

SUGGESTED TEXTBOOK ANSWERS

Chapter 19 Human ancestors

The following are suggested answers only. Other answers to the same questions may also be correct.

Science inquiry

Activity 19.1 Evidence for human evolution

What to do

Use a variety of research techniques to investigate the evidence for human evolution that Dubois and Dart discovered. Use your research to find out:

- 1 the fossils that were discovered
- 2 where and when the fossils were found
- 3 the scientific name that was given to the fossil finds at the time of their discovery
- 4 the significance of the find at the time, and any controversy that it raised in the scientific community
- 5 the significance of the fossils today, given that more fossil evidence is available for study.

Answer:

	Dart	Dubois
Fossils found	Small skull; natural endocast	Skull cap, femur, teeth
Where found	Taung in South Africa	Java in Indonesia
When found	1924	1891
Fossil name	<i>Australopithecus africanus</i> 'The Taung Child'	<i>Pithecanthropus erectus</i> , now known as <i>Homo erectus</i> 'Java Man'
Significance at time of find	Dart thought that the juvenile skull was the link between apes and humans. He was heavily criticised, because the skull showed bipedalism (position of foramen magnum) and not an enlarged brain. At the time it was thought the increase in brain size came before bipedalism	Thought to be intermediate between modern humans and the common ancestor of apes and humans
Current significance	<i>Australopithecus africanus</i> is considered to be a direct ancestor of modern humans	<i>Homo erectus</i> is considered a direct ancestor of modern humans Debate continues as to whether the femur and skull belong to the same individual.

Other scientists who made significant contributions in the early days of the search for human origins were Robert Broom and Louis and Mary Leakey. Find out about the work of each of these people. You may prefer to work in a group for this research.

Answer:

	Robert Broom	Louis Leakey	Mary Leakey
Fossils found	Purchased a jaw fragment containing a tooth from a quarry worker; found more skull fragments at site	Cranium	Jaws, teeth, part of a child's postcranial skeleton, footprints
Where found	Kromdraai in South Africa	Olduvai Gorge in Tanzania (found by Mary Leakey, but described by Louis)	Laetoli in Tanzania
When found	1938	1959	1974–1979
Fossil name	<i>Paranthropus robustus</i>	<i>Zinjanthropus</i> 'Nutcracker Man'	<i>Australopithecus afarensis</i>
Significance at time of find	Became the type specimen for the species	Skull specialised for heavy chewing; sometimes referred to as 'Nutcracker Man', because it had the biggest, flattest cheek teeth with the thickest enamel of any known hominin; thought to be the first hominin to use tools	Used as a type specimen; most complete dentition found for early hominids; footprints indicated bipedal locomotion
Current significance	Is the type specimen for the species	Now referred to as <i>Paranthropus boisei</i> (or <i>Australopithecus boisei</i>) and considered a side branch of hominin evolution; have the largest teeth of any hominin	Used as a type specimen; also studied <i>Homo habilis</i> and found that it was not an Australopithecine as first thought

Activity 19.2 A comparison of hominin skulls

What to do

- 3 Examine each of the fossils in turn. Using the numbers 1 for least to 5 for most, rank them according to the features listed below. Copy Table 19.3 and place your numbers in it.
 - a the least to the most vertical forehead
 - b the least prominent (or absent) brow ridge to the most prominent
 - c the least to the most projecting nasal bones
 - d the least prognathism to the most
 - e the smallest to largest cranial capacity
 - f the least to the most prominent cheek bones

Table 19.3 Anatomical trends in hominin evolution

Anatomical feature	<i>A. afarensis</i>	<i>A. africanus</i>	<i>H. habilis</i>	<i>H. erectus</i>	<i>H. sapiens</i>
Forehead					
Brow ridge					
Nasal bones					
Prognathism					
Cranial capacity					
Cheek bones					

Answer: Students would be expected to have a trend of '1' to '5' across the table from left to right however, students will interpret the images differently and may have different results.

Studying your data

- 1 With the aid of Table 19.1, describe the evolutionary trends for each feature that you examined.

Answer: The general trend for each of the features will be the 'smallest/least' for *A. afarensis* and the 'most/largest' for *H. sapiens*.

- 2 Are there any anomalies in any of the trends? If there are anomalies, suggest explanations for them.

Answer: Student responses will vary and teachers should encourage students who describe anomalies to provide their explanations in a scientific manner.

Review questions

- 1 Briefly describe how the environment could have contributed to the first hominins evolving the free striding gait. How would this gait have increased the chance of survival in that environment?

Answer: The forest environment separated by grasslands is thought to be the environment in which the free striding gait first evolved. This gait would have increased the chance of survival as the hominins would have needed to come down from the trees (no longer completely arboreal) and cross increasing distances to the next group of trees to find food and shelter. Being bipedal allowed the hominins to see over the top of the vegetation to spot predators and to locate food. The freeing of the hands enabled food to be carried more easily.

- 2 The australopithecines comprise an important group of fossils, even though some scientists question their significance in the light of new evidence. Describe the main physical features of this genus and distinguish between the gracile and robust forms.

Answer:

- Skull: low forehead; projecting upper and lower jaw; skull rounded at the back
- Brain: an average of 480 cubic centimetres; more human-like than ape-like
- Teeth: typically hominin being smaller than the apes; canines short and non-projecting and together with the incisors form a row of cutting teeth; lack a diastema, the teeth in the jaw form a parabolic shape
- Limbs: limb bones suggest bipedalism; pelvic and foot bones typically hominin; non-opposable big toe; thumb shorter and less mobile than later hominins
- Vertebral column: displays the curvature typical of hominins; foramen magnum more forward in position than in the apes

There were two main variants of australopithecines – gracile species and robust species. The robust forms were much bigger in size and about 30 cm taller and 40 kg heavier than gracile individuals. In addition, robust forms had large, broad molar teeth that contrasted sharply with their smaller canines and incisors. The robust forms had powerful chewing muscles that attached a large jaw bone to the skull and, as a result, they possessed massive bony crests on the skull for the attachment of these muscles.

- 3 Who was Lucy, and why is she such an important ‘person’ in present theories of hominin evolution?

Answer: Lucy was the nick-name given to a 40% complete, female *Australopithecus afarensis* skeleton that was found in the Hadar region of Ethiopia in November 1974. The age of the skeletal material is considered to be over three million years, making it the oldest hominin ever found at that time. The completeness of the skeleton enabled the discoverers to determine that she walked upright, strengthening the idea that bipedalism was a unique feature of hominins.

- 4 Describe the significance of the Laetoli footprints (Figure 18.1 on page 271). Why were they such an important discovery?

Answer: These footprints were evidence for early hominins walking in a similar way to modern-day humans over 3 million years ago. They give evidence for bipedalism and help determine a date for the evolution of this method of walking.

- 5 Who was *Homo habilis*? What does the available evidence suggest about this fossil hominin?

Answer: *Homo habilis* was so named as the discoverers believed the species was an adept tool maker. It had a larger brain and smaller teeth than the australopithecines, was taller than the gracile forms, and stood more erect. Further finds supported the view that this was a distinct species that displayed features that were more evolutionary advanced than the australopithecines. It was thought to be fully bipedal with hands that were more robust than modern humans, and a brain significantly larger than that of either the gracile or robust forms of australopithecine.

- 6 What assumptions are made when scientists infer the degree of intelligence from the cranial capacity of a skull?

Answer: When inferring the degree of intelligence from the cranial capacity of a skull, a scientist is assuming that the brain occupied all the space available in the skull and, more importantly, that an increase in the size of a brain indicates an increase in intelligence.

- 7 Describe the features of *Homo erectus* that are evident from a study of the skull.

Answer: A study of the skull of *Homo erectus* indicates:

- a long, low profile
- an increase in cranial capacity of around 900 cubic centimetres
- a protruding jaw, but less so than in *H. habilis*
- thick brow ridges
- teeth that were smaller than *Homo habilis*.

- 8 Outline the importance of the Steinheim and Swanscombe fossils. In your answer mention their age and their significance in the overall scheme of human evolution.

Answer: The importance of the Steinheim and Swanscombe skulls was that their discovery indicated that the brain had almost reached modern size 350 000 years ago, and that most of the modern contours of the skull had become evident.

9 a List the differences between Neanderthals and modern humans.

Answer: Compared to modern humans, Neanderthals had:

- big faces, a low forehead and heavy brow ridges
- a slightly larger and differently shaped brain
- a 'bun' shape to the back of the skull
- distinctive prognathism
- the lack of a definite chin
- a wider, larger nose
- short stature and a rugged appearance
- thick neck muscles
- a barrel shaped chest
- short and heavily jointed limbs, with powerful muscles.

b Neanderthals were once thought to be ancestors of modern humans. What evidence is there that Neanderthals were a separate species that became extinct?

Answer: Modern molecular evidence indicates that the Neanderthals were a distinct species that existed in Europe during the last ice age. DNA was extracted from a Neanderthal fossil and compared with the DNA of modern humans. This confirmed that Neanderthals were a distinct species.

10 Describe the physical appearance of Cro-Magnon people.

Answer: Compared to the Neanderthals, Cro-Magnon people had skulls that were shorter from front to back, higher in the region of the top of the skull, and rounder at the back. They also possessed less prominent brow ridges, showed a reduction in prognathism, had a smaller jaw with smaller teeth, and a chin.

Apply your knowledge

1 This chapter includes some good examples of science as a process of enquiry, and illustrates the way scientific knowledge accumulates as new discoveries are made. Refer to Figure 1.2 on page 6. How does the work of Dubois, Dart and Broom relate to the model for scientific method presented in Figure 1.2?

Answer: Dubois essentially followed the model – his interest in human evolution was reinforced by the writings of Haeckel and Wallace, and made him question where best to search for human ancestors. He obviously collected information as he studied all the available evidence available at that time and then hypothesised that, as Europe would have been too cold for a 'missing link', he needed to search in the tropics. He then travelled to Sumatra to gather evidence to support his hypothesis. He was extremely lucky and found fossils that belonged to the 'missing link' he was searching for.

Dart and Broom were in a different position as they received fossils from others, and then made their interpretations. However, in making their interpretations, they essentially proposed a hypothesis and looked at the evidence.

- 2 Dubois' discovery sparked off a controversy among the leading scientists of the day. Because they were all examining the same material, why do you think there was so much disagreement?

Answer: The leading scientists of the day would have been very conservative in their interpretations, especially as at that time, conventional wisdom was that the large brain developed before an erect stance and bipedalism, mainly due to the evidence of Piltown man. In addition, depending which of the features a scientist thought was more important, he or she would have favoured the fossils being either more ape-like, or human-like, and thus not the 'missing link'.

- 3 There are two main physical forms for the australopithecines. Propose a hypothesis to account for the evolution of these two types from a common ancestor.

Answer: From the available evidence it appears that the gracile form of australopithecines evolved first. Australopithecines were on Earth for a considerable period of time, over two million years at least, and in that time there would have been changes to the environment in East Africa. With changes to the environment, the robust forms evolved from early gracile forms along a separate pathway in habitats where they could use their large molar teeth to exploit hard plant foods (grasses, leaves, nuts, seeds). In such habitats where these foods were plentiful, the robust forms had a survival advantage. Gracile forms had a more varied diet supplementing plant materials with meat either scavenged or, possibly, from hunting, and therefore there would have been little competition between the two anatomical forms.

- 4 In the past, anthropologists have put a great deal of emphasis on the importance of the cranial capacity when defining the tribe Hominini. Does this seem reasonable, considering the hominins discussed in this and the previous chapter? What other physical features are important in a discussion of human evolution?

Answer: The increase in cranial capacity is an important feature of the tribe Hominini, but the importance of the development of the free striding gait along with an erect stance must not be overlooked. All hominins display this characteristic, and it was well established in the early, smaller brained members of the tribe. On the other hand, cranial capacity, shows more of an evolutionary trend, increasing markedly from early examples to modern humans.

Besides bipedalism, students may mention other features of the skull such as brow ridges and the forehead, the mobility of the thumb, the refinement of the precision grip, the size and shape of the teeth, the shape of the jaw, and the absence of a diastema.

- 5 There is growing evidence that, like many of the other mammals, the pathway to modern humans may have many more species existing at a particular time than was once thought. If this is the case, how would it have been possible for closely related species to have lived on earth at the same time? Describe a possible situation where three species of early *Homo* lived in the same region of Africa.

Answer: Early species of *Homo* would have formed very small groups and probably occupied a home range that provided the food and other materials required for survival. Such small groups probably had little chance of interacting over the vast African landscape, in much the same way as groups of other mammalian species would have done.

If we consider three species of early *Homo* co-existing in a region of Africa, we would need to assume that the three species exploited slightly different habitats and resources otherwise there would have been competition between them. Competition would not have existed if the home ranges of the different species were far enough apart.

Closely related species in all mammalian groups tend to exploit the environment in slightly different ways. In the case of the three *Homo* species, they would each need to be exploiting the environment in different ways. Perhaps one species was more frugivorous, the second a scavenger of meat from carcasses along with other plant food, and the third a hunter of small game.

6 Refer to Figures 19.1 (page 287) and 19.14 (page 296), both illustrations of a *Homo erectus* skull, and to Table 19.1 (page 292).

a What features of the skulls enable you to say that it is not an ape skull?

Answer:

- Relatively large cranial capacity
- Brow ridges slightly reduced
- A forehead beginning to form
- More prominent cheek bones
- Absence of a sagittal crest
- More central position of foramen magnum (Fig. 19.1)
- Smaller teeth, absence of diastema (Fig. 19.14)
- Less prominent canines

b What features of the skulls enable you to say that it could not have belonged to a modern human?

Answer:

- The presence of brow ridges
- Lack of a distinct forehead
- Relatively large teeth
- Robust mandible
- Absence of dome shape to cranium
- Absence of a chin

7 Describe the conditions that may have led to Neanderthals developing their characteristic anatomical features.

Answer: Besides the rugged features of the skull, Neanderthals were short in stature with thick neck muscles, the limbs being short and heavily jointed with powerful musculature, and the chest barrel shaped. These rugged features are thought to have evolved for survival in the harsh conditions of the last ice ages in Europe. They were also adept big game hunters, and their rugged features may have assisted them in the hunt.

- 8 Imagine what would happen if a world-wide disaster that wipes out every living human on this earth were to occur tomorrow. If visitors from outer space arrived a thousand years from now and excavated fossils of present-day humans, what interpretations do you think they would make? Into how many species do you think they would classify present-day people?

Answer: Student responses to this question will vary as there are a number of interpretations, and there is no one correct answer. Students may suggest classification may be based on anatomical features and have a number of species to explain, for example, the differences in height – pygmies (such as the Aka, Efé and Mbuti people of Central Africa), the Dinka people of Sudan, and, say, people of average height in Europe, the US and Australia.

Other students may suggest that the visitors from outer space would be quite sophisticated and able to do DNA and other analyses, and thus determine humans were all the one species.

- 9 Most of the major changes in human evolution from *Homo erectus* to modern *Homo sapiens*, identifiable from fossil evidence, are confined to the head. Identify five of these changes and explain their significance.

Answer:

- The shape of the skull tends to be shorter from front to back, and higher in the region at the top, to allow for an increase in the brain size without interfering with the balance of the skull on the spinal column.
- The back of modern skull is more rounded with a reduction in the size of the neck muscles contributing to a highly mobile head.
- The face is flatter with a projecting nose bone in modern *H. sapiens* to compensate for the smaller jaw and teeth.
- The forehead is more vertical and the brow ridge, if at all present, is limited to allow for the increase in the frontal lobes of the brain.
- The jaw is relatively lightly built in modern humans and the presence of a chin adds to its strength; the reduction in the size of the jaw is a consequence of smaller teeth and the refined diet of modern humans.
- The shortened jaw of modern humans has resulted in a parabolic curve for the arrangement of the teeth.
- The incisors and canines in modern humans are noticeably smaller than in *H. erectus* as a result of the more refined diet.

10 Compile a phylogenetic tree for the evolution of hominins from the early australopithecines to modern humans. List evidence in support of your evolutionary pathway and discuss any points of disagreement that others may have with it.

Answer: Student responses will vary – one possible tree is shown below. Encourage students to avoid joining species with straight lines as they should realise the phylogenetic tree is indicating an evolutionary trend. Students should list evidence that is credible and based more on modern DNA and protein analyses than simple anatomical structure where possible.

