THE VISIBLE APE PROJECT

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Lesson Plan

Educator Introduction
Answer key
Student Worksheet

EDUCATOR GUIDE & ANSWER KEY

What are the anatomical differences between common chimpanzees and bonobos?

Active learning time: 20 minutes

Lesson introduction: Common chimpanzees and bonobos are two species of chimpanzees that last shared a common ancestor some time between 2 million and 1 million years ago. These two species have very different social behaviors, but are about 99.6% genetically similar to each other and have a similar appearance. Follow the instructions below to find out just how similar the skeletons and muscles of bonobos and common chimpanzees are, and discover the few anatomical differences between these species.

Learning objectives: The goal of this lesson is for students to observe the numerous similarities and few differences of the musculoskeletal system of common chimpanzees and bonobos. This exercise should foster a discussion about the very few skeletal and muscular differences that are observed between chimpanzees and bonobos. An advanced discussion may highlight: 1) what muscular differences might tell us about differences in chimpanzee and bonobo growth and development, and 2) the fact that despite the anatomical similarities between these species, common chimpanzees and bonobos have remarkably different social behaviors.

Glossary definitions that will help you answer the questions below: Bonobo - Chimpanzee - Muscles - Skeleton - Sister species - Social system - Species - Sub-adult - Three-Dimensional (3D) models

Skeletons

1. Open up the 3D models of the skeletons of the adult chimpanzee and the subadult bonobo in two tabs.

2. Explore the models by clicking around them. Rotate them, zoom in and zoom out.

3. **How** are the skeletons of the two specimens **similar** to one another? **List at least two similarities.**

Students will likely provide one or more of the following answers:
- The skeletons look similar in overall size
- The skeletons look similar in overall shape
- The skeletons are in a similar position/orientation
- Other descriptions of specific similarities in shapes/sizes of bones (e.g. similar or same looking pelvis, scapula, face, head, arms, legs, ribcage, etc).

Best answer will incorporate at least two of the potential responses above, especially observations about specific bones in the skeleton.

4. **How** are the skeletons of the two specimens **different** from one another? **List at least one difference.**

Students will likely provide one of the following answers:
- The common chimpanzee has larger canine teeth than the bonobo
- The common chimpanzee has thicker, more pronounced ridges on the cranium
- The skeleton of the common chimpanzee is overall more robust than the bonobo
- The skeleton of the bonobo is overall more slight/gracile than the chimpanzee
- Other descriptions of specific differences in shapes/sizes of bones

Best answer will incorporate any one of the potential responses above.

The chimpanzee is missing many of the distal phalanges on the hands and feet. This is just an issue with the specimen that the 3D model is based on, not a true anatomical difference.

5. **Why** might the skeletons look **similar**?

Students will likely provide one of the following answers:
- The common chimpanzee and bonobo are both apes so they will look similar
- The common chimpanzee and bonobo are similar in size so their skeletons will be similar
- These species are closely related to one another/are sister species so their skeletons will look similar

Best answer:
- These species are closely related to one another/are sister species so their skeletons will look similar

6. **Why** might the skeletons look **different**?

Students will likely provide one of the following answers:

- (Even though they are closely related) the common chimpanzee and bonobo are different species so their skeletons will look different
- The common chimpanzee is an adult, the bonobo is a subadult. They are different ages so their skeletons will look different.
- They are different individuals and don't have the same parents so they will look different

Best answer will incorporate one of the first two potential responses listed above.

Bonus question: The chimpanzee skeleton is an adult and the bonobo skeleton is a subadult. How can you tell that the bonobo is not a fully developed adult?

You can tell that the bonobo is a subadult because many of its bones are not fully fused, which you can tell be looking at the rough lines/indentations on the bones, which can be seen on the head of the humerus, in between the bones that comprise the pelvis, ends of the radius and ulna, and ends of the tibia. Secondly, if you zoom in on the cranium and mandible of the bonobo, you can observe that the third molars (the equivalent of the "wisdom teeth" in humans), is not fully erupted. The eruption of the third molar is often an indicator that an individual has reached the adulthood stage of development.

<u>Head & neck muscles</u>

7. Open up the 3D models of the head & neck muscles of the common chimpanzee and bonobo.

8. Explore the models by clicking around them. Rotate them, zoom in and zoom out.

9. There is one small, subtle muscular difference between the head & neck muscles of common chimpanzees and bonobos. **Find it, and describe it below.** For a hint, check out the comparative muscular illustrations for these species.

Correct answer: Bonobos have a single belly of the omohyoideus, compared to the two bellies that are usually present in both common chimpanzees and modern humans. This can be observed in the muscle labeled 16a and 16b in the anatomical landmark key.

<u>Upper limb muscles</u>

10. Open up the 3D models of the upper limb muscles of the common chimpanzee and bonobo.

11. Explore the models by clicking around them. Rotate them, zoom in and zoom out.

12. There is one main muscular difference between the common chimpanzee and the bonobo upper limbs. **Find it, and describe it below.** For a hint, check out the comparative muscular illustrations for these species.

Correct answer: In the hand, the common chimpanzee has intermetacarpales and flexores breves profundi muscles, while in the hand of bonobos these muscles are not there. The bonobos instead have dorsal interossei, which result as a fusion of the intermetacarpales and flexores breves profundi muscles

Dorsal interossei is a feature that bonobos share with modern humans. Some other minor muscular differences between common chimpanzee and bonobo upper limbs is that bonobos have a stout tendon of the flexor digitorum profundus attaching to digit 1, and an attachment between the pectoralis minor and the coracoid process of the scapula

Bonus question: By studying embryonic and fetal development in humans, we know that the intermetacarpales are distinct muscles in early developmental stages (as they remain in adult common chimpanzees), and only in the later stages of human development do they become fused with the flexores breves profundi to form the dorsal interossei (as they are in adult bonobos). Knowing this, can you make any guesses about the rate of muscle development in these two species?

Correct answer: This might be evidence that common chimpanzees have slower rates of development than bonobos. Common chimpanzee intermetacarpales development ends at a developmental stage that bonobos surpass, as these muscles in adult bonobos are closer to the adult human condition than these muscles are common chimpanzees.

<u>Lower limb muscles</u>

13. Open up the 3D models of the lower limb muscles of the common chimpanzee and bonobo.

14. Explore the models by clicking around them. Rotate them, zoom in and zoom out.

15. There is one main difference between the common chimpanzee and the bonobo lower limb musculature. **Find it, and describe it below.** For a hint, check out the comparative muscular illustrations for these species.

Correct answer: In the posterior leg, bonobos have a scansorius muscle while the common chimpanzee does not.

Lacking a scansorius is common in both humans and common chimpanzees. Some other minor muscular differences between common chimpanzee and bonobo lower limbs is that bonobos have popliteus-fibula and extensor hallucis longus-proximal big toe phalanx attachments.

Summary

16. You're now an expert on chimpanzee and bonobo anatomy! If these species are mostly similar in appearance, do you think it important to study the anatomy of **both** these species? Why or why not?

Responses will vary. If students agree that it is important to study both species, their responses may emphasize that the small differences between bonobos and common chimps are important to understand. They may also suggest that since both species are closely related to humans, studying both of them will help us better understand human behavior, anatomy, and evolution.

If students do not think it is important to study both species, their responses may emphasize that chimpanzees and bonobos are so similar looking that it might not be worth it to study the anatomy of both.

Further reading for interested students and educators:

1. http://www.pbs.org/wgbh/evolution/library/07/3/l_073_03.html
2. https://evolutionaryanthropology.duke.edu/research/3chimps/chimps-bonobos
3. https://www.sciencemag.org/news/2018/02/chimpanzees-bonobos-and-even-humans-may-share-ancient-body-language
4. https://www.sciencealert.com/seven-human-muscles-found-in-apes-challenge-evolutionary-history

WORKSHEET

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Summary

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All done? Check your answers with the answer key.