

SUGGESTED TEXTBOOK ANSWERS**Chapter 17 Primate evolution**

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

Science inquiry

Activity 17.1 Living primates and trends in evolution

What to do

Select a lemur or loris, a New World monkey, an Old World monkey and two species of ape. For each of the selected species make as many of the following observations as you can. You will need to keep detailed records of your observations.

Answer: Responses will vary, depending on the primates chosen for this activity. Teachers should ensure students have selected species that are representative of the categories of primate required.

Studying your observations

1 Collate your observations of the different species to describe the discernible trends from lemurs and lorises to monkeys and apes. Describe each of the following separately.

a mobility and flexibility of the digits

Answer: The trend from lemur/loris to monkeys, then apes, is for digits to become longer and more flexible. Opposability of the thumb also increases. Nails become less like claws and more like those possessed by the apes.

b size, arrangement and shape of the teeth and how this may relate to diet

Answer: Lemur/loris → monkey → ape

- Decreased number of teeth
- Larger canines with diastema
- Four cusp molars → five cusp molars

c shape of the face and the presence of overlapping or stereoscopic vision

Answer: Lemur/loris → monkey → ape

- Some species exhibit a decrease in prognathism
- Eyes become more forward facing
- Vision becomes more stereoscopic

- d proportional size of the head compared to the rest of the body and how this may relate to the complexity of behaviour that you observed

Answer: Lemur/loris → monkey → ape

- Increasing head size accompanied by increase in brain size
- Increasing cognitive ability
- Increased ability to learn and increased complexity of behaviour

- e comparative size of offspring and their dependence on their mother or other adults.

Answer: Lemur/loris → monkey → ape

- Decrease in the number of offspring
- Increasing size of offspring
- Increasing dependence on parents
- Increasing length of gestation and parental care

- 2 Describe any behaviour you observed in any of the species studied that was similar to human behaviour. Is it possible to see an evolutionary trend in any of the behaviour observed?

Answer: Responses will vary depending on species chosen.

Yes, it is possible to see evolutionary behavioural trends occurring; for example, tool making/use, social behaviours and care of offspring.

In summary

Write a short summarising statement that accounts for all of the observations made during this activity and the evolutionary trends discussed in this chapter.

Answer: The lemur is the least evolved primate in this activity and the ape the most evolved. The trends found reflect this evolutionary pattern in terms of morphology and behaviour. These evolutionary trends reflect the shift from arboreal to terrestrial life and the environments in which the primates are found.

Activity 17.2 Mobility of the human thumb

Studying your observations

- 1 In relation to the palm of your hand, how is the position of the thumb different from the fingers? Give two reasons to explain the advantage of the thumb in this position.

Answer: The thumb is not in line with hand and other fingers.

- This improves fine motor skills – picking up and manipulating objects as in the precision grip.
- The power grip is also stronger because the thumb can wrap around objects in the opposite direction to the fingers.

- 2 What term is used to describe the movement of the thumb when it touches each fingertip in turn?

Answer: Opposability

- 3 a** Describe the position of your thumb and fingers when picking up a pen.

Answer: This is the precision grip. The index finger and thumb are both used to pick up the pen. The thumb and fingers are both able to touch and hold the pen but they are on opposite sides of the pen.

- b** Which muscles were used to hold the pen in this precision grip?

Answer: The muscles in the hand itself

- 4 a** List the differences in the position of the thumb and fingers when using the precision grip and the power grip.

Answer:

- Precision grip: Finger and thumb tips are together.
- Power grip: Hand clenched and thumb wraps around in the opposite direction to the fingers.

- b** How did your thumb assist in holding an object in the power grip? Describe how it did this.

Answer: It closed the grip so that thumb and fingers were wrapped right around the object, giving strength and power to the grip.

- c** Which muscles were employed in the power grip? Were these different from the ones used in the precision grip?

Answer: The muscles of the forearm were used in the power grip, not the muscles of the hand as in the precision grip. These large muscles gave the grip great strength.

- 5** Which of the two grips would be the most efficient at holding an object against force?

Answer: The power grip

- 6** List the features of the thumb that make both the power and precision grips possible.

Answer: Opposability; saddle joint of thumb; position on hand; the muscles of the hand and forearm; flexibility of the joints

Activity 17.3 A comparison of primate skulls

What to do

- 5** Look carefully at the two skulls, noting the scale listed for each, and take this into consideration when answering the following questions. For some questions it may help to go back and select other views of the skulls for comparison.

- a** Using the scale provided, estimate the length of each skull.

Answer:

- Baboon – approximately 14 to 15 cm
- Mouse lemur – approximately 3 cm

- b** Which skull has a more rounded profile?

Answer: Mouse lemur is more rounded in lateral view.

- c Estimate the length of the cranium of each skull. Which species would have the larger and more complex brain? Give reasons for your answer.

Answer:

- Baboon cranium – approximately 6 cm
- Mouse lemur cranium – approximately 1.5 cm

The baboon has the larger and more complex brain, because the cranium is larger and the baboon shows more evolutionary advancement than a lemur.

- d Compare the superior view of each skull. (To do this, choose 'superior' as the two views to compare.) What differences would there be in the eyes of these two animals?

Answer: Baboon eyes are slightly more forward-facing and better protected by bone.

- e Identify and count the teeth that are visible. What is the dental formula for each species?

Answer: Baboon 2:1:2:3. Mouse lemur 2:1:3:3. However, students may say 2:2:2:3 for the lemur, because one of the premolars looks more like a canine.

Studying your observations

Review your answers to the questions and use the information collected to describe evolutionary trends in the size and shape of the skull and teeth from lemurs to monkeys, apes and humans.

Answer: When progressing from lemurs to humans, there is a trend evident for the following.

- Skull: Increase in skull size; increased cranium size; more vertical forehead
- Teeth: Reduction in number of incisors; U shape to a parabolic dental arcade; increase in teeth size; increased canine size (exception is humans); 3 to then 5 cusp molars
- Eyes: the trend is to more forward facing eyes resulting in an increase in stereoscopic vision

Review questions

- 1 Describe the contribution that Carolus Linnaeus made to science and how this helped in understanding the evolution of primates.

Answer: Linnaeus designed the hierarchical classification system that was based on evolutionary relationships. He also developed the binomial naming system using both a genus name and species name. This gave scientists an accurate way of communicating about species or groups of organisms, especially when discussing the evolution of the primates.

- 2 To which of the primate families do humans belong? Who shares this family with us?

Answer: Humans belong to the family Hominidae, and we share this family with the great apes, and the ancestors of apes and humans.

3 Unlike most other mammals, primates are not distinguished by one or two conspicuous characteristics, but rather by a set of characteristics that serve to differentiate them from other mammals. List the characteristics that tend to be shared by all primates.

Answer: Primate characteristics include:

- non-specialised body
- unspecialised limbs
- pentadactyl
- nails instead of claws
- grasping digits with friction ridges
- opposable first digit
- forward-facing eyes
- stereoscopic and colour vision
- poor sense of smell
- four incisors in both upper and lower jaw
- large complex brain
- no restricted breeding season
- rhythmical sexual cycle
- usually one offspring at a time
- long period of parental care after birth.

4 a Differentiate between the terms 'opposable' and 'prehensile'.

Answer: Prehensile means grasping or gripping by wrapping around an object. Opposable means that the first digit can be moved so that it can touch all other digits one at a time, and it is also able to wrap around an object in the opposite direction to the fingers.

b Explain the advantage to primates of having friction ridges and nails, instead of claws, on the digits.

Answer: These are both advantageous for brachiation and grasping. Friction ridges aid grip and provide an advantage for picking up objects or grasping branches when brachiating; claws would hinder precise manipulation of objects and inhibit brachiation.

5 Describe the evolutionary trend evident in primates concerning the mobility of the thumb and the other digits.

Answer: The evolutionary trend has been an increase in the mobility and opposability of the thumb. The other digits have become longer and more mobile.

6 a Explain how the number and composition of the teeth has changed as one progresses from lemurs to monkeys, apes and humans.

Answer: Lemurs and lorises have 36 teeth and a dental formula of 2:1:3:3. New World monkeys have the same dental formula as the lemurs and lorises, but they show an evolutionary trend for the third molar that is usually small, and often absent in many of these monkeys. Old World monkeys, apes and humans all have 32 teeth and a dental formula of 2:1:2:3.

- b** What factors may have contributed to this change in the number of teeth?

Answer: A gradual reduction in the protrusion of the snout (the trend towards a flatter face); a change in diet; the development of prominent canines for carnivorous diet or for defence; four or five cusped molars for grinding vegetation.

- 7 a** Describe the noticeable shift that has occurred in primates from strong reliance on the sense of smell to almost complete dependence on vision.

Answer: Increased sensitivity of vision is due to an arboreal lifestyle and therefore the need to judge distances accurately. Smell became less important because colour vision allowed identification of ripe fruit, for example, and visual cues replaced olfactory ones for mating.

- b** What selection pressures in the habitat of primates may have contributed to this shift?

Answer: The move to an arboreal lifestyle. Efficient brachiation requires good stereoscopic vision and accurate judging of distances. Individuals with the best stereoscopic vision would be better able to move safely through the trees and would therefore be more likely to survive and pass on the favourable characteristic.

- 8** As the eyes become more forward facing, the field of view for each eye increases in its degree of overlap with the other.

- a** How has this been advantageous to primates?

Answer: It has allowed for three-dimensional vision and accurate judging of distance for jumping or brachiating between trees.

- b** What has compensated for the resultant decrease in the total field of vision?

Answer: Ability to move the head and neck over a wide range

- 9** How has the increased importance of vision affected the region of the primate brain concerned with the interpretation of visual information?

Answer: The region of the cerebral cortex that handles vision has greatly increased in size.

- 10 a** Explain why the skull of an ape has a proportionately larger cranium than that of lemurs and monkeys.

Answer: The increased size of the cranium is due to the increased brain size, especially the cerebrum. The increasing relative size of the cerebrum has resulted in the evolution of better vision, memory, reasoning abilities and manipulative abilities.

- b** List the advantages of having a large number of convolutions in the cerebrum of the brain.

Answer: The increased convolutions allow greater surface area in the cerebral cortex, and therefore a greater number of neurons. This is an advantage as it allows for higher order functioning of the brain and results in higher-order skills in primates. This includes tool making and more complex behavioural responses.

- c** Describe the trend in the number and complexity of the convolutions in the cerebral cortex as one progresses from the lemurs to the monkeys, apes and humans.

Answer: When progressing from lemurs to humans, the size of the cerebral cortex and the number and complexity of convolutions increases.

11 Why would it be necessary for the placenta of apes and humans to be more efficient than that of other primates?

Answer: The more efficient placenta allows better blood supply between the mother and foetus. The placenta of apes and humans needs to be more efficient as the gestation time is longer and the foetus is proportionately much larger. The placenta of these primates allows a closer contact between the blood supplies of the mother and the developing offspring, enabling better exchange of nutrients and wastes.

12 a What is the gestation period?

Answer: The time between conception and birth

b How does the gestation period change as one progresses through the primate order from lemurs to humans?

Answer: The gestation period became progressively longer as the primates evolved from lemur-like forms to ape-like forms.

c Describe the significance of this trend in terms of the development of the offspring.

Answer: The longer gestation period allows for more development of the foetus in a protected uterus and more complex offspring.

13 Of what advantage has the increased length of parental care been to the survival of apes and humans? List any disadvantages an increased period of parental care may have for a species.

Answer:

Advantages	Disadvantages
Allows development to occur with parental protection Longer period of learning Increased rate of offspring survival	Increased risk of death from predators while parents are looking after offspring Decreased number of offspring (more at risk of extinction) Parents may be exposed to risk when feeding/protecting offspring

Apply your knowledge

1 Scientific classification is not perfect. This is especially true of primate classification. Not all species fit neatly into the 'boxes' developed by those attempting to classify the primate order. Using a variety of research techniques find out:

a the current problems that exist in the classification of the primates

Answer: There are many issues with the current primate classification system. Many arise from the fact that there are primates that exhibit features from two classification groups. The classification groups may be changed to accommodate some of these issues, but often this creates even more problems. An example is the difficult-to-classify primate Goeldi's monkey, which is sometimes classified with the marmosets and tamarins, and sometimes placed in a family on its own. Current primate classification reflects information from DNA analysis, which is often in conflict with traditional classifications based on anatomical features.

- b** how general the acceptance is among scientists of the classification presented in this chapter.

Answer: This book uses a generalised and simplified classification that is widely accepted. Scientists have tended to accept the more recent evidence from DNA analysis and other biochemical studies.

- 2** Animals that have an acute sense of smell tend to have larger snouts than those that do not rely as heavily on smell. Humans have a reduced snout and our sense of smell is not as good as that of many other primates. What other sense organ has compensated for this reduction? How do you think this may have evolved?

Answer: In humans the eyes are well developed. This may have developed as primates became arboreal and needed to move through trees. Good eyesight was needed to judge distance for vertical clinging and leaping, and for brachiation. An acute sense of smell became less important for survival.

- 3 a** Describe why primates would have found claws difficult for a tree-dwelling environment.

Answer: The claws would be in the way when brachiating and grasping branches, and they would have prevented the fingertips from making contact with each other. Nails protect the fingertips, but do not get stuck in branches when moving through the trees.

- b** How would friction ridges have improved the way primates could use their hands and feet?

Answer: The ridges increase friction, thus aiding grip.

- 4** It is thought that primates evolved from an arboreal ancestor. Explain how life in trees would contribute to the evolution of:

- a** vision

Answer: Stereoscopic vision is required to judge depth and distance, so eyes became more forward-facing and vision more discriminating through the process of natural selection.

- b** prehensile digits

Answer: Prehensile digits may have developed as tree-dwelling primates would need to grasp branches when moving between trees and climbing. The digits would also be needed for grasping fruit and seeds from trees and for holding their young while in trees.

- c** intelligence.

Answer: Intelligence may have developed because primates needed to solve problems in the arboreal environment, such as finding food and shelter. Communication would have been more difficult in an arboreal environment and contributed to the need for more problem-solving ability.

- 5** Explain why tarsiers only possess rods, whereas most primates have both rods and cones in the retina of the eye.

Answer: Rods are far more efficient than cones when less light is available. Cones that allow for colour vision are sensitive to bright light. Because tarsiers are nocturnal, less light is available and the possession of cones in the retina would be of no use.

- 6** Chimpanzees have been observed using a range of simple tools, mainly associated with feeding. Describe the structural characteristics of chimpanzees that enable them to make and use tools.

Answer: Chimpanzees possess prehensile digits; opposable first digits; have dexterity of the hands and feet; unspecialised limbs; stereoscopic vision; a large brain, especially the cerebral cortex; nails not claws; and a skeletal structure that allows them to sit with hands free.

- 7 Primates tend to show an evolutionary pattern of a reduction in the number of young and a corresponding increase in the degree of parental care. Set out reasons to explain why primates have evolved in this way.

Answer: Living in trees would make it more difficult to care for multiple offspring so, through natural selection, the number of offspring born at one time would gradually become less. With the reduction in the number of offspring, the survival of any particular offspring becomes more important. To increase the chance of survival of that one offspring, an increase in parental care is necessary. If many offspring are born, survival of an individual is not so crucial, because it is likely that at least some of them will survive.

- 8 Describe the trends that can be observed in primates concerning the duration of gestation, length of infancy and adolescence, and life span. How would these trends contribute to species survival?

Answer: The duration of gestation, length of infancy and adolescence, and life span have all increased. These have contributed to the survival of the species, because the young are well cared for and have increased survival rates as they have a longer period in which to learn the art of survival. The adults live longer and reproduce for longer, ensuring the survival of the species.

- 9 One of the evolutionary trends in primates is the gradual change from eyes that face partly sideways to eyes that are fully forward facing. Describe how natural selection would have brought about this change in eye position. You may need to refer to the summary of the principles of evolution through natural selection on page 205.

Answer: Originally, there would have been variation in the eye position within early primates. In any species, more offspring are produced than can possibly survive to maturity. Due to the excessive birth rate, and limited resources, there is a struggle for existence, or competition for resources to survive. Those individuals with an eye position that better suited the environment would have more chance of surviving and reproducing – termed ‘survival of the fittest’. Therefore, in the gene pool of these primates, the proportion of alleles that produce the favourable eye position gradually increased. In this case, primates that had forward facing eyes that allowed for stereoscopic vision would have had a survival advantage in an arboreal environment. In addition, they would have produced more offspring, allowing the proportion of favourable alleles to gradually increase in the gene pool of the population.