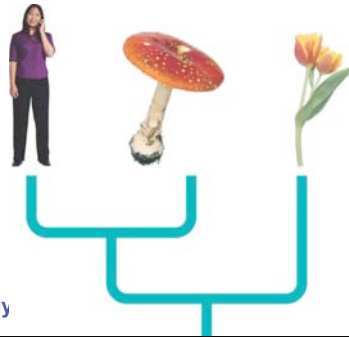




## Chapter 25.

# 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.

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## 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



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## Fossil record

- **Sedimentary rock are richest source of fossils**
  - ◆ fossil record is a substantial, but incomplete, chronicle of evolutionary history
    - spotty historical documents of biology
  - ◆ history of life of Earth is punctuated by mass extinctions

5000 year old ice mummy found on an Alpine ridge dividing Austria from Italy at 10,500 feet above sea level.



# Paleontology

- Study of fossils
  - ◆ fossils provide the strongest evidence of change
  - ◆ links past & current organisms

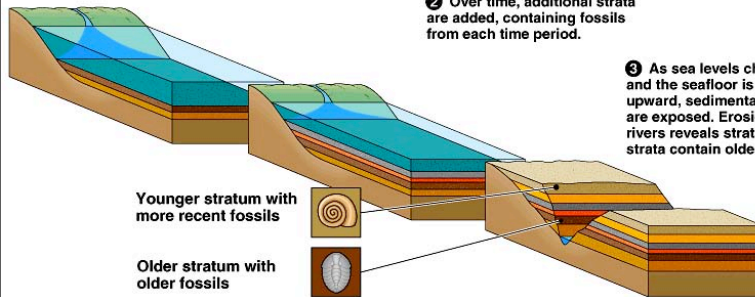


Woolly mammoth tusks

1 Rivers bring sediment to the ocean. Sedimentary rocks containing fossils form on the ocean floor.

2 Over time, additional strata are added, containing fossils from each time period.

3 As sea levels change and the seafloor is pushed upward, sedimentary rocks are exposed. Erosion by rivers reveals strata; older strata contain older fossils.



4-2005

# Fossils



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## Building phylogenies

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



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marsupial mole



placental mole

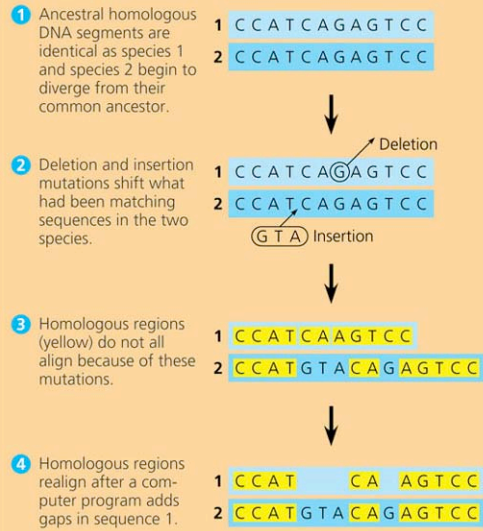
## Evaluating molecular homologies

### Aligning DNA sequences

- ◆ more bases in common = more closely related
- ◆ analyzed by software

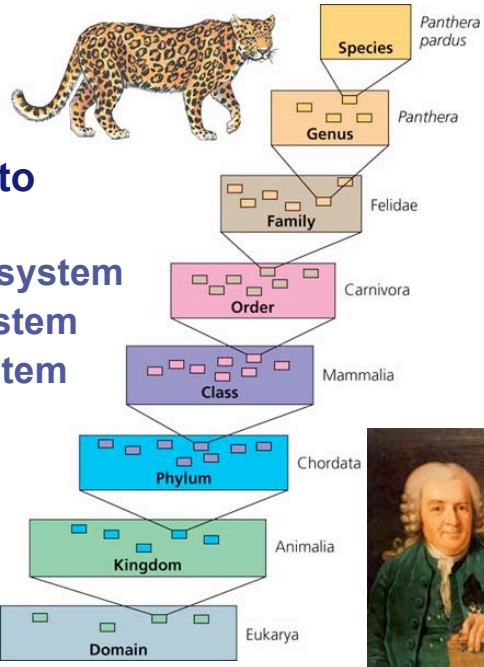
ACGGATAGTCCACTAGGCACTA  
 TCACCGACAGGCTTTGACTAG

beware of molecular homologies



# Systematics

- **Connecting classification to phylogeny**
  - ◆ hierarchical system
  - ◆ Linnaean system
  - ◆ binomial system
    - genus
    - species



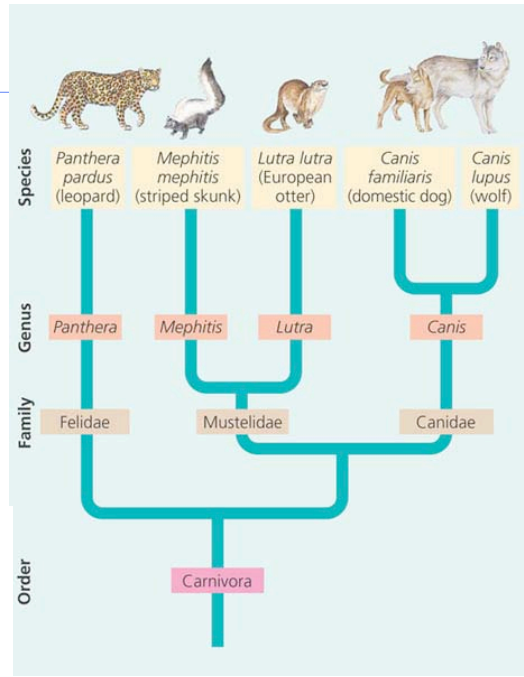
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## Building trees

- Connection between classification & phylogeny

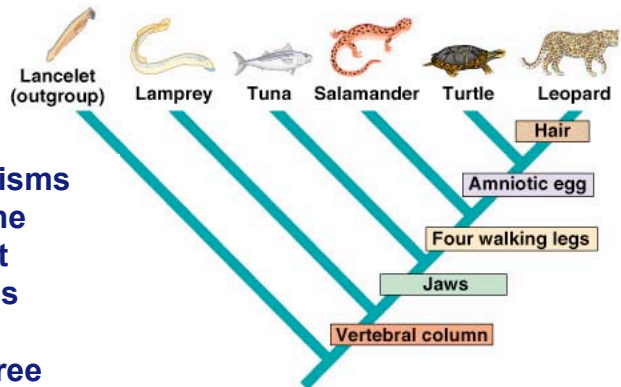
Tracing possible evolutionary relationships between some of the taxa of the order Carnivora, a branch of the class Mammalia.



## Illustrating phylogeny

### ■ Cladograms

- ◆ patterns of shared characteristics



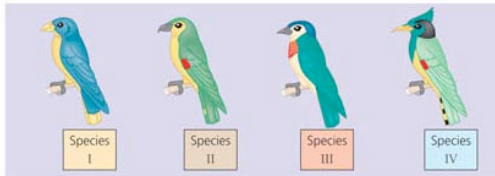
Classify organisms according to the order in time at which branches arise along a phylogenetic tree

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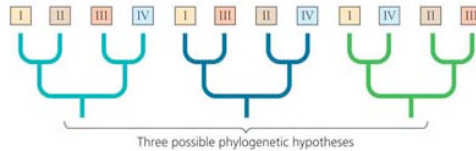
## Molecular Systematics

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

hypothetical bird species



3 possible phylogenies



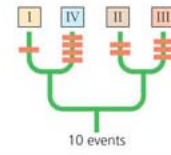
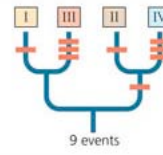
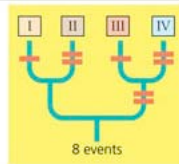
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# Parsimony

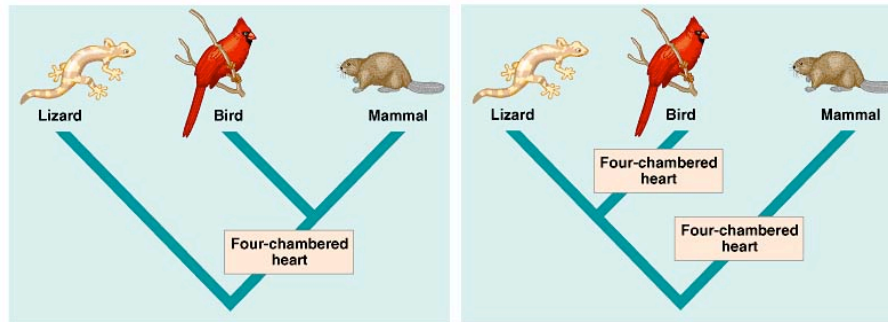
- Choose the “tree” that explains the data invoking the fewest number of evolutionary events

## RESULTS

To identify the most parsimonious tree, we total all the base-change events noted in steps 3-6 (don't forget to include the changes for site 1, on the facing page). We conclude that the first tree is the most parsimonious of these three possible phylogenies. (But now we must complete our search by investigating the 12 other possible trees.)



## Parsimony & analogy vs. homology



(a) Mammal–bird clade

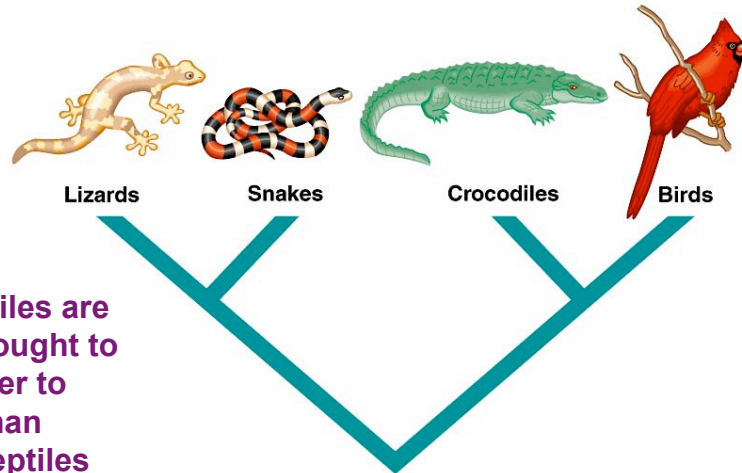
(b) Lizard–bird clade

**Phylogenetic trees are hypotheses**

**Which is the most parsimonious tree?**

## Modern Systematics

- Shaking up some trees!

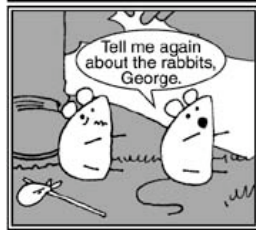


Crocodiles are now thought to be closer to birds than other reptiles

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## 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



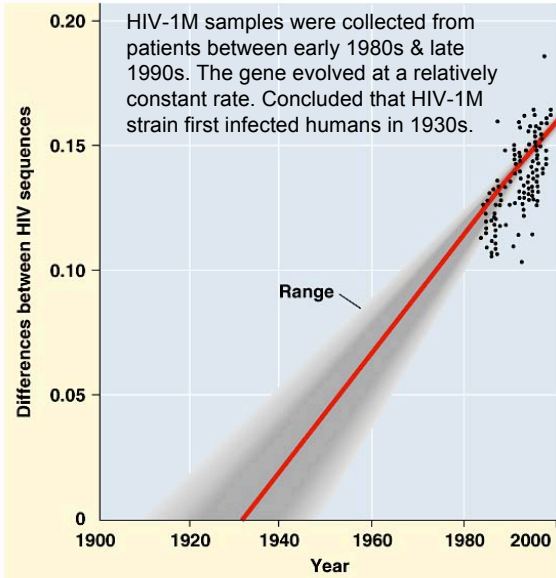
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## Molecular clocks

Trace variations in genomes to date evolutionary changes

Rate of change is calculated and then extrapolate back

What does this assume?



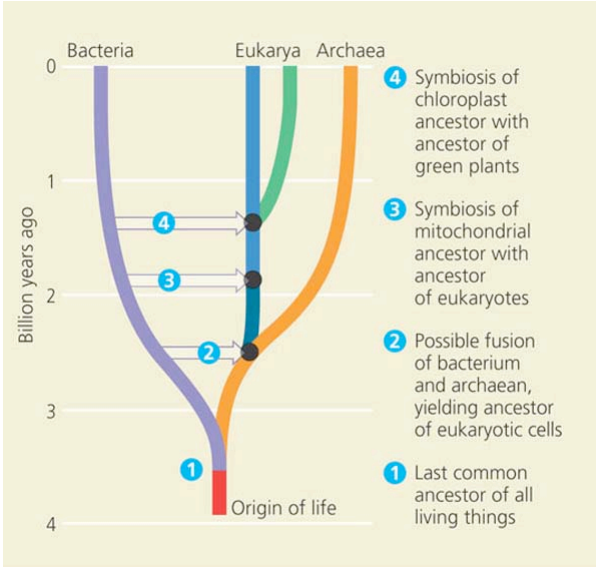
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# Universal Tree of Life

## ■ 3 Domains

- ◆ Bacteria
- ◆ Eukarya
- ◆ Archaea



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