San Diego Museum of Man

Lesson Plan 1: April 2002

BIPEDAL LOCOMOTION

OBJECTIVE

Through completing a set of five different exercises, students will understand how natural selection may have favored bipedal locomotion in the hominid lineage.

MATERIALS

paper
pencils
stopwatch
assorted objects (piece of fruit, big rock, broom handle)
flashlight
diagrams/photos of Laetoli footprints

DIRECTIONS

1. Define bipedal (walking on two feet) vs. quadrupedal (walking on four feet) motion. Ask students to think about how different animals move and how their feet are uniquely adapted to their movements.
2. Students will design a mini-experiment where they are comparing how long it takes to complete the following tasks:
   - walk quadrupedally vs. bipedally from two points in the room and measure how long it takes.
   - hold a piece of fruit and measure how long it takes to walk quadrupedally vs. bipedally from two points in the room.
   - hold a big rock and repeat the same measurement.
   - hold a broom handle and repeat the same measurement.

Complete three trials of each exercise. Take an average of each exercise. Students should design a chart where they can record their findings. One type of chart can look like this:

	Trial 1		Trial 2		Trial 3		AVG	
Activity	Bi	Quad	Bi	Quad	Bi	Quad	Bi	Quad

Ask students, "Looking at the average time for each, which form of movement is more efficient?"

4. For the last exercise, students will compare surface areas (instead of time) in moving quadrupedally vs. bipedally. A flashlight is used to represent the sun's rays. It is helpful to dim or turn off the classroom lights. One student in each group holds a lighted flashlight while standing on a table. Two others in the group stand and walk both quadrupedally and bipedally underneath the beam of light. The last student records observations. Which form of movement exposes more surface area of the body to the beam of light?

Explain the following to students, "The beam of light represents the sun's rays. Imagine the heat of the African savanna when our hominid ancestors were evolving, which form of movement exposes more of the body to the heat coming off the ground and the sun

overhead? Which form of movement would be more advantageous in terms of helping the body to keep cool?" Have students answer questions on a piece of paper.
5. To wrap up, have students answer the following questions:
   - "Which of the five exercises could be the 'control' for this experiment?"
   - "What kinds of things did you notice as you were moving in two different ways?"
   - "How are these movements similar or different from the type of movements and tasks early hominids performed?"
   - "Thinking back to all of the exercises, name two reasons why natural selection may have favored bipedalism."

BACKGROUND

A footprint can tell scientists much about the individual that made it, such as the kind of species, how they were moving, and their size. Modern humans and our extinct ancestors are hominids. Bipedalism, the ability two walk on two feet, is considered the most important hominid trait. The earliest bipedal species discovered so far, *Ardipethcus ramidus*, dates back to 4.4 million years ago. The earliest well-studied hominid is *Australopithecus afarensis* (popularized by D. Johanson's famous 1974 find of *Lucy*), and dates back to 3.8-2.9 million years ago. Fossilized hominid footprints, dating to 3.7 million years ago, were found in Laetoli, Tanzania and have been attributed to *A. afarensis*. The Laetoli Footprints are a remarkable find because they show early bipedal behavior in a fossilized medium.

Other Great Apes, such as gorillas, bonobos, and chimpanzees have been observed standing on two feet, but no other species is a habitual bipedal walker like *Homo sapiens*. There are a number of physiological changes that have to occur throughout the skeleton in order to support the body when walking upright. These changes can be seen in the position of the foramen magnum (the hole at the base of the skull rather than at the back of the skull), shape of the pelvis (thicker, shorter, and rounder as compared to the chimpanzee pelvis), femur (angled toward midline of body for greater balance, with a longer femoral neck), humerus, and the foot (big toe is aligned with the other toes and not opposable). In the earliest stages of hominid evolution, skeletal evidence indicating bipedalism is the only truly reliable indicator that these fossils were indeed hominids.

Natural selection may have favored bipedal locomotion for several reasons. It frees the hands to carry things such as food to safe locations, and allows for the manipulation of tools. Since heat stress is an adaptive problem for savanna-living animals, bipedalism helps keep the body cool since it means less surface area hit by the sun and more surface area cooled by the wind. In addition, bipedalism is an efficient form of terrestrial locomotion as compared to primate quadrupedalism found in the Great Apes.

SO WHAT?

Most students are usually familiar with common examples of natural selection such as the peppered moth, but sometimes have more difficulty with thinking about how natural selection works in more complex examples, over longer periods of time.

This activity was developed by Tina Zarpour, and presented at the National Science Teacher's Association Conference, March 2002.