

Evolution

Big Idea 1

Baker's Dozen Lab 3: NOVA Evolution Lab

Objectives

Before doing this lab you should understand what cladograms show and how they are constructed.

After doing this lab you should be able to use cladograms to answer questions on how different organisms are related.

Introduction

What could you possibly have in common with a mushroom, or a dinosaur, or even a bacterium? More than you might think. In this lab, you'll puzzle out the evolutionary relationships linking together a spectacular array of species. Explore the tree of life and get a front row seat to what some have called the greatest show on Earth. That show is evolution.

Mission #1: Training Trees

Red, Green, and Gecko: Your first question is simple: is a fungus more closely related to a plant or an animal? Be careful – first impressions can be misleading. Be sure to read and follow the prompts. They are there to help you get the hang of things. When you're done, answer the following questions before you move on to the next level, "Familiar Faces."

If fungi, plants, and animals all have nuclei, this makes them which type of cell? _____

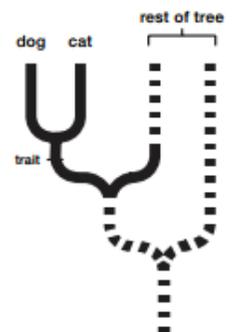
What trait do the mushroom and gecko share that the tree lacks? _____

Draw your completed tree below. Include the acquired characteristics.

Familiar Faces: Let's look at some common animals – a dog, goldfish, snake, and stick insect. Think you know which ones share the most traits? Answer the questions below before you move on to the next level, "Tree of Life: Vegetarian Edition."

What is an amniote, and which animals on this tree are amniotes? _____

If you added a cat to this tree, it would be placed as shown to the right. What biological trait could you use in the spot that is marked?



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Vegetarian Edition: Things are getting more challenging now, so be sure to use the magnifying glass to look at the species compare tabs. Answer the questions below before you move on to Mission 2, “Fossils – Rocking the Earth.”

What makes the seaweed different from all other plants on this tree? _____

What class of plant has petals in multiples of three? (circle one) MONOCOT DICOT/EUDICOT

What class of plant has petals in multiples of four/five? (circle one) MONOCOT DICOT/EUDICOT

Mission #2: Fossils: Rocking the Earth

Eating Dinosaurs for Dinner: Answer the following questions before you move on to the next level, “One small step.”

A clade is a fancy word for any group in a phylogenetic tree that includes an ancestor and all of its descendants. A simplified dinosaur tree is to the right.

Imagine that you have scissors and can cut the tree. You can tell a group is a clade if it only takes one snip to make the group fall off the tree. Five different clades have been marked on the tree with brackets.

Clade 1: Aves (birds)

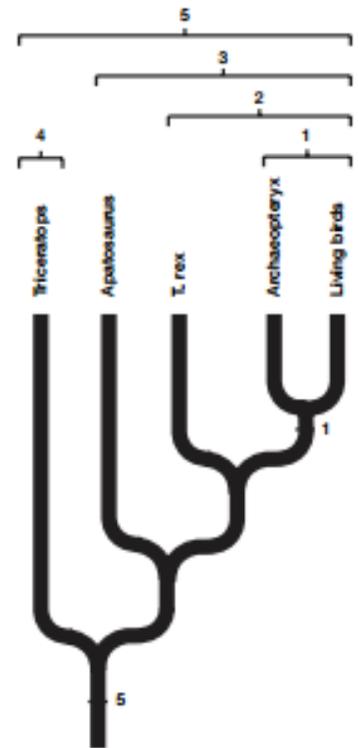
Clade 2: Theropoda (theropods)

Clades 3 and 4 are the two major groups of dinosaurs – clade Saurischia and clade Ornithischia.

Clade 5: Dinosauria (dinosaurs)

Mark on the tree using numbers 2-4 where you can snip off each clade. Numbers 1 and 5 have been done for you.

Triceratops belongs to two of the marked clades (4 and 5). *Triceratops* is both an ornithischian and a dinosaur. Which clades do birds belong to?



One Small Step: Answer the following questions before you move on to the next level, “Origin of whales.”

For an animal that lives in shallow water, what is an advantage of having eyes on the top of its head? _____

What do the *Tulerpeton* and the *Acanthostega* have that the *Tiktaalik* lacks? _____

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Origin of Whales: Answer the following questions before you move on to Mission 3: “DNA Spells Evolution.”

Whales are tetrapods, but living whales do not have four limbs. What is a more accurate way to describe tetrapods?

- Animals that have at least two limbs.
- Animals that descended from a four-limbed ancestor.
- Animals that have four limbs at some point in their lives.
- Animals that have evolved the ability to survive without limbs.

When two groups of organisms independently evolve similar adaptations, it’s called convergent evolution. Sharks and whales both have streamlined bodies and tail flukes. How do we know that these similarities are because of convergent evolution and not a common ancestor? (HINT: Are sharks tetrapods?)

Mission #3: DNA Spells Evolution

Frog Legs and Fish Eggs: In this level, you’ll get the hang of analyzing DNA by looking at a tiny 4-base snippet. A dash (-) represents either a blank space added to improve alignment or a position that is not important for the analysis. Don’t forget to also check out the species tab information. Answer the following questions before you move on to the next level, “One fish, two fish, red fish, lungfish.”

Draw your complete tree below. Include the appropriate DNA information.

One Fish, Two Fish, Red Fish, Lungfish: Answer the following questions before you move on to the next level, “Where the tiny wild things are.”

Scientists used to think that coelacanths were the closest living relatives to amphibians because of their similar anatomical features: big fleshy fins and hinged jaws. Using the DNA evidence, however, this cladogram shows that lungfish are closer relatives. Which do you think is more convincing – DNA or anatomy? Why?

To which organism(s) on the tree is the coelacanth most closely related?

- Frog
- Lungfish
- cichlid and shark equally
- frog and lungfish equally

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Where the Wild Things Are: Even with a microscope most people can't tell the difference between an archaea and a bacterium. Crack open their DNA, however, and the differences become pretty obvious. Answer the following questions once you have completed the cladogram.

A vinosum is most closely related to which organism(s)? _____

Can you tell whether a C at position 15 evolved before or after a T at position 15? Explain your answer. _____

When is it not possible to examine DNA but only use physical features to compare two species? _____

Mission #4: Biogeography: Where Life Lives

The goal of biogeography is to piece together all of the movements of tectonic plates, plants and animals to discover and explain the past and present distribution of life on Earth. Before you start the first level of this mission, watch the introductory video and answer the following questions.

How do organisms come to live on newly formed volcanic islands? _____

The Galapagos finches are an example of an array of species that

- a. migrated to an island as a group
- b. evolved from a single island species
- c. interbred to form one new island species
- d. each independently migrated to an island

Saving Hawaiian Treasure: In this level, you will again use DNA evidence to piece together a phylogenetic tree of honeycreepers, a species of bird very similar to Darwin's finches of the Galapagos Islands. Remember to use the outgroup to help you. Answer the following questions before you move on to the next level, "Cone Rangers."

The common ancestor of the Po'ouli and common rosefinch most likely had

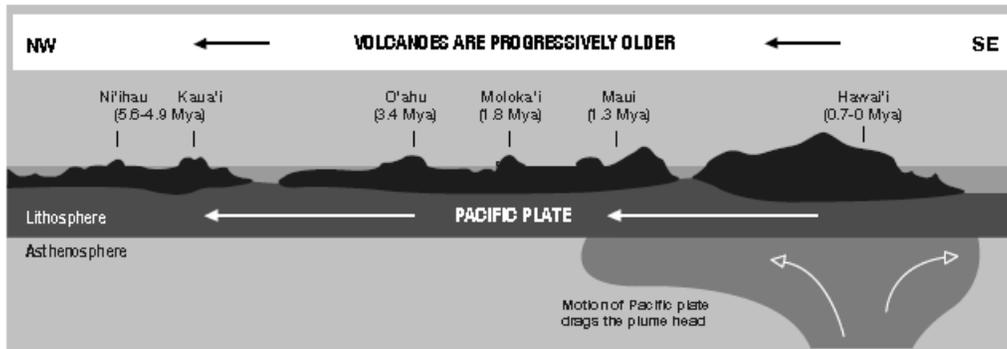
- a. an A at position 1
- b. an A at position 16
- c. a C at position 4
- d. a T at position 2

If a new species of honeycreeper were discovered, and it had a short, straight beak, which bird in the cladogram would likely be its closest living relative? _____

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Geologists think that the Hawaiian Islands formed as the Pacific plate moved over a hotspot in Earth's crust, where molten rock from the mantle made its way to the surface, as shown below.



Mya = million years ago

NOT TO SCALE

Would you expect a honeycreeper species that lives only on the island of Hawaii to have evolved before or after a honeycreeper species that lives on the islands of Hawaii, Oahu, and Maui? Explain your answer. _____

Cone Rangers: Before Pangaea, there was Gondwana, a massive continent made up of what are today Africa, the Arabian Peninsula, Antarctica, Australia, India, Madagascar, and South America. Gondwana eventually joined up with Laurasia to become Pangaea, which then broke up as already seen in the video. Figure out how conifers traveled across the world as these giant landmasses split. Answer the following questions before you move on to the next level, "Kanga, Gliders, and Snakes, oh my!"

Complete the table below. In the final column, use the species tab to write the location of the species.

	compound cones	cone scales w/o wings	large bladelike leaves	pollen w/o air sacs	smaller scaly leaves	small fleshy cones	location
<i>A. fibrosa</i>							
Bois bouchon							
Coral reef pine							
Monkey puzzle tree							
Norfolk Island pine							
Parana pine							
Pino hayuelo							

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Thanks to DNA testing, scientists have discovered that a tree in South America is genetically similar to one in Australia. What is one possible evolutionary inference they could make from this discovery? _____

Kangas, Gliders, and Snakes, oh my! When a single species diversifies and forms many different but closely related species, the process is called adaptive radiation. Adaptive radiation occurs as species adapt to slightly different environmental conditions. But what about the reverse or when very distantly related species come to look similar because they live in similar environments? That is called convergent evolution. Answer the following questions before moving on to the next mission.

Complete the character matrix below.

	vertebrate	gives birth to live young	pouch	prolonged development in womb	"warm-blooded"	location
Elephant						Asia, Africa
Flying squirrel						
Kangaroo						
Platypus						Australia
Rat snake						North America
Sugar glider						

Which species is the outgroup of this cladogram? _____

If flying squirrels were brought to Australia, what do you predict would happen?

- They'd compete with sugar gliders for resources.
- They'd form a symbiotic relationship with sugar gliders.
- They'd interbreed with sugar gliders.
- They'd evolve pouches and become identical to sugar gliders.

Despite living oceans apart, the North American kangaroo rat and the Australian hopping mouse have similar behaviors. They are both nocturnal and burrow underground. What can you infer? _____

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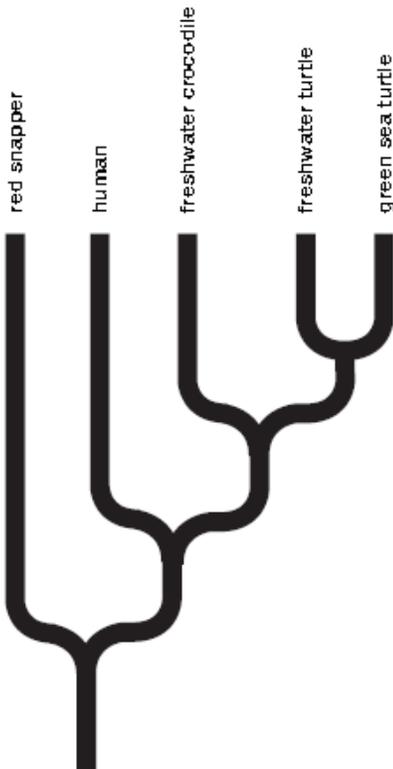
Mission #5: Tree of Life and Death

Hosting Blood Flukes for Dinner: Blood flukes are the common name given to parasitic flatworms. Parasites rely on their hosts, so they will often split into a new species at the same time as its host. When a parasite and its host speciate together, it's called cophyly. When a host and parasite do not speciate together, it may suggest that the parasite has evolved to rely on a different host. Answer the following questions before you move on to the next level, "Fatal Fangs."

Use the information on the species tab to complete the table below.

Parasite	Host
<i>E. euzeti</i>	
<i>G. amoena</i>	
<i>H. mehrai</i>	
<i>S. mansoni</i>	
<i>S. haematobius</i>	

A phylogenetic tree of the hosts is shown below. Draw your phylogenetic tree from this level next to it.



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Compare and contrast the host tree and the parasite tree. Where do they match up? Where are there differences?

In what ways do these trees suggest that some of these species of blood flukes have switched hosts? _____

If blood flukes were to exhibit strict cophyly over millions of years, you would predict that blood flukes would

- a. evolve in a way that's completely different from their current host
- b. evolve in a manner that parallels the evolution of their host
- c. spread to a species that's not closely related.

Fatal Fangs: The more closely related two snakes are, the more similar their venoms tend to be. Sometimes the venoms are so similar that an antivenom for one will work for the other. In this level, an unknown three-foot-long snake just bit Tyler. If you can identify the snake's closest relative, you can administer the right antivenom before it's too late. Answer the following questions before moving on to the next level, "Dawn of a modern pandemic."

Complete the character matrix below.

	nucleotide at position 3	nucleotide at position 8	gap between fangs	single undertail scales	treat with antivenom
Black whip snake					
Fierce snake					
King brown snake					
Taipan snake					
Tiger snake					
Unknown snake					

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Which snake is most closely related to the snake that bit Tyler? _____

If you were bitten by a snake that had a gap between its fangs and a double row of scales under its tail, which antivenom would be best to administer? _____

Dawn of a Modern Pandemic: Viruses are strange, and the more we learn about them, the stranger they become. Viruses are everywhere, but contrary to what most people think, many viruses are harmless. However, HIV is not harmless. From where did it come? Figuring that out is now your job. Answer the following questions before you move on to the next mission.

A Cameroonian woman living in Paris was the first to be diagnosed with HIV-1 P in 2009. Based on your completed tree, which ape virus is most closely related to HIV-1 P? _____

Based on your phylogenetic tree, how many times, at a minimum, do you infer that an HIV has jumped hosts to humans? Explain your answer. _____

Viruses such as HIV reproduce rapidly. What is the connection between reproduction rate and evolution? _____

Mission #6: You Evolved, Too!

You probably don't have any issue distinguishing a human from a chimpanzee, gorilla, or orangutan. But you might if you were looking at DNA instead of physical traits. The differences you see are caused by a shockingly tiny proportion of our DNA. Answer the following questions before you move on to the next level, "Back to skull."

<i>position</i>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Chimpanzee	-	-	G	-	-	-	-	T	-	T	-	-	G	-	-	-	G	-	-	-
Gorilla	-	-	T	-	-	-	-	T	-	T	-	-	T	-	-	-	G	-	-	-
Human	-	-	G	-	-	-	-	A	-	T	-	-	G	-	-	-	G	-	-	-
Orangutan	-	-	G	-	-	-	-	T	-	T	-	-	T	-	-	-	T	-	-	-

This data shows all of the nucleotide differences in a 500-base sequence. Approximately what percentage of DNA do humans have in common with a chimpanzee?

- a. $1/500 = 0.2\%$
- b. $5/500 = 1\%$
- c. $495/500 = 99\%$
- d. $499/500 = 99.8\%$

Based on your phylogenetic tree, who is your closest living relative? _____

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Back to Skull: Animals more closely related to modern humans than to modern chimpanzees are called hominins. All members of the hominins group are extinct except one – us, *Homo sapiens*. In the not-too-distant past, there were several other *Homo* species living on Earth. There were also many species of our closest extinct cousins, the Australopithecines, and several other hominin species as well. Hominin fossils have told us a great deal about our extinct relatives. In this level you'll explore features of various hominin skulls to learn about some of the things that make us human. Answer the following questions before you move on to the final level, "Inside out of Africa."

According to the complete tree, which trait is shared among all species in the genus *Homo*, but no others? _____

The date ranges for each of the hominins in this level are given below. Plot them on the timeline given. One has been done for you.

Species	Known Date Range
<i>Australopithecus afarensis</i>	3.85–2.95 million years ago
<i>Homo erectus</i>	1.89 million years ago–143,000 years ago
<i>Homo neanderthalensis</i>	400,000–40,000 years ago
<i>Homo sapiens</i>	200,000 years ago–present



At least how many *Homo* species shared this planet 500,000 years ago? _____

Inside Out of Africa: It is sometimes possible to extract DNA from ancient humans for analyses. The oldest hominin DNA ever sequenced came from a 400,000 year old thigh bone. Comparisons among ancient remains and populations of humans around the world have yielded insights into when and how various *Homo* species migrated out of Africa. Answer the following questions.

With which archaic human species did some of the ancestors of modern Europeans interbreed with during the past 100,000 years? (Read the background information of each group) _____

Yoruba peoples are most closely related to which other population, according to the phylogenetic tree? _____