

Introduction to Cladogram Construction

A Carolina Essentials™ Activity



Overview

Cladograms are diagrams that show phylogenies, the evolutionary relationships between organisms. In this introductory example of cladogram construction, students use observable traits of animals as a line of empirical evidence supporting the common ancestry among the animals. Students employ two graphical techniques, concentric circle diagrams and cladograms, to establish the ancestral connections between animals.

Phenomenon: Hold up or project the picture of a dog, wolf, and bear. Ask students if the animals are related. Let them share their thoughts and jot down ideas to revisit after the activity.

Life Science
Grades: 9–12

Essential Question

How is empirical evidence of common ancestry and evolutionary relationships identified and represented among several species?

Activity Objectives

1. Identify derived characteristics for several species of animals to use as a line of evidence for common ancestry.
2. Construct a cladogram based on the evidence of derived characteristics to illustrate common ancestry.

Next Generation Science Standards* (NGSS)

This activity can help you build toward the following dimensions of the NGSS:

HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communication Information <ul style="list-style-type: none">• Communicate scientific information about processes or phenomenon in multiple formats, including graphically and textually.	LS4.A: Evidence of Common Ancestry and Diversity <ul style="list-style-type: none">• The ongoing branching that produces multiple lines of descent can be inferred by comparing DNA sequences, differences in amino acid sequences, and from anatomical and embryological evidence.	Patterns <ul style="list-style-type: none">• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Teacher Preparation and Disposal

Copy or post student pages. Have the pictures of phenomena ready to show or project. No disposal required.

TIME REQUIREMENTS



PREP	ACTIVITY
15 min	30–45 min

Teacher Prep: 15 min

Student Activity: 30 to 45 min

MATERIALS (PER GROUP)

Pictures of animal species
Colored pencils, pens, or
highlighters

HELPFUL LINKS

[Genetic Kinship: Following the Globin Genes Through Time](#)

[Carolina BioKits®: Natural Selection](#)

[Constructing a Cladogram with Hydra, Planaria, and Daphnia](#)

[Making 3-D Phylogenetic Trees with Mobiles](#)

[Introduce Your Classroom to Classification](#)

[Comparative Anatomy](#)

REFERENCE KIT

[Carolina BioKits®: Cladograms and Evolution](#)

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Student Procedure

A. Respond to the phenomenon question.

Are these animals related? Explain the evidence behind your reasoning.

B. Identify common and derived characteristics.

1. For each animal, list as many characteristics of that animal as you can. If you know something about the physiology of the animal (that it lays eggs, for example), list that too.
2. Across all of the animals, color-code the traits. For example, if each animal has a backbone, color or highlight *backbone* in the same color. Choose a second color for other traits shared by the animals.
3. Circle the trait that separates each animal from the rest.

C. Create a characteristics chart.

4. List the traits you identified across the top row of the chart. List the animals in the far left column.
5. Use an X if the animal has the trait and an O if the animal does not have the trait.
6. Tally how many yes marks there are for each characteristic.

Note: The characteristics with a higher number of yes marks are ancestral characteristics because they are shared by many animals. Those traits with fewer yes marks are derived characteristics and evolved later.

D. Create a concentric circle diagram.

7. Draw a multi-circular diagram. You will need as many circles as there are unique characteristics.
8. On the outside, start with the characteristic that is shared by all the animals. (Make this a large circle.)
9. Inside each circle, write the species that has only that set of characteristics.

E. Create a cladogram.

10. Using the chart above, transfer the information on the derived characteristics to the main line, or limb, on the cladogram.
11. Using the diagram, write the species on the branches.

Teacher Tips

Give students a hint about the kinds of traits that may be important, such as:

- *Legs*
- *Number of appendages*
- *If the animal lays eggs or gives live birth*
- *If the animal has hair, scales, feathers, or just skin*

Circulate to see if the charts are being constructed correctly.

Remind students that the animal in the inner circle shares traits with all of the other animals. The animal on the outer circle does not share traits.

Remind students that the animal with the least number of shared ancestral traits will be to the left and the animal with the greatest number of shared traits to the right.

Share cladograms at the end of Part E.

Have students discuss any changes they made to their initial thoughts on the ancestry of dogs, wolves, and bears. You may even want to show or have them investigate the scientific name for each.

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Data and Observations

Student answers may vary.

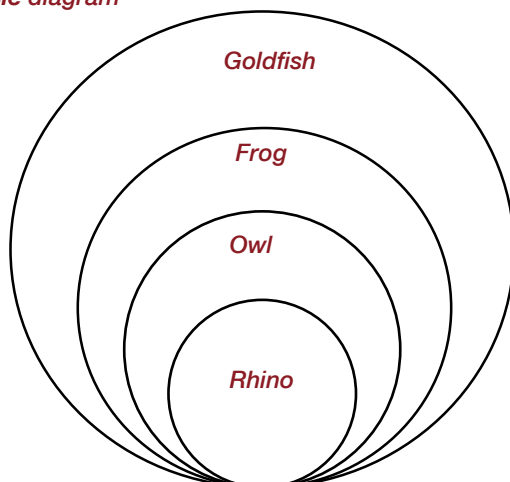
B. Identification of common and derived traits

Rhino	Frog	Owl	Goldfish
<i>Live birth</i>	<i>Eggs in water</i>	<i>Eggs with hard shell</i>	<i>Eggs in water</i>
<i>4 legs</i>	<i>4 legs</i>	<i>2 legs/2 wings</i>	<i>Fins</i>
<i>Lungs</i>	<i>Gills as tadpole Lungs as adult</i>	<i>Lungs</i>	<i>Gills</i>
<i>Hair</i>	<i>Skin</i>	<i>Feathers</i>	<i>Scales</i>
<i>Backbone</i>	<i>Backbone</i>	<i>Backbone</i>	<i>Backbone</i>

C. Chart

Animal	Hair/feathers	Legs	Lungs	Live birth	Backbone
<i>Rhino</i>	X	X	X	X	X
<i>Frog</i>	O	X	X	O	X
<i>Owl</i>	X	X	X	O	X
<i>Fish</i>	O	O	O	O	X
<i>Totals</i>	2	3	3	1	4

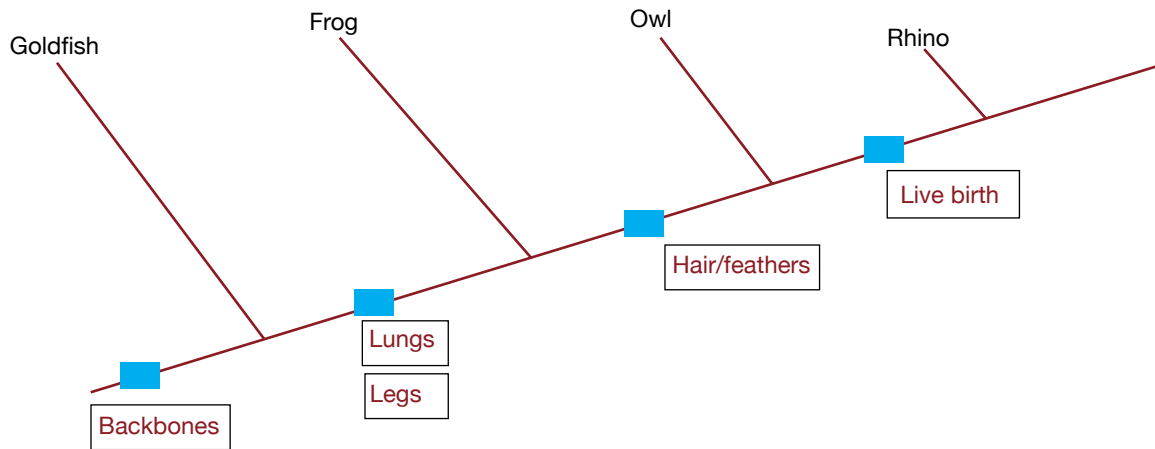
D. Concentric circle diagram



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E. Cladogram



Analysis and Discussion

1. Using complete sentences, explain why you put each species where you did on the cladogram. What is the empirical evidence that led to the placement of each animal?

Answers will vary depending on the traits selected, but all empirical evidence should be associated with an anatomical, physiological, or genetic trait of the animal.

2. According to your cladogram and derived characteristics chart, which species are more closely related and share the most traits? What evidence supports your claim?

Species more closely related will be closer on the limb, and they will share more common traits. In this case, rhinos and owls are more closely related.

3. According to your cladogram, what is the most distant derived characteristic? What evidence supports your claim?

The oldest derived characteristics are lungs and/or legs. All of the animals have backbones, and the next trait to separate species is the presence of lungs and/or legs.

4. Use the same procedure and determine the common ancestry between dogs, wolves, and bears.

Answers will vary. Size, hibernation, or pack/solitary lifestyle may be distinguishing factors for students. They should produce a list of very similar traits among the species. All 3 species have a backbone, fur, large canine teeth, and give birth to live young.

5. Explain if the evidence matches your initial thinking about the common ancestry among dogs, wolves, and bears.

Answers will vary. Most students will not think that bears, dogs, and wolves are related. Most will recognize that dogs and wolves are closely related.

Scientific names

Dog: Canis familiaris

Grey wolf: Canis lupus

Brown bear: Ursus arctos

Bears and wolves split evolutionarily about 40 million years ago. Examination of both families' teeth suggest how similar the two species are. Bears are larger, have smaller ears, and tend to be solitary. Dogs have smaller bodies and generally are social animals. Their classification is the same through the suborder Caniformia: Kingdom Animalia, Phylum Chordata, Class Mammalia, Order Carnivora, and Suborder Caniformia. The families are different. Dogs and wolves are family Canidae, and bears are family Ursidae.

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Phenomenon

Are these animals related? What do you think?

This image shows a full page of blank, lined paper. It features approximately 20 evenly spaced horizontal grey lines across its entire width, providing a guide for handwriting or typing. The paper itself is a clean, off-white color.

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TEACHER NOTES

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