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Were Australopithecines Ape–Human Intermediates or Just Apes? A Test of Both Hypotheses Using the “Lucy” Skeleton

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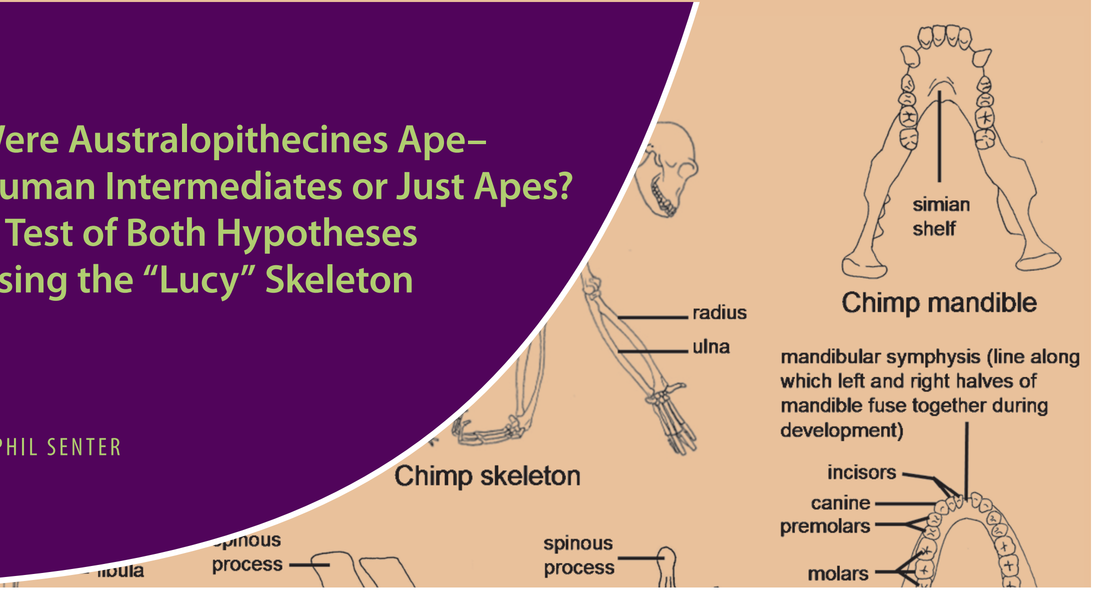

Abstract

Mainstream scientists often claim that australopithecines such as the specimen nicknamed “Lucy” exhibit anatomy intermediate between that of apes and that of humans and use this as evidence that humans evolved from australopithecines, which evolved from apes. On the other hand, creationists reject evolution and claim that australopithecines are “just apes.” Here, a point-by-point visual comparison with the skeletons of a chimpanzee, “Lucy,” and a human is presented in order to evaluate both claims, treating them as testable hypotheses. The results support the hypothesis that australopithecines are anatomically intermediate between apes and humans. Classroom applications of this test of hypotheses are also discussed.

Key Words: *Human evolution; comparison of human and chimpanzee skeletons; australopithecines.*

To effectively introduce the evidence for evolution, it is important that a biology teacher have a basic grasp of the anatomy of australopithecines. This is because the presence of evolutionary sequences in the fossil record is one of the main lines of evidence for evolution, and no fossil evolutionary lineage generates more interest than our own. As evolutionary intermediates between apes and humans, the australopithecines form a prominent part of that lineage, and their anatomy is a beautiful illustration of the anatomical transition from ape to human.

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A good way to become familiar with australopithecine anatomy would be to use a point-by-point comparison of their skeletons with those of apes and humans. Unfortunately, such is lacking in most biology textbooks (e.g., Starr & Taggart, 2004; Campbell et al., 2009), including those on evolution (e.g., Volpe & Rosenbaum, 2000; Barton et al., 2007). This makes it difficult for the biology teacher to illustrate exactly how australopithecines are intermediate between apes and humans. Here, I compare an australopithecine skeleton with those of the chimpanzee (*Pan troglodytes*) and the modern human species (*Homo sapiens*).

A point-by-point comparison of ape, australopithecine, and human anatomy presents another opportunity that should be seized. Such a comparison can be used to test two competing claims that can be treated as testable hypotheses: (1) the consensus among mainstream scientists that australopithecine anatomy is intermediate between those of apes and humans and (2) the young-earth creationist claim that australopithecines are “just apes,” unrelated to humans (Mehlert, 2000; Line, 2005; Murdock, 2006). In a time of rampant creationism (Mazur, 2005; Miller et al., 2006), it is important not to dismiss the latter claim out of hand but to explicitly put it to the test.

Hundreds of australopithecine specimens are known, but to keep this study simple and to avoid overwhelming the nonspecialist reader, I chose to use a single australopithecine specimen: AL 288-1, nicknamed “Lucy.” Discovered in Ethiopia in 1974 (Johanson et al., 1982), AL 288-1 is particularly appropriate to use for this test of hypotheses, for several reasons. First, at 40% complete (Johanson et al., 1982), it is one of the most complete australopithecine skeletons known to date; most of the skull is missing, but the preserved portions of the jaw, dentition, vertebral column, pelvis, and limbs are sufficient to test the two hypotheses with traits from a variety of skeletal regions. Second, cast replicas of the entire known skeleton of Lucy are commercially available – as are those of chimpanzees and humans – so this test of hypotheses can be repeated by any academic or other entity with an appropriate budget without having to travel to see the fossil itself. Third, AL 288-1 represents a species, *Australopithecus afarensis*, with important phylogenetic significance. It predates both our own genus (*Homo*) and the later australopithecines with which early *Homo* coexisted, and it is possibly ancestral to both (Stein & Rowe, 2006). Other specimens of *A. afarensis* show that AL 288-1 is similar enough to its conspecifics to serve as an exemplar of the species (Drapeau et al., 2005). Fourth, it is a particularly famous fossil, and the public’s familiarity with it continues to increase as a result of publicity generated by its current tour through the United States.

The hypothesis that Lucy is anatomically intermediate between apes and humans predicts that a point-by-point comparison will reveal a mixture of apelike features and humanlike features in the specimen. The hypothesis that Lucy is just an ape predicts that such a comparison will only reveal apelike features in the specimen. Some proponents of the latter hypothesis recognize that australopithecines had upright bipedal locomotion but do not consider this a feature linking australopithecines with humans (Mehlert, 2000; Murdock, 2006). To satisfy such strict interpreters of the “just an ape” hypothesis, the predictions can be modified: the hypothesis that Lucy is anatomically intermediate between apes and humans predicts that a point-by-point comparison will reveal in Lucy a mixture of apelike features and humanlike features in which some of the humanlike features are not necessary for upright bipedal locomotion. The hypothesis that Lucy is just an ape predicts that the comparison will reveal no humanlike features in Lucy that are unnecessary for upright bipedal locomotion.

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○ Materials & Methods

To test the hypotheses, I compiled a list of skeletal differences between chimpanzee and human skeletons, using direct examination of several chimpanzee skeletons at the U.S. National Museum and human skeletons at Fayetteville State University and the U.S. National Museum. I examined the australopithecine skeleton AL 288-1, which was on temporary display in Seattle, and tabulated which characters in the list exhibit the apelike state and which exhibit the humanlike state (Figures 1 and 2, Table 1). For features that I could not make out on AL 288-1 because of the position of the specimen as it was laid out for display, I used a cast of the specimen.

○ Results & Conclusion

Of 36 anatomical characters examined on AL 288-1, 14 (39%) exhibit the apelike state and 22 (61%) exhibit the humanlike state. Of the

Figure 1. Skeletons of chimpanzee (left), the australopithecine specimen AL 288-1 ("Lucy") (middle), and a modern human (right), with anatomical traits numbered according to Table 1. Numbers that represent humanlike states are underlined.

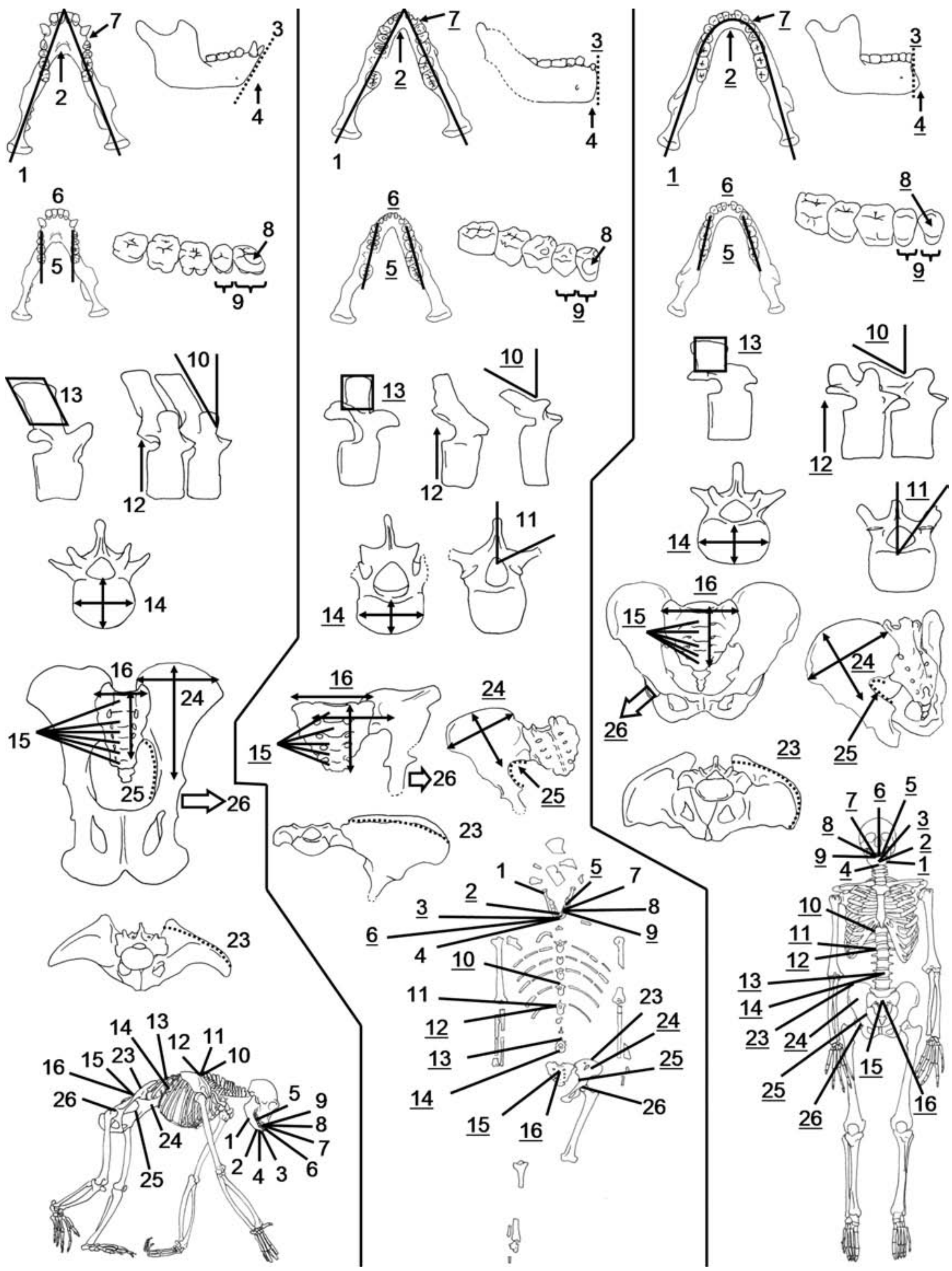
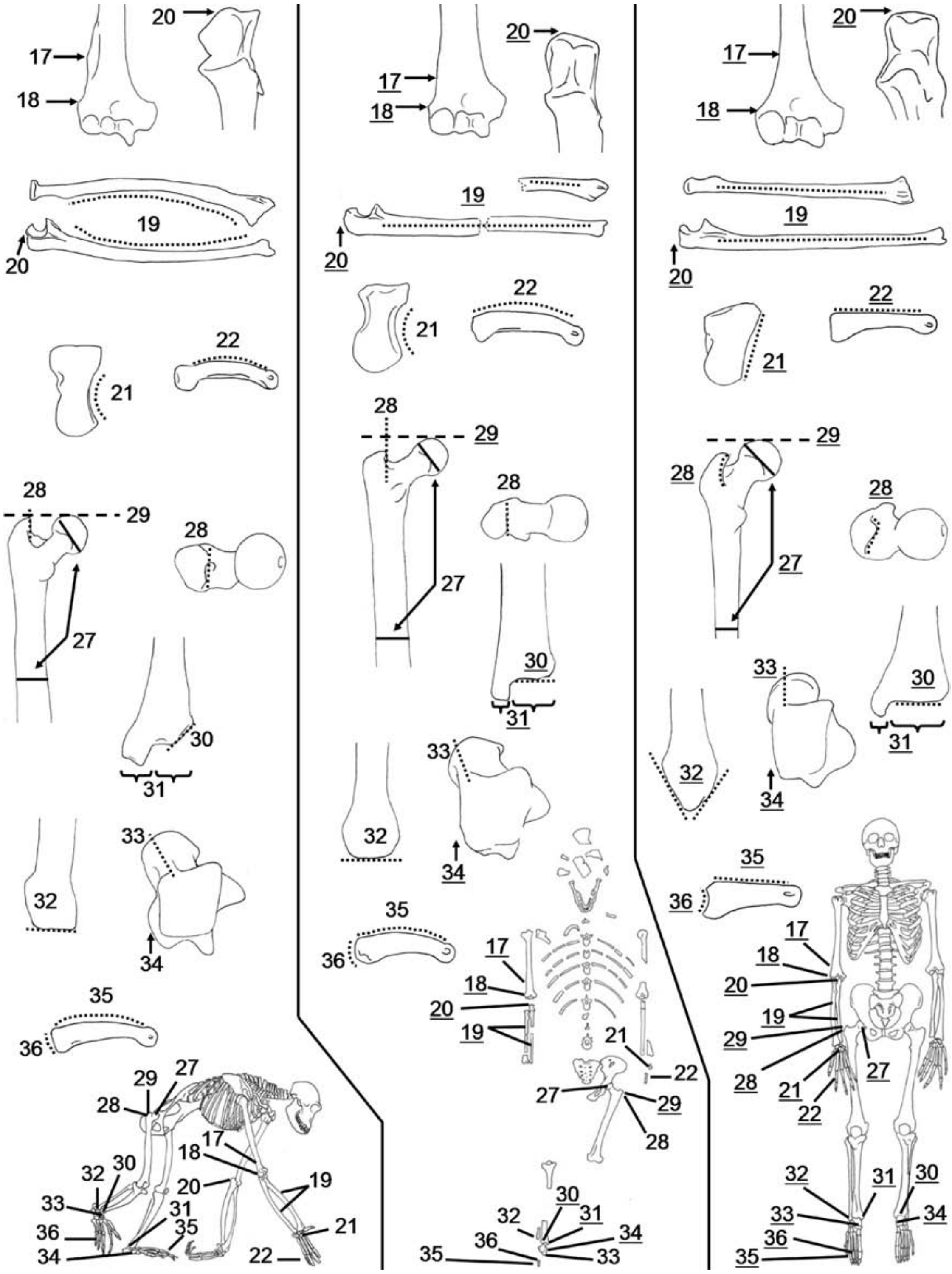


Figure 1. (*Cont'd*)

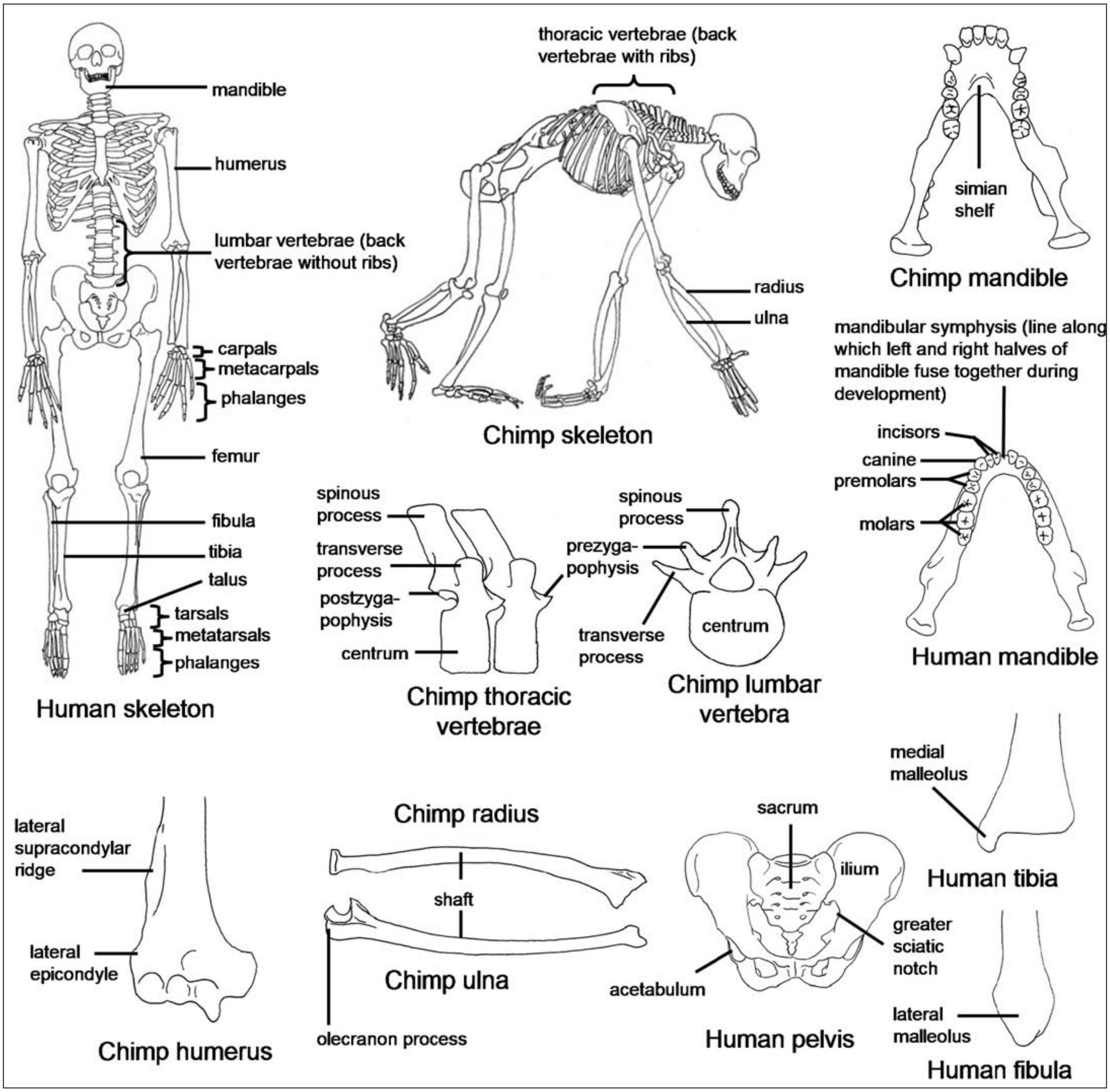


22 characters for which AL 288-1 exhibits the humanlike state, 12 (55%) are found on the vertebral column, pelvis, and lower limb and could therefore be construed as related to upright bipedal locomotion, whereas 10 (45%) are found on the jaw, teeth, and upper limb and are therefore unrelated to upright bipedal locomotion. The data therefore support the hypothesis that Lucy is anatomically intermediate between apes and humans and falsify the hypothesis that Lucy is just an ape.

○ Discussion

This study can be adapted as a classroom exercise using commercially available casts of the Lucy skeleton in conjunction with chimp and human skeletons or commercially available casts thereof (Table 2). For schools with lower budgets, pictures could be used instead of casts. Free images of human and chimpanzee bones in various views are available

Figure 2. Visual glossary of anatomical terms used in Table 1.



at http://www.eskeletons.org. Bone Clones (http://www.boneclones.com) sells a 14" × 11" poster of the Lucy skeleton for $10.00, although it shows the bones in only one view.

One way to adapt this study to the classroom is for a teacher to instruct students to come up with their own lists of differences between chimp and human skeletons and then run down the list with the Lucy skeleton to tabulate traits for which it exhibits the apelike state and those for which it exhibits the humanlike state. Alternatively, the teacher could instruct students to focus their attention on the traits used here (Table 1). Either way, at the end of the exercise, students can be asked to make up their own minds about whether Lucy is anatomically intermediate between apes and humans or not.

A potential criticism of such an exercise is that it does not employ a cladistic approach. Cladistics, the preferred method for determining relationships, uses shared, derived characters (traits) to determine which taxa are most closely related to which, ignoring shared ancestral characters. It treats all taxa as endpoints on an evolutionary tree rather than treating any taxon as ancestral to any other. By contrast, the approach used here treats "apes" (exemplified by the chimpanzee) as an ancestral grade from which "australopithecines" evolved and treats "australopithecines" (exemplified by Lucy) as an ancestral evolutionary grade from which humans evolved. Such a way of looking at things is accurate but may confuse students that have been taught in a strictly cladistic manner. It is therefore important for the teacher

Table 1. Comparison of chimpanzee (*Pan troglodytes*) and modern human (*Homo sapiens*) skeletal anatomy. Underlining shows the condition in "Lucy" (*Australopithecus afarensis*, specimen AL 288-1).

Anatomical Trait	Condition in Chimpanzee	Condition in Modern Human
1. Shape of mandible	V-shaped	parabolic
2. Simian shelf of mandible	present	absent
3. Slope of mandibular symphysis in lateral view	strongly sloped (receding inferiorly)	vertical
4. Protruding chin	absent	present
5. Orientation of left and right postcanine tooth rows	parallel to each other	posteriorly divergent
6. Incisor size	about the same as molar size	much smaller than molars
7. Diastema (toothless space) between lower canine and first lower premolar	present	absent
8. Lateral facet for canine on first lower premolar	present	absent
9. Size of first lower premolar	much larger than second premolar	about the same size as second premolar
10. Spinous process of 4th through 10th thoracic vertebrae	angled 20–45° toward tail	angled 50–90° toward tail
11. Transverse processes of 10th through 12th thoracic vertebrae	angled dorsally about 30°	angled dorsally 50–80°
12. Displacement of postzygapophyses beyond caudal margin of centrum on 11th and 12th thoracic vertebrae	absent	present
13. Spinous process of 2nd and 3rd lumbar vertebrae	angled toward tail; trapezoidal	not angled toward tail; square
14. Transverse width of centrum of 2nd through 5th lumbar vertebrae	not much greater than length or height of centrum	much greater than its length and height
15. Number of fused vertebrae in sacrum	six	five
16. Maximum transverse (side-to-side) width of sacrum (not counting 6th sacral vertebra of chimp)	about 2/3 the length of the sacrum	about equal to length of sacrum
17. Lateral supracondylar ridge of humerus	prominent	weak
18. Lateral epicondyle of humerus	prominent	weak
19. Shafts of radius and ulna	strongly bowed	straight
20. Proximal extension of olecranon process of ulna	present	absent
21. Medial margin of capitate (the carpal bone at the base of finger III)	concave	straight
22. Arching of metacarpals and manual phalanges	present; bones concave on palmar surface	no arching; bones straight
23. Orientation of wings of ilium	wings stick straight out to the sides	wings curve around toward the belly
24. Dimensions of ilium beyond acetabulum (hip socket)	much taller than wide	height and width about equal
25. Shape of greater sciatic notch	a broad, shallow curve	a narrow, tight curve
26. Orientation of acetabulum	acetabulum faces straight out laterally	acetabulum faces somewhat laterally and somewhat anteriorly
27. Diameter of femoral head	approximately equal to diameter of femoral shaft in anterior view	greater than diameter of femoral shaft in anterior view

(*Continued*)

Table 1. (*Cont'd*)

Anatomical Trait	Condition in Chimpanzee	Condition in Modern Human
28. Orientation of greater trochanter	extends straight proximally	tip is curved medially
29. Height of tip of greater trochanter	level with femoral head when femoral shaft is vertical	does not extend as far proximally as femoral head when femoral shaft is vertical
30. Middle part of distal margin of tibia in posterior view	slanted	perpendicular to shaft
31. Transverse width of medial malleolus of tibia	greater than 1/3 transverse width of entire distal end of tibia	less than 1/4 transverse width of entire distal end of tibia
32. Lateral malleolus of fibula in lateral view	rectangular	diamond-shaped
33. Distal process of talus (tarsal bone that supports the tibia)	angled medially	extends straight distally
34. Medial process of talus medial and plantar to tibial facet	present	absent
35. Arching of metatarsals and of pedal phalanges other than distal phalanx	present; bones concave toward sole	absent; bones straight
36. Shape of proximal margin of proximal phalanx of toes I–III in lateral view	convex	concave

Table 2. Commercially available casts of skeletons of chimpanzee, human, and "Lucy" (AL 288-1). Listed are the least expensive casts of which the author is aware.

Cast	Price (USD)	Vendor
"Lucy": mounted skeleton	$6300.00	Bone Clones
"Lucy": disarticulated skeleton	$1900.00	Bone Clones
Chimpanzee: mounted skeleton	$2900.00	Bone Clones
Chimpanzee: disarticulated skeleton	$1700.00	Bone Clones
Human: mounted skeleton	$359.00	Anatomical Chart Company
Human: disarticulated skeleton	$163.95	Anatomical Chart Company

to note that the results of this exercise do not show that the chimp is the ancestor of Lucy and that Lucy is the ancestor of humans. Instead, the results show that a representative of the australopithecine grade (Lucy) has too many anatomical traits in common with humans – and in contrast with apes – to support a conclusion that the creature is a mere ape.

A classroom exercise such as this can be taken a step further by noting functional implications of Lucy's anatomy as well as the anatomy of the chimp and the human. Table 3 lists functional hypotheses associated with locomotion and predictions that are testable with the Lucy material. For this, students should be instructed to compare each specimen's anatomy with the predictions of each hypothesis to determine which hypotheses are falsified (or not) by anatomical data. Such an exercise not only elucidates australopithecine locomotion but also involves the use of hypothesis testing, an important scientific tool.

Exercises such as these are not likely to change the mind of anyone who is strongly influenced by the religious dogmas that keep young-earth creationism alive. Nevertheless, they are potentially useful for students on both sides of the fence. For those who accept that humans evolved from apelike precursors, such exercises provide clarification of the evidence. For those who do not accept the evolution of humans from nonhumans, such exercises at least show that the idea is not just a baseless atheistic conspiracy, as is often falsely claimed (Gish, 1995; Sarfati, 2002), but is instead based on observable physical data.

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Table 3. Functional hypotheses regarding the chimpanzee, the human, and "Lucy," and their anatomical predictions.

Hypothesis	Predictions
The creature habitually walks quadrupedally, with its back horizontal.	1. Thoracic and lumbar centra are of similar size. 2. The head-to-tail length of the ilium is much greater than its transverse (side-to-side) width.
The creature habitually walks bipedally, with its back vertical.	1. Lumbar centra are larger (especially in cranial and caudal views, the views from the head and from the tail respectively) than thoracic centra. 2. The head-to-tail length of the ilium is similar to its transverse width.
The ability of the creature's fingers and toes to grasp branches is enhanced.	1. The metacarpals, metatarsals, and phalanges are curved (concave toward the palm/sole).
The ability of the creature's fingers and toes to grasp branches is reduced.	1. The metacarpals, metatarsals, and phalanges are straight.
The creature's capacity for brachiation (locomotion by using the hands to grasp branches while the body hangs beneath, like a human child on playground "monkeybars") is enhanced.	1. The radius and ulna are strongly curved. 2. The length of the humerus + forearm (radius and ulna) is greater than that of the femur + tibia.
The creature's capacity for brachiation is reduced.	1. The radius and ulna are straight. 2. The length of the humerus + forearm is similar to or less than that of the femur + tibia.

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