What you need to know:

- The taxonomic categories and how they indicate relatedness.
- How systematics is used to develop phylogenetic trees.
- The three domains of life including their similarities and their differences.
Systematics: classifying organisms and determining their evolutionary relationships

- **Systematics**
- **Taxonomy** (classification)
- **Phylogenetics** (evolutionary history)
Tools used to determine evolutionary relationships:

1. Fossils
2. Morphology (homologous structures)
3. Molecular evidence (DNA, amino acids)

Who is more closely related?

Animals and fungi are more closely related than either is to plants.
Taxonomy: science of classifying and naming organisms

- Binomial nomenclature \((Genus \ species)\)

Naming system developed by Carolus Linnaeus.
REMEMBER!!

- **Dear King Philip Came Over For Good Spaghetti**
- **Dear King Philip Crossed Over Five Great Seas**
- **Dear King Philip Came Over From Germany Stoned**
- **Your own???”
Phylogenetic Tree

- Branching diagram that shows evolutionary history of a group of organisms

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnivora</td>
<td>Felidae</td>
<td>Panthera</td>
<td>Panthera pardus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(leopard)</td>
</tr>
<tr>
<td></td>
<td>Mustelidae</td>
<td>Taxidea</td>
<td>Taxidea taxus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(American badger)</td>
</tr>
<tr>
<td></td>
<td>Lutridae</td>
<td>Lutra</td>
<td>Lutra lutra</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(European otter)</td>
</tr>
<tr>
<td></td>
<td>Canidae</td>
<td>Canis</td>
<td>Canis latrans</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(coyote)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Canis lupus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(gray wolf)</td>
</tr>
</tbody>
</table>
Branch point: where lineages diverge

This branch point represents the common ancestor of taxa A–G.

This branch point forms a polytomy: an unresolved pattern of divergence.

Taxon A

Taxon B

Taxon C

Sister taxa

Taxon D

Taxon E

Taxon F

Taxon G

Basal taxon
Activity: Constructing a Cookie Phylogenetic Tree
Living (extant) species

Common ancestor (fossil)
Extant species

Common ancestor
Example of a Cookie Tree
Clade = group of species that includes an ancestral species + all descendents

Shared derived characteristics are used to construct cladograms

Cladogram: diagram that depicts patterns of shared characteristics among taxa
Monophyletic, paraphyletic, and polyphyletic groups

(a) Monophyletic group (clade)  
(b) Paraphyletic group  
(c) Polyphyletic group
A 0 indicates a character is absent; a 1 indicates that a character is present.
Branch lengths can represent genetic change
Branch lengths can indicate time
Draw a phylogenetic tree based on the data below. Draw hatch marks on the tree to indicate the origin(s) of each of the 6 characters.

<table>
<thead>
<tr>
<th>Character</th>
<th>Lancelet (outgroup)</th>
<th>Lamprey</th>
<th>Tuna</th>
<th>Salamander</th>
<th>Turtle</th>
<th>Leopard</th>
<th>Dolphin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backbone</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hinged jaw</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Four limbs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Amnion</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Milk</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Dorsal fin</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

*Although adult dolphins have only two obvious limbs (their flippers), as embryos they have two hind-limb buds, for a total of four limbs.*
Answer:

(a)

Lancelet (outgroup)
Lamprey
Tuna
Salamander
Turtle
Leopard
Dolphin
Various tree layouts

Circular (rooted) tree

Rooted tree

Unrooted tree
• Principle of **maximum parsimony**: use simplest explanation (fewest DNA changes) for tree – “keep it simple”

• **Molecular clocks**: some regions of DNA appear to evolve at constant rates
  ▫ Estimate date of past evolutionary events
  ▫ Eg. Origin of HIV infection in humans = 1930’s
Tree of Life

- 3 Domains: Bacteria, Archaea, Eukarya