Chapter 19
Evolution of the human species

Unit 3B

Answers to end of chapter questions

Please note that the following answers are sample answers only. There may be many alternative answers to the same question that are also correct. These are examples of correct answers.

Working scientifically

Activity 19.1 Hominin skulls

In this activity you will research aspects of hominin evolution that show a distinct trend over the past 4 million years or so. Anthropologists have found skulls of hominins that represent a number of different species over a significant time frame. These skulls show two main features—an increase in brain size and a trend towards a flat face.

A: Increase in brain size

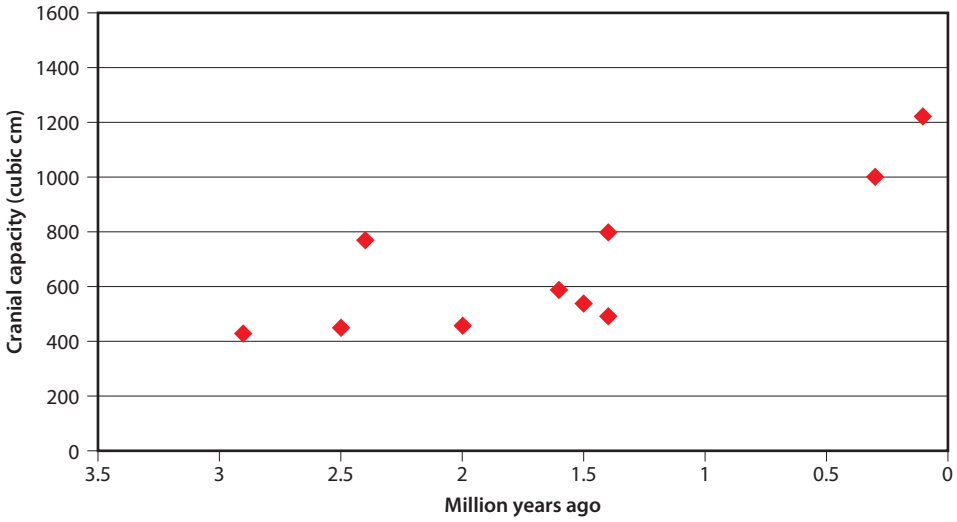
What to do

1. Go to http://www.archaeologyinfo.com/species.htm or a similar website that lists all of the species that are included in Table 19.2. Use the information on the website to determine how long ago each of the species became extinct (except for *Homo sapiens* which, of course, still exists).
2. Construct a table similar to Table 19.2 showing the average cranial capacity of the species but add an extra column to show how long ago each species ceased to exist.

Hominin	Cranial capacity (cm^3)	Extinction (mya)
Australopithecus afarensis	430	2.9
Australopithecus africanus	457	2.0
Australopithecus garhi	450	2.5
Paranthropus boisei	491	1.4
Paranthropus robustus	542	1.5
Homo habilis	590	1.6
Homo rudolfensis	774	2.4
Homo ergaster	800	1.4
Homo erectus	1004	0.3
Homo heidelbergensis	1226	0.1
Homo neanderthalensis	1485	0.03

3. Draw a graph of average cranial capacity versus the time when extinction of the species occurred.

Answer



Studying your data

1. Describe the evolutionary trend that the graph illustrates.

Answer
With evolution there has been an increase in cranial capacity. Younger hominin fossils have a greater cranial capacity than older fossils.

2. Are there any anomalies in the trend? If there are anomalies suggest explanations for them.

Answer
Neanderthals; their cranial capacity is larger than modern humans. This may be due to the large occipital bun that protrudes at the back of the skull. Neanderthal skulls are more robust than modern humans and skeletal muscles are much stronger, allowing for a larger skull case, but Neanderthals must have had a larger brain to fill the larger cranium.

B: Decrease in prognathism

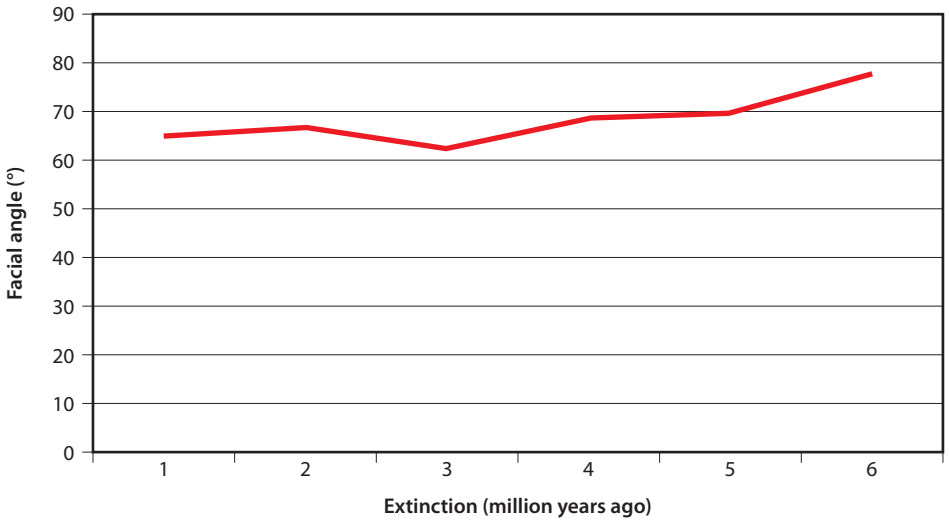
Table 19.3 The facial angle of various hominin crania

Hominin	Facial angle (degrees)
Australopithecus afarensis	65
Australopithecus africanus	67
Paranthropus robustus	63
Homo rudolfensis	69
Homo erectus	70
Homo sapiens	78

What to do

1. For the species listed in the table, use the extinction times from Part A of this activity.
2. Construct a graph of the facial angle plotted against the extinction time. The closer the facial angle is to 90°, the flatter the face.

Answer



Answer
Note: Extinction time may vary depending on which website is used since exact dates are not actually known.

Studying your data

1. Describe the evolutionary trend that the graph illustrates. Are there any anomalies to the general trend?

Answer
With evolution the facial angle of the skulls has flattened (become closer to 90°). *Paranthropus robustus* is an anomaly in this trend.

2. Does this graph follow the same trend as that drawn in the first part of this activity? Comment on any similarities or differences.

Answer
Yes, both graphs follow the same trends. The trend in activity A (cranial capacity) is more pronounced.

In summary

Write a summarising paragraph to describe the inter-relationship between an increase in cranial capacity and the trend towards a flatter face. What is the evolutionary significance of these trends?

Answer
As cranial capacity increases over time so does the trend towards a flatter face in hominins. This is significant as it suggests that the increasing cranial capacity was in the frontal region of the brain, leading to a more pronounced forehead and a flatter face. The increase in cranial capacity would have allowed the development of more complex cognition.

Activity 19.2 Upright stance and the striding gait

A striding gait is a form of locomotion that distinguishes humans from the other living primates. Its evolution has been dependent on changes to the skeleton and associated muscles and joints. In this activity some of these features will be examined to gain a greater understanding of the way we move.

You will need

A model of a human skeleton, charts or diagrams of the skeleton, the skull of an ape, reference to some of the diagrams in this book. If you wish you could do the whole activity by comparing the human and chimpanzee or gorilla skeletons at http://www.eskeletons.org.

What to do

Answer the questions listed below. As you answer the questions refer to the model of the human skeleton, ape skull and figures in the text as directed, or to images on a website.

Studying your observations

1. Compare the skull of an ape with that of a human. List the differences in the size and shape of the crania (brain cases).

Answer

Gorilla skull	Human skull	Chimpanzee skull
• Large sagittal crest	• No sagittal crest	• No sagittal crest
• Large eyebrow ridges	• Reduced eyebrow ridges	• Large eyebrow ridges
• Prognathic jaw	• Reduced jaw	• Prognathic jaw
• Small cranium	• Very large cranium compared with chimp and gorilla	• Small cranium

2. Locate the position of the foramen magnum. The foramen magnum is the opening in the base of the skull where the spinal cord enters the brain (refer to Figure 19.4). Look at the base of each skull and compare the position of the foramen magnum in the ape and in the human. Where is the foramen magnum in the human skull? Where is the foramen magnum in the ape skull?

Answer

Gorilla skull	Human skull	Chimpanzee skull
• Foramen magnum towards the rear	• Central foramen magnum directly under the centre of the skull	• Foramen magnum towards the rear

3. Which skull, ape or human, is most easily balanced on the vertebral column?

Answer
The human skull because as the foramen magnum is central, it allows the skull to be balanced on the vertebral column.

4. Look carefully at the model of the skeleton, then refer to Figure 19.3. Describe the curves of the vertebral column for both the ape and human. What extra curve exists in the vertebral columns of humans? (You may wish to refer to Figure 19.6 to assist you in answering this question.)

Answer

Gorilla spine	Human spine	Chimpanzee spine
• C-shaped	• S-shaped • Extra curve in lumbar region of the spine	• C-shaped

5. Look at Figure 19.7 on page 322 and compare the shape of the human pelvis with that of the gorilla. Which pelvis is wider? Which is longer? Suggest reasons for the relatively wide pelvis in humans.

Answer
The human pelvis is wider and shorter than that of a gorilla. This is an adaptation for upright stance and bipedalism. The broad bowl-shape lowers the centre of gravity and supports the organs.

6. The human pelvis is tilted forward and curves inward creating a basin shape. List the advantages this arrangement has for upright stance.

Answer
- Lowers the centre of gravity.
- Supports the abdominal organs when upright.
- Allows femurs to join at an angle that is advantageous for bipedalism (the carrying angle).

7. Look carefully at the model of the skeleton again, then refer to Figure 19.8. The narrow pelvis of the ape (Fig. 19.7) makes the legs hang vertically. This means the ape must keep its feet apart when standing and, when walking, sway from side to side to maintain balance (Fig. 19.13). Describe how the broadness of the pelvis contributes to the carrying angle of the femurs.

Answer
- It allows femurs to join the pelvis at an angle that is advantageous for bipedalism. The femurs come together toward the knee, then the lower part of the legs join the feet in such a way that the feet are together.
- It allows for the striding gait, with one foot being placed in front of the other so that there is no swaying from side to side of the body. The body weight is directly over the foot during each stride whereas an ape, walking bipedally, would have to sway from side to side to keep the body weight over the foot that was on the ground.

8. Explain the effect of the carrying angle on the arrangement of the knees, lower limb bones and the position of the feet in humans. What advantage does this arrangement have for human walking?

Answer
The carrying angle allows the knees in humans to lock in the fully extended position (i.e. straight). This aids in the striding gait. It also means the knee is hinged and only moves forward and backward, allowing walking. The tibia is also a straighter bone as a result and meets the ankle bones parallel to the ground, allowing standing (rather than squatting). The foot then needs to be weight bearing

for humans to be bipedal. The carrying angle allows body weight to be directly over each foot while walking; the upper body can remain relatively stationary.

9. The vertebral column of humans acts as a weight-supporting column. How does the shape of the lumbar vertebrae contribute to the lumbar curve? Look closely at the angle between the lumbar curve and the pelvis (you may wish to refer to Fig. 19.4). What effect does the lumbar curve have on the position of the trunk and legs in humans?

Answer
The lumbar vertebrae are thicker, wedged shaped and have flattened processes. They are the largest vertebrae. These features contribute to the five lumber vertebrae stacking in a way that produces the lumbar curvature. This curvature places the trunk over the centre of gravity and the legs directly beneath it. As a person walks, the centre of gravity moves from one side of the pelvis to the other so that it is always centred above the leg currently on the ground. These features give balance and stabilise the bipedal stance and the striding gait.

10. Refer to Figure 19.10 and compare the position of the centre of gravity in humans and apes. Which animal has the lower centre of gravity relative to body size? What features of the skeleton contribute to this difference?

Answer
Humans have a lower centre of gravity compared to body size. This is due to the broad bowl-shaped pelvis, the S-shaped spine, the lumbar vertebrae position, and the legs being relatively long and directly beneath the body.

11. Describe the pathway the body weight in humans follows from the pelvis down to the feet.

Answer
Pelvis → knee → ankle → foot

12. Remove your shoe and run your fingers over your foot from little toe side to big toe side. Can you feel the transverse arch? Reference to Figure 19.9 may help. How is this arch different to the longitudinal arch? What is the main function of the two arches?

Answer
The longitudinal arch has a weight-bearing function, whereas the transverse arch is to aid in the transmission of thrust when walking (from heel strike to thrust from the big toe).

13. Look carefully at the model of the skeleton again, and then refer to Figure 19.9. Compare the toes of a gorilla and human. What differences can you see?

Answer
The big toe of the gorilla is more like the human thumb. It is not in line with the other toes of the foot and is opposable. As such, it can be used for grasping. The human big toe is inline with the other toes of the foot and lacks opposability. It has a major function in the striding gait. The length of the toe bones and distance between joints are also different.

14. When humans stride, the big toe provides the thrust. What features of the big toe assist this? Would an ape be able to use the big toe in a similar way? Explain.

Answer
The big toe has a large surface area in contact with the ground, is in line with the other toes of the foot and is jointed to allow the push-off motion when

walking. Gorillas have an opposable big toe that may limit its function in bipedal walking.

15. Refer to Figure 19.12 and describe how the arches of the foot enable weight to be distributed from the heel to the big toe. Remove your shoes and try this for yourself.

Answer

The transverse arch distributes the body weight across the foot maintaining balance. The longitudinal arch allows the weight to be moved from the heel down the outer part of the foot, across the transverse arch and to the big toe.

16. Take a number of steps in your bare feet. Describe what takes place from the time the left heel hits the ground until the right heel hits the ground. Reference to Figure 19.13 may help you with your description.

Answer

Left heel strike → weight rolls down the longitudinal arch → across the ball of the foot → thrust from ball of foot rolling onto big toe → thrust from big toe

This rolling motion happens on both feet but not at the same time.

As the left foot thrusts off from the big toe, the right foot is airborne. The right foot heel strikes the ground and transfers the weight and balance forward.

17. Summarise the main features in the human skeleton that are adaptations for an upright stance and for walking bipedally with a striding gait.

Answer

Characteristic	Adaptations
Foramen magnum	Located centrally in the base of the cranium Allows skull to sit on top of the spine so humans can stand upright and walk bipedally
Jaw bone	Small and non-protruding so that it enables the skull to balance on the vertebral column Allows skull to sit on top of the spine so humans can stand upright and walk bipedally
Vertebral column	Lumbar vertebrae wedge-shaped producing an S-shaped curve that brings the vertebral column directly under centre of skull Allows spine to be in a position that allows humans to stand upright and walk bipedally
Pelvis	Broad; shallow from top to bottom Provides support for abdominal organs Allows an upright stance rather than carrying organs under the thorax when on all fours Attachment of femurs wide apart contributing to carrying angle Allows striding gait and upright stance
Femurs	Large head to femur that contributes to the carrying angle Allows the movement of the legs to walk bipedally Angle in towards the knee
Knee joint	Outer 'hinge' larger and stronger to take weight of body, thus the ability to stand upright and walk bipedally Knee able to be straightened; this occurs as part of the striding gait

Characteristic	Adaptations
Legs	Longer than arms, contributing to a low centre of gravity; therefore humans do not fall over when upright Carrying angle allows the weight of the body to be kept close to the central axis allowing a striding gait
Foot	Large heel bone and aligned big toe form a pedestal on which the body is supported; allows for a heel strike used in bipedal walking The large toe allows for a strong push off Foot has both longitudinal and transverse arches, again allowing for the striding gait

Activity 19.3 Are humans unique?

Modern humans like to think of themselves as unique. We consider ourselves to be different from (and perhaps superior to) all other species of animals. But are we unique? What separates us from other animals, especially the other primates?

With a partner, try to draw up a list of features that are unique to humans. Consider all aspects of humanity in your discussion—physical characteristics, behaviour, human achievements and others. Do some of the features selected follow an evolutionary trend? Are these features likely to evolve further in the future?

Have a class discussion on the lists proposed by the various pairs in the class and try to agree on a class list. Be prepared to criticise others, but do so in a constructive way. It is more important to be involved in actively thinking about the topic than in arriving at a correct answer. In fact there may be very few points on which the whole class will agree.

Answers

Unique to humans:

- technologically advanced
- culture
- ethics and values
- religion
- complex brain and large size
- some behaviours
- striding gait
- achievements
- precision grip
- written language.

Activity 19.4 Chimpanzees, Neanderthals and humans

This activity will enable you to use knowledge gained from previous chapters to examine the relationship between chimpanzees, Neanderthals and modern humans. Table 19.4 indicates the number of nucleotide differences between a region of mitochondrial DNA in two chimpanzees, a Neanderthal and two humans (see page 265 for a discussion of mitochondrial DNA).

Table 19.4 Nucleotide differences in a region of mitochondrial DNA

	Human 2	Chimpanzee 1	Chimpanzee 2	Neanderthal
Human 1	15	77	76	20
Human 2		79	80	27
Chimpanzee 1			23	72
Chimpanzee 2				71

What to do

Answer the questions listed below. As you answer the questions, refer to Table 19.4 and to previous chapters where necessary.

1. Based on the information in Table 19.4, which individual is most closely related to the Neanderthal and which is the least?

Answer
Most related: human 1

Least related: chimpanzee 1

2. The Neanderthal mitochondrial DNA was extracted from a fossil 25 000 years old. What other information obtained from the fossil would be valuable in determining the evolutionary relationships of the Neanderthal with chimpanzees and humans?

Answer
Where it was found; what was found with the fossil (signs of artefacts, culture, bones from other species); cranial capacity; shape of jaw, teeth; structure of pelvis and lower limb.

3. What dating methods could be used to determine the absolute age of the Neanderthal fossil?

Answer
Carbon-14 dating

4. What methods could have been used to determine a relative age for the Neanderthal fossil?

Answer
Stratigraphy or fluorine dating

REVIEW QUESTIONS

1. (a) In the hierarchy of biological classification, describe the meaning of the term tribe.

Answer
Tribe is the name given to a relatively new level of classification between subfamily and genus. Tribe, like any other classification group, means they all share the same characteristics.

(b) List the three tribes in the subfamily Homininae, and give an example of a member of each.

Answer
- Hominini—humans
- Gorillini—gorilla
- Panini—chimpanzees.

2. (a) List the components of the skeleton that allow humans to adopt an erect posture.

Answer
- Foramen magnum
- Jaw bone
- Vertebral column
- Pelvis
- Femurs
- Knee joint
- Legs
- Foot.

(b) How do these components differ from the corresponding ones in a quadrupedal animal?

Answer
- Foramen magnum—centrally located
- Jaw bone—reduced
- Vertebral column—S-shaped
- Pelvis—broad, shallow, bowl-shaped
- Femur—strength, at an angle to the vertical, ball and socket into hip joint
- Knee joint—hinge joint
- Legs—can straighten
- Foot—transverse and longitudinal arches, inline large toe.

(c) What are the (i) advantages and (ii) disadvantages of an erect stance and bipedal locomotion?

Answer

Advantages	Disadvantages
• For food hunting (can see further) • For food gathering (pick fruit high in trees) • Avoid predators; able to run faster • Better for reproduction • Better to walk longer distances (no longer arboreal) • Mechanical advantages for travelling longer distances	• Can no longer easily escape from predators into the trees • Slow moving compared to some quadrupedal species • Difficult to cover large distances quickly, therefore small, productive home range needed

3. (a) What is muscle tone?

Answer
Muscle tone is the partial contraction of skeletal muscles.

(b) How does muscle tone help to support the body against the force of gravity?

Answer
It helps to keep the head erect and the body in the upright stance position, supporting the spine, abdomen, knees and ankles.

4. (a) What is the carrying angle?

Answer
Carrying angle is the angle of the femur bones to the vertical. The pelvis, femur and knees all align in such a way as to carry the weight of the body in the upright stance.

(b) Compare the carrying angle of an ape with that of a human.

Answer
Humans have a wider carrying angle than apes, that is, the angle of the femur to the vertical in humans is greater. This allows for bipedalism in humans.

5. (a) How does the wide pelvis and carrying angle of the femur enable humans to walk without the body swaying from side to side?

Answer
It allows the body to rotate about the lower leg and foot, and centres the weight distribution over the foot so that the body does not sway from side to side.

(b) What contribution do the arms make to stabilising the body during walking?

Answer
The arms swing to compensate for the natural rotation of the body when walking. The legs and arms work in opposition: as the left leg goes forward, the left arm swings back while the right arm is swinging forward. The arm movement also helps keep the shoulders in the correct position: at right angles to the way the body is moving.

6. Describe the significance of the Laetoli footprints (Fig. 19.1, p. 318). Why were they such an important discovery?

Answer
These footprints are evidence for early hominins walking in a similar way to modern-day humans. Gives evidence for bipedalism.

It helps determine a date for this type of walking.

7. What is an endocast? What can it tell us about the size and shape of the brain?

Answer
Endocasts are impressions of the inside of a skull made of rock or some other solid material. They occur naturally or can be made by scientists when a skull is found. They give a model of the brain showing its size and shape.

8. Describe the major anatomical and functional developments that have occurred in hominin brains over the past four million years.

Answer
- Increase in cranial capacity
- Increase in number of convolutions

- Increase in frontal lobe size
- Increase in cognitive ability
- Increase in reasoning ability.

9. Human dentition is said to be unique.

(a) List the differences between the teeth of a human and those of an ape such as a gorilla.

Answer
- Human canines look more like incisors—they are not longer than other teeth.
- Molars are comparatively smaller.
- Humans have a parabolic dental arcade.

(b) How has the dental arcade changed in hominins when compared to that of an ape?

Answer
Hominins have a parabolic dental arcade rather than a U-shaped arcade.

10. Describe the change in the shape of the face of hominins over that past four million years or so.

Answer
- Flatter face
- Less prognathic (reduced jaw)
- Developed a chin
- Developed a more prominent nose
- Distinct forehead.

11. Briefly describe the environment in which the first hominins were thought to have evolved 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.

12. (a) What was the importance of meat eating to the future survival and evolution of the hominins?

Answer
Meat eating became important in providing higher energy requirements and the fats needed for bigger hominins with larger, more complex brains.

(b) How did tool manufacture and use contribute to this survival?

Answer
Tools were used in hunting and slaughtering of animals, and possibly as a defence from predators. They also enabled more food to be obtained.

13. *Homo erectus* (and the contemporaries of *H. erectus*) appears to be the first hominin to have used fire in a systematic way. List the ways fire could have improved their way of life, giving examples where appropriate.

Answer

- Hunting—directing and trapping animals to kill for food
- Deterrent—keep predators away
- Light and warmth—increased the length of the day; allowed less hospitable environments to be lived in
- Increased social activity at night—led to cultural activities and rituals around the figure
- Cooking—increased safety of food, taste and digestibility, and the range of foods that could be eaten.

14. Give two reasons for studying primate and hominin evolution.

Answer

- To define what it means to be human
- Curiosity and the acquisition of knowledge
- To understand modern humans
- To understand the past to aid in understanding the present and making future decisions.

APPLY YOUR KNOWLEDGE

1. For humans to be able to stand upright, a number of adaptations have taken place. Changes have occurred to the skull, vertebral column, pelvis, legs and feet. Describe how each of these has contributed—and how they have interacted—to enable humans to adopt an erect stance.

Answer

- Skull: Foraman magnum central to allow the skull to sit on top of the vertebral column.
- Vertebral column: S-shaped curve to allow the skull to sit on top of spine, to allow upright stance and to support the bowl-shaped pelvis.
- Pelvis: Broad bowl-shape; holds organs; lower centre of gravity for upright stance; attached to S-shaped spine; wide to contribute to carrying angle.
- Legs: Carrying angle of femur requires broad pelvis with ball and socket hip joints; the knees are structured with a hinge joint that can carry the mass of the body upright and bend for walking; the knee can straighten as required in the walking process; the femur is also very strong.
- Feet: Connected to the legs with joints to allow the pivotal motion for walking, arched feet to stand upright and carry body mass; feet allow upright stance to be balanced; inline large toe and large, strong heel bone for walking.

2. As a result of various conditions, the normal curves of the vertebral column may become exaggerated. Use references to describe the conditions known as scoliosis, kyphosis and lordosis.

Answer
Scoliosis:

- An abnormal sideways curve of the spine that makes the spine look tilted when viewed from the rear
- View from side usually shows a hump
- Different types—result from bone issues, muscular problems, degenerative (gets worse with spine growth and age)
- Pain, respiratory issues may result
- Hereditary
- More common in females (× 2)
- Corrected with brace or surgery.

Kyphosis:

- Type of scoliosis
- Abnormal curvature of the spine
- When the spine is viewed from side there is a front bending curve, frequently in the cervical or thoracic area; appear 'round shouldered'.

Lordosis:

- Type of scoliosis
- Abnormal curvature of the spine
- When the spine is viewed from side there is a backward-bending curve (sway back) in the lumbar region.

3. If you have seen chimps or gorillas walking bipedally, you will have noticed that they sway from side to side as they walk. Explain why they cannot stride as humans do.

Answer
These primates do not have the adaptations for bipedalism that humans do. They are essentially quadrupedal animals. They walk upright for only short periods of time. The narrow pelvis and lower limb bones do not allow the striding gait to be used. This is mainly because there is no carrying angle and the ape must sway from side to side to keep the centre of gravity over the foot that is on the ground.

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

Answer
The cranial capacity of the skull gives an indication of brain size. (That the skull is not occupied by extra fluid or other matter.)

Increased brain size is proportional to increased intelligence.

5. The human canine tooth is much smaller than that of the other hominids, especially where the males of the species are concerned. Describe the evolutionary processes that would have taken place in hominins to produce the current size of that tooth in humans today.

Answer
Natural selection would have resulted in the evolutionary trend toward smaller canine teeth. In the hominins there would have been natural variation in the size of

the canine teeth. As the diet moved towards softer foods and an increased amount of meat, the hominins with the smaller canines would have been move successful and had an increased chance of survival. When these hominins reproduced they would have passed on the favourable allele for smaller canine teeth. This would have occurred over many generations—a period of time during which the diet became softer and contained an increasing amount of meat. The resulting trend was toward smaller canine teeth, resulting in the current canine size in modern humans.

6. The primitive ancestor of the hominins is thought to have moved through trees by brachiation. Outline the characteristics that a brachiator, such as the gibbon, would possess that are likely to be of advantage in bipedal locomotion.

Answer
Rotating shoulder joints:

- Movement about the shoulder joint allows brachiation.
- Allows the arms to swing and aid balance in bipedal locomotion.

Flattened chest:

- Allows swinging in brachiation and moving the centre of balance.
- Allows swinging of arms and balance when bipedal.

Long limbs:

- Allows the swinging motion of brachiation (these are forelimbs).
- Allows for the striding gait in bipedal striding gait (these are hindlimbs).

7. There is some speculation among scientists that the large brain of *Homo erectus* would have required offspring to be born at a very early stage to allow the passage of the large head through a relatively narrow birth canal. Discuss the implications that the care of helpless young would have had for the social behaviour of *Homo erectus*.

Answer
Homo erectus had fire and this extended their social and cultural activities at night time. Their cooperation as a society had begun to form, but was not advanced. This would mean that young born at an early stage would have required increased parental care, thus removing some individuals from being as productive in society. The culture and society would have needed to be more cooperative and structured to allow for this extended time of parental care.

The home base would need to be established as the child would not be capable of travel over any distance for many years, unless carried. This also suggests that *Homo erectus* would have needed to have children one at a time, widely spaced apart, if they did wish to carry the child over distances, or had a cooperative system where there was help or a well-established social structure and home base where the women raised the children and the men hunted and shared food.

Essentially, monogamy or a family group situation would have been needed. This would have allowed for the mother and child to be provided for.

8. This chapter has discussed the evolution of erect stance and bipedal locomotion, and a large brain under separate headings. In the previous chapter, the development of the human hand and the precision grip were discussed. However, it is unlikely that these features would have evolved independently of each other. Discuss a possible evolutionary sequence that would account for the development of each of these characteristics.

Answer
Bipedal locomotion → power grip → increased cranial capacity → precision grip

Reasoning:

- 'Lucy', *Australopithecine afernensis,* exhibits small brain and bipedal locomotion.
- Some *Paranthropus robustus* have the same bipedal adaptations of 'Lucy' and are capable of tool use.
- All *Homo* species used tools. With time, the tools became more refined, indicating the development of the precision grip.
- Bipedalism freed the hands to allow increasing use of the precision grip.

9. Australopithecines may have been the first hominins to manufacture tools for a specific purpose. Describe the significance of this development in food gathering for later hominin evolution.

Answer
Tool use allowed an increase in the home range and venturing into varying habitats. These factors in turn allowed for the later colonisation of habitats out of Africa. During this time, the evolution of hominins continued as they moved into new environments. The new environments would have presented new challenges, challenges that required more problem-solving abilities, thus leading to an increase in brain size and hence cranial capacity.

10. For the past 100 000 years at least, hominins have adapted *culturally* to environmental change. Refer back to Chapter 15. Does natural selection affect cultural characteristics?

Answer
Natural selection does not really affect cultural characteristics in terms of Darwin's definition. Cultural characteristics can be a barrier to natural selection. Features such as religion and socioeconomic status can be barriers to gene flow.

Cultural characteristics are not inherited, they are learned. Thus, the selection of favourable alleles is not directly involved. However, the ability to learn is inherited, so natural selection could be indirectly involved in cultural evolution.

11. A recent article described how orang-utans could help each other get food by trading tokens. Read the article at http://news.bbc.co.uk/1/hi/sci/tech/7797776.stm and discuss whether this is an example of cultural evolution.

Answer

Arguments for cultural evolution	Arguments against cultural evolution
• Orang-utans not just trading, they have learned a value system • Orang-utans not just trading, they have learned a cooperative system • Evidence of behavioural adaptation	• The orang-utans were just using cognitive ability • This is teaching (humans teach orang-utans) not evolution • Evolution is more than just one generation

12. Eugene Dubois, Raymond Dart and Robert Broom were all early workers who made contributions to the knowledge of human origins. Use the internet or other references to determine the importance of each researcher's contribution, mentioning the fossil evidence they discovered.

Answer

	Dart	**Dubois**	**Broom**
Fossil found	*Australopithecus africanus* 'The Taung Child'	*Pithecanthropus erectus* Now known as *Homo erectus* 'Java Man'	*Paranthropus robustus*
Significance	Considered to be a direct ancestor of modern humans	First hominin to come out of Africa	Supported Dart's evidence