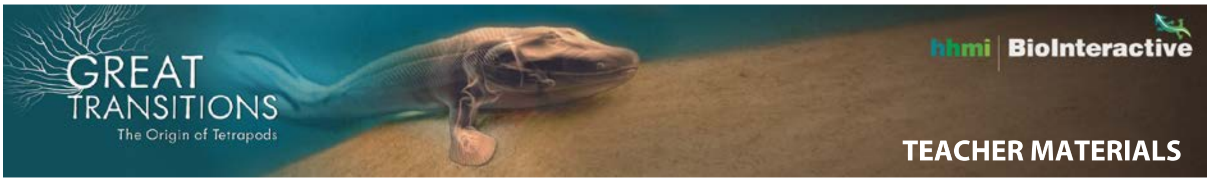


EXPLORE YOUR INNER ANIMALS WORKSHEET

OVERVIEW

This worksheet accompanies the Click & Learn "Explore Your Inner Animals" (http://www.hhmi.org/biointeractive/explore-your-inner-animals). As they work through the Click & Learn, students explore multiple lines of evidence for common descent found among the bodies and cells of both extinct and extant organisms. This content was also featured in the film *Your Inner Fish* and in the *Great Transitions: The Origin of Tetrapods* short film. Visit http://www.hhmi.org/biointeractive/your-inner-fish for more information.

The student worksheet is designed to help ensure students successfully navigate the interactive and can be completed in class or assigned as homework. Students may complete all of the different sections or only some of them.

KEY CONCEPTS AND LESSON OBJECTIVES

- Species descend from other species. Even distantly related species, like humans and sponges, can trace their shared ancestry back to a common ancestor.
- Evidence for common descent includes the fossil record and anatomical, genetic, and developmental homologies among organisms.
- The fossil record provides a history of life on Earth. It includes fossils with features that are intermediate, or transitional, between those of major groups of animals.
- When a series of transitional fossils are viewed together, they reveal the gradual sequence of change connecting one major group to another.
- An organism's DNA codes for proteins that result in an organism's visible traits.
- Scientists infer function and behavior from anatomical structures.
- Natural selection is the process by which heritable traits that confer a survival and/or reproductive advantage to individuals that possess them increase in frequency within a population over generations.

CURRICULUM CONNECTIONS

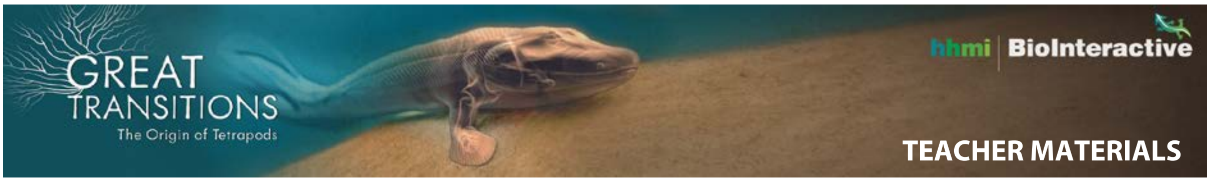
Curriculum	Standards
NGSS (April 2013)	MS-LS3-1, MS-LS4-1, MS-LS4-2 HS-LS1-1, HS-LS1-2, HS-LS3-1, HS-LS4-1, HS-LS4-2, HS-LS4-4
AP (2012–13)	1.A.1, 1.A.2, 1.A.4, 1.B.1, 1.C.3, 3.A.1, 3.C.1, 3.E.2, 4.C.1
IB (2009)	5.4.2, 5.4.5, 5.4.7, 5.4, D.3.5
Common Core (2010)	CCSS.ELA-Literacy.RST.9-10.4

KEY TERMS

adaptation, amphioxus, *Ardipithecus, evolution*, fossil, *Gorgonopsid,* natural selection, *Notharctus,* transitional form, primate, *Proconsul*, tetrapod, *Tiktaalik,* vertebrate

TIME REQUIREMENTS

Allow one to two hours to complete the entire Click & Learn and worksheet.



SUGGESTED AUDIENCE

The Click & Learn and worksheet are appropriate for high school biology (all levels including AP and IB) and introductory college biology.

PRIOR KNOWLEDGE

Most questions in the student worksheet can be answered directly from the Click & Learn. Students will however benefit from having some familiarity with the concept of common descent and with the evolutionary mechanism of natural selection.

MATERIALS

Internet-connected computers and head sets

TEACHING TIPS

- The Click &Learn and questions are divided into 6 sections. If you do not have sufficient in-class time to devote to this Click & Learn, consider breaking your class into groups, assigning each group selected sections, and then recombining the groups to share information. Alternatively you can assign the whole Click & Learn and worksheet to students and they can do part of the worksheet for homework.
- The questions labeled "Extend" require some background knowledge of evolution and natural selection. Preview these questions and assign only those that are appropriate for your class. You may also considering answering these questions in a class discussion.
- Instruct students on whether they need to respond in complete sentences.

RELATED RESOURCES

Skeletons Reveal Human and Chimpanzee Evolution
(http://www.hhmi.org/biointeractive/skeletons-reveal-human-and-chimpanzee-evolution)

A Click & Learn that explores human evolution and features the fossil "Ardi."

It's a Fishapod (http://www.hhmi.org/biointeractive/article-fishapod)

This article by Sean B. Carroll tells the story of the search for and discovery of *Tiktaalik*.

Great Transitions Interactive

(http://www.hhmi.org/biointeractive/great-transitions-interactive)

In this Click and Learn, students explore several transitional fossils in the transition from fish to tetrapods, including *Tiktaalik*.

Young Students Recognize a Transitional Tetrapod
(http://www.hhmi.org/biointeractive/young-students-recognize-transitional-fossil)

This short video demonstrates the power of observation and the importance of fossil evidence. When Neil Shubin shows a *Tiktaalik* fossil to small children, they immediately notice the presence of both fish and tetrapod characteristics.

ANSWER KEY

Section 1—Eyes

1. *How do we know that Kramer cannot see the same way most humans can?* **Kramer is shown a screen with a red "blob" on a green background. If he presses the red blob, he gets a treat. He does not press the red blob, so we know he cannot distinguish red from green like most humans can**.

2. *What are opsins and what do they do? Opsins are proteins in the eyes. They function to detect color.*

3. *Both humans and monkeys like Kramer have opsins, but monkeys like Kramer cannot see the same range of colors that most humans can. Why not?* **Kramer only has two types of opsins. Most humans have three. For this reason humans can see more colors than monkeys**.

4. *Describe what the "clues" scientists found in our DNA suggest about how humans might have evolved enhanced color vision.*

Scientists found that the most recently evolved opsin gene in humans is right next to, and extremely similar to, another one of the opsin genes. This suggests that during evolution one of the genes was duplicated, and then accumulated mutations. The mutated gene codes for a protein with different functions that allow it to detect different wavelengths of light.

Section 2—Legs

1.*Based on the age of the rock in which the fossil was found, how long ago did Ardi live*? **4.4 million years ago**

2. *Why was finding a hominid of this age significant*?

It's around the time that the human lineage split from the lineage that gave rise to chimps and humans were becoming bipedal.

3. *Describe the anatomical features of Ardi's upper and lower pelvis and what they indicate about how Ardi may have moved*.

The top part of the pelvis is short and broad like that of a human, which suggests that Ardi could walk on two legs. The lower part of the pelvis is longer than a human pelvis and more like that of a chimp, which suggests that Ardi could climb well.

4. *What does Dr. Shubin mean when he describes Ardi as a "creature in transition"?*

It means that *Ardi* had some characteristics that are like those of modern humans, who walk on two legs, and some that are like those of our common ancestors with chimps who primarily moved on 4 legs and lived in trees. *Ardi*'s anatomy suggests that she could walk on two legs, but not as well as modern humans.

5. *Does Ardi's foot structure support or refute the idea that Ardi was a creature in transition? Explain your answer*.

It supports it. The foot had full grasping capability, which is useful in climbing, but could also support walking.

6. *Dr. White and his team came to a surprising conclusion about the type of environment Ardi lived in. What type of environment was it, and what evidence led the team to this conclusion?*

***Ardi* lived in a woodland, not an open grassland. Wherever scientists found fossils of *Ardi*'s species, they also collected fossils of woodland creatures, such as parrots, monkeys, peacocks, and woodland plants**.

Section 3—Ears

1. *What are three bones are found in the middle ears of all mammals, including humans?* **The three bones are malleus, incus, and stapes.**

2. *How do these three bones work together to produce sound?* **They form a lever system that transforms vibrations in air to sounds that we perceive.**

3. *Explain why mammalian ears are more sensitive to sound than those of reptiles.* **Reptiles only have one ear bone, the stapes. In mammals, the two additional ear bones (the malleus and incus) act to amplify sound**.

4. *Describe two pieces of evidence that the three ear bones of mammals like the opossum evolved from reptiles.*
Developmental evidence: As embryos, opossums have only one ear bone, the stapes, just like reptiles.

The other bones form part of the jaw joint. As they develop to adults, the malleus and incus separate from the jaw, get smaller, and incorporate into the middle ear.

Fossil record evidence: Primitive mammal-like reptiles have multiple jaw bones in the back of the jaw, like the opossum embryos.

Section 4—Hands

1. *Describe what features the modern human hand shares with the hand of the 50 million year-old primate,* Notharctus. **It has a divergent (opposable) thumbs, long fingers, and nails (not claws)**.

2. *Dr. Shubin explains that the earliest primate ancestors could access the "fine branch niche." What is special about this niche, and how did their hand structure enable them to access it?*

The fine branch niche is rich in different types of food (i.e., flowers, fruits, and insects). Their long fingers and divergent thumb could grasp thin branches tightly and hold the animals stable.

3. *What characteristics of the modern human hand enable our "precision grip"?*

Human hands have relatively short fingers and a relatively long thumb.

4. *What is the earliest human ancestor thought to be capable of making and using tools, and how long ago did this ancestor live?* ***Homo habilis*** **lived 1.75–2 million years ago**.

5. *Describe the basic pattern of the bones in the limbs of humans and other four-limbed vertebrates (tetrapods) that Richard Owen first documented*. **The pattern is one bone, two bones, little bones, and digits.**

6. *How did Darwin explain common patterns like these among vertebrates*?

Darwin predicted that all vertebrates share a common ancestor that had a version of this pattern of bones.

7. *What is* Tiktaalik*? Why was the discovery of* Tiktaalik *so exciting to Dr. Shubin and his team?*

Tiktaalik **is a 375 million year old fishlike tetrapod ancestor. It was an exciting discovery because its anatomy is evidence that the basic form of the human hand emerged from the fins of ancient fish.**

8. *According to the last slide, what do a human hand, chicken wing, and fish fin have in common?*

They all have the same basic instructions (genes), inherited from a common ancestor, that pattern the forelimbs.

Seciton 5—Brain

1. *Dr. Shubin says that's it is very hard for him to see any similarities between the human brain and amphioxus. Where does Dr. Holland tell us that the similarities are?* **The evidence cannot be seen because the similarities are in the genes and development of both animals.**

2. *How many million years ago did the "first roots" of our modern human brain arise?* **The roots of the human modern brain date back to more than 500 million years ago.**

3. *Describe how our human brain is similar to the brains of other primates.*

All primate brains have large visual processing centers and specialized regions for controlling grasping and manipulating objects.

4. *According to the last slide, what feature of the human brain most likely accounts for the exceptional capability of humans compared to other primates?* **The feature that accounts for this capability is the larger number of neurons and connections among regions of the brain.**

Section 6—Back

1. *What is another word for coccyx?* **The coccyx is also known as the tailbone. It is a vestige because it's what's left of a structure (the tail).**

2. *Why can falling on our coccyx hurt so much?* **It hurts because the tailbone isn't protected by any cushioning tissue or muscles.**

3. *What is one of the easiest ways to distinguish an ape from a monkey?* **Apes don't have tails, monkeys do.**

4. *Discuss how the shape of the sacral vertebrae of the fossil ape Proconsul provide evidence that it may have been one of the first tailless apes.* **It is extremely tapered (like that of a modern chimp), which indicates that a tail would not have followed it. Proconsul is 18–20 million years old so it would be one of the first tailless primates in the fossil record.**

5. *Explain how going from walking on all fours to walking on just two feet affects balance.*

On all fours, weight hangs down from the spine; on two legs, all of our weight is out front.

Section 7—Teeth

1. *Describe the teeth of a typical reptile.* **Reptiles typically have identical, peg-shaped teeth (for tearing food).**

2. *How do the teeth of* Gorgonopsid *differ from those of reptiles? What can paleontologists infer from these teeth about how* Gorgonopsid *ate?*

Gorgonopsid **had differentiated incisors and canines (i.e., the teeth were different sizes). Paleontologists infer that they were able to pierce skin with their large canines, strip flesh off bone with their incisors, and chew more efficiently than most reptiles**.

3. *What is an advantage of chewing food over swallowing it whole?*

Chewed food takes less energy to digest, so there is more energy available for activities such as chasing prey.

4. *Why are teeth so important to paleontologists?* **Teeth fossilize more often than almost any other part of an animal. Paleontologist can identify a species from teeth.**

5. *What is* EDA *and why is it important that it is found in both humans and fish?*

EDA **is a master regulator gene that provides instructions for the development of skin features (i.e., hair, nails, sweat glands, and teeth). Because it is found in both humans and fish, we can infer that these features have a long evolutionary history**.

6. *Humans have both molars with flat surfaces and pointed canines. What does this suggest about the diet of human ancestors?* **It suggests that human ancestors ate both plants and animals.**

AUTHOR

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