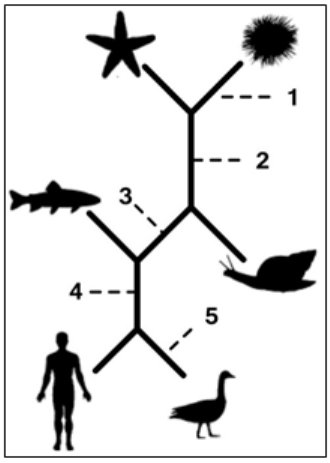
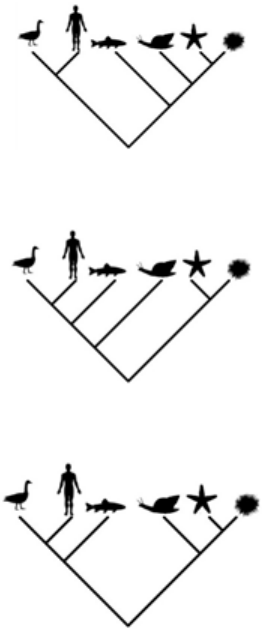
Problem Set 1

Due in class on Thursday, Sep. 14

Collaboration is allowed on this homework. You must hand in homework assignments individually and list the names of the people you worked with.

1. A phylogenetic tree with m branches represents m different rooted trees. The unrooted tree on the left has eight branches (only five are labeled). Three of its eight possible rooted trees are shown on the right. For each of the rooted trees on the right, give the number of the edge from the tree on the left that corresponds to its root.





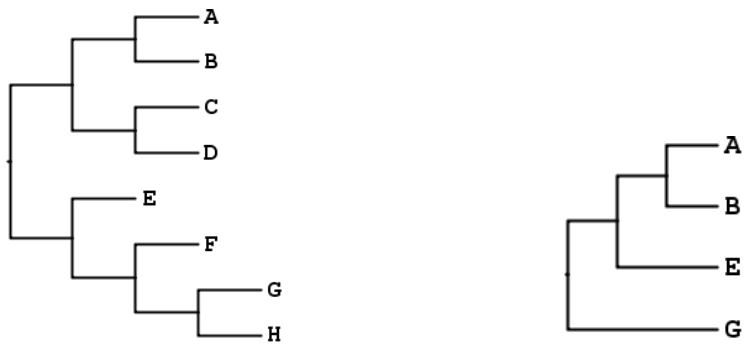
A:4
B:2
C:3

2. For each of the following pairs of trees:

   i Give the Newick specification for the tree on the right. Don't forget to balance your parentheses.

   ii Can the tree on the right be obtained by pruning and/or merging taxa in the tree in the left? If so, show which branches must be pruned and which clades must be merged to obtain the tree on the right. If not, state that the two trees are incompatible and circle the taxa that disagree.

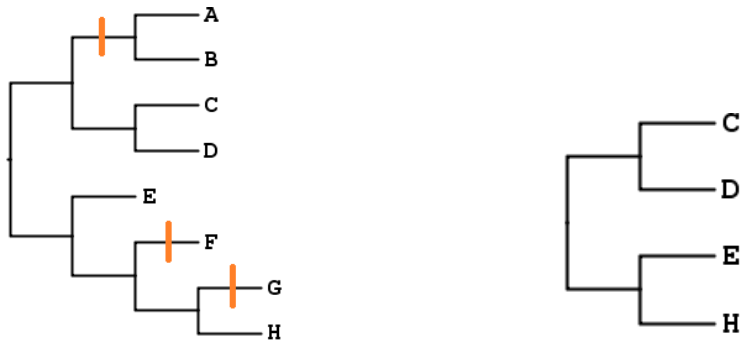
(a)



Newick: `( ((A,B),E), G );`

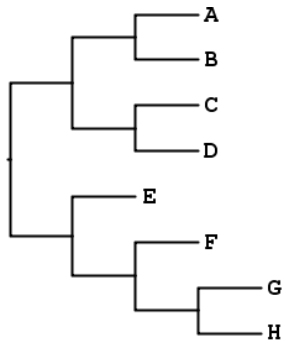
The tree on the left is not compatible with the tree on the right. E and G are sister taxa in the tree on the left, but not in the tree on the right.

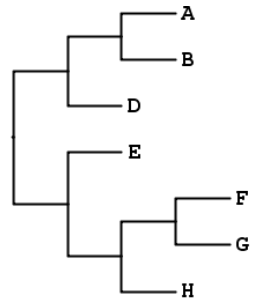
(b)



Newick: `( (C,D),(E,H) );`

(c)

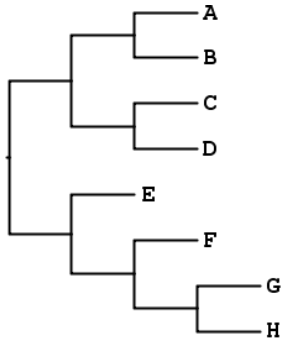


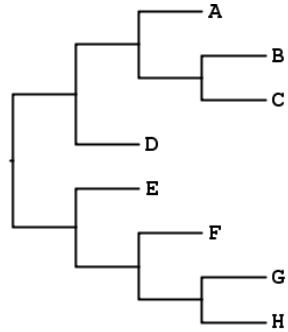


Newick: `( ((A,B),D), (E, ((F,G),H)) );`

The tree on the left is not compatible with the tree on the right. F and G are sister taxa in the tree on the right, but not in the tree on the left.

(d)

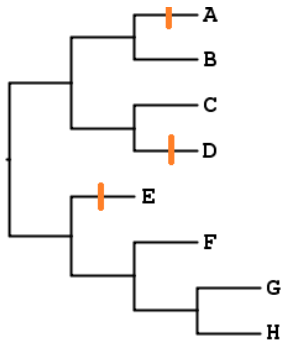


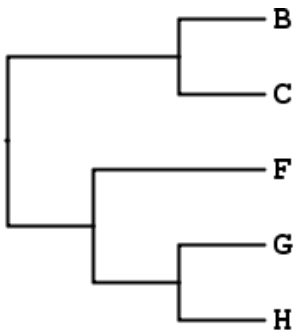


Newick: `( ((A,(B,C)),D), (E,(F,(G,H))) );`

The tree on the left is not compatible with the tree on the right. B and C are sister taxa in the tree on the right, but not in the tree on the left.

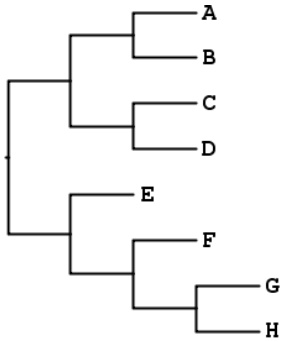
(e)

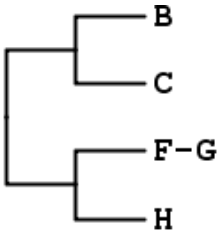




Newick: `( (B,C), (F,(G,H)) );`

(f)

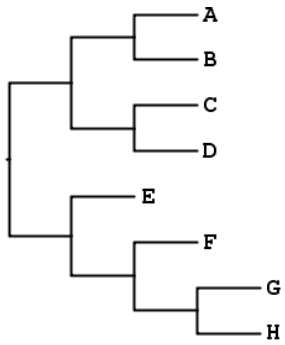


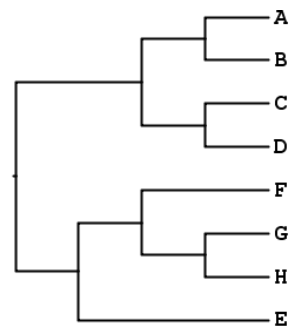


Newick: `( (B,C), (F-G,H)) );`

The tree on the left is not compatible with the tree on the right. Since F and G do not form a clade in the tree on the left, they cannot be merged to pruduce the tree on the right.

(g)

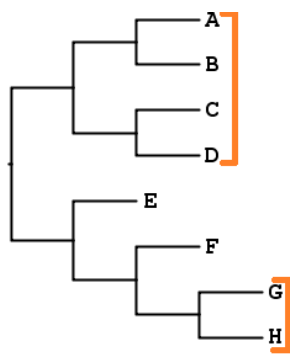


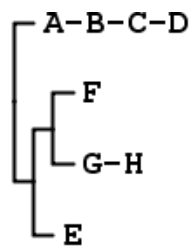


Newick: `(((A,B),(C,D)), (E, (F, (G, H))));`

The trees are topologically identical.

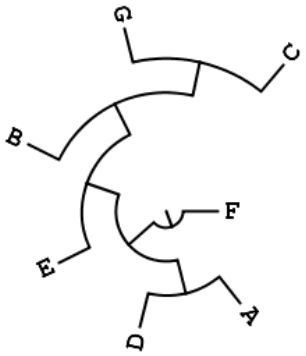
(h)



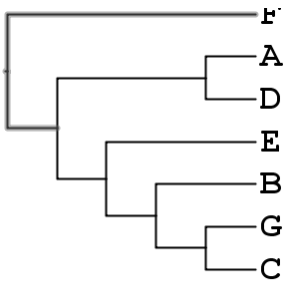


Newick: `( A-B-C-D, (E, (F, G-H)));`

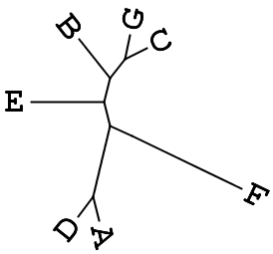
3. The figure on the right is a circular cladogram.



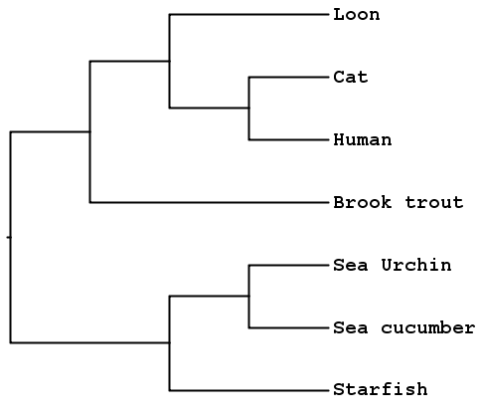
(a) Draw the equivalent rooted rectangular cladogram



(b) Draw the equivalent unrooted radial cladogram.



4. In the species tree below, which of the following sets of species form a clade? If you are not familiar with these species, you may need to do a little research. This is not intended to be a subtle question. Wikipedia, or something similar, should provide enough detail to answer the question.



(a) Species that stand on two legs.

Humans and loons are bi-pedal. They do not form a clade. This is because humans, cats and loons are all descendants of the common ancestor of human and loon, but cats are not bi-pedal.

(b) Warm blooded species

Humans, cats, and loons are warm-blooded. They form a clade.

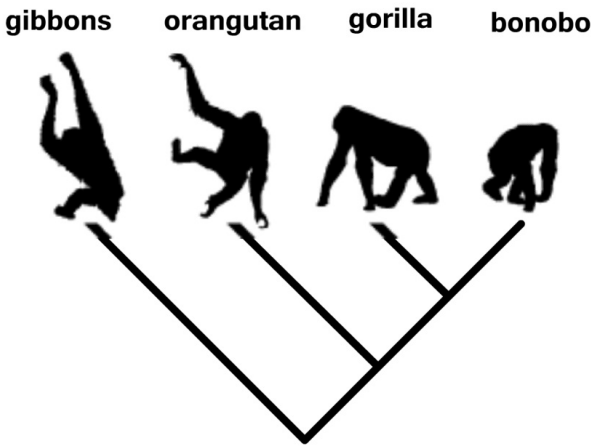
(c) Species that live in water

Loons, trout, urchins, starfish and sea cucumbers live in water. They do not form a clade, because the common ancestor of these species is the root of the tree and the tree includes several species that do not live in water.

(d) Species that live exclusively in salt water

If we restrict consideration to species that live exclusively in salt water (urchin, starfish and sea cucumber), then these species form a clade.

5. For each of the following statements, state whether it is true or false, according to the tree below. Explain your reasoning.



(a) The gorilla is more closely related to the bonobo than to the orangutan.

True. The common ancestor of the gorilla and the bonobo lived more recently than the common ancestor of the gorilla and the orangutan.

(b) The orangutan is equally related to the gorilla and the bonobo.

True. The orangutan and the gorilla share the same common ancestor as the orangutan and the bonobo.

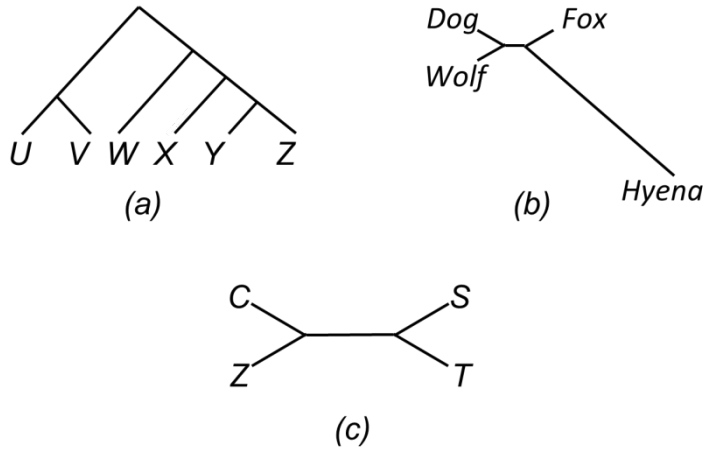
(c) The orangutan is equally related to the gorilla and the gibbon.

False. In this tree, the orangutan and the gorilla have two ancestors in common. The orangutan and the gibbon only share one ancestor.

(d) The gibbon is more closely related to the orangutan than to the bonobo.

False. The gibbon and the orangutan share the same common ancestor as the gibbon and the bonobo. The orangutan and the bonobo are equally related to the gibbon.

6. Assume that the branches in the trees below represent divergence (i.e., the amount of change). For each tree, is the rate of change the same in all branches? Possible answers are "Definitely yes", "Definitely no", and "There is not enough information available to determine whether or not the rates are the same or different". In each case, explain your reasoning.

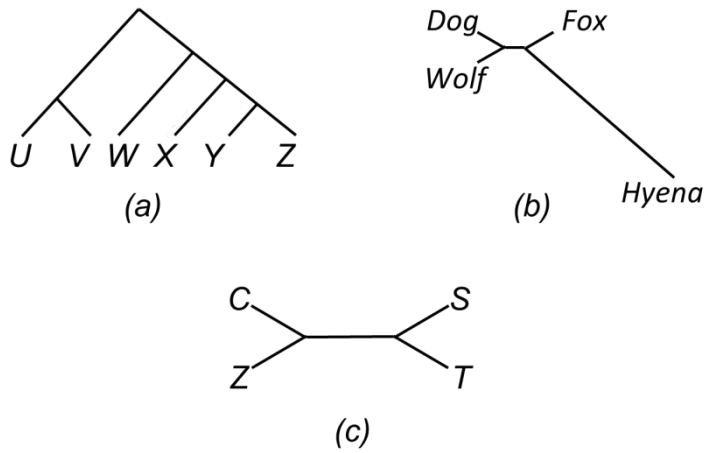


(a) In this tree, the root is the same distance from every leaf. Since the distances are the same, the rates must also be the same.

(b) No, the rate of change is much higher in the branch leading to the hyena.

(c) It is not possible to tell because the tree is unrooted.

7. Again, assume that the branches in the trees below represent divergence. For each tree, if it is rooted, is it ultrametric? If it is unrooted, is it possible to find a root such that the tree is ultrametric (i.e., a chronogram). In each case, explain your reasoning.



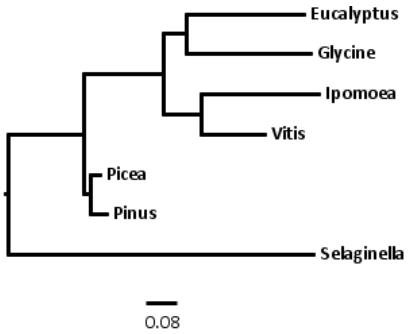
(a) This is a rooted tree and the root is equidistant from every leaf. This is one definition of "ultrametric", so, yes, this tree is ultrametric.

(b) If this tree were ultrametric, we could find a root that is the same distance from each leaf. That is not possible for this tree. For example, if we place the root at the midpoint between Hyena and Dog, the distance from the root to Fox will be shorter.

(c) If this tree is rooted at the midpoint of the central branch, it will be ultrametric. If rooted anywhere else, this tree will not be ultrametric.

8. Tree properties: branch lengths

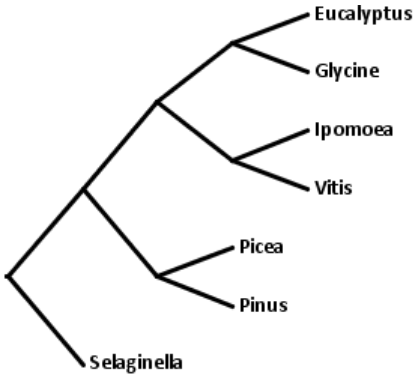
   (a) Is this tree a cladogram, a chronogram (or ultrametric tree, according to Page), or a phylogram (or additive tree, according to Page)? How do you know?



   This is phylogram. The variation in branch lengths indicates that they represent the amount of change. The presence of the scale bar also indicates that branches represent the amount of change.

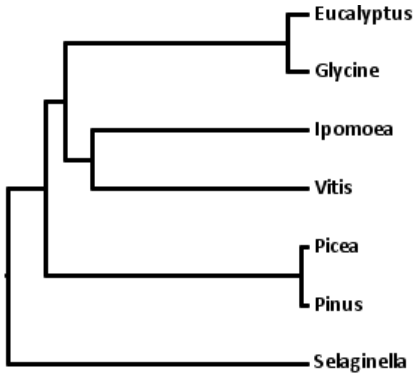
   The distance from root to leaves varies, indicating that branch lengths are not proportional to time and that this is not a chronogram.

   (b) Is this tree a cladogram, a chronogram (or ultrametric tree, according to Page), or a phylogram (or additive tree, according to Page)? How do you know?



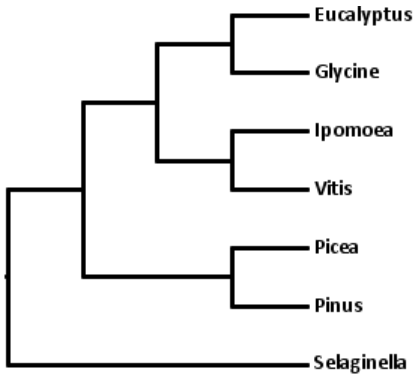
   This is a cladogram. All branches are exactly the same length indicating that branch lengths do not have meaning.

(c) Is this tree a cladogram, a chronogram (or ultrametric tree, according to Page), or a phylogram (or additive tree, according to Page)? How do you know?



This is a chronogram (or ultrametric tree). The variation in branch lengths indicates that they represent the amount of change. The distance from root to leaf is the same for all leaves, indicating that branch lengths are proportional to time and that this is a chronogram.

(d) Is this tree a cladogram, a chronogram (or ultrametric tree, according to Page), or a phylogram (or additive tree, according to Page)? How do you know?



This is a cladogram. Each increase in height is represented by a branch of the same length.