Chapter 18
Primate evolution

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 18.1 Living primates and trends in evolution

In this activity you will examine the primate evolutionary trends discussed in this chapter. To do so, you will need to study some of the structural and behavioural characteristics of a selected number of primates. The best outcomes from this activity will be achieved if you are able to observe living primates in a zoo. However, if this is not possible, you could use reference books on primates or visit websites such as:

- http://animaldiversity.ummz.umich.edu/site/accounts/classification/Primates.html#Primates
- http://nationalzoo.si.edu/Animals/Primates/MeetPrimates/default.cfm

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.

1. Record the common name and the scientific name of the species.
2. Observe the hands and feet of each selected primate carefully and make notes on the following:
   - Is there a claw present on any of the digits?
   - Is the first digit opposable to the others?
   - What is the relative length of the first digit to the others?
   - How mobile are the digits on the hands?
   - How mobile are the digits on the feet?
   - How does this species use its hands and feet for gripping objects?
   - Is this species able to use the precision grip?
3. Look at the mouth and teeth of each selected primate and answer the following:
   - Do the front teeth protrude to form a 'dental comb'?
   - How many incisors and canines can you see in each jaw?
   - Do the teeth appear to be of the same size? If not, which teeth appear to be larger?
   - Do any of the teeth overlap those in the jaw above or below? If they do, can you see a gap between the teeth which allows this to occur?
   - What type of food does the species eat; are you able to relate this to the size and shape of the teeth?

4. Examine the shape of the face and behaviour of each selected primate and pay particular attention to the position of the eyes.
   - Is there a snout present, or is the face flat?
   - Does the species appear to use its sense of smell to explore its environment?
   - Are the eyes directed slightly sideways or are they fully forward facing?
   - How large are the eyes—is the species nocturnal?
   - Are you able to estimate the degree of overlap of vision from the left and right eye?
   - Does the species appear to have to judge distances accurately, such as when leaping from one branch to another?
   - How mobile does the head appear to be on the neck? How far is each species able to turn its head?
5. Look at the size and shape of the cranial portion of the skull. This will give some indication of the size of the brain. Determine the following:
   - whether the skull appears rounded or flat
   - the proportion of the size of the head compared to the rest of the body
   - whether there is any toolmaking or other complex behaviours taking place
   - whether there is social interaction with other members of the species.
6. If the species you have selected has young present, be patient and observe:
   - the number of young and whether you can determine their parents
   - the maturity of the young members of the species
   - any interactions between adults and young
   - the dependence of young animals on their parents.

Answer
Self-research. Answers may vary depending on the primates chosen to research.

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
lemur/loris → New World monkey → Old World monkey → ape

- Increased mobility of digits and independent movement
- Increased first digit opposability
- Claws → nails.

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

Answer
lemur/loris → New World monkey →Old World monkey → ape

- Decreased number of teeth
- Large canines
- 4 cusp molars → 5 cusp molars.

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

Answer
lemur/loris → New World monkey →Old World monkey → ape

- Some species exhibit a decrease in prognathism

- 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 → New World monkey →Old World monkey → ape

- Increasing head size
- Increasing cognitive ability
- Increased learning

Need to relate to complexity of behaviour.

(e) comparative size of offspring and their dependence on their mother or other adults

Answer
lemur/loris → New World monkey →Old World monkey → ape

- Increased size of offspring
- More dependent on parents
- Increased 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
Self-research.

Yes, it is possible to see evolutionary behavioural trends occurring, for example, toolmaking, 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
lemur/loris → New World monkey → Old World monkey → ape

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 the primates are found.

Activity 18.2 Mobility of the human thumb

Apes and humans possess very mobile digits, but only humans can grip an object with true precision. The human hand differs structurally and functionally from that of the other primates. A longer, stronger thumb that can readily oppose each of the other digits has enabled humans to manipulate objects using a precision grip. Humans are also able to use a power grip, where an object is grasped between the undersides of the fingers and the palm of the hand, with pressure in the opposite direction being applied by the thumb. We use a power grip when holding a hammer.

In this activity you will compare the two main ways humans use the thumb and fingers to grip objects. Manipulation of objects with both power and precision enabled our ancestors to become efficient toolmakers.

You will need

A short length of broom handle or a ruler; a pencil or pen

What to do

1. Hold your hand out in front of you with the back of your hand towards your face. Observe how the position of the thumb is different from the fingers.
2. Move your thumb across the palm of your hand to touch each of your fingers in turn. Note the movement of the thumb.
3. Use your thumb and fingers to pick up a pen or pencil from your table. Observe the way the thumb and fingers are employed in the grip you used. This is the precision grip.
4. Squeeze the pen tightly and note which muscles are in use.
5. Grasp a length of broom handle or a ruler as you would a hammer. Observe the differences in the position of the thumb and fingers when this method is used to hold an object.
6. Squeeze the broom handle tightly and note which muscles are used. This is the power grip.

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
Thumb not in line with hand and other fingers.

Fine motor skills—picking up objects

Power grip

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
Precision grip. Index finger and thumb both used to pick up pen. The thumb and fingers are both able to touch and hold the pen.

(b) Which muscles were used to hold the pen in this precision grip?

Answer
Thumb and index finger muscles; the small muscles of the hand.

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: Index finger to thumb.

Power grip: Hand clenched and thumb wraps around the fingers (if grip is small enough).

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

Answer
It closed the grip, giving strength and power o the grip.

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

Answer
The finger and palm (hand muscles); not so much the thumb muscle. Muscles of the forearm add strength to the grip.

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; musculature of the hand and forearm
- Flexibility

Activity 18.3 A comparison of primate skulls

In this activity a website will be used so that you are able to compare a number of primate skulls to observe trends in the size and shape of the skull and teeth, as one goes from the lemurs and monkeys to apes and humans.

1. Log on to the following website: http://www.eskeletons.org.

2. Select 'Comparative Anatomy' from the left menu. This will enable you to compare the skulls of two different species of primate.

3. In the main screen under 'Select a Taxon' choose 'mouse lemur' on the left, then for 'bone' select 'male cranium', and finally in 'view' select 'lateral'.

4. Repeat step 3 on the right-hand side but select 'baboon', 'male cranium' and 'lateral', then click on 'compare'. You should now have the lateral (side) view of a mouse lemur and a baboon skull next to each other to compare.

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.
(b) Which skull has a more rounded profile?
(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.
(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?

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

6. Repeat steps 3 to 5 so that you can compare:
- **(a)** a baboon with a squirrel monkey
- **(b)** a squirrel monkey with a chimpanzee
- **(c)** a chimpanzee with a human.

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
Lemurs ——————————————→ Humans

Skull: Increase in skull size; increased cranium size; foramen magnum more central.

Teeth: Reduction in dental combs; U shape to a parabolic arc; reduction in teeth size; increased canine size (exception is humans); 3 to then 5 cusp molars.

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.

2. 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:

- 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.

3. (a) Differentiate between the terms 'opposable' and 'prehensile'.

Answer
Prehensile means grasping or gripping, especially by wrapping around an object, whereas opposable means that the first digit can be moved so that it can touch all other digits one at a time.

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

Answer
These are both advantages for brachiation and grasping. Friction ridges and nails aid grip and provide the advantage for picking up objects and grasping branches when brachiating.

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

Answer
The evolutionary trend has been increased mobility and opposability of the thumb, and other digits become aligned and are more mobile.

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

Answer
Lemurs ——————————→ Humans

Teeth: General decrease in number; loss of dental comb; 3 to 4 to 5 cusp molars.

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

- Evolutionary reduction in snout and face
- Change in diet
- Prominent canines for carnivores or for defence
- 4 or 5 cusped molars for grinding vegetation

6. (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. Smell became less important as colour vision allowed for the 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; brachiation requires good vision and accurate judging of distances.

7. 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 of advantage to primates?

Answer
It has allowed for a depth of vision and the accurate judging of distance for jumping between trees.

(b) What has compensated for the resultant decrease in the total field of vision?

Answer
The ability to move the head and neck.

8. How has the increased importance of vision affected the region of the primate brain concerned with the interpretation of visual information?

Answer
Increased visual area of the brain is required. This area has increased in size.

9. (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 the increased brain size. The brain has increased in size with 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. This is an advantage as it allows for higher order functioning of the brain and results in higher order skills in primates. This includes toolmaking and more comprehensive 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 brain and the number of convolutions increases.

Lemurs ——————————→ Humans
(Brain convolutions increase)

10. 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.

11. (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
Lemurs ——————————→ Humans
(Increased gestation time)

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

Answer
It allows for more development in a protected uterus and a more complex offspring.

12. 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 as a longer period where offspring still needs parental protection • Decreased number of offspring (more at risk of extinction) • Parents may be exposed to risk in 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:
(a) find out the current problems that exist in the classification of the primates

Answer
There are many issues with the current primate classification system. Many of these 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 then more issues arise.

An example is the difficult-to-classify primate Goeldi's monkey. Current classification reflects information from DNA analysis which is often in conflict with traditional classifications based on anatomical features.

(b) how general is the acceptance 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
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.

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 are a better alternative.

(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
This may have developed as primates needed to move through trees, because they need good eyesight to judge distance and depth. Stereoscopic vision is required to judge depth and distance.

(b) prehensile digits

Answer
This may have developed as primates needed to move through trees, because they need to grasp branches to move between trees and be able to climb. The digits would also be needed for the grasping of food from trees and holding their young while in trees.

(c) intelligence

Answer
This may have developed as primates needed to problem solve how to move around their environment, find food and generally survive. 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 need bright light to operate. As 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
- Prehensile digits
- Opposable first digit
- Dexterity of the hands and feet
- Unspecialised limbs
- Stereoscopic vision
- Large brain
- Nails not claws
- Large canines
- Skeletal structure—being able 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
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 young, an increase in parental care is necessary. If many offspring are born, survival of an individual is not so crucial, as 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 as the young are well cared for and have increased survival rates. The adults live longer and reproduce ensuring the species survival.

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 251.

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 best 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 which allowed for stereoscopic vision would have had a survival advantage in an arboreal environment. In addition, they would have produced more offspring, allowing the favourable alleles to gradually increase in the population.