Interpreting Evolutionary Trees

Target Audience: Middle school and above

Differentiated Instruction Summary

Strategy	Levels	Content/Process/Product	Grouping(s)*
Choice Board	Readiness (two levels)	Content Process	Small groups Peer partners Homogeneous Heterogeneous

* Varied grouping options can be used for this activity, depending on student needs and chaperone ability, but individuals or pairs are probably best.

Objective: To interpret evolutionary tree graphics.

Pre-assessment/Prior Knowledge: Prior to their visit, students should be familiar with the idea of phylogeny and have basic tree reading skills.

Activity Description: Students choose four of ten activities that involve interpreting tree diagrams associated with exhibits. Level 1 questions (left column) are more straightforward and can be obtained from a particular tree in an exhibit. Level 2 questions (right column) involve incorporating information from one tree diagram with additional information from other exhibits.

Materials Needed:

- Student
    - Choice Board handouts (see attached)
    - Pencils or pen

Note: Format to record/present findings determined by individual teacher. Provide clear instructions about expectations for documenting participation.

- Teacher
    - Content Outline

Content: Evolutionary Trees

Evolutionary tree diagrams are branching diagrams (dendrograms) that depict the phylogenetic relationships between taxa based on shared derived characters (synapomorphies) that reflect common ancestry. Phylogenies depict an historical pattern of divergence and descent as series of branches; these branches merge at points representing common ancestry, which in turn are connected with more distant ancestors.

Tree Diagrams. The key parts of a tree diagram are the nodes, branches and the root. The terminal nodes or tips of the tree represent the taxa (organism or group of organisms) whose relationships are being shown; the nodes represent ancestral species; these are connected with other taxa through branches that join at internal nodes—these represent a relationship term; and the outgroup is the most distantly related taxa in the tree, and is used to root the tree and indicate the most recent common ancestor shared by all the taxa. Alternatively, the internal

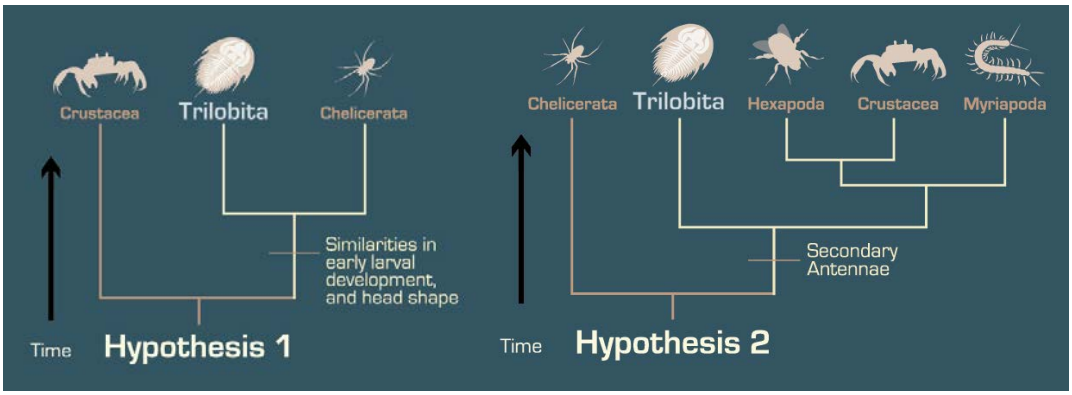
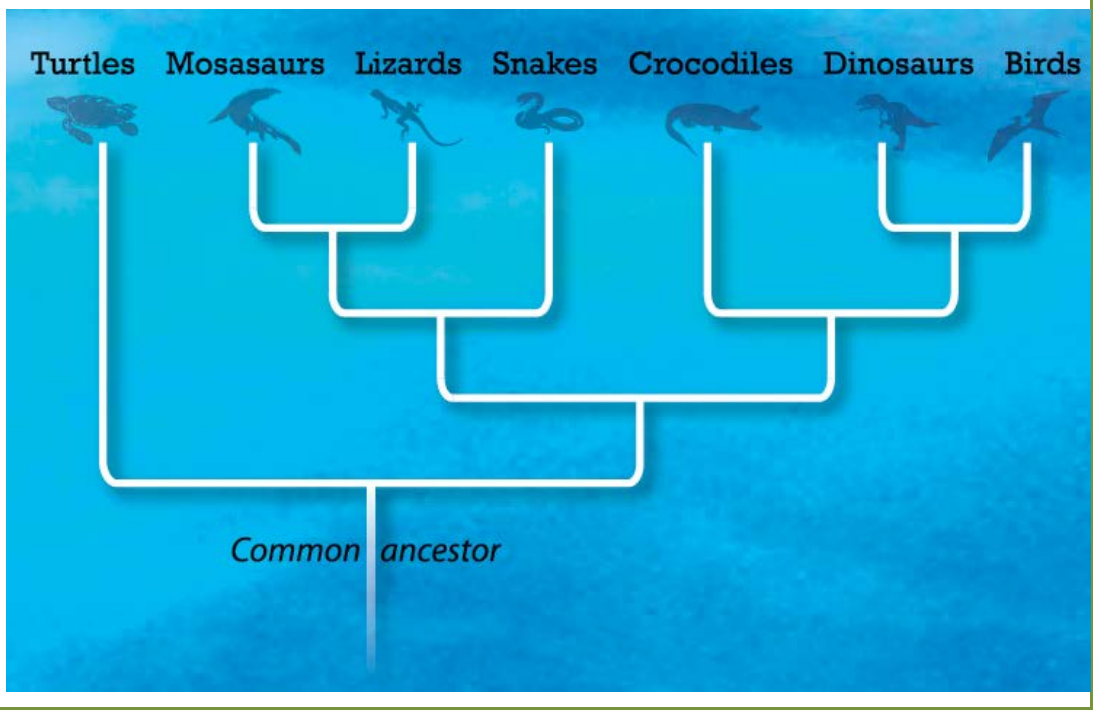
nodes can represent speciation events with segments of the ‘main branch’ from the root representing ancestral species, and branches to the tips depicting lineages evolving through time.

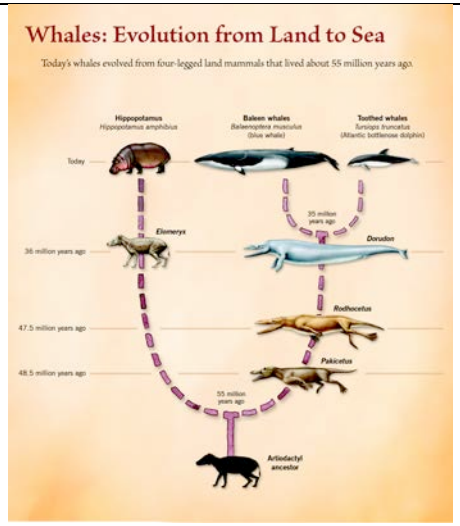
Shared derived characters (synapomorphies) that support these relationships can be included on the tree at relevant points. It is important to note that a shared derived character (synapomorphy) in one context can be a shared ancestral character in another (sympleisomorphy); hair would be a synapomorphy in a tree that include all vertebrates, but would be a sympleisomorphy in a tree with only mammals.

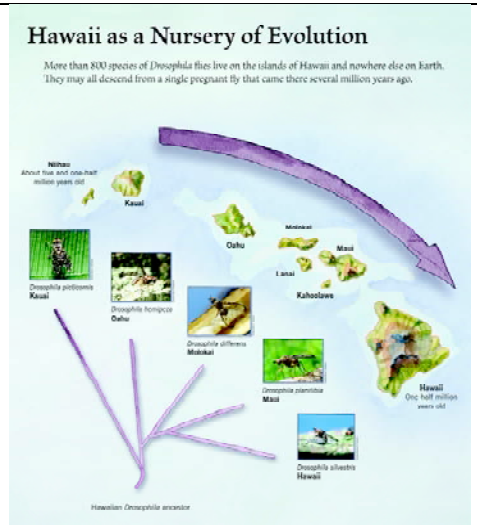
Tree Resources. A primer on phylogenetic trees can be found on the *Understanding Evolution* website (http://evolution.berkeley.edu/evolibrary/article/phylogenetics_01). Information on the importance of teaching phylogeny, tree diagrams and teaching with trees (including common misconceptions) can be found in the journal *Evolution: Education and Outreach* such as Volume 3, Number 4, December 2010 (http://www.springerlink.com/content/1936-6426/3/4/).

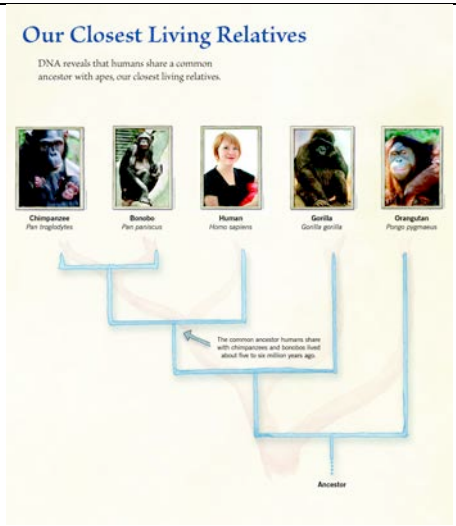
Textbooks and Museums. Students and museum visitors are exposed to a diversity of tree diagrams in textbooks, exhibits and the popular press, and there are several studies focusing on how these diagrams are interpreted an understood. A review of textbooks trees can be found in the 2008 study by Catley and Novick *Seeing the Wood for Trees: An Analysis of Evolutionary Diagrams in Biology textbooks* (BioScience Volume 58, 10). A collection of museum exhibit trees along with a study of these graphics can be found on the *Understanding the Tree of Life* project website (http://evolution.berkeley.edu/UToL/trees.html).

Content: Exhibit Trees

Tree Graphic	Tree Information
Explore Evolution	See tree diagrams associated with VIST graphics below
Invertebrate exhibit	See invertebrate tree graphic below
Trilobite exhibit	
Mosasaur exhibit	

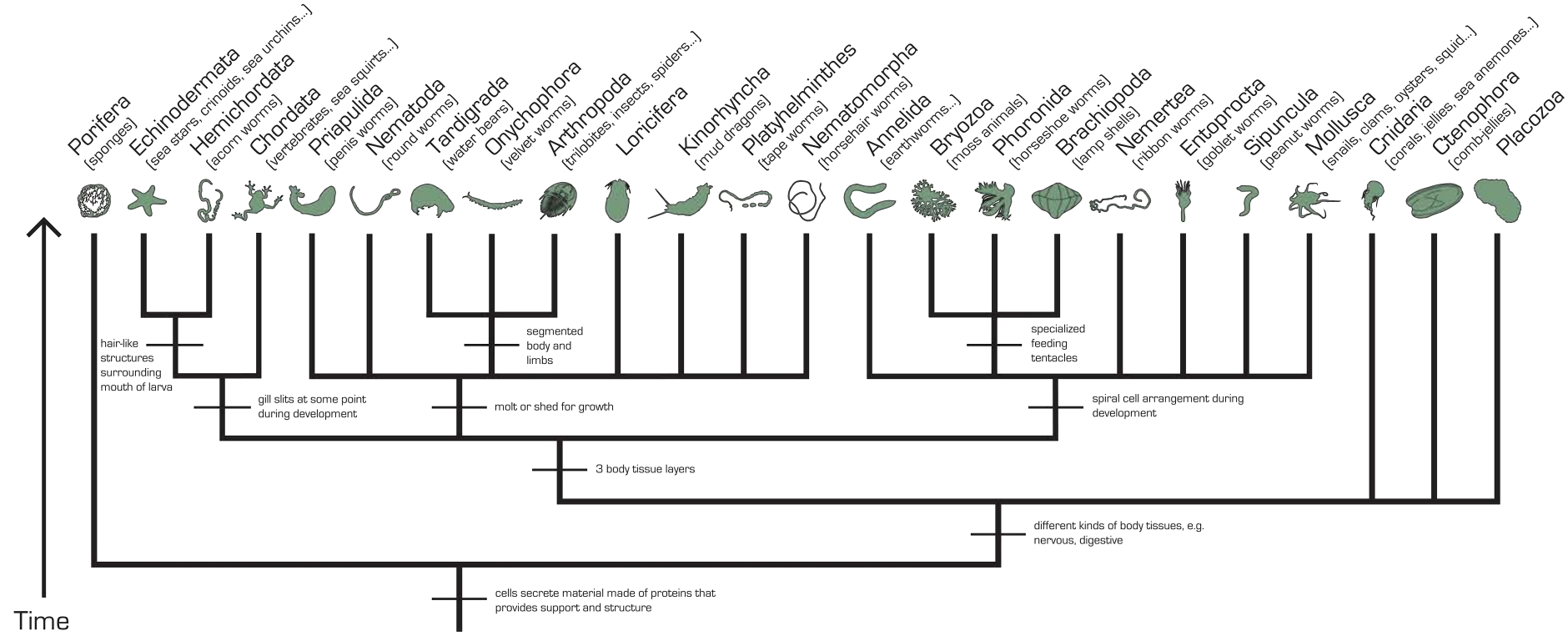






Tree graphic panels associated with VIST principles in *Explore Evolution* exhibit (whale, fruit flies, human/chimp).

Exploring the KU Natural History Museum



Invertebrate tree graphic, third floor, Dyche Hall, KU Natural History Museum

Exploring the KU Natural History Museum

Interpreting Evolutionary Trees

Choose any four activities to complete, and record your answers on a separate sheet of paper.

A) Find the tree diagram on the 5th Floor associated with the mosasaur specimen above the main museum entrance. How would you describe the evolutionary relationship between dinosaurs, mosasaurs and lizards?	B) Find the tree diagram on the 5th Floor associated with the mosasaur specimen above the main museum entrance. Where on the tree would you plot the following characters: (1) flexible, hinged jaws; (2) backbone; and (3) loss of limbs?
C) Find the tree diagram in the invertebrate exhibit (3rd Floor). List all the shared characters included in the tree that 'Nemertea' (ribbons worms) have.	D) Find the tree diagram in the invertebrate exhibit (3rd Floor). Select any specimen on display in this exhibit, provide its scientific name (if known), the general group it belongs to (as noted in the tree), and list ALL the characters that organism would have.
E) Find the tree diagram about whale evolution in *Explore Evolution*. Consider all the information available in this tree and associated panels, and describe two features you might infer about the Artiodactyl ancestor indicated on the tree.	F) Find the tree diagrams in *Explore Evolution* for humans and other apes AND for whale evolution. Consider all the information available in these two trees and associated exhibit panels, and describe three features you might infer about a common ancestor for ALL organisms shown in both trees?
G) Find the trees depicting two proposed hypotheses of trilobite relationships. To which group depicted in the overall tree diagram in the invertebrate exhibit do ALL the taxa in the trilobite trees belong?	H) Consider three tree diagrams: (1) Hypothesis 1 for trilobites; (2) Hawaiian fruit flies; and (3) mosasaur. Which group(s) in the overall tree diagram in the invertebrate exhibit do the taxa in each tree belong?
I) Find the following organisms on exhibit: (1) cockroaches; (2) sea star; and (3) giant squid. Using the tree diagram, what characters do these three groups share?	J) Find the following organisms on exhibit: (1) snail; (2) crinoid; (3) brachiopod; and (4) sponge. For two of these organisms, list the characters each would share with humans (e.g. Chordata).

Rubric: Exhibit Trees

A) Mosasaurs and lizards are most closely related to each other; dinosaurs and mosasaurs are only distantly related to each other (mosasaurs and lizards share a common ancestor more recently with each other than they do with dinosaurs).	B) Branch representing common ancestor/lineage of mosasaurs, snakes & lizards (1); 'Common ancestor' branch at root of tree (2); branch representing common ancestor/lineage of snakes (3)
C) Nemertea characters: material made of proteins secreted by cells that provides support and structure; different kinds of body tissue; 3 body tissue layers; spiral cell arrangement during development.	D) Answers will vary (see tree graphic).
E) Answers will vary, but could include could include general vertebrate, mammal and/or artiodactyl characters. Particularly relevant characters would include: long legs; double pulley ankle bone; nostrils at tip of snout; and thin (not thickened) auditory bulla.	F) Answer will vary, but could include general vertebrate and mammals characters (e.g. hair, single lower jaw bone, three middle ear bones, presence of hindlimbs, etc.).
G) Arthropoda	H) Arthropoda (1 & 2), Chordata (3)
I) Characters shared by Arthropoda (cockroaches), Mollusca (squid), and Echinodermata (sea star): material made of proteins secreted by cells that provides support and structure; different kinds of body tissue; 3 body tissue layers.	J) Characters shared with snail (Mollusca): material made of proteins secreted by cells that provides support and structure; different kinds of body tissue; 3 body tissue layers. Characters shared with crinoid (Echinodermata): material made of proteins secreted by cells that provides support and structure; different kinds of body tissue; 3 body tissue layers; gill slits at some point during development. Characters shared with brachiopod (Brachiopoda): material made of proteins secreted by cells that provides support and structure; different kinds of body tissue; 3 body tissue layers. Characters shared with sponge (Porifera): material made of proteins secreted by cells that provides support and structure.

Needs further support	Meets Expectations
A) Incorrectly describes relationships between taxa or does not include all three groups B) Incorrectly describes character placement or incorrect tree diagram or character location C to J) Does not correctly identify characters	A) Correctly describes relationships between all three taxa B) Correctly describes character placement or correct tree and character location C to J) Correctly identifies characters