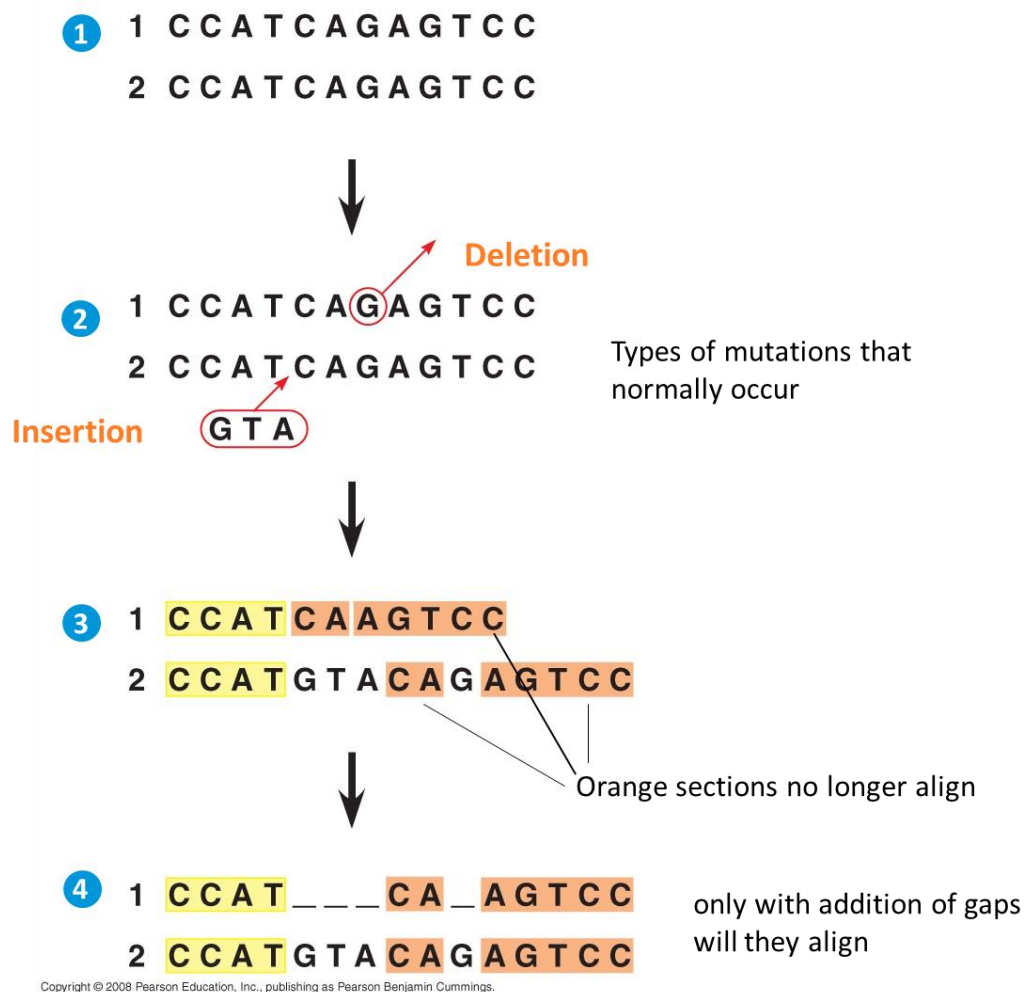




- It is also important to distinguish homology from analogy in molecular similarities
- Mathematical tools help to identify molecular homoplasies, or coincidences

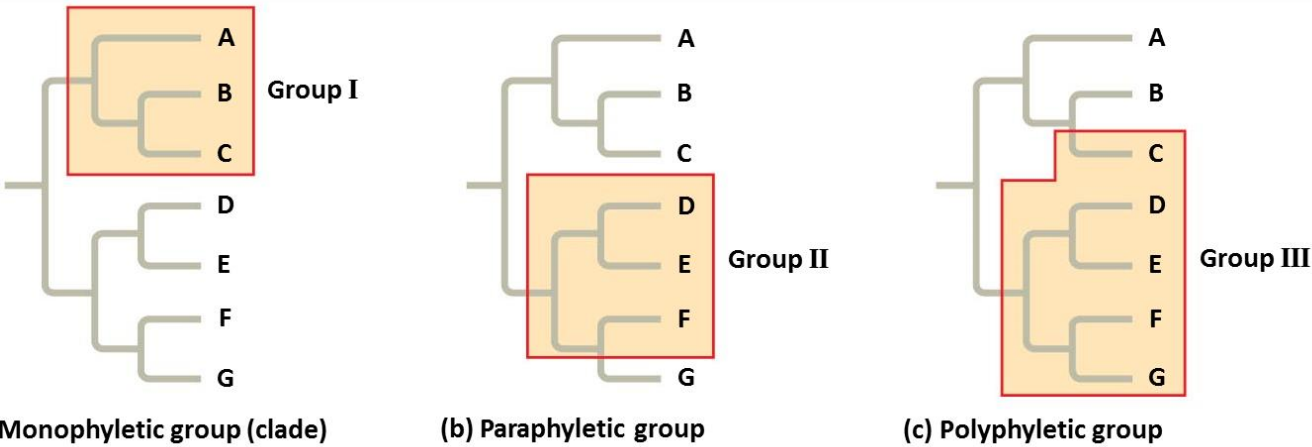
A C G G A T A G T C C A C T A G G C A C T A
T C A C C G A C A G G T C T T T G A C T A G

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- Molecular systematics uses DNA and other molecular data to determine evolutionary relationships

Shared characters are used to construct phylogenetic trees

- Cladistics groups organisms by common descent
- A **clade** is a group of species that includes an ancestral species and all its descendants
- A valid clade is monophyletic, signifying that it consists of the ancestor species and all its descendants
- A paraphyletic grouping consists of an ancestral species and some, but not all, of the descendants
- A polyphyletic grouping consists of various species that lack a common ancestor

Includes all descendants



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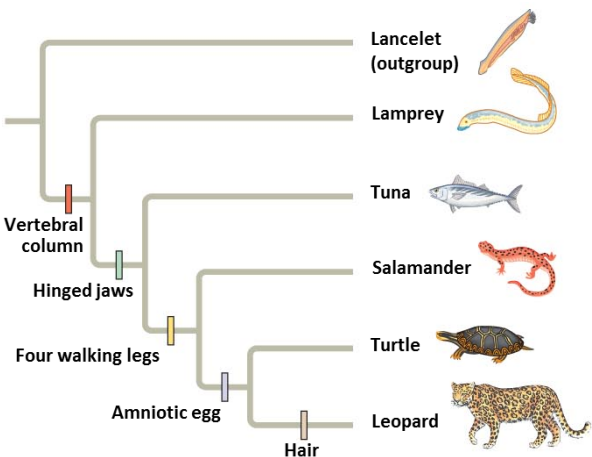
79-Shared Ancestral and Shared Derived Characters

- In comparison with its ancestor, an organism has both shared and different characteristics
- A shared ancestral character is a character that originated in an ancestor of the taxon
- A shared derived character is an evolutionary novelty unique to a particular clade
- A character can be both ancestral and derived, depending on the context, it is useful to know in which clade a shared derived character first appeared

CHARACTERS	TAXA					
	Lancelet (outgroup)	Lamprey	Tuna	Salamander	Turtle	Leopard
Vertebral column (backbone)	0	1	1	1	1	1
Hinged jaws	0	0	1	1	1	1
Four walking legs	0	0	0	1	1	1
Amniotic (shelled) egg	0	0	0	0	1	1
Hair	0	0	0	0	0	1

(a) Character table

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(b) Phylogenetic tree

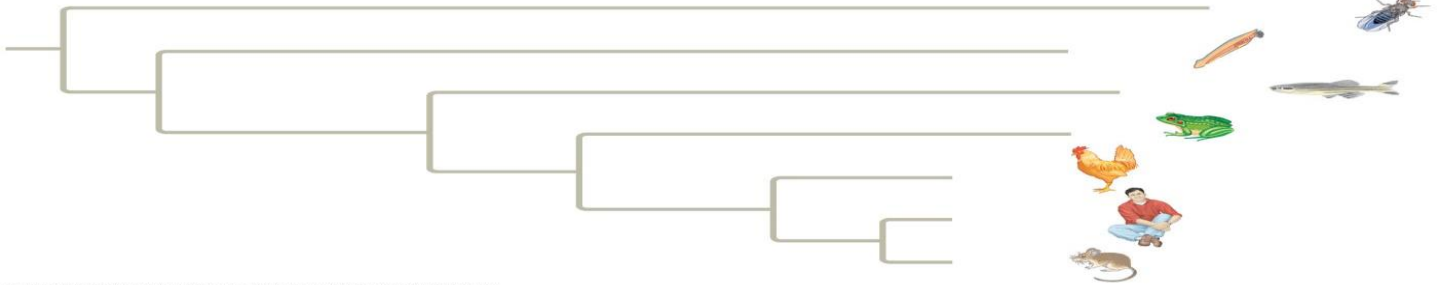
- An out-group is a species or group of species that is closely related to the in-group, the various species being studied
- Systematists compare each in-group species with the out-group to differentiate between shared derived and shared ancestral characteristics

80-Shared Ancestral and Shared Derived Characters

- Homologies shared by the out-group and in-group are ancestral characters that predate the divergence of both groups from a common ancestor

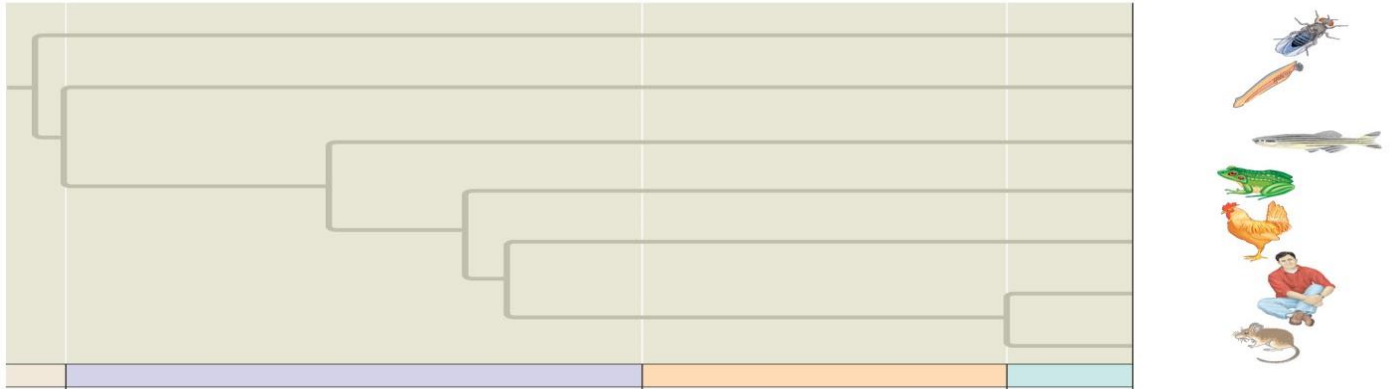
Phylogenetic Trees with Proportional Branch Lengths

- In some trees, the length of a branch can reflect the number of genetic changes that have taken place in a particular DNA sequence in that lineage



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- In other trees, branch length can represent chronological time, and branching points can be determined from the fossil record



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- Systematists can never be sure of finding the best tree in a large data set
- They narrow possibilities by applying the principles of maximum parsimony and maximum likelihood

Maximum Parsimony and Maximum Likelihood

- Maximum parsimony assumes that the tree that requires the fewest evolutionary events (appearances of shared derived characters) is the most likely
- The principle of maximum likelihood states that, given certain rules about how DNA changes over time, a tree can be found that reflects the most likely sequence of evolutionary events

81-Evolution of Definitions of Ecology

- Ecology = from the Greek root OIKOS, “at home”, and OLOGY, “the study of” Haeckle (1870):
- “By ecology we mean the body of knowledge concerning the economy of Nature - the investigation of the total relations of the animal to its inorganic and organic environment.”
- Burdon-Sanderson (1890s): Elevated Ecology to one of the three natural divisions of Biology: Physiology - Morphology - Ecology
- Elton (1927): “Scientific natural history”
- Andrewartha (1961): “The scientific study of the distribution and abundance of organisms”
- Odum (1963): “The structure and function of Nature”

Our Definition

- “Ecology is the scientific study of the processes regulating the distribution and abundance of organisms and the interactions among them, and the study of how these organisms in turn mediate the transport and transformation of energy and matter in the biosphere (i.e., the study of the design of ecosystem structure and function).
- Beyond Fundamental Ecology Applied Ecology:

- Using ecological principles to maintain conditions necessary for the continuation of present day life on earth.

Industrial Ecology

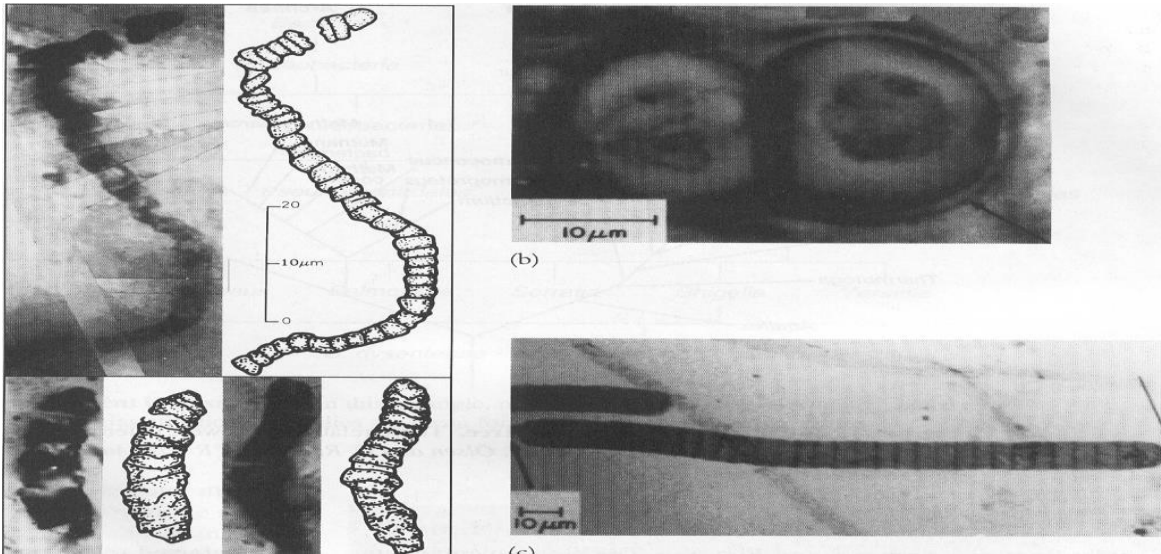
- The design of the industrial infrastructure such that it consists of a series of interlocking "technological ecosystems" interfacing with global natural ecosystems.
- Industrial ecology takes the pattern and processes of natural ecosystems as a design for sustainability. It represents a shift in model from conquering nature to becoming nature.

Ecological Engineering

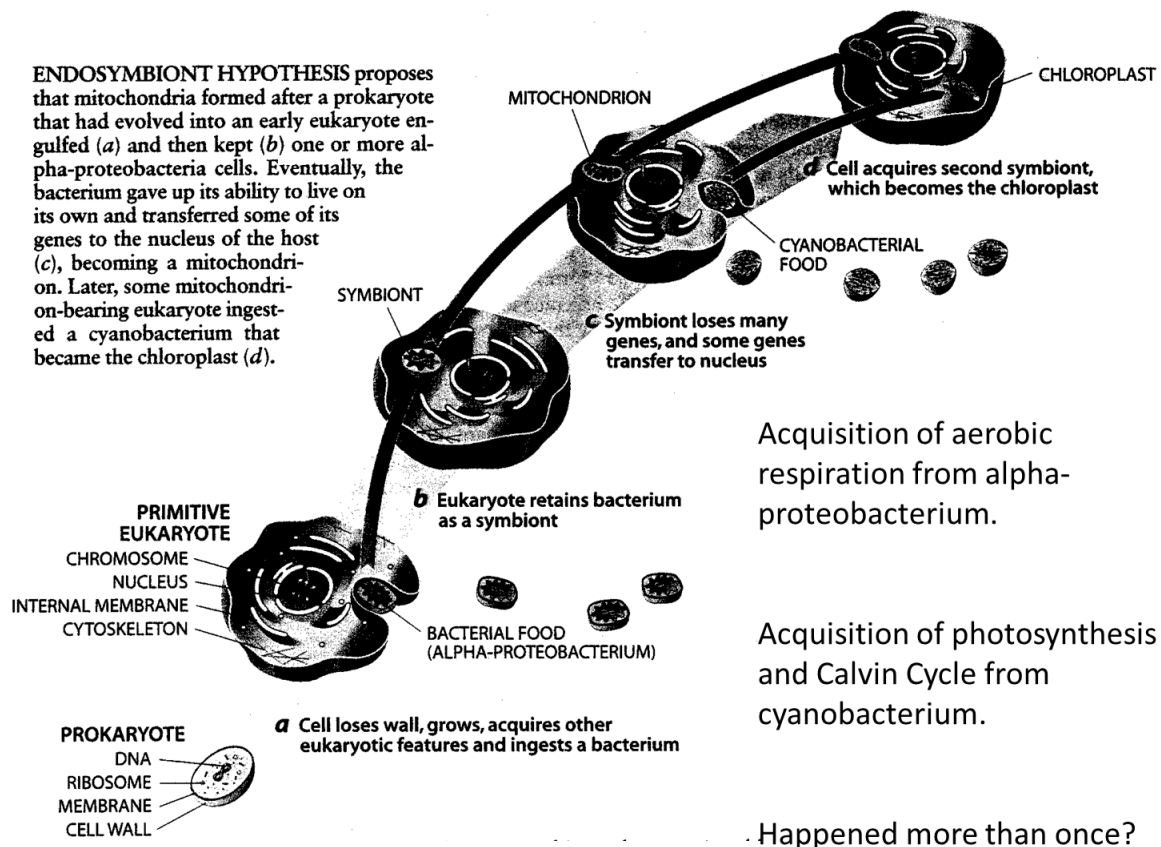
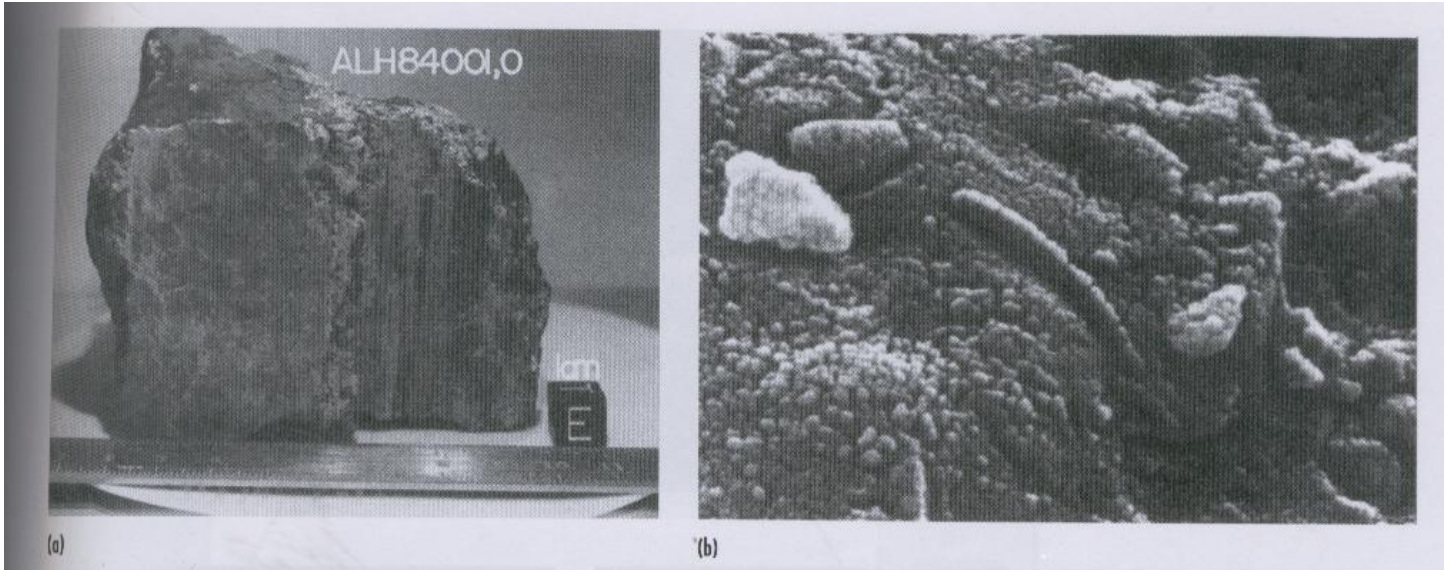
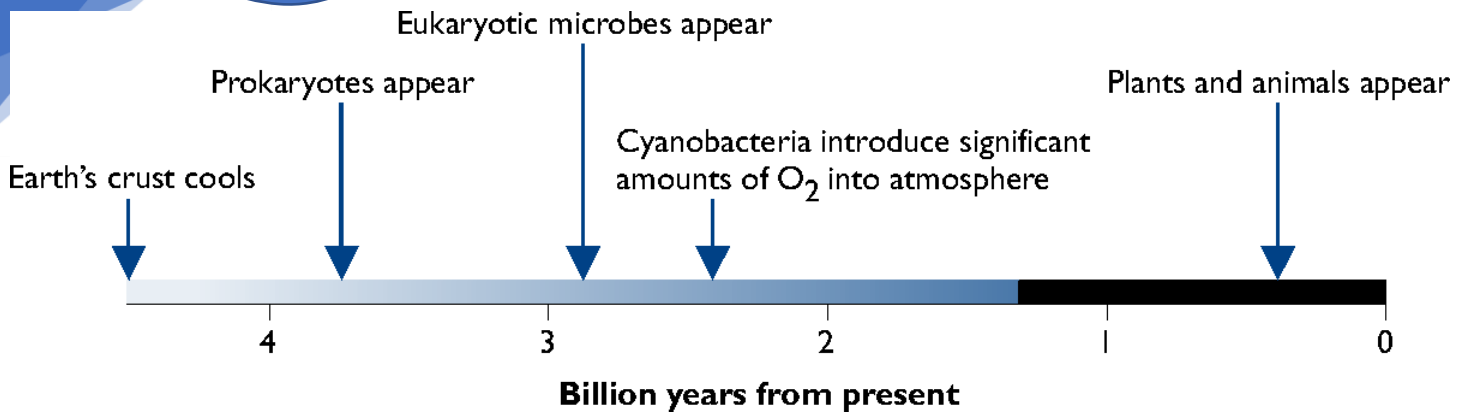
- Unlike industrial ecology, the focus of Ecological Engineering is on the manipulation of natural ecosystems by humans for our purposes, using small amounts of supplemental energy to control systems in which the main energy drives are still coming from non-human sources.
- It is the design of new ecosystems for human purposes, using the self-organizing principles of natural ecosystems.

82-Ecological Economics

Over 3.5 billion years of "microbes"



Micro-fossils of "cyanobacteria" and contemporary stromatolites.

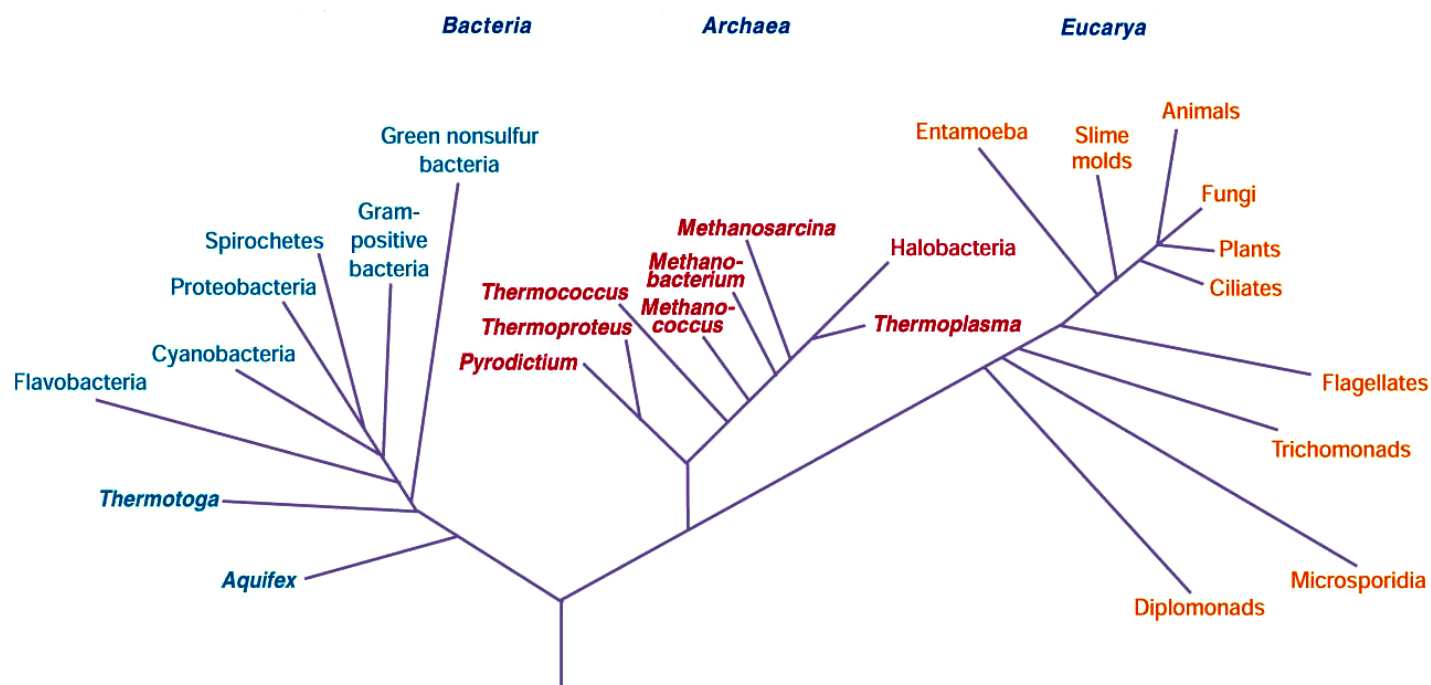


Major challenges for endosymbiotic theory

1. Most extant prokaryotes have rigid cell walls and don't do phagocytosis.
2. Hard to explain the nucleus (!) and flagella. (Eukaryotic flagella have a 9+2 arrangement of protein strands, vs. single strand for prokaryotic flagella.)

83-Evolution of Microbes

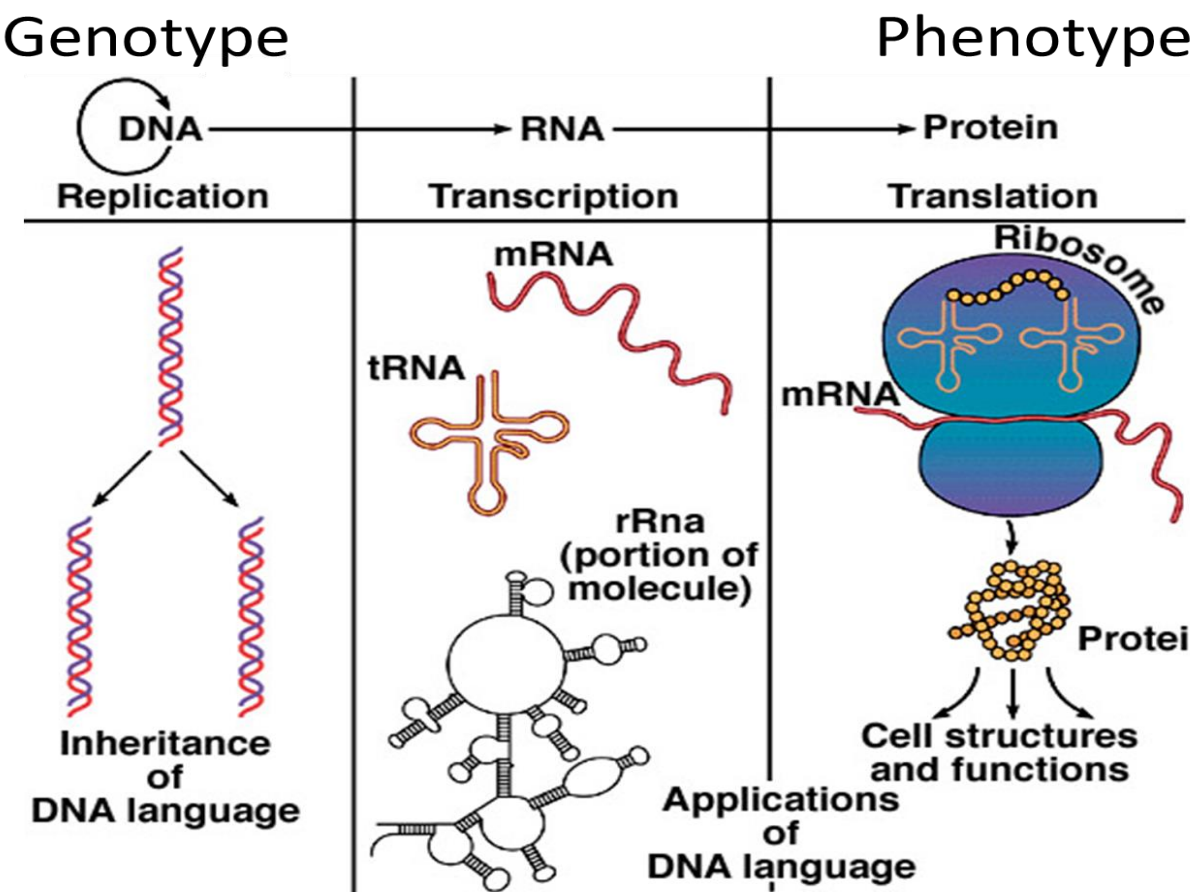
84-Phylogenetic Tree of Life



Rooted Tree based on 16SrRNA and 18SrRNA sequence data.

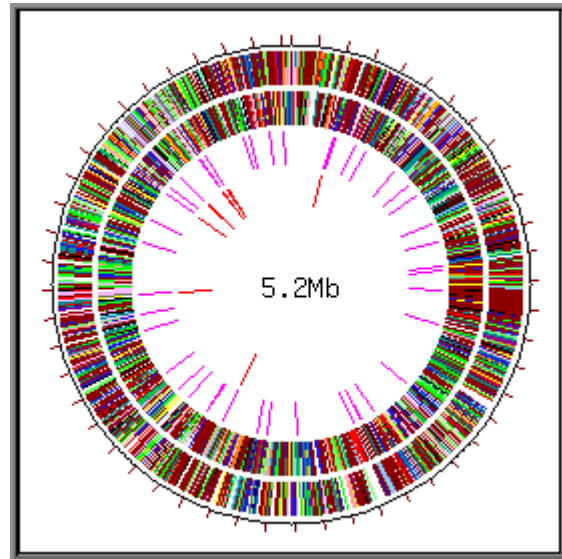
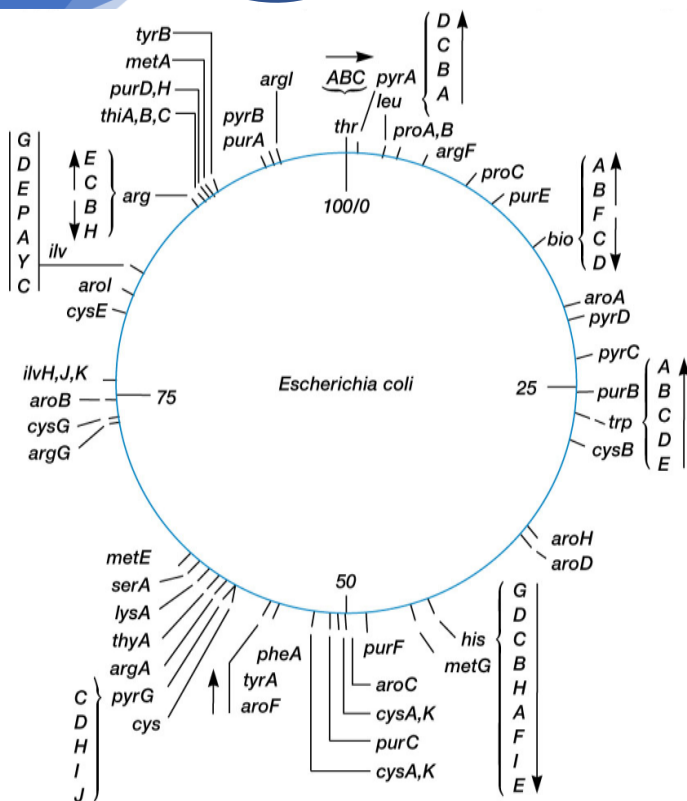
All extant life has evolved; evidence lost by extinction.

How does evolution work? We need to consider the molecule processes!



Bacterial Genomes

- Plasmids:
 - Size: 2-200 bp
 - Conjugative or not
 - Copy number varies
 - Gene functions vary



Scope of Mutation:

- A mutation is any change in the proper nucleic acid sequence of a specific gene in a cell's genome. It may result from a single base pair mismatch during DNA replication.
- Mutation can create genetic diversity within a population; either beneficial, neutral, bad, or lethal.
- Mutation could result in a new phenotype that is advantageous to successful reproduction of the mutated individual; this depends on particular environmental conditions, called selective pressures.
- Such beneficial mutations stay within a population from generation to generation, and drive the evolution of that species.
- Bad or lethal mutations are often lost from a population over subsequent generations.

Mutation types:

- Macrolesions (large sequence sections)
 - Deleted $a-b-c-d-e-f-g-h \rightarrow a-b-c-g-h$
 - Inserted $a-b-c-d-e-f-g-h \rightarrow a-b-c-d-x-y-z-e-f-g-h$
 - Inverted $a-b-c-d-e-f-g-h \rightarrow a-b-c-f-e-d-g-h$
 - Duplicated $a-b-c-d-e-f-g-h \rightarrow a-b-c-d-e-f-d-e-f-g-h$
- Microlesions (1 or 2 bp alteration)
 - Point Mutations (Base Substitutions) $ACTG \rightarrow AITG$
 - Frameshifts (Insertions or Deletions)

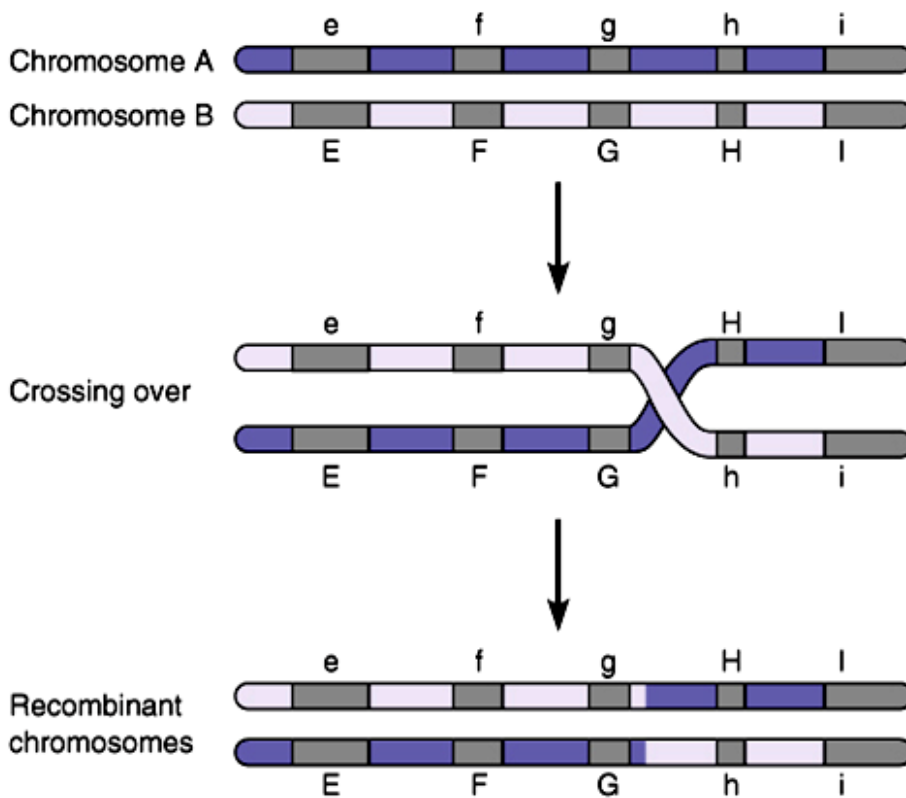
see the cat eat the rat $\rightarrow$ see thc ate att her at

- Mechanisms of microlesion mutation types
 - Spontaneous (1 per million; most corrected; 1 per billion remain)
 - Chemical mutagens
 - Radiation as mutagens

85-Genetic Recombination

Genetic Recombination:

- Two DNA molecules may recombine segments of their molecule in a process called crossing over.
- This is a relatively common event between chromosome copies in eukaryotes during meiosis. (Note the example here.)
- Prokaryote chromosomes, viral DNA, and smaller fragments of “foreign” DNA may recombine, adding new genes (or different alleles) to an individual cell.
- Bacteria can receive a foreign source of DNA for recombination through one of three different mechanisms of Genetic Exchange.



Horizontal Gene Transfer(= lateral gene exchange)

- Conjugation
- Transformation
- Transduction

