BUILDING BODIES: Student Activity Pages
Primate Bipedalism: Understanding Standing Up

SELF CHECK: Based on your reading of the previous Background Information, check your understanding at this point by answering the following questions (place all answers on seperate sheet):

1. Fossil and other evidence indicates that the first major innovation in hominid evolution was:
a. increased brain size b. tool making c. material culture d. bipedal locomotion

2. Current evidence indicates that hominids first emerged in:
a. Africa b. North America c. Asia d. Indonesia

PART 1: Modern Clues to Bipedality: Comparing Anatomy of Humans and Chimpanzees
Fortunately for us, an ancient ancestor of modern chimpanzees also left descendants that eventually developed upright walking, tool making and bigger brains. We are the result of these changes in an evolutionary history spanning 6-8 million years. As important and profound a change as it may have been, the transformation from walking on all fours to walking upright on two legs among primates is not as drastic a transition as it might at first appear. Unlike the quadrupedal locomotion typical of dogs or horses, many four-legged primates regularly stand upright and some can even walk upright. These observations lead some scientists to view human upright posture not as a unique trait of human evolution, but as a primate evolutionary trend.

So why don't apes walk upright like us? With so much already in common with humans, what prevents apes from habitual bipedal locomotion? Though apes can walk upright for short periods, it is less energetically efficient. Anatomical differences which among other things produce a higher center of gravity, result in a stooping upright posture that requires the use of the hands to periodically prop up the upper body during walking. This style of locomotion, called "knuckle walking", is common among the chimpanzees and gorillas. Unlike a human's fluid gate, a chimpanzee attempting to walk upright shows a noticeable side to side rocking as each step is taken forward in order to keep the body balanced over widely spaced legs. The more graceful human motion results from modifications of the pelvis, legs, and foot which have produced shifts in the center of gravity and noticeable improvements in the ability to balance on each leg as a stride is taken. Also, changes in the positioning of the skull on the spine insure a natural angle for carrying the head and being able to look forward while walking.

Do It:
Remove the mixed set of 12 transperancy film anatomical illustrations in envelope #1. Carefully read the clues enclosed in their given, numbered order (or listen to your teacher read the clues), and place the transperancy films ***<u>in order</u>*** onto the "Reconstructions" page. Six pieces are for the human reconstruction and the other six are for the chimpanzee reconstruction. Place the pieces within the boarders of the outline of the human and chimpanzee. Pieces will overlap, indicating the order in which they were placed on the sheet. Hold these plastic pieces to the "Reconstructions" page with a large paperclip. Once completed, check your and your partner's understanding by describing the several anatomical features just observed, and how each contributes to the locomotion posture of modern apes, and of modern humans.

Check Question:
3. Compare the features of a chimpanzee and human, and select any items below that are <u>not</u> correct:
   a. Chimpanzees are knock-kneed , but this allows them to better balance the body over their legs while walking upright.
   b. Compared to chimpanzees, humans show relative shortening of the arms and lengthening of the legs.
   c. Despite having a torso of about the same size as a human, a chimpanzee cranium is much smaller than a human cranium.
   d. The human pelvis is long and narrow providing little support for internal organs , and little surface area for the attachment of large buttock muscles useful in standing and walking upright.
   e. The human foot has a divergent big toe, giving the foot a strong and efficient grip.

PART 2: Interpreting Ancient Hominid Tracks

Most scholars have concluded that early human ancestors never did pass through a dedicated knuckle-walking phase, but became bipedal hominids soon after leaving the trees (Campbell, p. 217). But actual evidence of how early human ancestors may have walked seemed remote and unlikely to be found until, in 1976, a team led by Mary Leakey discovered the fossilized footprints of human ancestors at Laetoli, Tanzania. Dated at 3.6 million years, these tracks provide a direct record of early hominid locomotion that can help us understand their anatomy and behavior. The trackways were made when a few individuals (one in the left trackway, and two in the right trackway, producing the appearance of a larger footprint on the right) walked across an African plain recently covered by ash and rain from a volcanic eruption. The wet ash hardened like cement and then was covered by more ash and sediments. The tracks are as unmistakable as they are remarkable. An early hominid had developed upright posture and was, several million years ago, already walking capably on two legs across Africa, the continent of human origins.

Recall from Part 1 that chimps have a strongly divergent great toe. A modern human foot has an arch and strong heel strike, and so did the individuals that left their footprints in the Laetoli trackway. This seems to suggest that these early hominids were strong walkers. Yet, without actual bony fossil evidence, conclusions about their anatomy can be difficult. Look at the photo of the trackway. What conclusions can be drawn from this evidence?

Do It

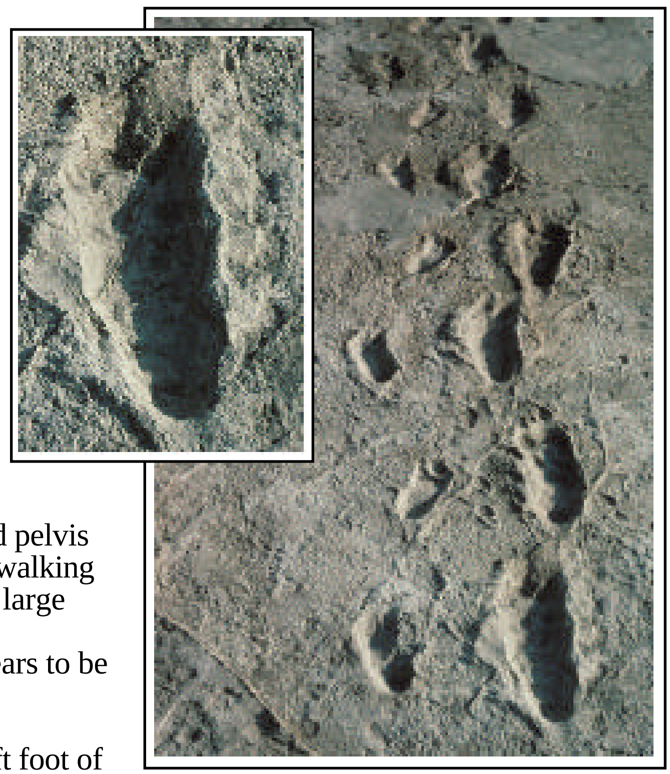
Within your student teams, discuss the **Statements** 4-13, and then select the lettered **Response** A-D that most accurately fits each numbered statement .

Response Choices (based on tracks observed):

A. can be directly observed
B. can be logically inferred
C. contradicted by the evidence given.
D. no way to determine the validity of the inference based on the evidence given

Statements:

4. one set of tracks was made by a child.
5. the big toe is inline with the other toes
6. these hominids made and used tools.
7. these tracks indicate a knuckle walker.
8. these hominids had a thigh that was angled in down to the knee and a broad bowl shaped pelvis
9. the legs of an individual are close together while walking
10. the individuals that made these tracks possessed large brains
11. a set of smaller tracks runs alongside what appears to be a set of larger tracks.
12. these sets of tracks were made at the same time.
13. the left foot of one individual is alongside the left foot of the other individual.



Depending on how the known bony fossil evidence has been interpreted, early hominids may have had a slightly bent, bow legged, and bent-kneed gait similar to that of a chimpanzee attempting to walk on two legs, or a longer striding gait similar to modern people (Klein, p. 204). But these tracks, which provide distinctive evidence of a strong heel strike, distinct arch, and non-divergent big toe support the latter conclusion. Very likely able to forage over long distances, these creatures were walking like us nearly four million years ago.

Do It

Rub a wet paper towel over the soles of both bare feet. Then take several strides along a concrete walkway. Or walk in firm damp sand. Observe the pattern of the tracks, and the side to side distance of your left and right feet. Compare your trackway to the above photo of the Laetoli tracks. Are your tracks widely spaced or close together? How close together are the left and right feet of an individual in the Laetoli trackway? Notice the distance between successive tracks for the 2 visible sets of tracks above. What do the short strides for the larger track indicate about the rate of walking compared to the smaller, though more widely spaced, set of tracks? Were they walking or running? How can you tell? How close together are the two individuals in the trackway? Make tracks while walking with another person (if possible, taller if you are short, or shorter if you are tall), and see how close you would have to be to duplicate the pattern seen in the Laetoli tracks. What does this suggest about how the Laetoli individuals were moving?

PART 3: Fossil Evidence and Mosaic Evolution of Hominids.

To date, the bones of thousands of fossil hominids have been unearthed, representing a number of distinct taxonomic groups dating back to about 5 million years ago. Most such fossils are fairly fragmentary, often just a single bone. However, sometimes several bones from a single individual are found together. On rare occasions a large portion of an entire skeleton may be preserved. These more complete remains allow scientists to reconstruct body size, shape, and proportions with some confidence.

One particular discovery which had a profound impact on our understanding of human evolution, occurred in 1974. In that year, a team led by Donald Johanson discovered the now famous "Lucy" fossil at Hadar, Ethiopia. This partial skeleton, along with hundreds of additional fragmentary fossils of *Australopithecus afarensis* is close to 3 million years old. Not only was this the oldest so-complete hominid ancestor ever discovered up to then, but it also possessed a range of characteristics that confirmed that fully capable bipedalism started very early in the evolution of the hominid line. These and other finds of *Australopithecus afarensis*, show that early human ancestors had already developed a host of physical traits to make efficient bipedal locomotion possible.

Though small relative to humans, Lucy and her kin were relatively humanlike from the neck down, but remained much more apelike from the neck up. Increases in cranial capacity did not occur for almost another million years. Here then was a mosaic pattern of evolution. Our ancestors continued to evolve above the neck after most of the rest of the body had essentially reached a modern form capable of walking upright.

Do It

Remove the 6 anatomical illustrations for a reconstructed skeleton of *Australopithecus afarensis* from the envelope labeled Part #3. Examine each sketch carefully, and decide , with the input of your partner(s) if the anatomy is more humanlike or apelike. Write on the plastic piece with an overhead marker an "A" if that general feature is more Apelike, an "H" if it is more humanlike, or an "I" if it is intermediate between human and ape. Then read the enclosed clues labelled "Part 3 Clues" ***in order*** (or those read by your teacher) to place each piece on the "Reconstructions" page over the outline of an Australopithecine in the specific order. Again, pieces will overlap, indicating the order in which they were placed on the sheet.

SELF CHECK: Answer the following question

14. Fossil evidence from specimens of *Australopithecus afarensis* indicate that
    a. All anatomical traits of hominids evolved together at the same rate and time.
    b. Some traits, like those that make bipedalism possible, evolved first , with other traits like a bigger brain, evolving later.
    c. No pattern is discernible in the fossil record since modern humans and their ancient relatives remain unchanged throughout their history.

PART 4: Walking Upright: Consequences, Benefits, and Causes.

Certainly one of the greatest challenges to paleoanthropologists who study human evolution is to understand why early human ancestors stood up. Though the fossil record of apes remains sparse between 4-12 million years ago, it appears that successful and expanding monkey populations in the trees, during a global climate that had become much cooler and drier, increased competition for food in the forests. Current evidence supports the conclusion that early apelike ancestors became bipedal while still in this familiar forest environment.

A large number of hypotheses have been offered for the evolution of bipedalism including : energy efficiency, temperature regulation, food gathering, and predator avoidance & threatening displays. But these are largely secondary causes that leave little, if any, clues in the fossil record. Many anthropologists concede that scientists may never know with certainty why hominids stood up and began walking on two feet. But certainly the evidence leads us to conclude that the events that happened so early in the hominid line had profound effects on our anatomy and evolution. It seems in some ways ironic that common ailments such as low back pain, herniated vertebral discs, fragile knee and ankle joints, and flat feet are all a reflection of imperfections in the structures that evolved to allow biomechanically efficient bipedal locomotion.

Do It

Discuss with members of your group some of the anatomical problems associated with upright walking in humans and those that may have affected you or your family and friends. Consider how these injuries occurred and what could have been done to redesign the body to prevent these damaging effects. Be sure to include injuries that happen to older people or people that participate in aggressive physical sports. With an overhead pen, circle the items that you mention, or were mentioned in the paragraph above, on the plastic overlays of the human anatomy.

Check Question:

15. Human anatomy which evolved to facilitate bipedal locomotion can best be described as:
    - a. A functional compromise of workable , though rarely perfect , physical adaptations limited by modification of existing structures inherited from ancient quadrupedal primate ancestors.
    - b. A complete collection of perfect adaptations that allow us to move faster and more efficiently than any other animal.
    - c. Unchanged and no different from modern ape anatomy.

CONCLUSIONS:

In future years it is certain that paleoanthropologists will continue to unearth fossil evidence which helps us to better understand the events and physical changes that define the evolution of our species in the process of becoming human. Though it remains uncertain whether physical evidence can be found to help us understand what specific selection pressures may have contributed to our development as a biped, a number of hypotheses remain intriguing.

Final Cleanup:

After wiping clean the overhead pen from the human plastic anatomy strips, return both the chimpanzee and human strips and paperclips to envelope #1. Then return the australopithecine plastic anatomy strips and the paperclip to envelop #2.