Lesson created by: Ashley Grapes
Grade: 10th Grade Biology, AP Biology
Duration of Lesson: 2 fifty minute classes

Building Evolutionary Trees: Old-School & New-School

Purpose: The purpose of this lesson is to show students the advantages and shortcomings of technology in solving scientific problems and building evolutionary trees. The students will build an evolutionary tree based on morphological traits, and then one based on genome sequencing. A historical look on Lamark and Darwin will be used to explain the evolution of the phylogeny tree and how scientific views of evolution have changed throughout time. To elaborate on the use of technology in the 21st century, the students will complete a bioinformatics lab in which they use genome sequences of different plants to determine which plant made an Appalachian Trail hiker sick. They will then use ClustalW to see the computers building an evolutionary tree of their plants, and learn the difference between cladograms and phylograms. Finally, the students are asked to evaluate the limitations of technology in building evolutionary trees based on fossil records, such as that of dinosaurs, or early hominids.

SOL's:

BIO.1 The student will plan and conduct investigations in which conclusions are formed based on recorded quantitative and qualitative data; appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results;
BIO.2 The student will investigate and understand the history of biological concepts. key concepts include scientific explanations of the development of organisms through time (biological evolution);
BIO.6 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include exploration of the impact of DNA technologies. systems of classification that are adaptable to new scientific discoveries.
BIO.7 The student will investigate and understand bases for modern classification systems. Key concepts include structural similarities among organisms; fossil record interpretation;

NSES Standards: Science and technology in local, national, and global challenges, Historical perspectives, Characteristics of organisms, Biological evolution

Materials & Resources:

Computer for each student
Photocopies of animal gene sequences
Whiteboard
5 pictures of great apes

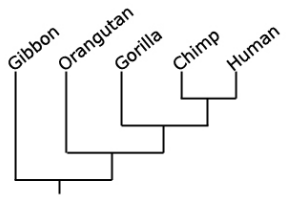
Class Management and Safety Issues:

The student's should work individually for the elaborate, Bioinformatics lab.

***NOTE* The students should have learned how to read a phylogeny tree prior to this lesson. If this is not the case, the following website is a great source for an introduction: http://evolution.berkeley.edu/evolibrary/article/phylogenetics_01**

Engage (5 minutes)

For the engage activity, draw a simply evolutionary tree like the one shown in this picture with the five branches up on the board. Have 5 index cards which contain the name and picture of the great apes, which should sound familiar. Ask the students to place the pictures of the animals on the branch they think they go on. Most students will not know that humans and chimps are more closely related than chimps are to the other great apes.



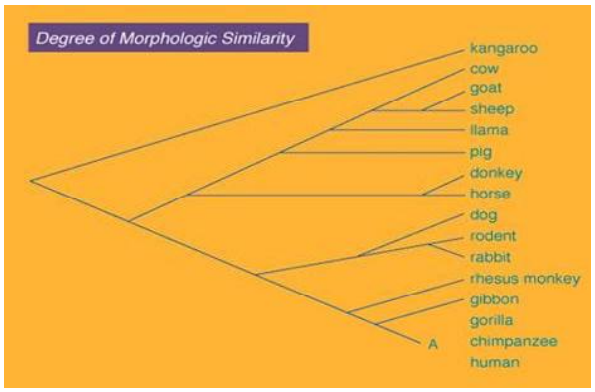
After doing this activity, tell yo**ur s**tudents that genetics has led to great advancement in the realms of evolutionary biology. State that by utilizing genetics to compare base pair sequences of animal genomes, scientists have been able to build more accurate evolutionary trees. Tell your students that before genetics, people had to base evolutionary relationships on physical characteristics, like bone morphology.

Explore (20 minutes)

For the explore section of the lesson, the students will each build two evolutionary trees. The first will be based on the "old-school" way of morphological characteristics, and the other will be based on comparing "percent-alike" nucleotide bases. First ask the students to fill in the skeleton evolutionary tree provided by you with the animals they think are most related. Provide the placement of the human for them. Explain that this is what Darwin, or other scientists in before the 20th century, would have had to do in order to build an evolutionary tree (although they would have used more sophisticated characteristics).

Discuss with the class what limitations they met by using this method. Then provide them with the same evolutionary tree backbone, the human placement on the tree, and the following "genome sequences." Explain that they are now 21st century scientists with genetic technologies that were not available to Darwin. Tell them to first count how many base pairs an animal's genome has in common with a human's genome. This should help them build the tree much more accurately. By comparing the animals to each other, they can get an even more accurate tree. Cutting the sequences up and placing them next to each other will make comparison easier. Following this activity, discuss with your students how technology has aided them in their findings and how their genetically-based tree compares with their original one.

Kangaroo	ATGGCCCGGTACAAT
Cow	GCGTTCCCTGAAGTC
Goat	GCGTTCCCTAGGTTC
Pig	TAGTTCGCTTCCATC
Dog	GCCCAAGCTAGGTAG
Rabbit	GCCCATGCTACGCAT
Human	TACCATGCTAGCCTA



Explain (20 minutes)

Explain to your students that technology has helped advance science tremendously in the past 100 years, especially in the realm of genetics. Many years ago, it was the common held belief that the earth and animals were static and unchanging, and therefore, there was no such thing as evolutionary trees. In the 18th and 19th centuries, scientists began to change their view, and see nature as ever-evolving. Carl Linneaus is known as the "Father of Taxonomy" and started to classify organisms. He also invented the genus and species system. Lamarck is known as the "Kepler of Biology," and proposed soft-evolution, in which animals could pass down physical traits acquired in their lifetime. Darwin came along and proposed evolution by natural selection, which includes heredity, competition, variation, and sexual selection. Give your students the example of the tortoise shells on the different Galapagos Islands, and explain that this led Darwin to believe that they all came from a common ancestor. He was the first to propose that all organisms have descended from a common ancestor (he did not discuss the origin of life), and drew a rather in depth evolutionary tree in his book, "On the Origin of Species."

Studying the phylogeny of organisms can help us explain similarities and differences among plants, animals, and microorganisms. Scientists are using these trees to trace HIV infection or choose appropriate model organisms to study cancer. Technology and genetics have helped us build these trees with more and more accuracy.

Elaborate

The students will learn how scientists can use technology to solve problems and build evolutionary trees via a bioinformatics lab. This lab comes with a detailed procedure, an activity sheet, and an accompanying PowerPoint. The steps in the procedure should be done individually on a student's own separate computer, and the teacher should use a smartboard to project the computer screen. I suggest that even though the students must complete the steps themselves, the teacher and class go through the steps together. Each student should be assigned a plant number. The "presentations" should only take 5-10 minutes to research and 1-2 minutes each to present.

Following the lab, discuss the shortcomings of programs like ClustalW for dinosaurs and other fossilized species. Discuss that even technology has it's limitations.

Evaluate

Evaluation for this lesson plan will be based on the completion and effort on the activity sheet that accompanies the Bioinformatics lab.

Each question on the activity sheet is worth 2 points. 1 point is awarded for effort, and two points awarded for correctness and effort. No points will be given if a question is incomplete or shows no effort.