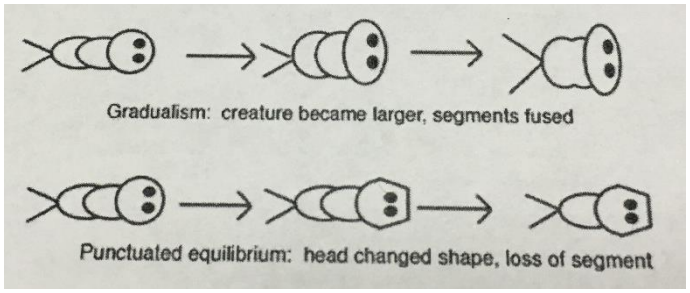
Lab: Marine Fossils and the Phylogenic Tree

Background: Fossils are traces of organisms that lived in the past. When fossils are found, they are analyzed to determine the age of the fossil. The relative age of the fossil can be determined by the Law of Superposition (Steno) which states that undeformed sedimentary rock layers are older than layers above them. This means that older layers are found deeper within the earth than newer layers. The absolute age of the fossil can be determined through methods such as radiometric dating, amino acid racemization or fission track dating.

The age and morphologies of fossils can be used to place fossils in sequences that often show patterns of changes that have occurred over time. This relationship can be depicted in an evolutionary tree, also known as a phylogenic tree.

There are two major ways in which evolution proceeds through time: gradualism (Darwin) and punctuated equilibrium (Gould & Eldredge). Gradualism suggests that organisms evolve through a process of slow and constant change. For instance, an organism that shows a fossil record of gradually increased size in small steps, or an organism that shows a gradual loss of a structure. Punctuated equilibrium suggests that species evolve very rapidly, often exploiting a newly opened niche, and then stay relatively the same for a large period of time. This rapid change is attributed to a mutation in a few essential genes. The sudden appearance of new structures can be explained by punctuated equilibrium.



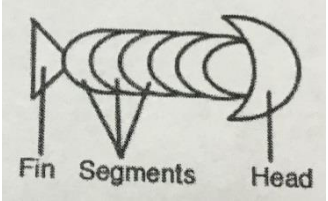
There are two ways that speciation occurs. Phyletic speciation suggests that abrupt mutations in a few regulatory genes occur after a species has existed for a long period of time. This mutation results in the entire species shifting to a new species. Phyletic speciation is generally associated only with punctuated equilibrium. Divergent speciation occurs with the gradual accumulation of small genetic changes results in a subpopulation of a species becoming so different from the parent population that reproduction between subpopulations no longer occurs. Divergent speciation is generally associated with gradualism.

Prelab Questions:

1. How does the Law of Superposition allow us to identify when fossil organisms lived in the past?
2. Why are phylogenic trees useful?
3. Compare and contrast gradualism with punctuated equilibrium.
4. Compare and contrast phyletic speciation with divergent speciation.
5. Give two ways in which subpopulations might be separated prior to divergence? (not given in text)

Procedure:

a. The group of fossils you will be working with are fictitious fish (say that three times real fast!). Each fossil is identified with a time period. The morphology of the fish is depicted in the picture to the right. Using the chart provided, arrange the fossil first by age. The term "upper" means more recent and should be placed lower in the row. The term "lower" means an earlier time period and should be placed towards the older time periods. In each fossil column, you may have three specimens, one from the main time period, one from the upper and one from the lower. Not all fossils are represented, illustrating the incompleteness of the fossil record.



b. Once you have the fossils in the proper age order, arrange them by morphology (appearance). Center the oldest fossil at the top of the fossil column (toward the oldest layer). Through the chart, those fossils that appear to be the same, or close to the same, as the fossils preceding them should be placed in a vertical line. During a certain period, the fossils will split into two branches. In other words, one fossil from that period will show one type of change, and another fossil will show a different change. When this happens, place the fossils side by side in the appropriate time period. From that point on, you will have two lineages.

Postlab Questions:

6. Draw a generalized phylogenic tree using the fossils you have just arranged. (accentuate the traits that are changing)
7. Describe the general trends in morphology you observed as time progressed.
8. Hypothesize the purpose of the various tail fins observed in this activity.
9. Identify two features, other than tail fins, that you observe in the species given and hypothesize the purpose of those features.
10. Identify a lineage that shows phyletic speciation. What environmental conditions might act as a selective pressure to cause these changes?
11. Identify a lineage that shows divergent speciation. What environmental conditions might act as a selective pressure to cause these changes?

Visit the website http://evolution.berkeley.edu/evolibrary/article/fishtree_01 to answer the following questions as you look from left to right (oldest to youngest evolutionarily) across the phylogenetic tree.

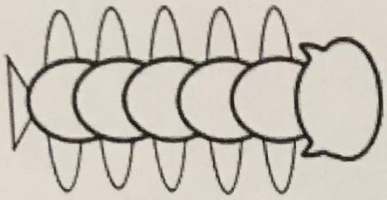
12. (green bar: Craniata) All fish are craniates. What are the six features that define a craniate?
13. (green bar: Chondrichthyes) Chondrichthyans include sharks and rays. What differentiates them from other fish?
14. (red circle: From Water To Land) Sarcopterygians gave rise to all tetrapods. Describe the evidence that supports this.
15. (red circle: From Water To Land) Explain the relationship between gills, lungs and swim bladders.
16. (green bar: Actinopterygii) Actinopterygii are the ray-finned fishes. What are the four features that define them.
17. (red circle: Fish on Equal Footing) Explain the concept of rotation around a node in a phylogenetic tree.
18. (red circle: A Light in the Darkness) How is bioluminescence achieved in fish?
19. (red circle: A Light in the Darkness) Name the five lineages that have evolved bioluminescence.
20. (red circle: Gender-Bending Fish) Explain the two types of hermaphroditism: protandrous and protogynous.
21. (red circle: Gender-Bending Fish) Name the eight lineages of fish that are hermaphroditic.
22. (red circle: Oh Fish, Where is Thy Sting?) Venom has evolved many times independently in fish. Why is this?
23. (red circle: Oh Fish, Where is Thy Sting?) Name the four lineages that have evolved venom.

Click on “see the full tree” in the upper right corner of the page to show more detail among the Actinopterygians.

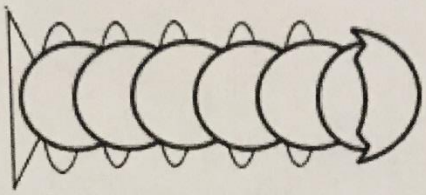
24. The order Perciformes is the largest order of vertebrates in the world, and include 41% of all bony fish. How many species are in the order?
25. (green bar: Smegmamorpharia) Smegmamorpharians have a weird name, don’t you think? Name a fish in this taxonomic group.

Time Period (fyi-these are fictitious)	Age (Years Ago)	Fossils
Wyomington	995,000-745,000	
Ohioian	745,000-545,000	
Nevadian	545,000-445,000	
Texian	445,000-395,000	
Oregonian	395,000-320,000	
Coloradian	320,000-170,000	
Montanian	170,000-80,000	
Californian	80,000-30,000	
Idahoan	30,000-present	

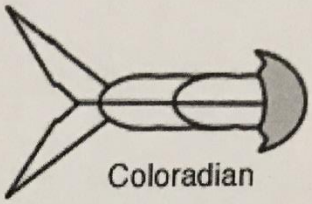
Fossils



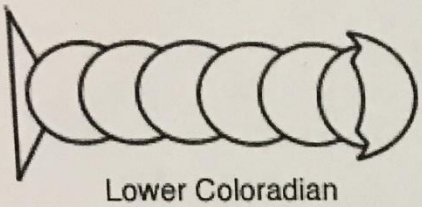
Californian



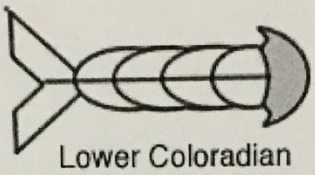
Coloradian



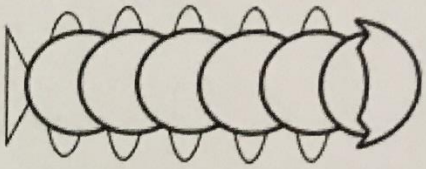
Coloradian



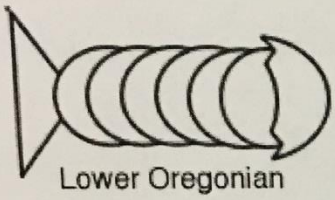
Lower Coloradian



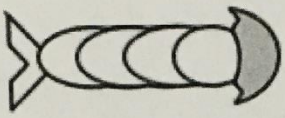
Lower Coloradian



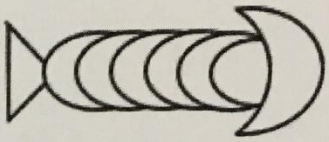
Lower Montanian



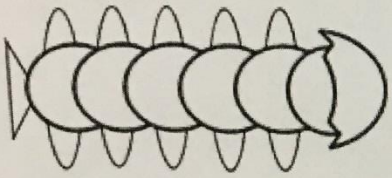
Lower Oregonian



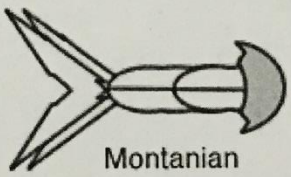
Lower Oregonian



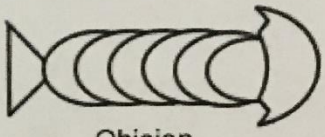
Lower Wyomingian



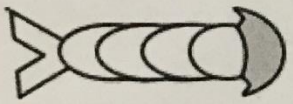
Montanian



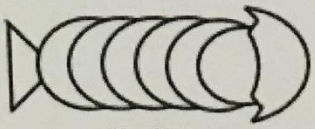
Montanian



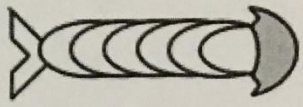
Ohioian



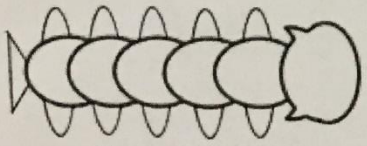
Oregonian



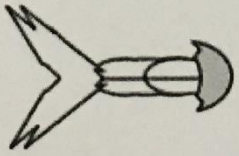
Texian



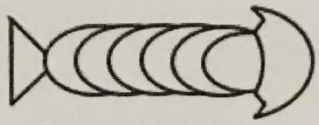
Texian



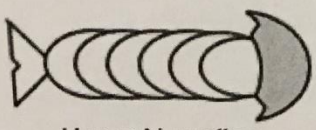
Upper Montanian



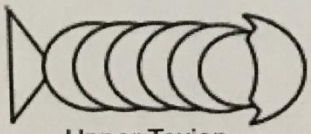
Upper Montanian



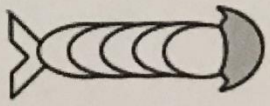
Upper Nevadian



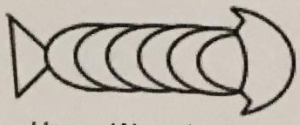
Upper Nevadian



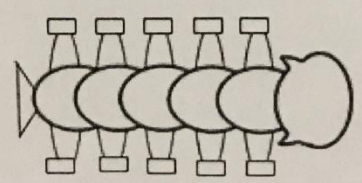
Upper Texian



Upper Texian



Upper Wyomingian



Idahoan