**Phylogeny**

Ways to think about “trees”

- Darwin’s 1837 sketch
- A recent tree of life showing 191 species whose genome has been sequenced

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**Lecture outline**

- What are phylogenies?
- Phylogenetic trees
- Tree of life

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**What does a modern taxonomist do?**

- They do:
  - **Systematics**: scientific study of classifying organisms and determining their phylogeny
- So, they study:
  - **Phylogeny**: the evolutionary history of a species
- Incorporate DNA, biochemistry, morphology, fossils
- However, much current taxonomy ≠ phylogeny. Why?

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**Classification**

- **Linnaean system**
  - Carl Linnaeus (1707 – 1778)
- **Hierarchical**
- **What’s a taxon?**

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**Phylogenetic trees**

- Trees represent an attempt to bridge classification and phylogeny
- Represent an hypothesis about evolutionary relationships

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**Phylogenetic tree terminology**

- Branch point: where lineages diverge
- **ANCESTRAL LINEAGE**
  - This branch point represents the common ancestor of taxa A–G.
  - This branch point forms a polytomy: an unresolved pattern of divergence.
  - **Early divergence**

- **Sister taxa**
  - Share an immediate common ancestor

- **Basal taxon**
  - From a common ancestor; Usually a split or dichotomy

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“Data” needed for trees

- Homologous characteristics
- NOT analogous ones
  - = homoplasies
  - Homoplasies represent features arising from convergent evolution,
    - e.g., wings of birds, bats, and bees

Approach for building trees

- Cladistics: method of classifying organisms into clades based on common ancestry
- Each clade contains an ancestral species (i.e., the common ancestor) and all of its descendents
- Key component—hypothesis driven, can predict evolutionary relationships and test your predictions

Cladogram construction (1)

- Need a group of taxa (hopefully related + an outgroup taxon)
- Assemble several characters for the taxa and assess which taxa have which characters
- Assess whether the characters are ancestral or derived
- Draw the cladogram

Cladogram construction (2)

Fig. 26.12a

Cladogram construction (3)

Fig. 26.12a

Cladogram construction (4)

Fig. 26.12b
Some more key terms

- **Shared ancestral characters** are also called **symplesiomorphies**
  - **Plesiomorphy** represents the ancestral state of a character
- **Shared derived characters** are also called **synapomorphies**
  - **Apomorphy** represents the derived state of a character

Two other species concepts

- **Phylogenetic species concept**
  - Minimum number of individuals that share a common ancestor forming a branch on an evolutionary tree
- **Ecological Species**
  - Group of organisms sharing resources, called a species
  - Many other concepts of species exist besides the phylogenetic
  - Different species can be found in the same place at the same time
  - They differ mostly very poorly understood concept

Two other species concepts—example

- Is Class Reptilia a clade?

Clades and friends

- **C.A. & all descendants**
  - C.A. & all descendents
  - (a) Monophyletic group (clade)
  - (b) Paraphyletic group

- **Different C.A.s & some descendents**
  - Different C.A.s & some descendents
  - (c) Polyphyletic group

- Fig. 26.10

Clades and friends—example

- Is Class Reptilia a clade?

Cladogram construction (5)

- How are the many characters (e.g., think an entire genome) evaluated?
  - **Principle of maximum parsimony**
    - Simplest or fewest changes wins
    - Example: fewest number of DNA base changes
  - **Principle of maximum likelihood**
    - Assign some rules or assumptions about how characters change based on data and see which cladogram best fits the rules or assumptions
  - With enough data, the same tree or cladogram usually results; computer driven

Tree of Life (1)

- Linnaeus separated all of life into two kingdoms:
  - Vegetabilia and Animalia
- However, I learned 5 kingdoms:
  - Kingdom Monera
  - Kingdom Protista
  - Kingdom Plantae
  - Kingdom Fungi
  - Kingdom Animalia
- Now, we instead focus on Domains for our biggest grouping
  - Domain Bacteria
  - Domain Archaea
  - Domain Eukarya
- As we learn more, our view of the tree of life changes

Ernst Haeckel's tree in 1866; first good one
One major complication

- **Horizontal gene transfer**: transfer of genes via means other than reproduction (which would = vertical)

![Diagram of the Tree of Life](image1.png)

**Common Ancestor of All Life**

![Diagram showing the web of life](image2.png)

**Web of life?**

![Diagram of ancestral cell populations](image3.png)

**Ancestral Cell Populations**