Evidence of Common Ancestry
Biological Evolution and Classification

STUDENT GUIDE

Part I: Anatomical Homologies

Since a period of time called the Cambrian explosion (starting about 530 million years ago), life has flourished on our planet. Most of the major phyla that we see today came into being after the Cambrian explosion. Scientists have found evidence for this in the fossil record. The fossil record includes the total number of fossils, as well as their locations in rock formations and sedimentary layers. 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.

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

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

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. All mammals show similar patterns of bone structures in their forelimbs. However, mammals also show forelimb similarities to birds and reptiles.

Please continue to the next page.
Part I: Anatomical Homologies, continued

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.

1. Scapula
2. Radius
3. Phalanges (finger bones)
4. Humerus
5. Ulna
6. Carpals (wrist bones)
7. Metacarpals (bones in your palm, between fingers and forearm)

Next, you will analyze the bone structure of some other mammals, 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 animal species.

Procedure:

1. Color the human forelimb from your Student Reference Sheet as instructed by your teacher.

2. Cut out the diagram with its title. Study the human forelimb structures as labeled above in this Student Guide.

3. Next, each group member repeats procedure with a different remaining mammal.

4. Attach your completed diagram onto a poster board. Include the human forelimb that you created as a group, the forelimb that you created on your own, and the two forelimb models created by your other group members. Label the seven different types of bones on the poster board, and then draw lines from the label to its correct bone in each of the skeletons.

Complete Part I of your Student Journal.
Part II: Developmental Homologies

Developmental homologies can be observed by studying similarities in how embryos form. For this section, 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 that 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 during their development 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.

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

**Postanal tail:** In contrast to invertebrates, which have a digestive system that runs the entire length of their body (for example, worms), chordates have a muscular tail that extends past their anus.

Complete Part II of your Student Journal.
Part III: Molecular Homologies

Now let’s evaluate molecular homologies and how molecules are similar in species that are closely related. An excellent molecule for studying evolutionary relationships is the protein Cytochrome c (Cyt c), which is found in the mitochondria of plants, animals, and even several unicellular organisms like yeast.

Remember that mitochondria are organelles found in the cells of all eukaryotes that generate energy for the cell to use in the form of ATP. Cytochrome c is an important protein in the electron transport chain which generates ATP, so it is easy to understand why Cyt c is found everywhere. It is the structure of Cyt c, however, that makes it such a useful protein for evolutionary biologists. An organism’s genes determine the shape and function of that organism’s proteins. Therefore, species that are genetically similar should also have similarities in the structure of their proteins.

Cytochrome c is a protein made of a chain of about 100-104 amino acids. The order of these amino acids within that chain demonstrates relatedness of species. Examine the Amino Acid Sequences page in your Student Reference Sheet. You will see that humans and chimpanzees (which share 98% of gene sequences) have identical amino acid sequences for this protein. Rhesus monkeys, which share 93% of their DNA sequence with humans, differ by only one amino acid (the 66th amino acid is threonine instead of isoleucine). Similarly, chickens and turkeys have identical sequences to one another, and ducks have sequences that differ from chickens and turkeys by only a single amino acid.

Biologists can calculate the rate of evolutionary change in these sequences and can thus determine how long ago each species branched away from the others.
Examine the Amino Acid Sequences of Cytochrome c Proteins chart in the Student Reference Sheet. The comparison of humans/chimpanzees to rhesus monkeys is done for you as an example. You will compare the Cyt c amino acid sequences for each of the remaining organisms: cows, kangaroos, and bullfrogs. Did you know that cows, sheep, and pigs also all share the same Cyt c sequences?

Complete Part III of your Student Journal.