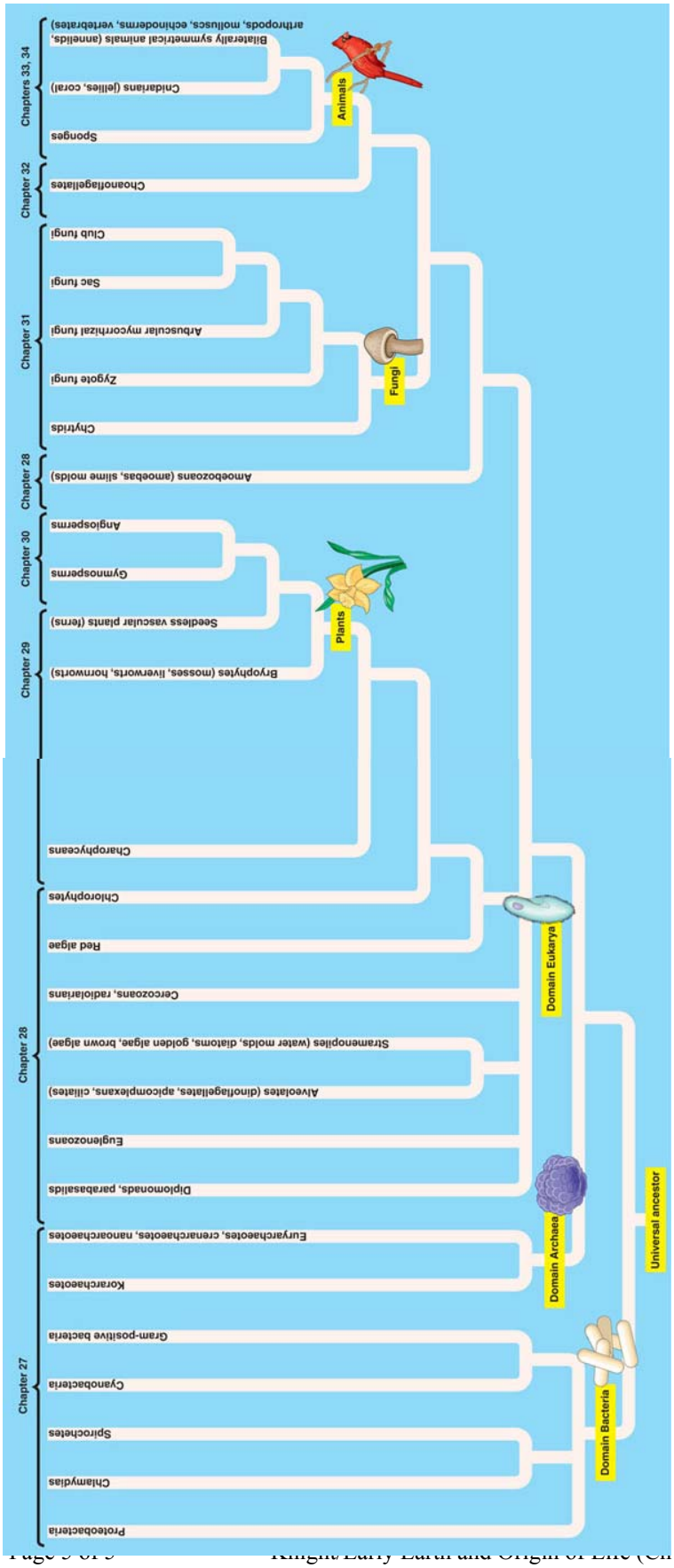
4) 3 Domain System
   a) Domain is a "SuperKingdom"- higher taxon than kingdom.
      i) Domain Bacteria (Eubacteria)
      ii) Domain Archaea (Archaebacteria)
      iii) Domain Eukarya (Eukaryotes)

What does the 3 domain system show?

- ✓ Not all prokaryotes are closely related (not monophyletic).
- ✓ Prokaryotes split early in the history of life into two lineages (Doman Archaea and Bacteria); not all in one lineage.
- ✓ Archaea are more closely related to Eukarya than to Bacteria.
- ✓ Eukarya are not directly related to bacteria.
- ✓ There was a common ancestor for all extant organisms (monophyletic).
- ✓ Eukaryotes are more closely related to each other (than Prokaryotes are to each other)

Table 27.2 A Comparison of the Three Domains of Life

CHARACTERISTIC	DOMAIN		
	Bacteria	Archaea	Eukarya
Nuclear envelope	Absent	Absent	Present
Membrane-enclosed organelles	Absent	Absent	Present
Peptidoglycan in cell wall	Present	Absent	Absent
Membrane lipids	Unbranched hydrocarbons	Some branched hydrocarbons	Unbranched hydrocarbons
RNA polymerase	One kind	Several kinds	Several kinds
Initiator amino acid for protein synthesis	Formyl-methionine	Methionine	Methionine
Introns (noncoding parts of genes)	Rare	Present in some genes	Present
Response to the antibiotics streptomycin and chloramphenicol	Growth inhibited	Growth not inhibited	Growth not inhibited
Histones associated with DNA	Absent	Present	Present
Circular chromosome	Present	Present	Absent
Ability to grow at temperatures > 100°C	No	Some species	No


Universal ancestor
Domain Bacteria
Domain Archaea
Domain Eukarya
Animals
Fungi
Plants
Chapters 33, 34
Bilaterally symmetrical animals (annelids, arthropods, molluscs, echinoderms, vertebrates)
Cnidarians (jellies, coral)
Sponges
Chapter 32
Choanoflagellates
Chapter 31
Club fungi
Sac fungi
Arbuscular mycorrhizal fungi
Zygote fungi
Chytrids
Chapter 28
Amoebozoans (amoebas, slime molds)
Chapter 30
Angiosperms
Gymnosperms
Chapter 29
Seedless vascular plants (ferns)
Bryophytes (mosses, liverworts, hornworts)
Chapter 28
Charophyceans
Chlorophytes
Red algae
Cercozoans, radiolarians
Stramenopiles (water molds, diatoms, golden algae, brown algae)
Alveolates (dinoflagellates, apicomplexans, ciliates)
Euglenozoans
Diplomonads, parabasalids
Chapter 27
Euryarchaeotes, crenarchaeotes, nanoarchaeotes
Korarchaeotes
Gram-positive bacteria
Cyanobacteria
Spirochetes
Chlamydias
Proteobacteria