The Tree of Life Web Project

http://tolweb.org

"The affinities of all the beings of the same class have sometimes been represented by a great tree... As buds give rise by growth to fresh buds, and these if vigorous, branch out and overtop on all sides many a feebler 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."

Charles Darwin, 1859

Tree of life **Name: _____**

The existing diversity of life is vast, but most of us are seldom exposed to this diversity. For example, the three kingdoms of older classifications — plants, animals, and fungi — together form just a small branch at the tip of one of the major divisions — Eukaryota— used in modern classification. Even within the familiar groups, most branches are unfamiliar even to biologists. As you do this assignment, I encourage you to explore some of the side branches along the way.

Evolutionary biologists have spent much of the last two centuries working out the relationships among organisms so that we can classify them. In the last few decades that effort explicitly searched for evidence of evolutionary relationships (phylogeny). For this assignment you will be using the Tree of Life Project, which is an ongoing attempt display all of the relationships for all living organisms in one giant tree posted on the web. The Tree of Life is an international collaborative project organized by David and Wayne Maddison at the University of Arizona. Experts volunteer to write the section of the Tree that concerns the group of organisms they know most about. The branches are connected by hypertext links that effectively let you climb up and down the Tree one set of branches at a time. Eventually, every lineage (branch) of life will be represented, including a separate page for every one of the more than 1 million known living and extinct species. At this time however, only some parts of the Tree are posted.

Each page in the Tree of Life corresponds to at least one taxon. Remember that a taxon is just a group of organisms. Usually a taxon corresponds to the group of organisms that all descend from a particular common ancestor. Another name for this is a clade. At the base of the tree each taxon will consists of millions of species – at the tip of the tree each taxon represents a single species. Each page will have a name corresponding to the name of a taxon. In some cases, several taxa may be listed on the same page. For example, on the Eukaryote page, you will see the name "opisthokonts" on the branch leading to the Animals, Fungi, and two other groups. The opisthokonts are another taxon which contains these groups.

1. Go to http://tolweb.org/tree/
2. Click on the link for the Root of the Tree

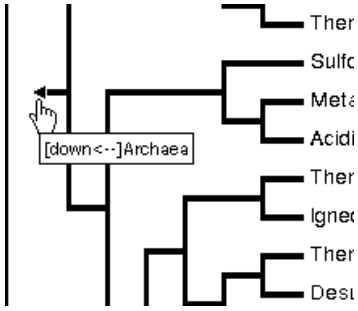
3. There you should see a page that looks like the screen capture to the right. This page is meant to represent the current understanding of the “Root of Life.” Notice how there is no label or name on the single root at the far left. This is because we do not yet know with any certainty what or if there was a single ancestor to all life on Earth. Also notice that viruses are not part of the tree. This is because biologists do not consider viruses to be alive.
4. **Briefly explain a few of the reasons viruses are not considered alive.**

5. Make sure you are still on the Life on Earth Page. Circle the level of classification are we currently viewing: **Domain, Kingdom, Phylum, Class, Order, family, Genus, Species**
6. Click on the *Archaea* to follow this branch. This will bring you to a new page with information about the *Archaea* and any subsequent branches that are currently known to have evolved. Follow the kingdom *Crenarchaeota* by clicking on its name. Scroll down past the pictures and look at the tree diagram. What is the number of subgroups *Crenarchaeota* shown on the tree? _____

7. Now read the introduction paragraph to find the information to the following questions.

8. The organisms in the kingdom *Crenarchaeota* have the highest known _____ _____ of any organisms.
9. They are _____, single-celled organisms they flourish under conditions that would quickly kill most "higher" organisms. As a rule, they grow best between _____.
10. Several species also prefer to live under very acidic conditions in dilute solutions of _____ _____ _____.
11. A species that is _____ is one that lives in marine or terrestrial volcanic environments, such as_____.
12. Although they are simple, microscopic organisms, ***Archaea*** are quite distinct from more commonly encountered Bacteria, having branched off from the latter very early in evolutionary history probably more than _____years ago. In fact, *Archaea* are more similar to humans than to Bacteria in many important ways, and are probably more closely related to us as well!
13. What factors would make biologists think Crenarchaeota would be similar to life on Mars?

14. Scroll back up to the top of the page and click the arrow at the left edge of the tree. (shown at right) Throughout the rest of this activity you will always be able to move back one level by clicking the root, this may be helpful if you take a wrong turn or just want to explore… but you'll have time for that later. If you haven't already, click to return to the Archaebacteria page.
15. What are the three kinds of Archaebacteria?



a. b. c.

16. Return to life on earth. You can also use the navigation control in the right hand tool bar.
17. Ok, now that we are past the introductory stuff here is you mission: follow the tree and record each branch you follow to eventually reach yourself (modern humans) using the following page write each step you take on a separate line. I've done the first two for you. You should also try to include brief explanatory information about each level of classification. Finding explanatory material may require the use of external resources.

Google is usually a good place to start.

Good luck and have some fun exploring your place in the tree of life.

One warning: don't waste too much time now, after you make it all the way through modern humans there may be time left to investigate the other branches. After you have shown me your phylogeny for humans I have a series of bonus phylogenies that you may attempt to complete (you may also do them as "extra work" at home or during a free) they are included at the end of this packet along with the rules for proper completion.

The Complete And Almost Unabbreviated Phylogeny Of A Modern Human (in 35 steps)

1. **Domain:** Eukaryotes: Organisms with nucleated cells
2. Unikonts: The group includes eukaryotic cells with a single flagellum, at least ancestrally. Some research suggests that a unikont was the ancestor of opisthokonts (animals, fungi and related forms) and Amoebozoa, and a bikont (a eukaryotic cell with two flagella) was the ancestor of Archaeplastida (plants and relatives),
3. Opisthokants: They are small single-celled protists, found in both fresh waters and the oceans, taking their name ("collar-flagellates") from the circle of closely packed microvilli, or slender fingerlike projections, that surrounds the single flagellum by which choanoflagellates both move and take in food.
4. **Kingdom:**
5.
6.
7. **Phylum:** Chordata
8. **Subphylum:**
9.
10. Node 1: Mineralized exoskeleton, sensory-line canals and grooves
11. Node 2:
12. Node 3:
13. **Infraphylum:**
14. Node 1:
15.
16.
17.
18.
19. **Superclass:**
20.
21.

22.

23.

24.

25.

26.

27. *Theriodontia*

28. *Cynodontia*

29. **Class:** Mammalia

30.

31. Order:

32.

33. **Family:**

34. Genus:

35. **species:** Homo sapiens

What other extinct species were once parts of our genus? Find out a little about each one

1.

2.

3.

4.

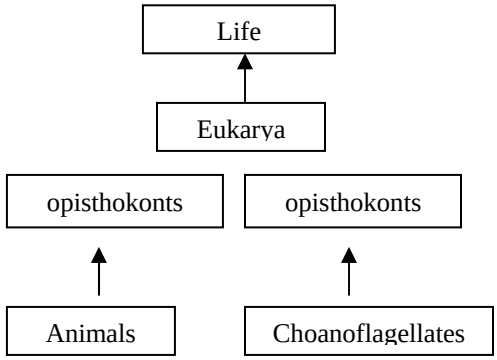
Bonus Phylogeny Rules

At the end of this introduction there are a series of 10 different species pairs. Your mission is to find the location of these two species and create a phylogenetic tree that shows both species and the point at which they parted ways (evolutionarily).

1. On a sheet of paper, write down the name of each new taxon you pass through on your way to the targets. The taxon higher up in the tree is the "daughter" taxon of the one nearer the base of the tree. Draw a line connecting the parent taxon with the new daughter taxon. Be careful in your note taking as sometimes there is more than one taxon on a page.

2. Make your way all the way up the Tree to each of your target species. Since it may be unclear which branch actually leads to your species, you will probably have to do some exploration by trial and error. You can often guess which direction to go based on similarity of names (higher levels are often named after a prominent genus), from the description, or from your own knowledge. Many links at the tips of trees include a rough list of their contents e.g., "Hymenoptera (wasps, bees, ants, and sawflies)”Once you reach each target species, write down its URL

3. Go back down the Tree until you reach the point that the next target species splits off and repeat the process of going up the tree until you reach the next target. Again record all the taxa you pass through, and connect them up with lines. Once you have done this for all of your species, you will probably have a big mess. Recopy your results into one neat readable tree that looks something like this, but with many more branches.



4. Now that you have your phylogeny, go back and search through the pages for information on the character states that define three (not all) of the taxa you have found. For example, in the above tree, these taxa could be Eukarya, Metazoa, and primates. Remember that groups are defined by the character states that they share that are different from the character states found elsewhere in the tree. These are known as "shared derived characters" or by the $10 word "synapomorphies." Many pages contain material about the taxon, and usually these pages have a section entitled "Characteristics" that will give the defining character states. Other pages have no such information. For example the page for the fungal taxon Ascomycota contains the statement "The shared derived character that defines the Ascomycota is the ascus." Other times, the description of shared characters may be more obscure – for example the characters of the fungi are described by "Fungi are characterized by non-motile bodies (thalli) constructed of apically elongating walled filaments (hyphae)."

5. For each of your three shared derived characters, find out what the description actually refers to, perhaps by using the description in the web page, or if necessary by looking up the term in another reference source.

6. **<u>On a separate sheet of paper from your tree</u>,** write out the names of the three taxa you have found synapomorphies for, plus a brief description in your own words of at least one of the shared derived characters for each of these three taxa. With your description, convince me that you really do know what the character states are. Thus, if you were describing the synapomorphy of the Ascomycetes, merely quoting that "The shared derived character that defines the Ascomycota is the ascus" is not sufficient to obtain full credit. You would need to describe what an ascus actually is.

7. When you are done staple or tape your slips of paper with your target species to your paper. Make sure you include the URLs for each target species somewhere.

One last bit of advice: You may need to use your book's appendix or the Internet to find the family that each organism belongs to. Most of these species cannot be found just by using the search feature of the Tree of Life web site (I did say this was going to be extra work). Searching by family name should bring you more success.

The List Of Mysteriously Connected Species

(You get 10/10 points per successfully completed pair with explanations)

1. *Cladonia cristatella* and *Saccharomyces cerevisiae*
2. *Ulva lactuca* and *Stentor coeruleus*
3. *Sphagnum squarrosum* and *Osmunda cinnamonea*
4. *Ginko biloba* and *Sequoiadendron gigantean*
5. *Opuntia fragilis* and *Acer saccharum*
6. *Spongillia lacustris* and *Tethya auvantitium*
7. *Taenia solium* and *Necator Americanus*
8. *Adamsia palliata* and *Arca zebra*
9. *Alligator mississippiensis* and *Desmodus rotundus*
10. *Gorilla gorilla* and *Orcinus orca*