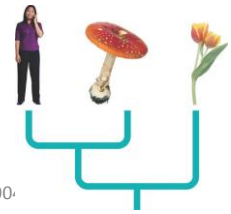
## Phylogeny & Systematics



An unexpected family tree. What are the evolutionary relationships among a human, a mushroom, and a tulip? Molecular systematics has revealed that—despite appearances—animals, including humans, and fungi, such as mushrooms, are more closely related to each other than either are to plants.



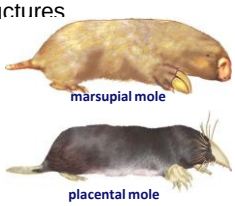
# Phylogeny & Systematics

- Phylogeny
  - evolutionary history of a species
  - based on common ancestries inferred from
    - fossil record
    - morphological & biochemical resemblances
    - molecular evidence
- Systematics
  - connects classification system to phylogeny by categorizing & naming organisms



# Building phylogenies

- Morphological & molecular homologies
  - similarities based on shared ancestries
    - bone structure
    - DNA sequences
  - beware of analogous structures
    - convergent evolution

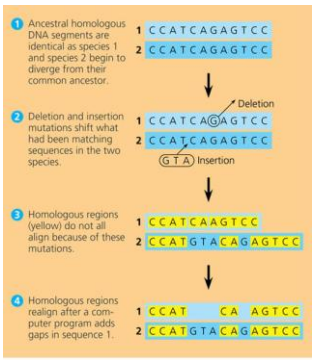


marsupial mole

placental mole

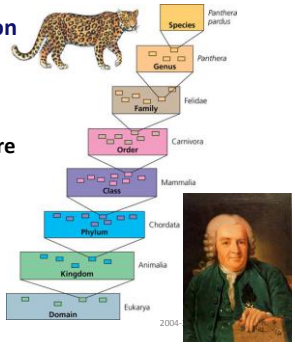
# Evaluating molecular homologies

- Aligning DNA sequences
  - more bases in common = more closely related
  - analyzed by software

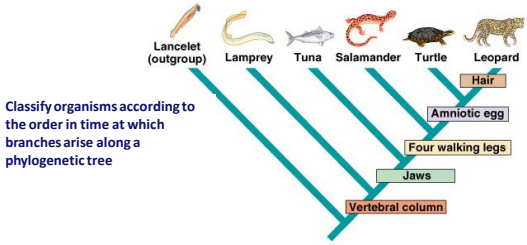
# Systematics

- **Connecting classification to phylogeny**
  - **hierarchical system**
  - **Carolus Linnaeas**
  - **Binomial nomenclature**
    - **genus**
    - ***species***



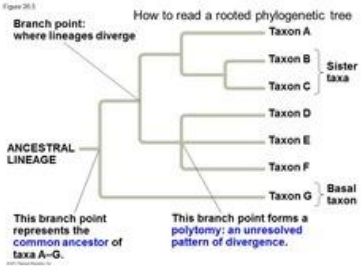

# Illustrating phylogeny

- Cladograms
  - patterns of shared characteristics



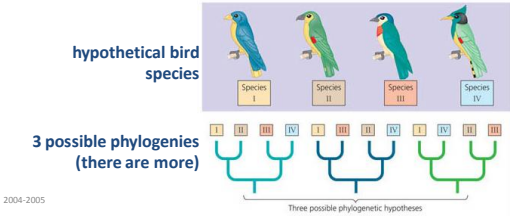

# Illustrating phylogeny

- Page 538 fig. 26.5: How to Read a Phylogenetic Tree



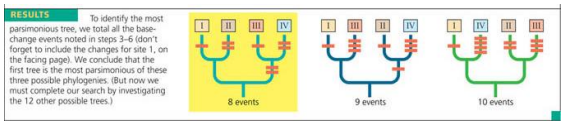

# Molecular Systematics

- Hypothesizing phylogenies using molecular data
  - apply principle of parsimony
    - simplest explanation
    - fewest evolutionary events that explain data



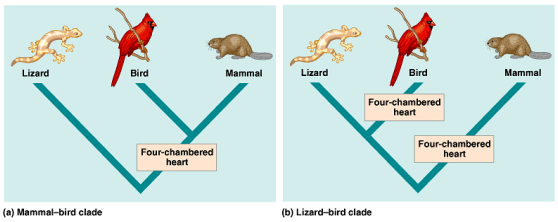
## Parsimony

- Choose the "tree" that explains the data invoking the fewest number of evolutionary events




2004-2005

## Parsimony & analogy vs. homology



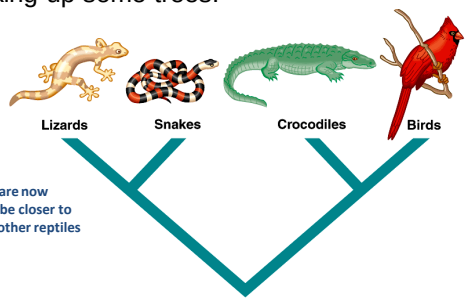

Phylogenetic trees are hypotheses

Which is the most parsimonious tree?

2004-2005

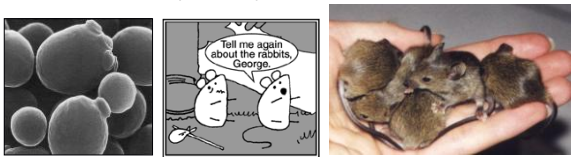
## Modern Systematics

- Shaking up some trees!



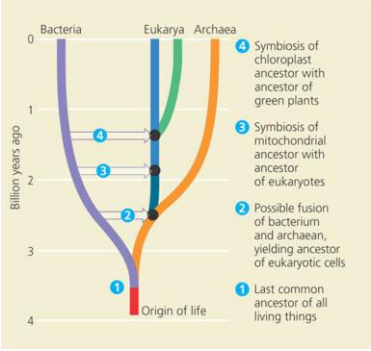

## Of Mice and Men…

- Evolving genomes
  - now that we can compare the entire genomes of different organisms, we find…
    - humans & mice have 99% of their genes in common
    - 50% of human genes have a close match with those of yeast!
      - the simplest eukaryote

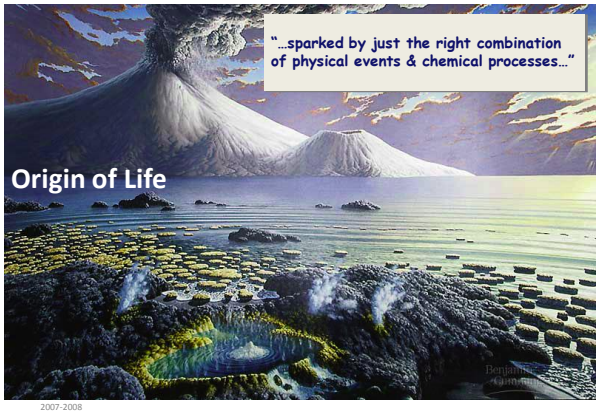


## Universal Tree of Life

- 3 Domains
  - Bacteria
  - Eukarya
  - Archaea




2004-2005




2007-2008

## The Origin of Life is Hypothesis

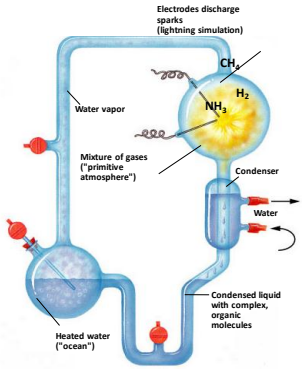
- Special Creation
  - *Was life created by a supernatural or divine force?*
  - not testable
- Extraterrestrial Origin
  - *Was the original source of organic (carbon) materials comets & meteorites striking early Earth?*
  - testable
- Spontaneous Abiotic Origin
  - *Did life evolve spontaneously from inorganic molecules?*
  - testable

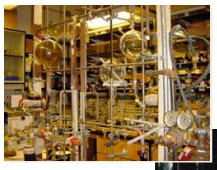
## Conditions on early Earth

- Early atmosphere
  - water vapor ($H_2O$), $CO_2$, $N_2$, $NO_x$, $H_2$, $NH_3$, $CH_4$, $H_2S$
  - no free oxygen
- Energy source
  - lightning, UV radiation, volcanic

# Origin of Organic Molecules

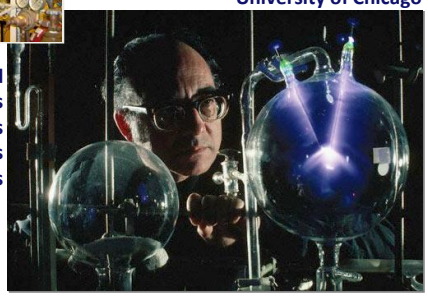
- Abiotic synthesis
  - 1920
    Oparin & Haldane
    propose reducing atmosphere hypothesis
  - 1953
    Miller & Urey
    test hypothesis
    - formed organic compounds
      - amino acids
      - adenine



## Stanley Miller

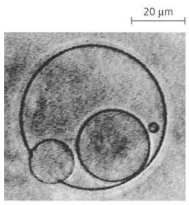
University of Chicago



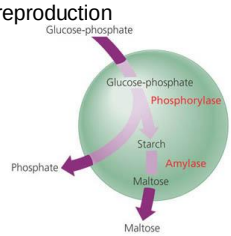
produced
-amino acids
-hydrocarbons
-nitrogen bases
-other organics

# Origin of Cells (Protobionts)

- Bubbles → separate inside from outside
  → metabolism & reproduction



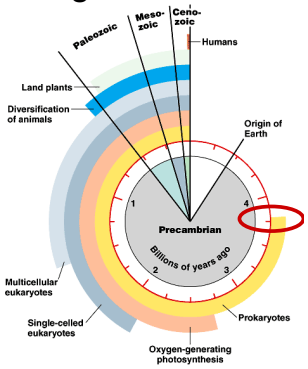

**(a) Simple reproduction.** This liposome is "giving birth" to smaller liposomes (LM).



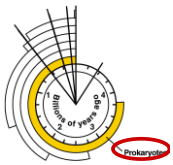

**(b) Simple metabolism.** If enzymes—in this case, phosphorylase and amylase—are included in the solution from which the droplets self-assemble, some liposomes can carry out simple metabolic reactions and export the products.

# Key Events in Origin of Life

- Key events in evolutionary history of life on Earth
  - life originated 3.5–4.0 bya



## Prokaryotes



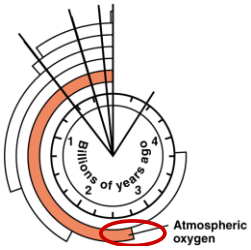

- Prokaryotes dominated life on Earth from 3.5–2.0 bya

3.5 billion year old fossil of bacteria

modern bacteria


## Oxygen atmosphere

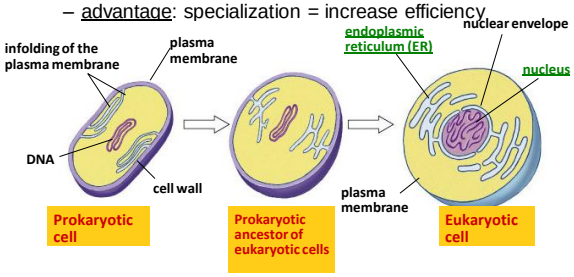
- Oxygen begins to accumulate 2.7 bya
  - evidence in banded iron in rocks = rusting
  - makes aerobic respiration possible




## First Eukaryotes

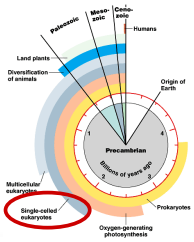
~2 bya

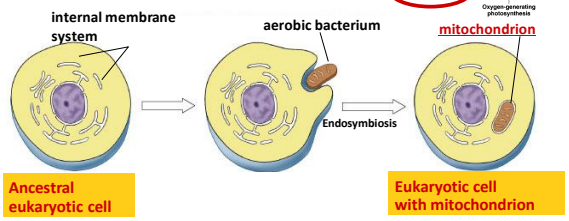
- Development of internal membranes
  - create internal micro-environments
  - advantage: specialization = increase efficiency




## Endosymbiosis

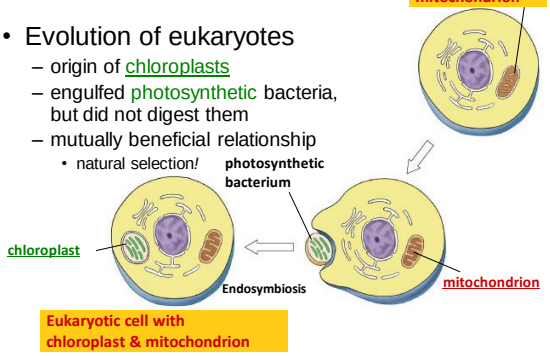
- Evolution of eukaryotes
  - origin of mitochondria
  - engulfed aerobic bacteria, but did not digest them
  - mutually beneficial relationship
    - natural selection!



# Endosymbiosis

- Evolution of eukaryotes
  - origin of chloroplasts
  - engulfed photosynthetic bacteria, but did not digest them
  - mutually beneficial relationship
    - natural selection!



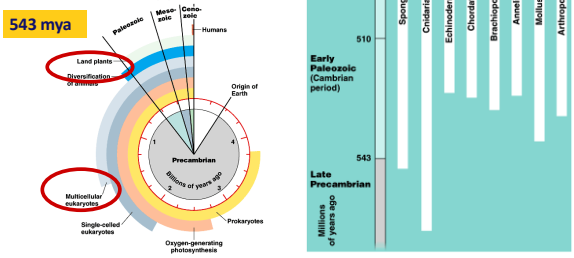

# Theory of Endosymbiosis

- Evidence
  - structural
    - mitochondria & chloroplasts resemble bacterial structure
  - genetic
    - mitochondria & chloroplasts have their own circular DNA, like bacteria
  - functional
    - mitochondria & chloroplasts move freely within the cell
    - mitochondria & chloroplasts reproduce independently from the cell

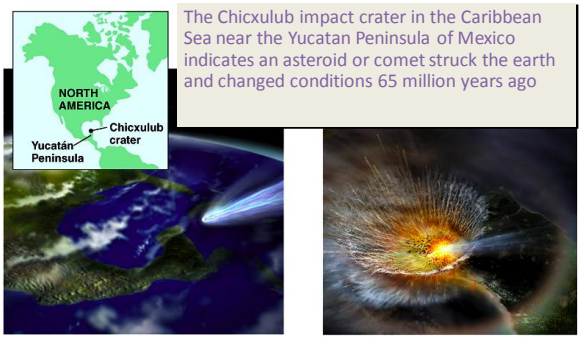
Lynn Margulis

# Cambrian explosion

- Diversification of Animals
  - within 10–20 million years most of the major phyla of animals appear in fossil record




# Cretaceous extinction




The Chicxulub impact crater in the Caribbean Sea near the Yucatan Peninsula of Mexico indicates an asteroid or comet struck the earth and changed conditions 65 million years ago

# Early mammal evolution

- 125 mya mammals began to radiate out & fill niches