Phylogenies

The history of Life
What is Phylogeny?

• The relationship of an organism to other organisms
  • organisms from which it is thought to have evolved from
  • species that are closely related and not so closely related
  • provides information on the shared ancestry

• may even provide timeline information
  • rooted phylogenetic trees – attempt to indicated timelines by length of branches
A Phylogenetic Tree

Some terminology relating to phylogenetic trees:
• branch point
• basal taxon
• sister taxa
• polytomy
Purpose & Limitations of Phylogenetic Trees

• Purpose – to gain an understanding of evolutionary history
  • Systematics = the field of study that organizes and classifies organisms based on evolutionary relationships
    • What information can be used to develop these phylogenetic trees?
      • fossils
      • physical traits
      • DNA and other biochemical features

• One thing to remember … a phylogenetic tree is a hypothesis!
  • meaning?
Purpose & Limitations of Phylogenetic Trees

What can go wrong?

• we can make assumptive mistakes based on visible features
Purpose & Limitations of Phylogenetic Trees

- Using a phylogenetic tree, you can see easily the shared and unshared traits between groups of organisms.
Purpose & Limitations of Phylogenetic Trees

Don’t view these events as terminal!
• just because “hair” evolved in mammals, doesn’t mean biological evolution has stopped in the other branches
  • otherwise the only “newest” species would be capable of change.
• just because DNA is traditionally passed from parent to offspring, it doesn’t mean it can’t happen differently!
  • sometimes there is Horizontal Gene Transfer
    • most commonly occurring in prokaryotes
    • though can happen in eukaryotes... remember the water bear?

• Soo, aside from the limitations, we do need to have an understanding of taxonomy for this to make sense...
Taxonomy – required for phylogeny to work

• Taxonomy = “arrangement law”
  • the science of classifying organisms from general to very specific and more inclusive groups
• How would you group these?
Levels of Classification

• Standardized system = Linnaean system creates a hierarchical structure, from least exclusive (domain) to most exclusive (species)

• The largest least exclusive level = domain
  • all life fits into just three large groups, by nature these groups must include a wide variety of organisms
    • but each group has to have a major difference to keep them separate!

• Subsequent classification levels become more and more exclusive

  kingdom ➔ phylum ➔ class ➔ order ➔ family ➔ genus ➔ species

• Linnaean system uses binomial nomenclature to indicate individual species
  • first name is the Genus (and is always capitalized), the second name is the species (and is not capitalized).
  • The name is either italicized, or underlined
    • ex. Pisaster ochraceus

Mnemonic device: Daring King Phillip Came Over From Germany Swimming
<table>
<thead>
<tr>
<th>Domain: Eukarya</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingdom: Animalia</td>
</tr>
<tr>
<td>Phylum: Chordata</td>
</tr>
<tr>
<td>Class: Mammalia</td>
</tr>
<tr>
<td>Order: Carnivora</td>
</tr>
<tr>
<td>Family: Canidae</td>
</tr>
<tr>
<td>Genus: Canis</td>
</tr>
<tr>
<td>Species: Canis lupus</td>
</tr>
<tr>
<td>Subspecies: Canis lupus familiaris</td>
</tr>
</tbody>
</table>

**Taxonomy of Canis lupus familiaris**
Developing Phylogenies

- Scientists look for
  - similarities in traits... may be
    - homologous structures
      - similar embryonic origins
    - analogous structures
      - different embryonic origins
      - similar selective pressures
  - molecular similarities using DNA
- together both morphological and molecular information are effective tools in developing phylogenies
The first phylogenetic tree..

The affinities of all the beings of the same class have sometimes been represented by a great tree. I believe this simile largely speaks the truth. The green and budding twigs may represent existing species; and those produced during former years may represent the long succession of extinct species. At each period of growth all the growing twigs have tried to branch out on all sides, and to overtop and kill the surrounding twigs and branches, in the same manner as species and groups of species have at all times overmastered other species in the great battle for life. The limbs divided into great branches, and these into lesser and lesser branches, were themselves once, when the tree was young, budding twigs; and this connection of the former and present buds by ramifying branches may well represent the classification of all extinct and living species in groups subordinate to groups. Of the many twigs which flourished when the tree was a mere bush, only two or three, now grown into great branches, yet survive and bear the other branches; so with the species which lived during long-past geological periods, very few have left living and modified descendants. From the first growth of the tree, many a limb and branch has decayed and dropped off; and these fallen branches of various sizes may represent those whole orders, families, and genera which have now no living representatives, and which are known to us only in a fossil state. As we here and there see a thin straggling branch springing from a fork low down in a tree, and which by some chance has been favoured and is still alive on its summit, so we occasionally see an animal like the Ornithorhynchus or Lepidosiren, which in some small degree connects by its affinities two large branches of life, and which has apparently been saved from fatal competition by having inhabited a protected station. As buds give rise by growth to fresh buds, and these, if vigorous, branch out and overtop on all sides many a feeble branch, so by generation I believe it has been with the great Tree of Life, which fills with its dead and broken branches the crust of the earth, and covers the surface with its ever-branching and beautiful ramifications.

Developing Phylogenies

• Why do we care about phylogenies?
  • understanding relationships between existing organisms can benefit us with regards to
    • medicine
    • foods
    • chemicals

• Gives us an understanding of the unity and diversity of life

If you know rosy periwinkle contains chemical compounds that help to fight childhood leukemia... then what do you do?
Other proposed models to indicate relationships among organisms extinct and extant

1. The Web of Life
   • shows the concept of horizontal gene flow
   • indicates multiple “roots” giving rise to the different domains
Other proposed models to indicate relationships among organisms extinct and extant

2. Ring of Life Model
   • indicates life branching out from a “pool” of prokaryotic cells
   • all sharing and swapping genomes
   • most are skeptical

So... what is the correct model?