

# Common Ancestry

## Activity

Scientists have long wondered where organisms came from and how they evolved. One of the main sources of evidence for the evolution of organisms comes from the fossil record. The fossil record includes the total number of fossils that scientists know of, as well as their locations in rock formations and sedimentary layers. Their location in the rock layers is important, as it shows how long ago those organisms lived. This record provides a wealth of information about the organisms that existed in the past. The record suggests that many of these organisms have distant ancestors dating back hundreds of millions of years.

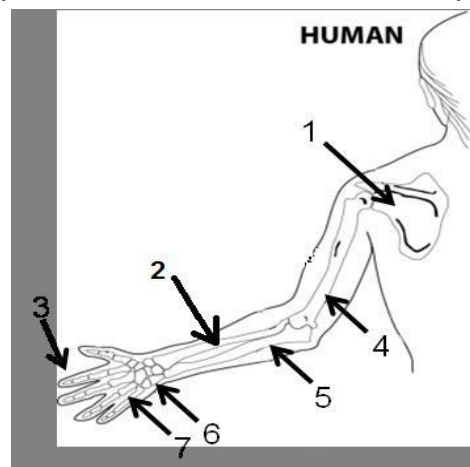
Scientists have discovered that there was a sudden increase in the diversity of organisms found in the fossil layers within the fossil record around 530 million years ago. Scientists have named the time in which this burst in diversity occurred as the Cambrian explosion. It was during this time that the diversity of life on planet Earth increased dramatically. Most of the major phyla that we see today came into being after the Cambrian explosion. Scientists agree that the organisms that came into being after the Cambrian explosion must share common ancestors with the organisms that came before this time.

The fossil record, however, is not the only evidence that supports the common ancestry of organisms. We also see this evidence in similarities in characteristics between organisms, known as homologies, that may have originated from a common ancestor. A homologous structure is something that is similar in position, structure, or evolutionary origin between organisms. There are three main categories of homologies among organisms: anatomical, developmental, and molecular. You will examine all three types of homologies in this activity.

## Station 1: Anatomical Homologies

In this section, you will explore anatomical homologies by examining the structure of vertebrate forelimbs. Look at the human forelimb in this diagram and study its bone structure. You will use this information to help you analyze the bone structure of some other mammals. You will then evaluate their similarities as possible evidence of common ancestry. You will do this by building the skeletal structure of their forelimbs, and then demonstrating how the scapula, humerus, radius, ulna, carpals, metacarpals, and phalanges share common placement between vertebrate species.

1. Scapula
2. Radius
3. Phalanges (finger bones)
4. Humerus
5. Ulna
6. Carpals (wrist bones)
7. Metacarpals (bones in the palm of your hand)



# Common Ancestry

## Activity, continued

### Station 1: Anatomical Homologies, continued

#### Procedure:

1. Cut out the diagram of the human forelimb from your Student Reference Sheet, along with its title. Study the human forelimb structures as labeled above in this activity.
2. Each member of your group will work to color the human forelimb from your Student Reference Sheet as instructed by your teacher. You will use this as a guide for the other animals shown.
3. Three remaining animals appear in your Student Reference Sheet. Each group member will choose one of these animals, and will repeat this procedure with the chosen animal.
4. Attach all of the completed diagrams to a poster board. Include the human forelimb you created as a group, the forelimb you created on your own, and the two remaining forelimb models created by your group members. Label the seven different types of bones on the poster board, and then draw lines from the label to the correct bone in each of the forelimbs.

### Station 1: Anatomical Homologies Log

1. How is the human forelimb similar to that of the other three mammals you examined? Be specific.

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1. Why might this evidence suggest a distant, common ancestry between different vertebrate species? Explain your answer.

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2. Analyze the forelimbs you constructed and labeled. What similarities would you expect to find in the forelimb of another vertebrate species, such as a small reptile like the gecko? Identify these similarities and explain why those similarities might exist.

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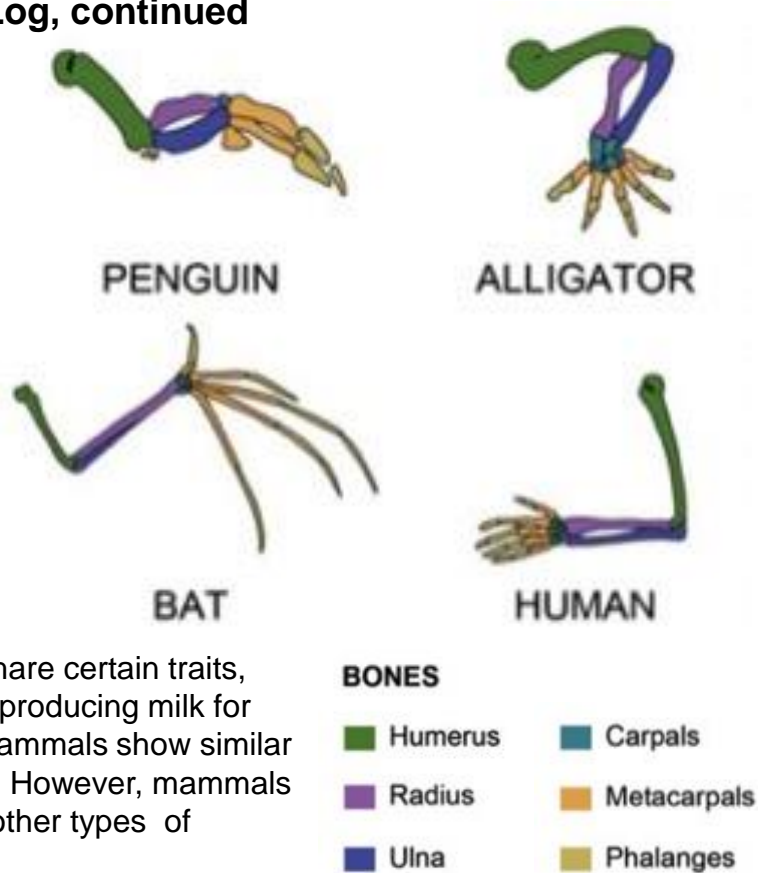
## Common Ancestry

### Activity, continued

#### Station 1: Anatomical Homologies Log, continued

As you have just learned, anatomical homologies are similar anatomical structures that exist between species that can be identified as a link to a common ancestor. Similar features suggest relatedness among the organisms. Anatomical homologies are sometimes easy to observe, as is the case with modern Asian and African elephants and the now extinct woolly mammoth. All three are distinct species, but they belong to the same family of organisms (*Elephantidae*) that have large skeletons, trunks, and tusks.

Mammals are a class of organisms that all share certain traits, such as breathing air, having hair or fur, and producing milk for their young. As you have already seen, all mammals show similar patterns of bone structures in their forelimbs. However, mammals have forelimb structures strikingly similar to other types of animals, including birds and reptiles.



4. What is a homologous structure, and what are some examples?

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5. Humans are mammals, which are defined as having a certain set of anatomical homologies. What are some homologous structures shared by all mammals? List them.

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6. What occurred during the Cambrian explosion? How is this significant in terms of common ancestry?

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# Common Ancestry

## Activity, continued

### Station 2: Developmental Homologies

At this station, you will examine some hand-drawn pictures of early embryonic development of seven different animals. These images are by no means 100% accurate, but these are the types of tools that early scientists used when comparing animals that may share common ancestry.

Procedure:

Using the images found on page 5 of your Student Reference Sheet, fill in the table below by placing the number found in the upper left hand corner of each picture in the space of the correct animal at each stage of development. You may want to use a pencil for this, as your answers may change as you examine each image.

STAGE OF DEVELOPMENT	FISH	TORTOISE	CALF	HUMAN	CHICK	RABBIT	SALAMANDER
STAGE I							
STAGE II							
STAGE III							

### Station 2: Developmental Homologies Log

1. What did you notice as you were trying to match the images of each stage of development to the correct animal? Was it difficult? What were some of the challenges in doing so?

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2. After you have matched the cards, describe some of the similarities that you found among the embryos of the seven different animals.

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3. Explain how the similarities in early embryonic development may point to common ancestry among these animals. Make sure to state what they all have in common.

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## Common Ancestry

### Activity, continued

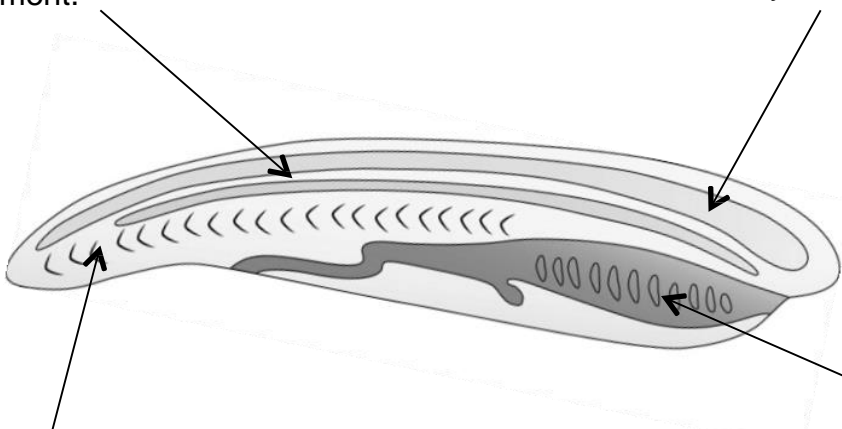
### Station 2: Developmental Homologies Log, continued

Developmental homologies can be observed by studying similarities in embryos' formation. For this station, you will analyze common features of early chordate development, then evaluate these similarities as evidence of common ancestry. Chordates, from the phylum Chordata, are animals that are mostly vertebrates (this phylum does include some related invertebrates). Humans, whales, fish, and squirrels are all chordates.

All chordates share four anatomical structures that appear during specific embryonic developmental stages. Below is a diagram of a very early embryonic chordate. This illustration shows the different parts that all chordate embryos share at some point in their development. The fact that all chordate embryos share these features at some point is one of the major pieces of evidence that points to the common ancestry of all chordates.

**Notochord:** A stiff rod of cartilage provides support to the chordate. In vertebrates, this develops into the spine. In other organisms, the notochord remains as the sole means of muscle attachment.

**Dorsal hollow nerve chord:** This feature is unique to chordates. This dorsal (near the back) chord is what eventually develops into the central nervous system of chordates.



**Post-anal tail:** In contrast to invertebrates, which have a digestive system that runs the entire length of their body, such as worms, chordates have a muscular tail that extends past their anus.

**Pharyngeal slits:** These structures are present in all chordates at some point during their development. In some animals, they develop into the pharynx (part of the throat). In fish, they develop into gills.

# Common Ancestry

## Activity, continued

### Station 2: Developmental Homologies Log, continued

4. What are developmental homologies, and how are they studied?

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5. What is a chordate, and what do all chordates have in common? Explain.

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6. List five familiar organisms that are in the phylum chordata.

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7. What is a notochord and where is it found?

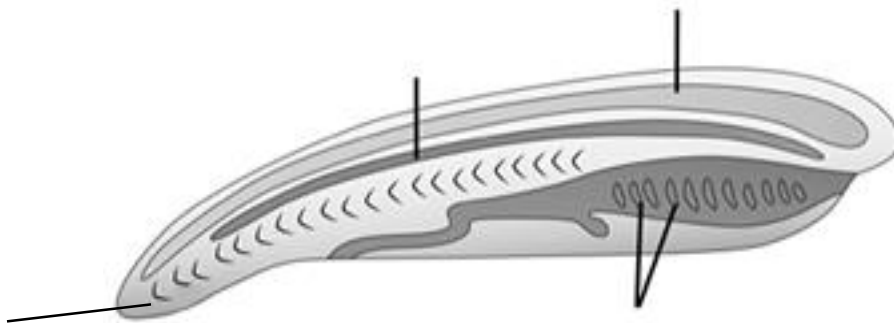
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8. Title and label the diagram below.

TITLE: \_\_\_\_\_



9. What do all chordates have in common during some stage of development?

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## Common Ancestry

### Activity, continued

### Station 3: Molecular Homologies Log

Number of Differences in Cyt C Amino Acid Sequences

	Human & Chimpanzee	Rhesus Monkey	Cow, Pig, & Sheep	Kangaroo	Bullfrog
Human & Chimpanzee	0	1			
Rhesus Monkey		0			
Cow, Pig, & Sheep			0		
Kangaroo				0	
Bullfrog					0

You will see that humans and chimpanzees have identical amino acid sequences for this protein. Further evaluation shows that Rhesus monkeys differ by only one amino acid; the 66th amino acid is threonine instead of isoleucine. Similarly, chickens and turkeys have identical sequences, whereas ducks have sequences that differ from chickens and turkeys by only a single amino acid.

Biologists can calculate the rate of evolutionary change by looking at these sequences. They can then use this information to determine how long ago each species branched away from the others. Examine the chart named Amino Acid Sequences of Cytochrome c Proteins in the Student Reference Sheet. Note that the lighter letters for amino acids in the table on page 6 of your Student Reference Sheet are those amino acids that all of the animals share in common. You will not need to count these columns.





# Common Ancestry

## Activity, continued

### Station 3: Molecular Homologies Log, continued

1. Why are organisms with similar genetic sequences also likely to have similar protein configurations? State at least one specific example of this.

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2. Cows, pigs, and sheep have identical amino acid sequences for Cyt c. What does this say about their evolutionary relatedness? What other properties or traits do these species have in common?

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3. Look at the table you completed on the previous page. If you were to sequence the amino acids for a snapping turtle, which organism on the list would you predict the sequences to most closely resemble? Make sure to state an explanation of why you chose that organism, expressing this choice in terms of common ancestry.

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