Beyond Bone Dry Memorization

Photo by Alicia Solario

USING COMPARATIVE ANATOMY TO BETTER UNDERSTAND HOW THE HUMAN BODY WORKS

by **Ben Overman** and **Katherine Larson**

ABSTRACT: Oftentimes students learn about the skeletal system by simply viewing pictures of bones or, if they are fortunate, by observing real bones, but then going no further than being told the names of the bones. While this approach may result in students recalling names and locations of particular bones, it does not promote an understanding of these individual structures' function and importance. Here we present an inquiry approach to teaching human anatomy that has students observe body movements, comparing these observations to other species, and then returning to look more deeply into the role of bones. This inquiry approach to comparative anatomy helps students better understand how the human body works. *This article promotes National Science Education Standard A, and Iowa Teaching Standards 1, 2, 3, 4, and 6.*

Most of us can remember the long-anticipated frog dissection day in 7th grade science, or watching a video of huge bones being dug out of a dinosaur dig. These experiences are often used to teach about animal anatomy by telling students information such as “This is the femur; it is the strongest and thickest bone in the human body”. While students may remember the names of particular bones, we want our students to understand why the femur is the strongest and thickest bone in the human body and why muscles are attached in a particular way?

The original activity, on which this article is based, started with a good idea: begin with a discussion about comparing horse bones to human bones. However, the main discussion question was: “Do you know what the word paleontologist means?” a simple “yes” or “no” response settled such a question. Moreover, the question introduces a term prior to students having experienced what the term labels. We modified this activity to be more inquiry oriented so that students first experience some of the things that paleontologists do observing, comparing/contrasting structures and

functions, critically thinking, and trying to make connections. Although our lesson plan is geared towards students with some knowledge of human and comparative anatomy, it can easily be adapted for nearly any grade level.

Observing Structure and Function

On day one we have students observe how their classmates walk, run, jump, stand, etc. Tell students that they will observe each other as they move around the room. Watch each other walk, run, sit, stand, and jump. Before beginning, ask students, "To better understand the purpose of different body parts during movement, what are some things you should pay close attention to?" Student ideas might include: how their feet move against the ground, what their arms do, what their knees, ankles, and other body parts do as they perform a wide variety of actions. Encourage many answers from students by using positive non-verbal behaviors like looking expectantly around the room and gesturing with hands out inviting more ideas while providing enough time for students to process the question as well as other student comments. Rather than clarifying or interpreting student ideas, and ask for clarification and ask follow-up questions that push student thinking. If students struggle with the task, ask more guiding questions such as,

- "How might your feet move when you are running as opposed to walking?"
- "How could we find out?"
- "What kinds of movements might we want to observe to investigate how different appendages interact or relate?"

Once the students know what general behaviors (i.e. walking, running, sitting, standing, jumping, etc.) and particular structures they are observing, they pair up to observe each other. As you walk circulate throughout the room, encourage students to try different movements and asking questions to help students make connections between types of movement and the role of different body parts. For example:

- What could you do to more closely observe how the foot moves? This may encourage students to remove their shoes and socks so that they can directly observe the foot.
- You noticed the foot rolls from heel to toe when walking. How might this be different when running?"

After several minutes of observing, have students discuss with their partner what they saw. Then have the pairs of students share with another group of two what they observed.

After small group discussions, have a whole class discussion about what students noticed about their feet, knees, legs, hips, etc. during different movements. A fruitful question is, "What's special about our appendages that permit the body to do what you observed?" Students may have noticed that when they run, their knees bent more, and their bodies leaned forward more. Again, the teacher must use effective questioning, wait time and encouraging non-verbal behaviors to promote student engagement. Students should report precisely what the feet did, and how the knees, legs, hips, arms, etc. moved. This may require students to repeat their observations of the general behaviors. These direct experiences will help students understand future discussions that highlight how the skeletal system works together to allow our bodies to move in different ways.

Ask students how they will remember what they observed and how this may best be expressed to someone who was not present during the activity. A number of ways exist including drawings, taking digital pictures, and extensive descriptions. This discussion is important because students learn that effectively communicating their work is best achieved with both visual expression and a written or verbal explanation. Moreover, the effort to express their ideas more deeply engages them in thinking about what they are doing and making sense of human anatomy. After day one students

should have a better understanding of how we move when performing different activities so they can compare and refer back to their observations during subsequent instruction.

Comparing Structures and Functions

Day two builds on the previous day by moving beyond the concrete experiences students had with human beings to include other animals. If a zoo is nearby, set up a field trip. Some forethought will be necessary to ensure a successful trip. The goal of the field trip is for students to compare how different animals move and behave and relate an animal's anatomical structure to the observed function. If a zoo is not accessible, have students observe dogs, cats, rabbits, birds, or any other local wildlife. As a last resort, you might find a suitable video that shows a variety of animals moving in several ways.

Points to Address if Considering a Field Trip:

- Clear objectives for students
- Parental permissions and adult chaperones for supervision
- Admission to the site
- Water and snacks
- School policies and safety procedures

Prepare the students for this experience by asking questions such as: "What adaptations allow each animal to get their food?" and "What can a giraffe do that an elephant cannot?" These questions encourage the students to compare the body structures of each animal in the context of what function the structures serve. We try to have students observe at least five different mammals' movements and their anatomical structures. As a class you can decide what animals you will watch, though some suggestions for diverse anatomy include: elephants, giraffes, zebras, tigers, primate and marine mammals. By having students observe these particular organisms, the teacher can later discuss adaptations and similarities between the species that can be segued into a discussion on evolution. We also recommend that students bring a notebook to write down all of their observations so they can remember specific details.

Videos of animal movements abound on the Internet. From YouTube:

Elephant
http://www.youtube.com/watch?v=g1Gldu1KS44

Giraffe
http://www.youtube.com/watch?v=R0uNbM0dADc

Zebra
http://www.youtube.com/watch?v=EVqc7e8JCco

Tiger
http://www.youtube.com/watch?v=NSJnppzwIIM

Electric Eel
http://www.youtube.com/watch?v=QMk5N5w-ZVU

Note: Always preview all video clips in their entirety before showing them to students!

Instruct the students to concentrate on the similarities as well as differences in how the animals move. You might direct the students to pay attention to how the animals move; how they get their food; how they rest, how they move when they appear content or threatened. You may want to take video or pictures of the animals for reference during discussions that will occur back in class. This permits students see behaviors they may have missed and focus on structural similarities and differences between the mammals.

During the field trip and back in the classroom, further guide the students toward the goal of comparative anatomy with questions such as: "What are some actions you saw other animals do that humans cannot?" and "What behaviors can humans do that other mammals cannot?" We suggest having students try to move like an elephant or zebra. Students have fun doing this, and it raises questions regarding what about their anatomy is similar or different from the animals they attempt to mimic.

has been that their interest in observing the X-ray pictures is sufficient to keep them engaged. Next, have students individually write down their own observations and insights for a few minutes. Then, have each student discuss their observations with a partner, adding any new insights to their lists. When this is completed, have groups of students share their observations and insights with the class, and write these on the board.

Lead the class discussion toward comparative anatomy with questions such as:

- "What function do you think this appendage has?"
- "How does this mammal's appendage compare to …?"
- "How do you account for this mammal's running behavior compared to…?"

Based on the students' responses, ask questions that help students make the link between an appendage's structure and its function. A human hand has an opposable thumb for gripping; a bat's wing has bones spread out so it can fly. During discussion the teacher can refer to the x-rays and student experiences for concrete examples. These carefully designed questions draw students' attention to comparative anatomy. During the discussion, teachers can encourage students to reflect on their prior experiences by asking students to not only compare the x-rays but also how the different animals might have specialized structures for specific functions.

To have students apply what they are learning about anatomical bone structure and function, ask students to observe an X-ray of an unnamed mammal appendage and have them speculate on its function, size of the mammal, and their evidence or rationale to support their claim. Further, the students might try to figure out what type of habitat each animal comes from, what they eat, how they live, and what adaptations the x-ray demonstrates that might help the organism survive. Teachers might even bring in models of the actual appendages to further build student observations and understanding to include external anatomy. The students can look at the models and predict how they function for the animal and its environment. The teacher can ask, "How does the animal's skeleton determine what the animal looks like on the outside?" which can lead the class into making inferences based on their experience, the x-rays, and now the models.

Because instruction has focused on conceptual understanding of structure and function relationships of different pieces of anatomy, the students now have a much richer understanding and experience on which to base new vocabulary words. The students are ready to learn the names and specific functions of bones and/or muscles. By providing students with concrete experiences and having them reflect thoughtfully on those experiences, the teacher has set students up for meaningful learning of specific terms.

At this point, the teacher can branch out to several topics. More advanced grades can lead into a study of functional anatomy, including naming the bones seen in the x-rays. By comparing the x-rays and observations of how the appendages move from previous activities, the teacher can lead into lessons on evolution and adaptations. Lower grades might further focus on comparative anatomy. The teacher can highlight similarities between mammal's bones by showing an x-ray of a bat's wing, human hand, chimp's hand, and possibly even a whale's fin. The teacher can highlight similarities between all mammals' anatomy and perhaps discuss other animal groups.

Summary and Final Thoughts

The inquiry approach described above encourages students to be far more mentally engaged, and it promotes many important science education goals. It does so by having students make a number of observations of different mammals and accounting for the differences and similarities. Observing and comparing human motion to zoo animals, linking this to their bone structures, and then observing x-rays of hands, legs, and arms of different species all create a context where learning

the names of bones has some value. Furthermore, the activity encourages critical thinking, problem solving, communication and other important behaviors crucial in learning. Finally, the lesson provides opportunities for teachers to branch out to various subjects such as evolution, or animal behavior. Students are much more engaged with activities that require them to observe, reflect and think critically. We as teachers want our students to be reflective and critical thinkers, and this requires going well beyond simply telling students, “This is the femur”.

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